Strategic choices in curriculum design to facilitate knowledge and competency development
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Document Version
Publisher's PDF, also known as Version of record

Publication date:
2014

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):
Kerdijk, W. (2014). Strategic choices in curriculum design to facilitate knowledge and competency development. [S.l.]: [S.n.].
Cumulative assessment versus assessment at the end of a course: effects on self-study time and test performance

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Submitted
ABSTRACT

Introduction Academic procrastination is one of the factors associated with study delay. Cumulative assessment uses distributed learning in order to stimulate students to study more frequently throughout a course and to prevent procrastination. In this random controlled study, we investigated how cumulative assessment may affect time spent on self-study and test performance as compared to end-of-course assessment. Furthermore, we investigated how students perceive both assessment methods to influence their learning.

Methods 78 students in a second-year course were randomly divided over two conditions: cumulative assessment or end-of-course assessment. At the start of the experiment, students completed a questionnaire about the extent to which either assessment method influences certain aspects of their learning. Students in the cumulative assessment condition were assessed in weeks 4, 8 and 10, and students in the end-of-course condition were only assessed in week 10. Each week, students reported the number of hours they spent on self-study. Performance was measured with 48 questions in week 10 in both conditions.

Results Students in the cumulative assessment condition spent significantly more time on self-study in all weeks (p<.05), except weeks 5, 9 and 10. Their self-study time peaked around exam weeks. Overall, they spent 69 hours more on self-study during the course than their peers in the end-of-course assessment condition (p<.05). Students in the cumulative assessment condition scored significantly higher on questions concerning the content of the last two weeks of the course. No differences were found in overall performance. Cumulative assessment was generally perceived to have a more positive influence on learning than end-of-course assessment.

Discussion Our study shows that cumulative assessment benefits student learning by encouraging students to distribute their learning activities over the course and preventing procrastination. Our findings also suggest that cumulative assessment leaves students more room to study content of the last part of the course. Cumulative assessment can be a useful tool to guide students’ study behaviour.
INTRODUCTION

STUDY DELAY is a common problem in higher education. A factor that is associated with study delay is students’ tendency to procrastinate, i.e. postponing test preparation. Up to 30% of students procrastinate, delaying their tasks until just before or even beyond the deadline, while even more students procrastinate slightly. Consequently, students’ self-study time decreases. Since assessment influences students’ study behaviour, frequent testing may help prevent procrastination. However, empirical evidence for this assumption is lacking. Cumulative assessment combines principles of distributed testing, repetition of content and compensation among tests in order to stimulate students to study regularly and benefit students’ test performance. In this randomized controlled study, we investigated how cumulative assessment affects students’ self-study time and test performance as compared to end-of-course assessment. Furthermore, we investigated students’ perceptions of the influence of both assessment methods on their study behaviour.

One of the main reasons why students postpone test preparation is that they experience the test date to be too far away. If there is a lot of time before the test date, students are likely to prioritize other activities such as work, friends or hobbies. This line of reasoning is supported by the finding that most students start test preparation three to four weeks before a test. As a corollary, students who procrastinate will run short on time to prepare for tests appropriately. The availability of sufficient self-study time in curricula is central to students’ study progress. However, students who procrastinate, try to master all knowledge of the course using only part of the available self-study time. Therefore, it is not surprising that procrastination is associated with lower grades and increased time needed to graduate a course.

A possible solution to the problem of procrastination may be to increase the number of tests in a course, in order to consistently decrease students’ perceived temporal distance to the tests. With cumulative assessment, students are frequently tested which should encourage them to study more regularly and prevent procrastination. Furthermore, each subsequent test has an increasing number of questions and students can compensate among tests, which should encourage them to further increase the time they spend on self-study. Therefore, we hypothesize that students who participate in cumulative assessment will study more and more frequently during a course than students who are only assessed at the end of the course.

Intuitively, one would expect that spending more time on self-study results in better test performance. Additionally, cumulative assessment may improve students’ test performance because each subtest assesses the content of all preceding weeks and, consequently, the same content will be repeatedly tested and studied. Earlier studies have shown that repeated testing of the same content can positively influence knowledge retention. Distributed testing and studying can also positively
influence knowledge retention.\textsuperscript{21-25} However, these benefits mostly concern long-term knowledge retention. On the short term, massed learning and distributed learning can yield similar test results.\textsuperscript{21-23} As a corollary, it is difficult to predict whether cumulative assessment will benefit students' test performance. On the one hand, test performance may be higher in cumulative assessment, because of repeated testing and studying. On the other hand, students who participate in cumulative assessment and students who are only assessed at the end of the course may perform equally well, because distributed and massed learning can yield similar short-term results. Therefore, we investigate whether students who participate in cumulative assessment outperform students who are assessed only at the end of a course.

The implementation of educational measures, such as cumulative assessment aimed at regulating students' study behaviour, can lead to resistance among staff and students.\textsuperscript{26,27} When we initially implemented cumulative assessment, we experienced such resistance. One purpose of this study was to find further support for the benefits of cumulative assessment. Several years after the implementation, we were interested in how students experience cumulative assessment as compared to end-of-course assessment. Therefore, we investigated how they perceive both assessment methods to influence their study behaviour and which method they prefer.

In summary, cumulative assessment combines several theories about assessment in order to stimulate students to study regularly, to prevent procrastination and to increase students' test performance. In a randomized-controlled experiment we endeavoured to answer three research questions. First, what is the effect of cumulative assessment on self-study time? Second, what is the effect of cumulative assessment on students' test performance? Third, how do students perceive cumulative assessment and end-of-course assessment to influence their study behaviour? Concerning the first research question, we hypothesized that students who participate in cumulative assessment will spend more time on self-study and study more frequently during the course. For the second and third research questions, we did not formulate hypotheses.
METHODS

Participants and Setting
At the University of Groningen each year of the preclinical phase is divided into four integrated 10-week courses, addressing a combination of topics. Cumulative assessment has already been implemented in two out of four courses of the second year of the undergraduate medical curriculum. In the other two courses, students are encouraged to keep studying through PBL tutorials. The current study was conducted among students in the fourth course of the second year (n=395). In this course, lectures were combined with PBL tutorials and students were assessed at the end of the course. All students had experienced cumulative assessment as well as end-of-course assessment in earlier courses. The topic of the course was chronic illnesses (internal medicine). Before the start of the course, all students were invited by e-mail to participate in the experiment. Initially, 105 students responded and after information was provided 78 of them signed an informed consent form. They were randomly assigned to either the cumulative or the end-of-course assessment condition. When the experiment was finished, students received a 20 Euro gift certificate and got the opportunity to observe an open heart surgery.

Ethical approval for the experiment was obtained from the Ethical Review Board of the Netherlands Association for Medical Education (NVMO-ERB) and the institutional Board of Examiners. In order to minimize the influence of the experiment on students’ pass rate, we conducted the study in a course where students were already stimulated to keep studying using PBL tutorials.

Procedure
After informed consent was obtained, the participants were invited to fill out an online questionnaire. Based on their experience, we asked all students to respond to six items and indicate on a 10-point scale to what extent cumulative assessment and end-of-course assessment stimulated them to influence their study behaviour. Furthermore, at the end of each week they were asked to report the number of hours they spent on self-study. Students in the cumulative assessment condition sat three multiple choice tests at the end of weeks four, eight and ten. These exams consisted of 19, 28 and 48 questions, respectively. In each test the study content of all previous weeks was assessed. After each test, the right answers to the test and information about students’ performance were made available through the digital learning environment of the university. Compensation among tests was possible. Students in the end-of-course assessment condition sat one multiple choice test at the end of week 10. This test consisted of 95 questions, including the 48 questions of the third test in the cumulative assessment condition. These 48 questions were used as a measure of performance and covered the content of weeks 1-4, 5-8 and 9-10, with 10, 21 and 17 questions, respectively.
Analysis
We used t-tests to investigate differences between the two conditions regarding time spent on self-study per week and during the entire course. To assess the effect of cumulative assessment on students’ test performance, we compared both conditions in terms of percentages of correctly answered questions of weeks 1-4, 5-8 and 9-10 separately and of the total test, i.e. 48 questions. We analysed test performance with t-tests. For all comparisons between conditions, we calculated Cohen’s d as a measure of effect size. Effect sizes are considered small when they are lower than 0.3 and large when they are higher than 0.8 (Cohen). Differences in perception of cumulative assessment versus end-of-course assessment were investigated using paired t-tests.

RESULTS
Over the course of our study seven students dropped out of the cumulative assessment condition because they had missed one or more subtests. Furthermore, exploratory analysis revealed that students, who were retaking the course, were distributed asymmetrically across conditions. Because we expected retaking the course to influence performance and study behaviour, we excluded 7 and 2 students from the cumulative assessment and the control condition, respectively. The final test analysis was performed with 25 students in the cumulative and 37 in the end-of-course assessment condition. During the first four weeks, students in the cumulative assessment condition spent twice the amount of time on self-study than their peers in the end-of-course assessment condition. Differences between the groups were significant in each week (Table 1; Figure 1a). In weeks six through eight students in the cumulative assessment condition also spent significantly more time on self-study. In weeks five, nine and ten, we found no significant differences in self-study time. At the end of the ten-week course students in the cumulative assessment condition had, on average, spent 182 hours on self-study and students in the end-of-course condition 113, which is a significant difference of 69 hour with an effect size of 1.01 (Table 1; Figure 1b).
Table 1. Means, standard deviations, T values and Effect sizes for differences in self-study time between students in the cumulative and end-of-course assessment conditions in a 10-week course.

<table>
<thead>
<tr>
<th>Week</th>
<th>Cumulative assessment condition</th>
<th>End-of-course assessment condition</th>
<th>T-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (hrs)  SD</td>
<td>Mean (hrs)  SD</td>
<td>T</td>
</tr>
<tr>
<td>1</td>
<td>7.8   8.6             3.8   3.8</td>
<td>-2.13*</td>
<td>0.57</td>
</tr>
<tr>
<td>2</td>
<td>8.2   7.4             4.5   3.9</td>
<td>-2.29*</td>
<td>0.60</td>
</tr>
<tr>
<td>3</td>
<td>13.8  9.9             6.2   5.3</td>
<td>-3.48**</td>
<td>0.91</td>
</tr>
<tr>
<td>4</td>
<td>29.5  13.3            5.8   5.1</td>
<td>-8.46**</td>
<td>2.22</td>
</tr>
<tr>
<td>5</td>
<td>10.5  11.5            7.6   6.8</td>
<td>-1.28</td>
<td>0.30</td>
</tr>
<tr>
<td>6</td>
<td>11.6  9.6             7.3   4.8</td>
<td>-2.05*</td>
<td>0.54</td>
</tr>
<tr>
<td>7</td>
<td>17.8  7.7             10.3  7.9</td>
<td>-3.55**</td>
<td>0.96</td>
</tr>
<tr>
<td>8</td>
<td>30.8  13.8            11.8  7.5</td>
<td>-6.62**</td>
<td>1.65</td>
</tr>
<tr>
<td>9</td>
<td>20.5  11.5            18.4  10.6</td>
<td>-0.71</td>
<td>0.19</td>
</tr>
<tr>
<td>10</td>
<td>30.4  12.4            37.0  15.8</td>
<td>1.70</td>
<td>0.47</td>
</tr>
<tr>
<td>Course total</td>
<td>182.4  76.8</td>
<td>113.2  55.6</td>
<td>-3.81**</td>
</tr>
</tbody>
</table>

* = significant at the α = .05 level ** = significant at the α = .001 level

Concerning the 48 items assessing performance, we found that students in the cumulative assessment condition performed significantly better on the 17 test items about the content of the last two weeks of the course (t(59.6) = -2.01; p < .05; ES = 0.52). No significant differences between the two conditions were found for the 10 and 21 items regarding the content of weeks 1-4 and 5-8, respectively (Table 2). No difference...
in overall performance was found (Table 2).

Students generally perceived cumulative assessment to stimulate them more in regulating their own learning than end-of-course assessment (Table 3). They also regarded cumulative assessment as more stimulating to plan self-study time, prepare for a test, repeat content, and study the content in detail. Furthermore, they perceived cumulative assessment to prevent procrastination more than end-of-course assessment. The students did not regard cumulative assessment as more stimulating critical thinking. Finally, 52 out of the 62 students preferred cumulative assessment over end-of-course assessment.

Table 3. Means, standard deviations and T values for differences in students’ perceptions of cumulative assessment versus end-of-course assessment.

<table>
<thead>
<tr>
<th>Question (10-point scale)</th>
<th>Cumulative Assessment</th>
<th>End-of-course assessment</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>the extent to which it...</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>stimulates planning self-study time</td>
<td>7.8</td>
<td>1.0</td>
<td>6.1</td>
</tr>
<tr>
<td>helps to prevent procrastination</td>
<td>7.8</td>
<td>1.1</td>
<td>5.1</td>
</tr>
<tr>
<td>stimulates repeated studying of the same content</td>
<td>7.3</td>
<td>1.3</td>
<td>5.3</td>
</tr>
<tr>
<td>stimulates to prepare for tests</td>
<td>7.6</td>
<td>0.8</td>
<td>7.0</td>
</tr>
<tr>
<td>stimulates to study the content in detail</td>
<td>6.8</td>
<td>1.2</td>
<td>6.1</td>
</tr>
<tr>
<td>stimulates critical thinking</td>
<td>6.7</td>
<td>1.5</td>
<td>6.4</td>
</tr>
</tbody>
</table>

*= significant at the α = .05 level

DISCUSSION

The results of our study confirmed the hypothesis that students in the cumulative assessment condition distribute their self-study time more and spend more hours on self-study throughout the course than their peers in the end-of-course assessment condition. We also found a positive effect of participating in cumulative assessment on students’ test performance concerning the content of the last part of the course. Furthermore, 84% of all participating students preferred cumulative assessment over end-of-course assessment. In general, cumulative assessment was perceived to influence students’ study behaviour more positively than end-of-course assessment.

Our study revealed significant differences in self-study time between the two conditions in weeks 1-4 and 5-8. However, we did not find significant differences in week 5 and weeks 9-10. A possible explanation for not finding a significant difference in week 5 may be that students who participated in cumulative assessment took some time to unwind after preparing and taking the first test. This is even more likely because week 5 was furthest away from the subsequent test. Not finding a significant difference in weeks 9-10 can be explained by the fact that, in both conditions, students were preparing intensively for the final test during these weeks. Our findings provide evidence that cumulative assessment is an effective method to stimulate students to study regularly.
throughout a course and to prevent procrastination. Furthermore, our results confirm earlier findings that students’ test preparation increases drastically as test dates get closer.\textsuperscript{10,14,28} In the cumulative assessment condition, self-study time evidently peaked in the weeks the tests were taken – weeks four, eight and ten – suggesting that test dates influence students’ study efforts and students are just-in-time managers (Figure 1).

We found a significant difference in performance across conditions regarding items about the content of the last two weeks of the course. A possible explanation may be that students who participated in end-of-course assessment may not have had enough time to study all course material, because they were cramming. Students in the cumulative assessment condition had already studied the course material of the first eight weeks and probably had more time left to study the content of the last two weeks of the course.

We did not find differences in overall test performance between both conditions. Considering the large differences in self-study time across conditions, this finding is rather counterintuitive. However, it is in line with the notion that massed learning can be as effective as distributed learning in the short term.\textsuperscript{21-23} Since test preparation peaked just prior to the final test in both conditions, students in both conditions may have reached similar knowledge levels. It has been argued that the superiority of distributed learning over massed learning is that information is forgotten more slowly.\textsuperscript{21,23} Therefore, future research investigating the effect of cumulative assessment on long-term knowledge retention may still yield results in favour of cumulative assessment.

The PBL tutorials throughout the course may have interfered with our results concerning students’ test performance. PBL tutorials engage students, support self-directed learning and stimulate deep rather than surface learning.\textsuperscript{29,30} Furthermore, similar to cumulative assessment, PBL tutorials stimulate students to retrieve and apply acquired knowledge regularly throughout a course, which improves retention.\textsuperscript{31,32} Therefore, an effect of cumulative assessment on overall test performance may have been tempered by the PBL tutorials. A similar experiment in a more traditional, lecture-based course may determine whether this was the case.

Most students (84\%) preferred cumulative assessment over end-of-course assessment. They also perceived cumulative assessment to stimulate regulating their own learning. These findings suggest that initial resistance students may have experienced during the implementation of cumulative assessment is no longer commonly held. The reason that students did not regard cumulative assessment as more stimulating critical thinking, may be that this intervention is mostly aimed at time management and continuous engagement with the course content rather than the level of engagement and how students process the content.

A limitation of this study concerns the dropout we experienced in the cumulative assessment condition. During the experiment seven students dropped out during the study because they missed one or more
tests. This dropout rate is inherent to an experiment in which assessment programmes with single versus multiple tests are being compared. It is unclear how this influenced our findings. However, we feel that the medium to large effect sizes we found consistently across the course are too substantial to be explained away by bias stemming from dropout.

Another limitation is that we cannot attribute the effects in self-study time solely to distributed testing. Given the peaks in self-study time just prior to tests, it stands to reason that the increased self-study time in the cumulative assessment condition is related to the distribution of tests across the course. However, it remains unclear to what extent the other aspects of cumulative assessment influenced students’ study behaviour. For example, if the tests would not have been compensatory, students with initial bad results might have been discouraged and might not have studied as much during the rest of the course. The increasing number of questions in each subsequent test and the fact that each test assesses content of all preceding weeks may have been of influence as well. Further research is needed to unravel how each aspect of cumulative assessment influences students’ study behaviour.

The current study shows that cumulative assessment can prevent procrastination. Distributed testing in cumulative assessment has a significant effect on the time students spend studying during a course. Students take more time for self-study and distribute their learning more throughout a course. Students also perceived cumulative assessment to help them study effectively. Our findings suggest that cumulative assessment benefits students’ study progress, since procrastination has been negatively associated with study progress. Furthermore, the availability and use of sufficient self-study time in a curriculum is positively associated with study progress. Concerning test performance, we only found a positive effect of cumulative assessment with respect to the last part of the course. However, an earlier study yielded evidence that cumulative assessment helps initially low-scoring students improve their test performance, while it stimulates initially high-scoring students to keep up good performance. Additional evidence for an effect of cumulative assessment on test performance and long-term retention is needed to further determine its effectiveness and usefulness. For now, we conclude that cumulative assessment can be a useful tool to positively influence students’ study behaviour.
REFERENCES

93.