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Effects of Web-Based Feedback on Students' Learning

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Feedback plays an important role in supporting students' learning process. Nonetheless, providing feedback is still rather unusual in higher education. Moreover, research on the design of ideal feedback as well as its effects is rare. In order to contribute to the development of this field, a web-based feedback system was implemented in a lecture at the University of Cologne. The effects of this feedback on the students' learning process are presented in this article. Differences in the students' learning success and motivation, as well as their assessment of competencies, are analyzed within an experimental setting. Students who received individual feedback through this system achieved higher grades and showed increased levels of motivation. Moreover, they felt more competent with regard to solving tasks related to the learning material.

In recent years, there has been increased awareness of the importance of feedback for student learning in higher education (Hernández, 2012; Weurlander, Söderberg, Scheja, Hult, & Wernerson, 2012; Yorke, 2003). In Europe, developments in the context of the Bologna Process have underlined the relevance of feedback for students (Hochschulrektorenkonferenz, 2008; Wissenschaftsrat, 2008). However, research on the construction, let alone the effect, of feedback in higher education is rare (Narciss, 2004; Yorke, 2003). This deficit is even more surprising considering the crucial role that feedback plays in self-regulated learning:

> Intelligent self-regulation requires that the student has in mind some goals to beachieved against which performance can be compared and assessed. [. . .] Feedbackis information about how the student's present state (of learning and performance)relates to these goals and standards (Nicol & Macfarlane-Dick, 2007, p. 200).

With regard to learning objectives, students need to know when they should be at a certain point in their learning process in relation to where they actually are. This information enables them to figure out and—depending on the feedback—reduce possible learning deficits (Narciss, 2004). In addition, providing feedback helps teachers obtain an overview of their students' progress. If they see that most of the students are not reaching the predefined learning goals, they can try different ways of explaining the material or use other teaching approaches. In summary, providing feedback might be beneficial for students and teachers in many respects.

Nonetheless, feedback is still not an integral part of higher education teaching (Bargel, Müßig-Trapp & Willige, 2008; Müller, 2007). This is especially the case with regard to formative feedback throughout the semester, even though this is when it would support students' learning process the most (e.g., Clark, 2012; Han & Finkelstein, 2013; Wilson & Scalise, 2006). Usually, students receive summative feedback, e.g., a grade on their final exam without further comments from the teacher (Yorke, 2003). This lack of (elaborated) feedback is partly a result of the general trend, such as increasing student numbers and the developments in education policy in Europe in the last few years. In Germany, there has been a 30% increase in student numbers in the last ten years (winter semester 2002/2003 to winter semester 2012/2013) (Statistisches Bundesamt, 2013), and they will continue to rise in the years to come (Kultusministerkonferenz, 2012). This tendency can also be observed for Europe as a whole, with an overall increase in student numbers of 19% from 2003 to 2012 (Eurostat, 2015). At the same time, universities are suffering from underfunding and thus increasingly limited resources in terms of time and personnel (Berthold, Gabriel & Ziegele, 2007; Dohmen & Krempkow, 2014; Hölscher & Kreckel, 2006). As a consequence of these developments, the number of students per course is increasing even more (Metz, Rothe & Pitack, 2006) and resulting in unfavorable staff-student ratios (Heinbach & Kühnle, 2012; Hölscher & Kreckel, 2006; Irons, 2008; Rust, 2002). Therefore, the call for a shift to learner-centered higher education as stated in the Bologna reform is difficult to implement in practice (Nickel, 2011). As a consequence, providing individual, regular feedback seems to be impossible in classes with a high number of participants.

The aim of this study was to find a way of providing students with feedback throughout the semester, even in classes with a high number of participants. This included finding a way to assess a student's individual performance. In this context, electronic voting systems (EVSs) (also known as audience response systems), were considered to be a practicable solution for assessment and maybe even for sustainable feedback in higher education. This article analyzes the effects of the web-based system Votepoint+ on the students' learning.

Electronic Voting Systems and Their Effects

The basic principle of EVSs is that the teacher asks a (multiple choice) question, which the students answer by using a transmission device (E-Teaching, 2014). Usually, the results and answers to the questions are shown in a digital presentation. Therefore, transmission and receiver devices, as well as software to present the results, are needed in order to implement EVSs. Unfortunately, a system that allows bidirectional communication and feedback between teachers and students has not existed up to now.

Today the two main kinds of transmission devices that are used are clickers or mobile devices (e.g., smartphones). Clicker devices have to be purchased (e.g., by the university) and are usually handed out before the class and collected afterwards. The substantial time and financial expenditure that this entails can be reduced by using a "bring your own device" (BYOD) system. Students use their own mobile devices (e.g., smartphones, tablets or laptops) to transmit the answer to the questions asked by the teacher. For most BYOD systems, students need to install an app prior to use.

The implementation of EVSs has been shown to have positive effects on students' learning success, which is measured by the grade received on a final exam (Majerich, Stull, Varnum, & Ducette, 2011). This finding might have several reasons. Kay and LeSage (2009) found out that attention in class is higher when EVSs are used. Furthermore, several studies have shown that students who use EVSs are more confident about and satisfied with their learning progress (Kundisch et al., 2012; Stuart, Brown, & Draper, 2004). Moreover, their understanding of concepts and motivation to actively participate has been shown to increase (Schmidt, 2011). This aspect is supported by the finding that EVSs might lead to a higher degree of involvement (Stuart et al., 2009), as well as increased interaction between teachers and students in class (Kay & LeSage, 2009).

The state of research presented shows that EVSs have an influence (in one way or another) on students' learning. Nevertheless, systematic research on the construction and effects of feedback, as well as a definition of the determinants of success, are still lacking. However, there seems to be general agreement that it is appropriate to use EVS for assessing student performance. The studies presented here have one thing in common: None of the interventions used EVSs to provide individual feedback from the teachers to students. The EVSs that have been developed so far do not contain this component. Therefore, developers at the University of Cologne created a new web-based EVS called *Votepoint+,* which is described in the following paragraph.

Votepoint+

Votepoint+ is a web-based feedback system that was originally designed for implementation in classes with a high number of students. The main requirement for using the system is a web-enabled device (e.g., laptop, smartphone, tablet), which most of the students have access to (Rietz, Franke & van Koll, 2013). Votepoint+ can be easily used by accessing a webpage (http://vote.uni-koeln.de); no app needs to be installed, and students do not have to register to use it. The only action required prior to implementation is setting up a teacher account, which is used to create a library of questions (single or multiple choice) with answer categories and feedback comments.

A Votepoint+ session is started when the teacher logs into his/her account. A "vote-ID" is shown, which the students need to enter on the webpage in order to be assigned to the session. Alternatively, the students can enter a short name if they wish. If not, their answers remain absolutely anonymous. Once the teacher activates the question, the answer categories are presented on the students' mobile devices. They can then decide which one(s) is (are) correct and submit their final choice. After the participants have voted, the teacher is able to see the results immediately and respond accordingly. If most of the students did not answer the question in the correct way, the teacher can explain certain aspects again or use a different approach.

After one session of questions, the students can request individual feedback. During the voting session, a PDF document is created which contains the questions, answer categories and correct answers with respect to their responses. The students can then have this feedback document sent to them immediately by providing their email address.

Votepoint+ and Feedback

Which and how much information the feedback document contains is a decision made by the teacher. While there is a great deal of research available within the context of schools (e.g., Hattie & Timperley, 2014), there is a huge research deficit and only few empirical studies with regard to designing feedback for students (Narciss, 2006). At least there is agreement that feedback should be fully oriented towards learning goals (Rust, 2002; Sippel, 2009). Furthermore, it should be provided promptly (Rust, 2002) and contain a few constructive comments instead of overly detailed information (Sippel, 2009).

Narciss (2006) introduced the concept of informative tutorial feedback. Within this framework, the role of feedback is to support the students' process of self-regulation. In order to stimulate the active construction of knowledge, this

process needs to contain elaborate elements rather than just providing the correct answers (Narciss, 2006). Students need information that helps them to find the correct solution to a problem on their own, although the amount of information provided depends on the individual's abilities (Narciss, 2006; Huth 2004; Moreno, 2004; Mory, 2004). Moreover, Vollmeyer and Rheinberg (2005) found out that sometimes simply providing feedback helps: the "[…] expectation of feedback simply leads to a higher commitment to do the task, because the learners themselves […] can find out how well they performed" (p. 600).

Although there is no agreement on how an ideal feedback system should be designed, it is clear that feedback is important in supporting students' learning process. Due to the fact that time and personnel resources are often limited, providing feedback is almost impossible for teachers in higher education. Votepoint+ could offer a possible solution for generating individual feedback with relatively low effort for students and teachers.

Hypotheses

Due to the lack of systematic research on feedback and its effects, there are only two main assumptions that can be made: Feedback seems to be important for students' learning processes, and EVS seem to have an effect in this area. Narciss (2006) classified cognitive, meta-cognitive and motivational indicators for the effects of feedback. Some of these indicators can be observed while others need to be reported by the students. In this article, the number of questions answered correctly and the grade received on the final exam are used as an observable indicator of the effects of feedback (cognitive/meta-cognitive) on learning success (Narciss, 2006). Accordingly, the learning success of students who receive feedback is supposed to be higher, which leads to one of the two main hypotheses:

> H_A: Students who receive feedback via Votepoint+ show higher learning success than those who do not.

Moreover, Narciss (2006) states that feedback is supposed to have an effect on motivational aspects. Some of the indicators for the effects of feedback are that students rate tasks as more interesting, are more satisfied with their performance on tasks, and report a strong willingness to work on similar tasks in the future. This results in the second hypothesis:

> H_B: Students who receive feedback via Votepoint+ show higher motivation levels and rate their competencies higher than those who do not.

Method

Design and Procedure

The main study of the effects of feedback on students' learning was conducted during the summer semester of 2014 within the scope of three lectures entitled, "Introduction to Research Methods" at the University of Cologne. These compulsory lectures were identical with regard to the learning material discussed. The students were randomly assigned to one of the three lectures. Predefined review questions were given after each chapter of learning material for discussion purposes. In one of the three lectures, these questions were asked via Votepoint+ and included individual feedback for the students (experimental group "Introduction to Research Methods A"). The other two lectures defined the control group. In the second lecture, the same predefined questions were presented; however, the discussion did not include individual feedback via Votepoint+ ("Introduction to Research Methods B"). In the third one, no predefined questions were used. Instead, students asked questions that came up during the lecture ("Introduction to Research Methods C"). This design (see Figure 1) was chosen to find out whether working with review questions had an effect regardless of whether Votepoint+ was used or not. In order to analyze the possible effect that individual feedback via Votepoint+ had on motivation and self-assessment of competencies, pre- and posttests were conducted. In addition, the students were asked to fill out an online survey. The pretests took place within the first two weeks of the semester before the first questions were discussed (April 2014), and the posttests were conducted during the last weeks of the semester (June 2014).
The exam results were used for analyzing the effect on general learning success. The final exam took place during the last week of the summer semester (July 2014).

Participants

All three lectures were included in the analysis in order to study the learning success of the participants. A total of 342 students in the special needs education study program took the final exam. Of those, 169 belonged to the experimental group, i.e., "Introduction to Research Methods A" (49%). In the "Introduction to Research Methods B" (control group) lecture, 133 students (39%) took the final exam. The smallest group (12%) was the "Introduction to Research Methods C" (control group, n=40). In total, 84 (25%) of the 342 students who took the exam did not pass.

With regard to a possible change in motivation and abilities, only those students that took part in the online survey at the beginning and end of the semester (pre- and posttest) could be analyzed. Since participation in

Figure 1
Research Design for Testing the Effects of Votepoint+

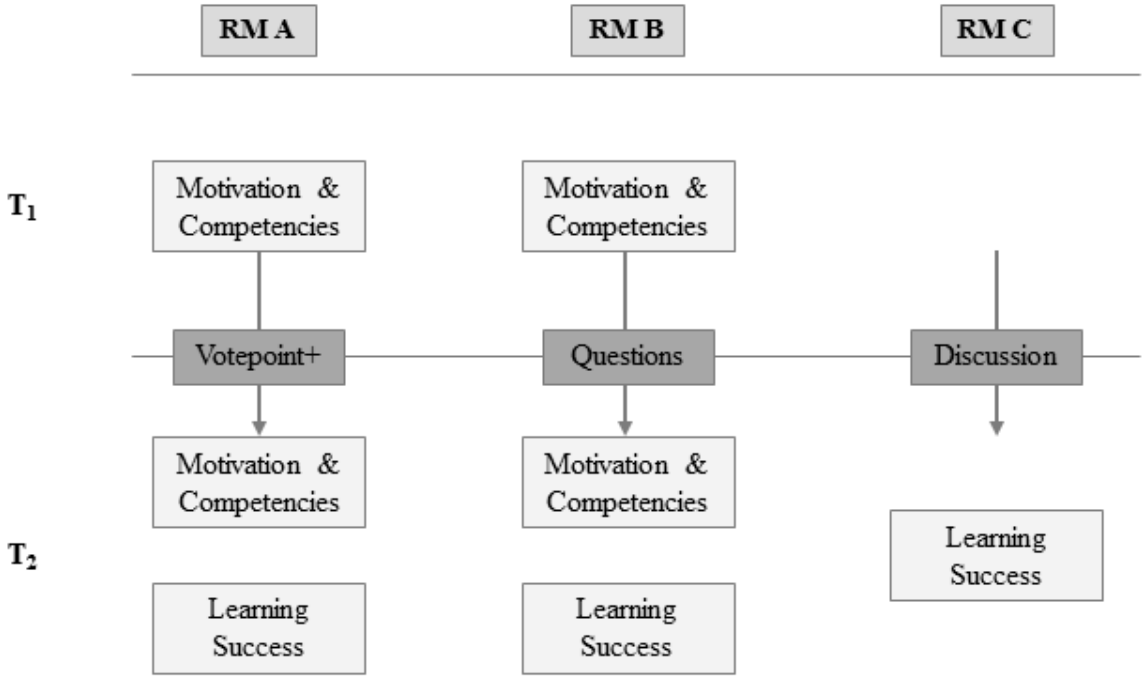


Figure 1. RM A (1) = Introduction to Research Methods A; RM B (2) = Introduction to Research Methods B; RM C = Introduction to Research Methods C.

the survey was voluntary, the response rate was not equal to the number of students who took the final exam. Moreover, the students in the "Introduction to Research Methods C" lecture were not surveyed because they did not use the predefined questions. The response rate for the pre- and posttest in the other two lectures was characteristic for a student survey (e.g., Schmidt, 2015): A total of 52 students answered the questionnaire at the beginning and end of the semester. Of these, 31 (60%) were enrolled in "Introduction to Research Methods A" and 21 students (40%) in "Introduction to Research Methods B." Even though the students were reminded of the survey several times via email as well as during the lectures, it did not have much effect on the response rate.

Measures

The students' learning success was measured by the number of correctly answered questions on the final exam. The exam consisted of 100 multiple choice questions with three answer categories, of which at least one was correct. However, it was also possible for two or even all three of them to be correct. An answer was counted as correct if the student chose exactly those categories that were true. If, e.g., only one of the two correct answer categories was selected, it did not count. The exam questions were not identical with the review questions that were asked throughout the semester. Since there was no obligation to attend the lectures, an additional question was included on the exam: the students were supposed to specify how often they had been present when the review questions were discussed. This allowed the effects of individual feedback on learning success via Votepoint+ to be controlled for frequency of attendance. The review questions and answers were available online for the students in the "Introduction to Research Methods A" and "Introduction to Research Methods B" lectures. Feedback was only provided within the lecture since this could only be done on an individual basis.

A questionnaire by Narciss (2006) was used to measure the students' motivation and self-assessment of competencies. This questionnaire included a measurement of the preactional self-assessment of competencies (three items) as well as of intrinsic (two items) and performance-related motivation (four items). One statement for measuring the preactional self-assessment of competencies was, "Solving these types of tasks is usually very easy/very hard for me," while an indicator for intrinsic motivation was the statement, "I usually do/do not find these types of

Figure 2
Feedback Document Votepoint+ (Example)

Votepoint+
27.06.2014
Access: vote2.uni-koeln.de
Information: www.votepoint.de

Number of correctly answered questions: 4
X = correct answer
Correct means: a) a correct answer category was chosen OR b) an incorrect answer category was not chosen

X = incorrect answer
Incorrect means: a) a correct answer category was not chosen OR b) an incorrect answer category was chosen

Votepoint+ report for name.surname@uni-koeln.de

Questions for chapter 2

Question: 1) Independent Variables

[X] 1. ... ideally have an effect on dependent variables. X

Comment:
Correct, dependent variables can be influenced and predicted by independent variables.

[X] 2. ... might correlate with other independent variables. X

Comment:
Correct, if several independent variables are included in a model, they can be interrelated.

[X] 3. ... are defined by the researcher. X

Comment:
Correct, variables are not defined as dependent or independent by nature. Researchers have to classify them as dependent or independent.

tasks very interesting/interesting at all." In addition, during the second measurement, eight items for the postactional self-assessment of competencies were included. For example, one statement within this construct was, "I am very satisfied with my performance with regard to the tasks in today's class." The statements presented here were translated by the author for the purposes of this article; however, the original statements in German were used for the study. All of the statements were answered according to a rating scale of one to six, where one represented a high level of competence and motivation and six a low level of competence and motivation.

On the one hand, the feedback implemented in "Introduction to Research Methods A" via Votepoint+ was designed based on qualitative interviews with students. On the other hand, it could be kept rather simple and without too many elaborate components because factual knowledge was taught in the lectures (Narciss, 2006). In summary, it included the question, answer categories, and information on the answer category(ies) chosen (see Figure 2). Furthermore, the feedback contained information on why certain answer categories were correct and others were not, as well as recommendations for further reading.

Data Analysis

All the analyses were conducted using SPSS. A single factor analysis of variance was carried out for studying the effect on learning success. A repeated measures multivariate analysis of variance (MANOVA) was conducted for studying the effect of Votepoint+ on motivation and self-assessment of competencies. A

one-way MANOVA was calculated for analyzing the postactional items.

Results

Learning success

In looking at the descriptive statistics for learning success (Table 1), the first thing that stands out is that the number of students who failed the final exam was highest in the "Introduction to Research Methods C" lecture, which is the one that did not include review questions for discussion. In contrast, the percentage of participants who failed in each of the other two lectures was around half of that of "Introduction to Research Methods C." Moreover, the descriptive statistics for "Introduction to Research Methods C" show the lowest average number of questions answered correctly, as well as the lowest average grade in comparison to the other two lectures. The average number of correctly answered questions and the average grade was highest in "Introduction to Research Methods A," the lecture in which Votepoint+ and feedback were used.

The tendency for learning success to be influenced by a discussion of predefined questions could be confirmed in an ANOVA with the number of correctly answered questions as a dependent variable. The results indicate significant differences between the means of the "Introduction to Research Methods A" and "Introduction to Research Methods B" lectures on the one hand and "Introduction to Research Methods C" on the other ($F(2, 339) = 6.1$, $p = 0.002$). When controlling for the frequency of attendance, group differences were found ($F(4, 238) = 5.6$, $p < 0.001$). Again, it was the "Introduction to Research Methods C" lecture that differed significantly from the others (Table 2).

Interestingly, there is no significant difference between "Introduction to Research Methods A" and "Introduction to Research Methods B" lectures with respect to those students who participated regularly ($p = 1.0$). There was a significant difference, however, within the "Introduction to Research Methods A" ($p = 0.04$) lecture. Here, the students who attended regularly achieved a significantly higher number of correctly answered questions and therefore a better grade on the final exam compared to those who attended the lecture only infrequently.

Table 1
Descriptive Statistics for Learning Success

Lecture	Passed	Failed	Correct Questions	Grade
Research Methods A	133 (79%)	36 (21%)	70	3.3
Research Methods B	102 (77%)	31 (23%)	69	3.4
Research Methods C	23 (57%)	17 (43%)	63	3.9
Total	258 (75%)	84 (25%)	69	3.4

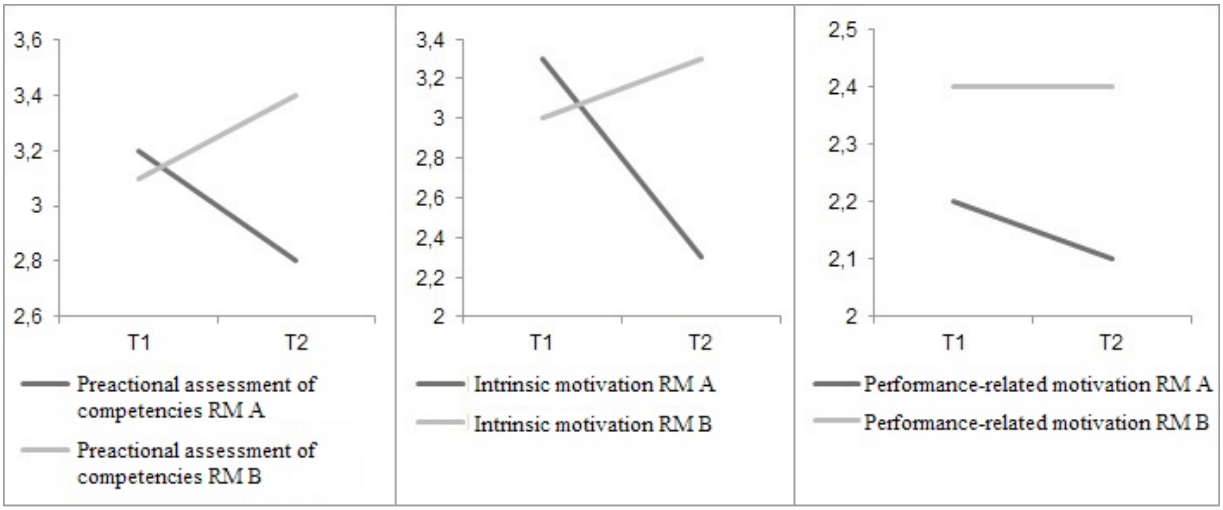
Table 2
Post Hoc Test (Bonferroni) for Correctly Answered Questions by Lecture and Frequency of Attendance

	RM A (1)		RM B (2)		RM C (3)		
Correct Questions	M	SD	M	SD	M	SD	Post Hoc
Regular Attendance	72.1	11.4	70.9	11.9	62.6	13.3	3 < 1, 2
Rare Attendance	66.4	13.2	70.2	11.9			3 < 2; 1 = 3, 2
Total	167		81		40		

Note. RM A (1) = Introduction to Research Methods A (group 1); RM B (2) = Introduction to Research Methods B group 2) RM C (3) = Introduction to Research Methods C (group 3); M = Mean; SD = Standard Deviation.

Figure 3

Development of Means for Motivation



Motivation and Self-Assessment of Competencies

As mentioned before, only "Introduction to Research Methods A" and "Introduction to Research Methods B" could be included in the analysis of motivation and self-assessment of competencies. The reason for this is that items in the survey related to the predefined questions discussed in the lectures.

For a start, possible changes in the students' motivation and self-assessment of competencies were analyzed by taking a closer look at the descriptive statistics (Figure 3). The three dimensions preactional self-assessment of competencies, intrinsic motivation, and performance-related motivation showed the same tendency: the values for "Introduction to Research Methods B" where Votepoint+ was not used increased or at least stayed on the same level while those for "Introduction to Research Methods A" decreased over time. This means that the participants in the "Introduction to Research Methods A" lecture who received individual feedback felt more competent over time with respect to finding the correct answer to the questions discussed. Moreover, their intrinsic and performance-related motivation increased from the time of the first measurement to second one. The repeated-measures MANOVA confirmed this tendency by showing a significant interaction between competencies, motivation, time and lecture ($F(5.33, 266.43) = 6.52$, $p < 0.001$). In other words, the means for the students changed over time depending on whether they attended "Introduction to Research Methods A" and therefore received individual feedback or not. When analyzing each of the three dimensions separately, significant differences between the lecture groups become obvious for the self-assessment of competencies and intrinsic motivation. The students who received individual feedback via Votepoint+ seemed to rate their competencies and intrinsic motivation higher than those who attended "Introduction to Research Methods B."

The items for the postactional self-assessment of competencies were analyzed using a one-way MANOVA. There was a significant difference between the students' answers depending on which lecture they had attended ($F(8, 43) = 2.92$, $p = 0.01$). Therefore, a t-Test was calculated to analyze the items between the groups. All of the items except for one differed significantly between the students who attended "Introduction to Research Methods A" and "Introduction to Research Methods B" ($p < 0.05$). The one non-significant item was the only one that did not relate to the specific questions asked, but rather to the general knowledge gained in the lecture ($t(50) = -0.79$, $p = 0.22$). With regard to the other items for the postactional self-assessment of competencies, the students who received individual feedback via Votepoint+ described themselves as more qualified to answer the questions than those who attended "Introduction to Research Methods B" and were more satisfied with their performance with regard to the questions. Moreover, they found the questions easier to answer and more interesting than the students who did not receive individual feedback. The students who attended "Introduction to Research Methods A" also expressed that they would like to work on questions like these in future sessions, which might be an indicator for the perceived benefits of Votepoint+.

Discussion

Teaching in higher education faces the challenge of adapting to changing conditions. Although the number of students continues to rise, financial resources at universities have stayed the same. This means that there are more students per class due to limited resources in personnel. At the same time, it has become clear that more in-depth teacher-student interaction with regular, individual feedback is needed in order to support self-regulated learning. Under the given circumstances, the practical implementation of feedback seems almost impossible.

The web-based feedback system Votepoint+ provides a low-cost solution for providing feedback. The effort of implementation is relatively low, and the system can even be used in classes with a high number of participants. Feedback only needs to be entered once because the system automatically generates individual documents for each student.

The analysis showed that the participants who attended "Introduction to Research Methods A" where Votepoint+ was used answered more questions correctly on the final exam and achieved a better grade. However, no significant differences were found between the students who received feedback via Votepoint+ and those who discussed the same predefined questions with the teacher. There might be two possible reasons for this non-significance: One might have to do with the type of feedback given. The feedback via Votepoint+ only contained information about which of the answer categories were correct or wrong and the reasons for this. This type of basic feedback was chosen because research on the construction of feedback in higher education is rare. The students who participated in "Introduction to Research Methods B" received similar information: After each session, the correct answers were marked in a document provided online, and the teacher discussed them within the lecture. The other possible reason for non-significant differences between the two groups might be that it was not possible to control for how much time the students invested in working with the feedback at home. A question concerning this was asked in the survey at the end of the semester; however, since only a few students answered the questionnaire, too much information would have been lost if the answers had been included in the analysis. It is also possible that the students did not work with the feedback document at home because they felt that looking at it during the lecture was sufficient.

However, the students who received individual feedback via Votepoint+ showed increased motivation and rated themselves as more competent in answering the review questions. Moreover, they showed a higher interest in the learning material. The students who used Votepoint+ even stated that they had fun answering the questions and felt like they were participating more actively in the lecture.

The positive effect of feedback on the learning success of students might (partly) be a result of their increased motivation and perception of themselves as more competent. The feedback provided by Votepoint+ might not only support review and a deeper understanding of the learning material, but also more self-confidence with regard to the final exam. For the type of lecture that was analyzed within the context of this article, it can be concluded that receiving feedback in one way or another supports students in their learning process. Providing individual feedback through Votepoint+ helps students not only to achieve a higher grade but also become more motivated. However, there is one limitation to the effect on feedback: it needs to be provided and implemented on a regular basis. Students who never or rarely used Votepoint+ and therefore only received feedback on an irregular basis showed significantly lower learning success than those who used it regularly.

The first results reported in this article show that the implementation of Votepoint+ might be a possible approach to the provision of feedback even in classes with high numbers of students. It not only helps teachers to observe the learning progress of students as a basis for possible interventions, but also supports students' learning success and leads to higher motivation and more self-confidence with respect to the learning material. However, further research is needed with regard to the design of an ideal feedback as well as the transferability of Votepoint+ to other kinds of classes that do not focus exclusively on factual knowledge.

Limitations

Although the implementation of a web-based feedback system like Votepoint+ seems to be a promising approach, there are some limitations.

First of all, Votepoint+ was tested in the "Introduction to Research Methods" lectures, in which (mostly) factual knowledge was taught. Therefore, the learning progress of the students could be easily controlled by working on predefined multiple choice questions. But what happens in classes where the goal is to foster critical thinking? In these classes, predefined questions with answer categories are useless because the definition of a correct answer might not be possible. Moreover, the question arises of how feedback via Votepoint+ could be given in classes that focus on the development of higher order thinking skills. In this case, the feedback would have to focus on the quality (e.g., time needed) of the approach that the students choose to solve a problem rather than the correctness of

an answer. This brings up the question of the transferability of the system to other class formats. For example, even though Votepoint+ has been implemented in lectures, it may also find use in other settings such as seminars or tutorials.

Secondly, an analysis of the effect of a different feedback design (e.g., length, inclusion of elaborated components) would have been helpful. However, this could not be done mainly due to the lack of research on feedback in higher education. In addition, there is still no agreement on which components ideal feedback should contain. While more elaborate feedback might help some students, the construction used in this study with only basic elements might be sufficient for others.

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