What Intervention Combination of Peer Teaching, Individualization, and Process Feedback Increases Student Engagement and Performance in Digital Science Classes?

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Abstract

Student engagement is often below average in courses that are cognitively demanding, such as statistics. When this content is delivered in digital learning formats, engagement sometimes drops further and academic procrastination threatens course completion. Ways to address this include peer support, customizability through optional assignments, and high-quality feedback through process feedback.
With the aim of supporting student engagement and increasing knowledge acquisition, a study design with 8 different groups (with/without peer teaching, with/without optional additional tasks, with/without process feedback, and all possible combinations) was conceived and conducted in an online course (N = 268). The dependent variables were engagement (punctual uploading of application tasks), quality of the application tasks (content assessment), and results in the final test (seventh task).
The main effects (MANOVA) were that engagement was higher in social learning situations (peer teaching) as well as in individualization (additional tasks) and that the quality of the application tasks was higher in groups with process feedback.
In addition to the main effects, there were the following interaction effects: In groups with peer teaching, both individualization and process feedback caused the quality of submitted tasks to be higher, and in groups with process feedback, individualization caused the quality of submitted tasks to be higher. Final test scores were not affected by any of the independent variables.
Exploratory analyses revealed that students who used individualizability only sporadically and performed poorly on the final test already had less engagement during the semester. Students who had less engagement also scored lower on the test. The quality of the application assignments and engagement were together significant predictors of passing the course.
The results clearly show that even in a blended learning context it is important to carefully consider how tasks and lessons are implemented.

Keywords: *Student Engagement, Procrastination, Science Education, Digital Teaching*

1. Introduction

In every degree program, there are courses that are more cognitively demanding than others. In courses with complex content (such as statistics), student engagement is often below average [1]. Reasons for this among many students are that they have negative attitudes [2], sometimes based on fear of being overwhelmed and failing. Nevertheless, voluntary additional offers such as individual mentoring are hardly taken up [3]. Therefore, it is purposeful to consciously increase engagement in the course to facilitate successful completion [4].

When cognitively demanding courses (e.g., statistics) are taught in digital learning formats, engagement sometimes drops even further, leading to academic procrastination [5]. Academic procrastination is the behavior of putting off academic work until the last minute, which is often compensated with so-called bulimic learning [6]. Procrastination is seen in the majority of university students [7] and threatens course completion [8]. Studies consistently show that students who start their work later, turn it in later, are more likely to have negative academic outcomes [9], and academic procrastination is negatively correlated with grades on submitted assignments [8]. Furthermore, procrastinating students devote relatively little time to their studies and, in particular, rarely engage in independent study [10], which is why continuous learning [11] and completing regular assignments is challenging [12].

Ways to achieve this include peer support [13], because peers lead to positive emotions through social interaction [14], course customizability through optional assignments [15], because individualizability makes courses more attractive to many students [15], and high-quality feedback

through process feedback [16], because this encourages students and makes them feel professionally supported [17].

2. Methods

The data was collected in 11 blended learning courses (N = 268), five in the summer semester 2021 and six in the winter semester 2021/22.
In each course, students had to work on six contents (boxplot, histogram, mean and variance, maximum likelihood, t-test, chi-square). The content was delivered via the moodle learning platform (via video, script, and literature) and was to be completed in a 2-week cycle.
For each topic, there was an application task that had to be completed and uploaded to moodle in order to receive the participation certificate. The deadlines for the assignments were communicated to the students at the beginning of the semester. Every six weeks (after every three contents, twice in the semester) there was a face-to-face appointment for consultation, repetition and application of the topics using the statistical software SPSS in the university. At the end of the semester was a final test (learning assessment, without a grade).
There was systematic variation in whether the application tasks were to be completed alone or as a group of 3 (peer teaching), there were optional application tasks for individualization, and feedback was given as elaborated process feedback (rather than pure feedback on results). An overview of the variations can be found in Table 1.

Table 1. Variations and sample sizes

	Peer Teaching	Optional Application Tasks	Process Feedback	n
Group 1	-	-	-	37
Group 2	-	-	X	34
Group 3	X	X	-	29
Group 4	-	X	-	33
Group 5	X	X	X	30
Group 6	-	X	X	35
Group 7	X	-	-	34
Group 8	X	-	X	36
N				268

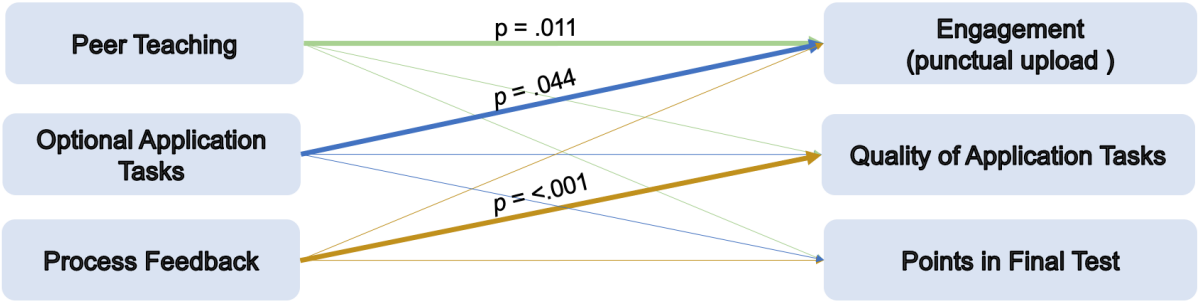
The dependent variables were engagement (punctual upload of the six application tasks, no procrastination), the quality of the six application tasks (content assessment), and results in the final test. The six application tasks were graded in all courses according to the same criteria by the first author, and 100 points could be achieved in each of the six tasks. Ten percent of the submitted tasks were additionally graded by the second author without knowing from which group the tasks originated. In addition, the timing of the uploading of the assignments by the students in Moodle was recorded in whole days, with a negative number indicating uploading before the deadline and a positive number indicating uploading after the deadline.
The final exam was automatically graded in Moodle and 30 points could be earned. Peer teaching, optional assignments, and process feedback was coded as a dummy variable for the evaluation.

3. Results

Three main effects were found (MANOVA). First, there was less procrastination (more engagement) in groups with peer teaching (Kruskal-Wallis-Test $H(1) = 6.455$, $p = .011$). Second, in groups with

optional tasks, the engagement was higher, too (Kruskal-Wallis-Test H(1) = 4.044 ,p = .044). And third the quality of the application tasks was higher in the groups with process feedback (Kruskal-Wallis-Test H(1) = 17.646, p < .001, see figure 1).

Figure 1. Overview of the significant effects with the corresponding p values



In addition to the main effects, there were the following interaction effects: In groups with peer teaching (groups 3, 5, 7, and 8), both the potential for individualization through optional additional tasks and process feedback caused higher quality in submitted tasks. In the groups with process feedback (groups 2, 5, 6 and 8), the potential individualizability also caused a higher quality of the submitted tasks.

Sadly, the score from the final test was not affected by any of the variations.
Deeper exploratory analyses of the data revealed that students who used the additional assignments sporadically during the semester (max. 1 time) and performed poorly on the final test (1 SD below average) were the same students who were already late in turning in their mandatory application assignments during the semester.
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The quality of the submitted application tasks and the commitment (meeting the time requirements) were together significant predictors for passing the course (linear regression with passing the course as dependent variable).

4. Implicationen

Since peer teaching had medium effects on procrastination on a global level, it can be assumed that social learning and connectedness with other learners also leads to engagement in blended learning. Experiencing competence through high quality support (through high quality feedback; process feedback) also seems to foster the development of skills to implement what has been previously learned in digital settings.
The results imply that peer teaching and individualization increase engagement, while process feedback rather affects performance in task completion and the combination of these possibilities in digital settings should be well considered.

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