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DIGITAL FORMATIVE LEARNING ASSESSMENT TOOL – TOWARDS HELPING STUDENTS TO TAKE OWNERSHIP OF THEIR LEARNING

Research in Progress

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Abstract

Over the last years, the number of students has constantly risen while the number of lecturers remained steady. To the consequence are large-scale classes with often hundreds of students. Large-scale classes have didactical challenges such as providing effective feedback for the students' learning success. This is in particular problematic, since feedback belongs to the most influential factors for the student learning success. In order to overcome the challenges of providing feedback in large-scale classes, we suggest using an IT-based solution we label digital formative learning assessment tool (DFLAT). In this research-in-progress paper, we will show the development of this tool by using the method of action design research (ADR). More precisely, we will concentrate on the first part from the requirements gathering to the alpha-version. In order to collect the requirements, we conducted expert interviews with lecturers and students and also derived requirements from scientific literature. Based on the requirements, we will define the key design elements of the first version of DFLAT. The next steps in our research are then the intervention and evaluation of our alpha-version in a large-scale lecture. With our completed research, we aim to contribute to literature by developing a theory of design and action for providing individualized feedback for students in large-scale classes.

Keywords: Digital formative learning assessment, action design research, higher education, large-scale class, feedback

1 Introduction

Over the last years, the number of students has constantly risen while the number of lecturers remained steady (Nicol and Macfarlane-Dick, 2006). In fact, the number of students per lecture is still rising, making large-scale classes with more than 100 students per lecturer a common default at universities (Fortes and Tchantchane, 2010; Pridmore *et al.*, 2010). This class format contains advantages such as comparably low class costs per student. However, it poses also didactical challenges such as designing interactive courses and providing effective feedback on the students' learning success (Bligh, 1998). The latter point is of peculiar importance since Hattie and Timperley (2007), for instance, synthesized 12 meta-analyses involving 6,972 effect sizes from 196 studies, and observed an average effect size of feedback on student achievement of 0.79. Hence, feedback was found to be under the top three most influential factor for student learning success. Despite the fact that the importance of feedback in the learning process is widely accepted, especially in large-scale classes, the final exam is usually the only time for students to receive feedback on their respective learning success. Furthermore, this feedback is often aggregated into a single learning success score providing hardly any insights into strengths and areas with a need to be improved (Boud and Falchikov, 2007). Together with the fact that feedback on and reflection of the own learning success are the basis to achieve higher-level-learning effects and training skills such as critical thinking, knowledge creation, and problem evaluation which are becoming increasingly important in the digital age (Biggs, 1999; Coleman *et al.*, 2016). Given the fact that the trend towards increasing class sizes is likely to continue, the challenge is to find new and innovative ways of providing individual feedback on the students' learning success throughout the learning process (Benamati and Rajkumar, 2013).

Overcoming the challenge, we follow an ADR approach and aim at developing an easy-to-use application for lecturers and students. This application empowers the lecturers to ensure that their students are able to receive individualized feedback and reflect on their learning success. As a result, we expect that this tool will help students to learn more effectively and have a higher-learning-success. The basic idea of DFLAT is that lecturers enter the learning outcomes (LO) of their courses and respective tests into the tool while students have the possibility to carry out a) self-assessments (SA) and b) computer based assessments (CbA) for each LO to receive feedback on their current state of knowledge. The combination of SA and CbA is important for several reasons: First, subjective as well as objective learning successes are stimuli of student satisfaction (Janson *et al.*, 2014). Consequently, a lecturer should get feedback on his or her students' performance on the basis of both dimensions. Secondly, we cannot expect young students to judge their current state of knowledge according to reality. Thus, by combining SA and CbA, we empower them to reflect on how well their judgement (SA) is in line with their actual test performance (CbA) and how they learn to correctly judge their state of knowledge in situations where no objective feedback is available. Furthermore, we rely on insights of the social comparison theory whereby students assess their current state of knowledge in relation to their peers. Within this research-in-progress paper, we present the requirements we derived from literature and interviews with lecturers and students. Furthermore, we present the subsequent design elements that are implemented in the first version of our DFLAT. The paper ends with examining the next steps in our project, focusing on an upcoming evaluation with selected lecturers and students as well as a first field test of DFLAT in a large-scale lecture during the next semester, and our expected contributions.

2 Theoretical Background

2.1 The Importance of Feedback in the Context of Learning

Previous research shows that SA is able to enhance students learning success (Nicol and Macfarlane-Dick, 2006). For example, McDonald and Boud (2003) have shown that training in how to carry out SA can improve students' performance in final exam. According to Sadler (1989), students carrying out SA, of the their own work, contribute to improving learning in the course being studied and providing a foundation for lifelong learning. SA can be defined as the involvement of students in identifying standards and/or criteria to apply to their work and making judgements about the extent to which they actually met these criteria and standards (Boud, 1991). However, SA by itself can lead to an overestimation of ones' skills. Kruger and Dunning (1999) found out, that overestimation often goes along with a lack of metacognitive skills among less skilled participants. Hence, SA paired with objective feedback (such as CbA) leads to an awareness and understanding of how to control the own learning and consequently trains metacognitive skills which lead to a better SA (Nicol and Macfarlane-Dick, 2006).

When it comes to objective feedback we use the definition of Hattie and Timperley (2007), who have stated that feedback is conceptualized as information provided by an agent, for example a lecturer who provides corrective information. Hence, feedback is provided as a consequence of students' performance. The outcome of feedback is an information specifically relating to the task or process of learning that fills a gap between what is understood and what is aimed to be understood (Sadler, 1989). According to Hattie and Timperley (2007), feedback in higher education must answer three major questions. The first question aims at defining what the goals are about. The second question asks which progress is being made towards meeting the goal. The third question asks what activities need to be undertaken in order to achieve a better learning success. More precisely, the first question addresses the learning goals related to the task or performance. The judgement concerning the learning goal may occur on many dimensions, such as directly "passing a test" or "completing an assignment". The second question involves providing information in relation to a task or performance goal. Usually, this is related to prior performances and/or to success or failure on a particular task. Feedback is effective when it consists of information regarding the progress and/or on how to proceed with a certain task. The last question helps the students to guide or provide advice that can lead to greater possibilities for learning. This could contain more self-regulation over the learning process, greater fluency and automaticity, deeper understanding, more strategies and processes to work on the tasks, and more information about what is and what is not understood (Hattie and Timperley, 2007).

2.2 Social Comparison Theory

Festinger (1954) claimed, over 60 years ago, that people possess an drive to evaluate their opinions and abilities. In the digital age with social media such as Facebook, this statement is truer than ever before. There are basically two types of evaluation, on the one hand by referencing to the physical reality or on the other hand, where objective means of evaluation are unavailable due to comparison with other people (Festinger, 1954). One is able to compare with others by means of upward comparison or downward comparison (Buunk *et al.*, 1990). According to Wheeler and Miyake (1992), upward comparison can be defined as the unidirectional drive upward as meaning that people prefer to compare themselves to others whose performance or abilities are slightly better. Furthermore, Aspinwall and Taylor (1993) generally define that upward comparisons (to those doing better than the self) produces negative affect and downward comparisons (to those doing worse than the self) produces positive affect. The definition of downward comparison according to Wills (1981) is that people enhance their own subjective well-being by comparing themselves with less fortunate others. The favorable comparison between the self and the less fortunate other enables a person to feel better about his or her own situation (Wills, 1981). The social comparison model of competition defined by Garcia *et al.* (2013) examines when social comparison takes place and which factors it is influenced by. The model indicates two basic building blocks: individual factors and situational factors. In affiliation with one another they influence the degree of comparison concerns and, thus, of competitive behavior.

There are four situational factors: number of competitors, social category fault lines, proximity to a standard, and incentive structures. The number of competitors in social comparison is an important factor. For instance: Does the competitiveness of students changes when the number of students changes? Research studies have found out that the intensity of competitive behavior increases when the number of competitors' decreases. However, these studies generally confounded expected payoff with the number of competitors (Garcia *et al.*, 2013). Another important factor are social category fault lines (SCFL). Cross SCFL such as university A vs. university B increase comparison concerns and consequently lead to competitiveness, versus to within SCFL such as university A vs. university A. The third situational factor is concerned with the proximity to a standard. Students who are ranked at the top of a leader board tend to have a higher competitiveness than those ranked in the middle (Garcia *et al.*, 2006). The last factor describes the importance of incentive structures, divided into direct and indirect incentive structures. One example is grading in classes, the manner of grading has a major influence on the competitiveness of students. Course grading on a curve leads to higher competitiveness than using an absolute scale (Garcia *et al.*, 2013).

Individual factors can be divided into personal factors and relational factors. Personal factors indicate individual differences and the relevance of the performance dimension (Garcia *et al.*, 2013). An important individual difference, when it comes to social comparison of students, is setting performance goals (Darnon *et al.*, 2012). While one student just wants to pass the exam, another works as hard as possible to get the highest grade possible. Along with the individual differences goes the relevance of dimension. Students compete on dimensions that are relevant and important to them. Concerning education, students compare their academic performance. Relational factors aim on the actors' perception of their similarity, relationship closeness, and personal history with their targets (Garcia *et al.*, 2013). Social comparison takes place when the perceived similarity between two students increases (Festinger, 1954). Similarity can be related to the performance, ability, personal character or general attributes. For example, students who come from the same university, attend similar courses and participate in the same sport clubs are highly similar in terms of personal characteristics and attributes (Garcia *et al.*, 2013). The likelihood of mutual social comparison is higher. A further important factor is the relationship closeness: Is the person we socially compare with, a friend, a family member, or a stranger? Previous research results have interestingly shown that participants provided fewer helpful clues to friends than to strangers on competitive tasks that were self-relevant (Tesser, 1988).

3 Research Method

To achieve the research goal, we use the action design research (ADR) method of Sein *et al.* (2011) for this project. We follow this approach because we want to a) use a scientific method to solve a set of practical problems that researchers and practitioners experience in their own practice and b) contribute to the existing body of knowledge by designing and evaluating a new research artifact (Cole *et al.*, 2005). In the ADR process of Sein *et al.* (2011), the first stage will emphasize the problem formulation; whether it is practice-inspired research or a theory-ingrained artifact. In the second stage, after the formulation of the problem, the building, intervention and evaluation (BIE) cycles will be described. Six semi-structured interviews with practitioners and end-users were conducted. From the interviews, the users and requirements had been derived and the design elements of the alpha-version described. The generic schema of IT-dominant BIE proposed by Sein *et al.* (2011) with all three BIE cycles is thus used. The third stage "reflection and learning" as well as the fourth stage "formalization of learning" will not be part of this research in progress paper (Sein *et al.*, 2011).

4 Towards Designing and Evaluating our DFLAT

4.1 Stage 1: Problem Formulation

Over the last years we have observed a tremendous increase of students at our university (Universität St. Gallen, 2017). Interestingly, this has an impact on the teaching style of the professors and the learning behavior of the students. With 1000 students in the first year of the bachelor program and 120 students aiming for a masters degree, the amount of feedback inclines towards nearly zero. Hence, students lack feedback in large-scale classes. Professors at our university as well as of others confirm this observation and its mentioned consequences. This input from the practitioners and the end-users led to practice-inspired research for developing the DFLAT in order to enhance students learning success. Consequently, we will address the principle 1 of the ADR process "practice-Inspired Research" (Sein *et al.*, 2011).

4.2 Stage 2: IT-Dominant Building, Intervention, and Evaluation Stage

The second stage of ADR uses the problem formulation of stage one as a platform for generating the initial design of the DFLAT. This is further shaped by the subsequent design cycles (Sein *et al.*, 2011).

Figure 1 shows the adapted schema for the IT-dominant BIE from Sein *et al.* (2011). Our ADR team consists of research professors and lecturers which represent the practitioners. The end-users are general lecturers (e.g. from other disciplines) and students at the universities. Three BIE cycles are used for the design of the DFLAT. The black rectangle in *Figure 1* shows the part which will be the focus of this research in progress paper. The first BIE cycle consists of a pilot test of the alpha version with the practitioners of the ADR team. In a first step of this cycle we conducted six semi-structured expert interviews with the lecturers (practitioners) and students (end-users). The structure and questions of the interviews were developed in a workshop by researchers and are based on the common procedure of requirements gathering user stories (Cohn, 2004).

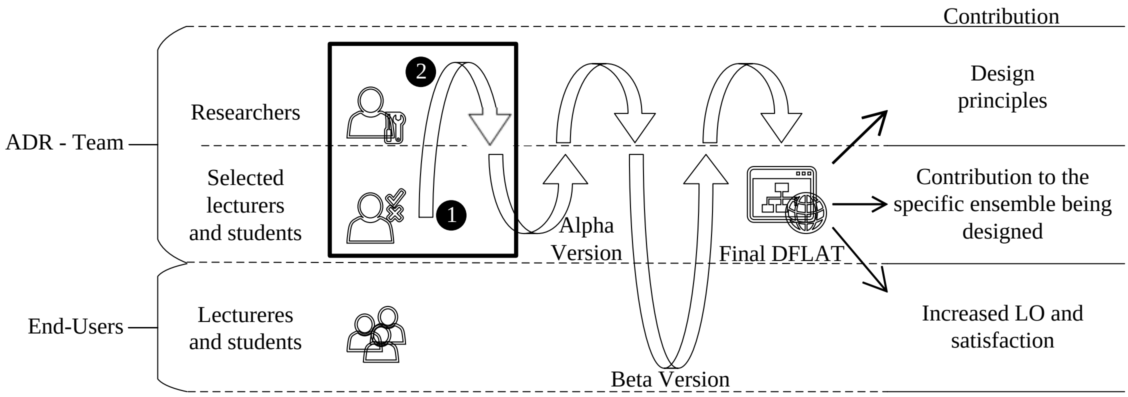

Figure 1. IT-Dominant BIE for the Development of DFLAT (adapted from Sein et al., 2011)

Three interviews have been carried out with lecturers who teach large-scale classes and three with students in those large-scale lectures. After completing the questionnaire in all six interviews, we showed the interviewees a paper based mock-up of the web application to get immediate feedback. The interviews took between 45 and 60 minutes. In the second step of the first BIE cycle, we took user stories from the interviews which have been translated into a) requirements for lecturers (RL) and b) requirements for students (RS) afterwards. The user story and requirements formulation from the sentence structure is based on the method of Cohn (2004). Additionally to the practical requirements, we identified further requirements from scientific literature. Based on these requirements, design elements have been developed. After the completion of step two, the first alpha version was ready for the intervention and evaluation (next step). After the intervention and evaluation, a second BIE cycle is following, which contains a refinement of the DFLAT results in the beta-version. The beta-version is tested afterwards in large-scale classes in as many as three different subjects: IS, economics, and academic writing in 2017. The IS course consisted of 120 master students, the economic and academic writing courses consisted of 1000 first-year bachelor students. The last BIE cycle eventually leads to the final version which, again, will be tested in the three courses.

4.2.1 Requirements from Expert Interviews

Table 1 shows the user stories and the deduced requirements of the expert interviews. We identified three user stories (USL) and six requirements for the lecturers (RS) as well as two user stories (USS) and five requirements for the students (USS). User story one (USL1) reflects the lack of information of the students learning success during the semester. The lecturers have the requirement that the DFLAT provides statistical information of the student’s learning success throughout the semester, in particular the main value and distribution of student’s learning success per LO. Furthermore, the statistics should contain clusters such as top 10 percent or bottom 10 percent of the students learning success. The second user story (USL2) represents the fact that the DFLAT is easy to use and self-explanatory. Hence, the DFLAT should provide wizards and instructions to minimize the lecturers time for adopting the tool. The third user story (USL3) addresses the problem that lecturers want to develop the student’s action competences'. However, the LOs are usually summative tested in the final exam using simple multiple choice questions (MCQ), due to a lack of resources. The DFLAT should provide the possibility to create CbA for lower-level learning as well as higher-level learning. Furthermore, often LOs are complex and can be assessed by more than one CbA. Henceforth, there should be the possibility that LO´s can be assessed by multiple CbAs with weights.

Taken from the interviews with the students, we derived two user stories. The first user story (USR1) represents the need of the students to know what their current state of knowledge is and which content needs to be deepened. Hence, the DFLAT should provide the possibility to carry out SA and CbA of the LOs and graphically presents the learning success as well as differences between SA and CbA. The second user story (USR2) indicates the demand for comparing student's learning success with the learning success of their fellow students. DFLAT should provide the possibility to compare the SA and CbA of one student to the class average, as well as the top 10 percent or lowest 10 percent. However, the competiveness of a student should be defined, beforehand.

User-Stories of the lecturer (USL)	**Requirements from the lecturers perspective (RL)**
USL1) As a lecturer I need to know, how the students judge their perceived and objective learning success, to know which content the students understood and which may need to be deepened.	RL1) The DFLAT should view the SA and CbA of the student's and its difference. RL2) The DFLAT should provide statistics of the student's learning success such as class average, per LO, per LU, per semester, top 10 percent and lowest 10 percent.
USL2) As a lecturer I need to easily configure and create LOs and CbAs, to provide students objective feedback.	RL3) The DFLAT should provide instructions and guidance for creating LOs and CbAs. RL4) The DFLAT should automatically read presentation slides and store the content.
USL3) As a lecturer I need to assess the LOs in different ways, to assess lower-level as well as higher-level learning.	RL5) The DFLAT should provide different CbAs to test the LOs, for lower- and higher-level learning. RL6) The DFLAT should provide the possibility to test one LO with one or more CbAs.
User-Stories of the student (USS)	**Requirements from the students perspective (RS)**
USS1) As a student I want to get feedback concerning my current state of knowledge per LO, to know what I have understood and which content I need to revise.	RS1) The DFLAT should provide the students the possibility to self-assess their current state of knowledge of each LO. RS2) The DFLAT should provide the students objective feedback through CbA per LO. RS3) The DFLAT should provide graphical easy to understand statistics of the difference between the SA and CbA of the student and how the values changed over time.
USS2) As a student I want to compare my learning success with my fellow students, to reflect about my current state of knowledge.	RS4) The DFLAT should identify the student's competitiveness. RS5) The DFLAT should provide the possibility to compare the student's individual learning success with the average of the class, the top 10 percent, and lowest 10 percent.

Table 1. Requirements derived from the expert interviews with the lecturers and students

4.2.2 General Requirements from Scientific Literature

In this section we gather the requirements from scientific literature for developing a DFLAT. The first requirement (RT1) deals with the aspects of feedback. Feedback should answer three important questions in order to provide optimal feedback for the students learning success: What are the goals?, What progress is being made towards the goal?, and What activities need to be undertaken to make better progress? (Hattie and Timperley, 2007). The second (RT2) and third requirement (RT3) address the possibility to compare the students learning success to the learning success of fellow students. According to Festinger (1954), in the human organism exists a drive to evaluate ones opinions and abilities. However, the cultural and characteristical attributes of the students need to be taken into account as the DFLAT should provide the possibility to disable social comparison mechanisms whenever the demand for competitiveness is low. According to Nicol and Macfarlane-Dick (2006), feedback on the students learning success leads to an improved awareness and understanding of how the student can control his learning. In order to do this, the student needs the possibility to actively monitor his progress of the learning success (RT4). Hence, the DFLAT should provide an overview of the learning success, aggregated from each LO to, LU, to course, to semester. The fifth requirement (RT5) deduced from scientific literature deals with the observation that if students receive feedback often and regularly, it promotes better monitoring and self-regulation of a student's learning progress (Gibbs and Simpson, 2005). Hence, the DFLAT should enable any student to get feedback at any time and any place.

Scientific Literature	Derived Requirements from Theory (RT)
Hattie and Timperley (2007)	RT1) The DFLAT should provide the students feedback based on three aspects: What are the goals?, What progress is being made toward the goal?, What activities need to be undertaken to make better progress?.
Festinger (1954) Social Comparison Theory	RT2) The DFLAT should provide the possibility to compare the learning success of the students with their fellow students. RT3) The DFLAT should provide the possibility based on the competitiveness of the student do turn off social comparison, for students who are not competitive.
Nicol and Macfarlane-Dick (2006)	RT4) The DFLAT should provide the student the possibility to active monitor his learning success
Gibbs and Simpson (2005)	RT5) The DFLAT should provide the students the possibility to get feedback at any time any place.

Table 2. Requirements derived from scientific literature

4.2.3 Design Elements of the DFLAT

Addressing the building phase of the first BIE cycle in stage two, the following section is to describe the design elements (DE) (Table 3) based on the identified requirements from the practitioners, end-users and scientific literature (Table 1 and Table 2). Time is one of the main limited resources of lectures as well as students (Gibbs, 1992). Most obstacles of innovations, while being of high quality, are not to be easily usable by a broad range of lecturers without extensive support of the researchers who designed the system (Penuel and Yarnall, 2005). Therefore the aim of the tool is to reduce the effort for the lecturer in managing the LOs as good as possible. This is achieved by DE1 that the DFLAT automatically reads the LUs slides and eventually storing them in the database. If the lecturer has defined no LOs yet, a wizard helps the lecturer with creating LOs and corresponding CbAs. If the lecturer has already created CbA´s such as MCQs, those can also be parsed and stored by the tool.

We mainly distinguish the CbA´s in, addressing higher level LOs (HLLO) and lower level LOs (LLLO). For instance HLLO´s could be assessed by flaw diagrams. Students need to analyze, e.g. a business process model with syntactical or logical errors. The students would have to find and correct the errors in the business process. The students search process addresses HLLO, namely on the “analyze” and “evaluate” domain of the Bloom/Krathwool taxonomy (Krathwohl, 2002). To assess LLLO, CbA “assigning” task could be used. For example the student would have to assign the different software process models to its advantages and disadvantages. This would address the first and second domain, “remember” and “understand” of the Bloom/Krathwool taxonomy (Krathwohl, 2002). However, CbA´s for HLLO will be part in the second BIE cycle.

In order to facilitate the lecturers and students, the DFLAT graphically represents the course with its LUs and LOs (DE2). For the presentation we use a treemap (Google, 2016) in which a lecturer is able to link the LO to one or more CbAs using drag&drop. The third design element addresses the requirement for visualization of the learning success and comparison with the learning success of fellow students. The lecturer can view the distribution of the students learning success per LO, summarized to a LU, a course or a semester. Concerning the design we use common patterns, for example regarding dashboard designs (Few, 2006). To reduce complexity and provide students with the possibility to use the DFLAT on smartphones, tablets, or computer screens, we use a responsive UI (DE4). Patterns from the UI interface design are used, such as responsive disclosure, responsive enabling, and liquid layout (Tidwell, 2010). Not every student is equally interested in comparing his learning success with those of fellow students (Kruglanski and Mayseless, 1990). Hence, with the registration process students respond to assessment questions regarding their competitiveness (DE5). For the competitiveness assessment, the "Iowa-Netherlands Comparison Orientation Measure" by Gibbons and Buunk (1999) is used which consists of 11 items that are based on a 5-point Likert scale ranging from disagree strongly to agree strongly. The last design element (DE6) addresses the three characteristics of feedback provided to the students. The concept of individualized and adaptive feedback is used (Dempsey and Sales, 1993). Students have to define their goal at the beginning of the course. Therefore, the first property of feedback addresses this goal. The second characteristic of the feedback concerns the difference between SA and CbA and the last one is adjusted to the dimensions proposed by Dempsey and Sales (1993): individual differences (e.g. on-task performances) and content errors (e.g. the number of errors).

Design Elements (DE)	Description	Addressed Requirements
DE1) Walkthrough wizzards	Walkthrough wizzards to create LO and CbA. Walkthrough wizzards to import the LOs from the lecture slides.	RL3, RL4
DE2) Tree-Structure of the LOs with drag and drop	The hierarchy of LOs and LUs are viewed as a tree structure. The CbAs can per drag&drop be assigned to the LOs.	RL5, RL6, RS2, RS3, RS1
DE3) Learning success charts	The lecturer gets a chart of the learning success distribution per LO. The student gets a graphical view of his learning success compared to his fellow students.	RT4, RL1, RL2, RS5, RT2
DE4) Web-based application with responsive UI	The DFLAT is based on the latest web application technology which supports responsive UI for different screen sizes, such as smartphone, tablet or computer screen.	RT5
DE5) Assessment questions	The student is answering questions during the registration process concerning their competitiveness.	RS4, RT3
DE6) Individual and adaptive Feedback	The DFLAT provides the feedback based on the students learning success.	RT1

Table 3. Design Elements of the DFLAT

5 Next Steps, and Expected Contribution

Within this research-in-progress paper, we presented the requirements we derived from literature as well as from expert interviews with lecturers, and students. Furthermore, we presented the subsequent design elements that are currently implemented in the first version of our DFLAT. Our next steps are the intervention and evaluation of our first BIE cycle. Therefore, we will test the alpha version in a large-scale bachelor class of approximately 110 IS students. The primary goal is to test the requirements derived from lectures, students, and scientific literature, in order to improve and refine the tool. With our completed research, we aim to contribute to literature by developing a theory of design and action for providing individualized feedback to students in large-scale classes (Gregor and Hevner, 2013). With the creation of design principles we would like to address the following class of problem "providing individual feedback in large-scale classes". Therefore, we will generalize the derived design principles from the design research outcomes.

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