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Proceedings, Part III

Part 3

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Contents – Part III

Interacting and Learning

Interacting and Playing

Intuitive Visualization of Complex Diagnostic Datasets to Improve Teachers' Individual Support of Learners Based on Data Driven Decision Making

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Abstract. Being able to read and write properly is an important aspect of social participation. There are 6.2 million adults living in Germany who are considered to have low literacy levels. However, supporting people with low literacy is very time-consuming and personnel-intensive. For teachers in literacy courses, we have developed a dashboard for automated diagnosis as well as individual support and tested and evaluated it in the context of UX studies. The goal is to develop a tool that uses visualizations to present complex competence diagnostics in such a way that teachers can intuitively derive profound and individualized support measures for learners.

Keywords: UX research · Teaching · Data driven decision making · Literacy

1 Background: People with Low Literacy in Germany

Germany is populated by 6.2 million German-speaking adults with low literacy (Grotlüschen et al. 2019). These people have considerable problems reading and writing coherent texts, which presents them with major challenges in various life situations. Being able to read and write sufficiently is an important aspect for social participation. For those affected, it is possible to attend literacy courses at an adult education center, both free of charge and for a fee. In 2018, about 25,000 people attended such literacy courses (Reichart et al. 2019). However, diagnosing and supporting these individuals is often time- and staff-intensive. For use in a course context, the online diagnostic otu.lea was developed in the lea project (runtime: 2008–2010, BMBF) and will be adapted to current technical and didactic requirements in the lea.online project (runtime 2019–2021, BMBF). The otu.lea diagnostics enables learners to independently complete an online test, which provides a differentiated evaluation of their learning status. The evaluation is based on a competency model developed specifically for adults with low literacy in the areas of reading, writing, speaking fluency, and arithmetic. The evaluation of each participant is based on many sub-competencies, which together form a comprehensive competency diagnostic. Because skills in adults with low literacy are often not distributed in a linear fashion, small-step diagnostics and the individual support based on them are

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particularly important. For literacy teachers, this means time-consuming and personal attention to each learner. Similarly, the Leo study makes statements about the highest vocational qualifications of low-literate adults. According to this, 38.3% have no vocational training, 5.3% are in vocational preparation measures, and 41.7% have completed an in-company apprenticeship or vocational school (Dutz and Kleinert 2019). It becomes clear that the majority of low-literate people have attended a vocational school, at least during their training. This results in the high importance of vocational schools to recognize and sustainably promote low literacy. Wolf and Koppel (2017) note that although digital support and diagnostic tools are currently available in the field of literacy, there is a lack of tools for linking support and diagnosis.

This is where the dashboard for course instructors, which is also being developed in the lea.online project, comes in. The goal is to develop a tool that enables course instructors in literacy courses as well as teachers at vocational schools to automatically and time-savingly recognize differentiated learning levels in the test results and at the same time to derive individual support needs.

2 Conceptual Development of the Dashboard

Since the effects of datafication (Cukier and Mayer-Schönberger 2013) have become an integral part of everyday professional and private life, we think that the evaluations and visualizations of complex data sets also offer great potential for the literacy field. The central question for the development is how the learners can be individually supported by the teachers based on data driven decision making. In combination with the user interface, data visualizations should provide information transport and enable even non-experts to explore and understand complex diagnostic contexts. Datnow and Hubbard (2016) note in an international literature review on data driven decision making in education that this is a growing area worldwide. They go on to describe that it is important that teachers also have the skills to analyze datasets and that these datasets provide a wealth of information about learning results and students.

Various diagnostic information is presented in the dashboard. First, an overall assessment is made for each user. This is done by assigning the user to a level. In the competence model, each individual sub-competence is assigned to a level. If a partial competence is tested sufficiently often in the test, it is integrated into the evaluation algorithm. 80% of all sub-competencies of a level must have been successfully completed for a test taker to be assigned to this level. This is useful to get an overview, but not helpful for concrete support. What is needed here is strength-oriented and fine-grained feedback that enables the course instructors to derive concrete support measures. The data visualizations of the sub-competencies serve on the one hand to represent (complex) correlations and to enable the user to explore and understand them (Schuhmann and Müller 2000) as well as to provide an information transport to the user (Fischer-Stabel 2018), which goes beyond the mere representation of the test results.

So far, there is little knowledge about the usage habits and media skills of teachers in literacy practice (Wolf and Koppel 2017). The goal is to develop a tool that can be learned quickly and used intuitively by teachers. User experience and usability are parts of the research on human-computer interaction. According to ISO 9241-210 (en) user

experience is defined as "A person's perceptions and responses that result from the use and/or anticipated use of a product, system or service". Usability is defined as the "extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" by the DIN EN ISO 9241-11. In current scientific literature, usability is often described as part of the user experience (Vermeeren et al. 2010). This approach is also used outside of science. The nngroup defines as follows: "User experience encompasses all aspects of the end-user's interaction with the company, its services, and its products". (Norman & Nielson n.d.). To ensure a high level of user-friendliness, usability criteria (DIN EN ISO 9241-11, Molich and Nielsen 1990) were taken into account in the conceptual and design development of the dashboard. The following goals, superior to the criteria, were essential for the development: (a) The dashboard provides a wide range of information. In order to make the functions of the dashboard as easy as possible to experience for the user, special attention was paid to the clarity of the user interface. (b) An evaluation of each learner's competency diagnostics should be presented in a differentiated and detailed manner. To achieve this, these points were taken into account in the design and conceptual development:

- *Clear design:* In order to make the functions of the dashboard as easy to experience as possible for the user, special attention was paid to clarity. The arrangement of elements was based on the laws of Gestalt from cognitive psychology (Anderson 2013) and colors were chosen based on color theories and the perceptual capabilities of the human brain in terms of physiological and cultural aspects (Wegman and Sahid 2011).
- *Present relevant information:* The data sets enable us to present a wide range of information. But which is really relevant for the users or which information is needed to make concrete diagnostic statements? The needs of the target group were determined and evaluated by analyzing the existing otu.lea test evaluation and expert interviews.
- *Individual usage options:* A filter system enables the user to obtain a comprehensive and at the same time clear overview of the competencies of the tested person. Didactically useful filter options, such as individual results, performance progressions and, among other things, levels of difficulty, can be viewed separately. In this way, the often heterogeneous literary competencies of learners in literacy courses (Koppel 2017) can be recorded and viewed in a differentiated manner.

A good design, the presentation of relevant information for the derivation of concrete support needs, and an individual filter system which allows significant reduction of complexity without the loss of important content should make the analysis of data and the recognition of correlations intuitively understandable for the user (Fig. 1 and Fig. 2). In this way, teachers with little media skills or experience in digital data analysis should also be able to make well-founded and data-supported decisions for the individual support of learners.

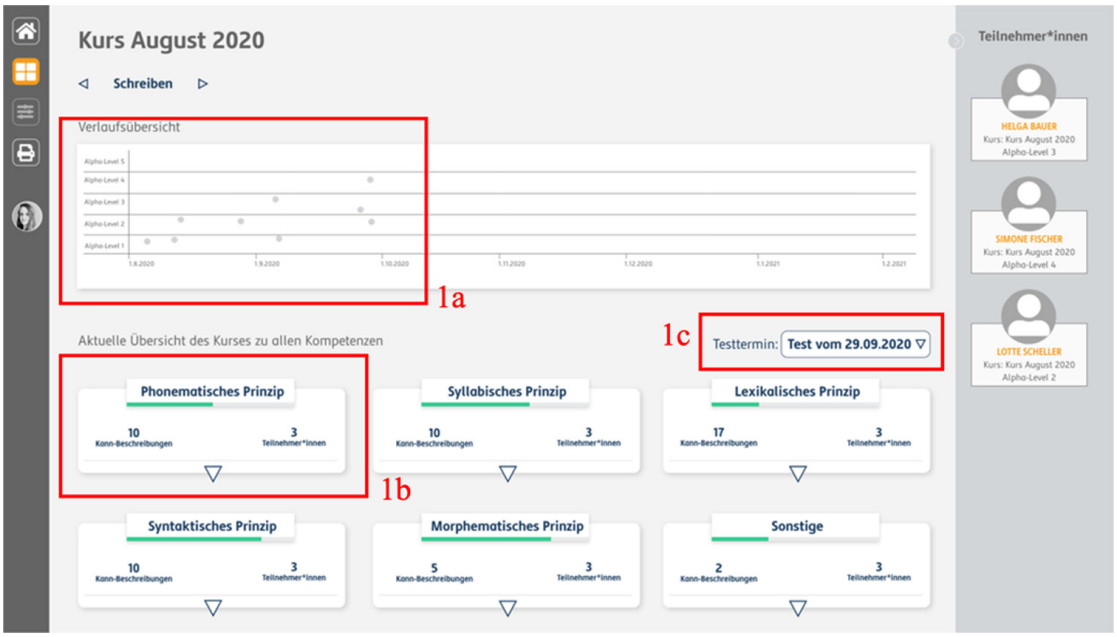

Fig. 1. Screenshot of a "course overview" page. 1a: Progress of each participant in a course, determined on different test dates. 1b: List of individual sub-competencies with results of each student, teacher can expand and collapse the lists. Each list contains several sub-competencies of one group. 1c: Selection of the test date for the list view.

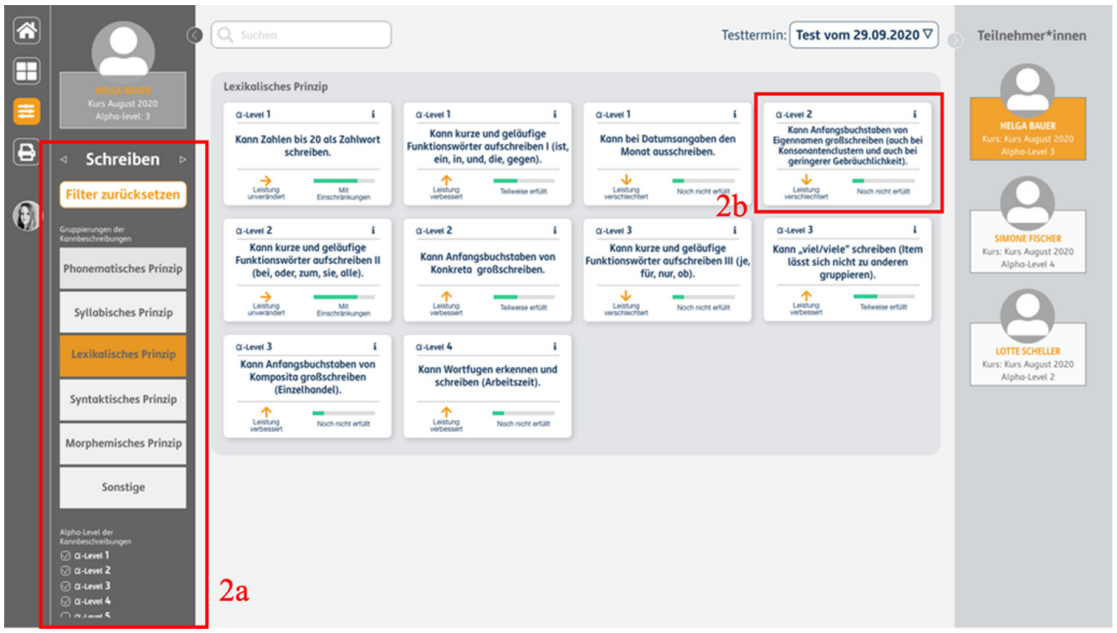

Fig. 2. Screenshot of a "student result" page. 2a: Filter system. Teachers can filter the competencies presented according to their own diagnostic needs. 2b: Each competence is presented on a card. Each card shows the learning level for that competency, the difficulty of the competency, and the student's learning progress.

3 Methodology: UX Testing as Part of a Design-Based Research Project

The dashboard for teachers in literacy practice is developed using the design-based research approach (Anderson and Shattuck 2012). This means that content is developed and evaluated iteratively in small steps. The target group is involved in the development process at an early stage, which is an important factor in the context of user-oriented software development. Consequently, the methodological approach is built on the different phases of the development of the dashboard.

The dashboard has already been conceptualized (phase 1), initial design drafts have been created and revised based on expert interviews (phase 2), and an interactive prototype has been tested with the target group (phase 3). There is a wide range of methods for evaluating the usability and user experience of prototypes and software (Vermeeren et al. 2010, Darin et al. 2019), which have advantages and disadvantages depending on the underlying goals of the study. The dashboard study is a formative evaluation, an intermediate evaluation during the process (Goodwin 2009). The Think Aloud method was used to conduct the usability tests. The users had to perform a previously defined set of tasks with the prototype and were encouraged to express their thoughts, feelings and opinions. Due to the Corona pandemic, testing was conducted digitally via the Zoom platform. All testing was screen-recorded. In total, the dashboard was tested with 12 teachers. Six of the test subjects were from literacy courses at an adult education center and six were from vocational schools. After the usability testing, short interviews were conducted with the test persons about the innovative power and possible applications of the dashboard in their daily work.

4 Results

Overall, the test subjects were able to use the tool well and execute the tasks without errors or with only minor errors. During the test, all test persons already became familiar with the tool and described it as easy to learn. The clarity of the user interface was particularly emphasized by the test persons. Nevertheless, there were clear differences in the speed of use, which, according to the test participants, can also be attributed to the general computer skills of the test subjects. The following additional areas could be identified from the test results:

- *Competence model and evaluation algorithm:* Literacy teachers expressed the need for more information about the scoring algorithm of the test. The test participants were interested in learning how concrete results are generated for individual competencies. On the other hand, teachers from vocational schools needed support in understanding the competency model. This group of people is much less familiar with competency diagnostic knowledge than teachers from literacy courses, which is a very important aspect for the use of the dashboard.
- *Learning materials:* Some teachers from literacy courses expressed the wish to have concrete task sets and/or learning materials suggested and provided in the dashboard on the basis of the test results, which they can then use in class with the learners. This wish was not mentioned by the teachers from the vocational school.

- *Learning progressions:* Especially the presentation of the learning progress of individual participants was mentioned by the test persons. The small-step presentation of partial competencies as well as the coarser feedback related to individual levels were positively emphasized.
- *Use in everyday work:* The vocational school teachers rated the tool as innovative and useful for use with learners. However, many test persons saw a problem with the actual use in the schools. Although many learners also in vocational schools show great problems with basic literacy skills, there is usually no time scheduled in the curriculum for special support for these students. The teachers mentioned on the one hand that they would like to use the dashboard and at the same time expressed concerns about how they can basically implement a literacy support for affected learners in their school, which goes beyond the normal lessons. The feedback regarding a possible use of the Dashboard in the daily work of teachers from literacy courses was consistently positive. The teachers saw the automated and at the same time small-step evaluation of the test results as a great added value for their own work practice. The individual filtering possibilities of results of sub-competencies were mentioned by the test persons as useful for deriving individual support measures.

5 Further Steps

The user experience tests with the think aloud method proved to be a useful tool for evaluating the interactive prototype of the dashboard. The short interviews conducted after the tests also brought good results. Potentials as well as weaknesses of the dashboard were revealed and can be revised in the upcoming project phase. The implementation of the tests as pure online sessions caused problems at various points. Poor internet connections as well as working with Zoom and the prototype at the same time led to interruptions and ambiguities at some points. Since these problems can be taken into account when evaluating the results, it was still a good way to conduct the tests.

In the next step, a first version of the complete usable software will also be tested in connection with the otu.lea test environment. The goal is to test the currently created revisions as well as the use of both tools together. After the release of the dashboard as well as the otu.lea test, usage data will be collected and evaluated as the last step of the surveys. In this way, the results of the qualitative UX surveys will be supplemented by quantitative analyses.

The tests with vocational school teachers have highlighted structural deficits in the support of people with low literacy in vocational schools. These should be examined more closely in further research projects in order to derive concrete approaches for action and reform for the work with people with low literacy in vocational schools.

Several steps can be derived for the use of the dashboard in literacy courses. On the one hand, a strategy must be developed to make the dashboard known and thus support a broad use of the tool. On the other hand, the tests have revealed potentials for further development of the dashboard. The diagnostics could be linked to concrete learning materials and task sets and thus be extended to a comprehensive tool for diagnosis, derivation of support measures as well as provision of task materials, execution and evaluation of these.

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