



The impact of online video lecture recordings and automated feedback on student performance

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ABSTRACT

To what extent a blended learning configuration of face-to-face lectures, online on-demand video recordings of the face-to-face lectures and the offering of online quizzes with appropriate feedback has an additional positive impact on the performance of these students compared to the traditional face-to-face course approach? In a between-subjects design in which students were randomly assigned to a group having access to the online lectures including multiple choice quizzes and appropriate feedback or to a group having access to the online lectures only, 474 students (161 men and 313 women) of a course on European Law agreed to participate in the experiment. By using regression analysis we found that the course grade of the students was predicted by their grade point average, their study discipline, their grade goal for the course, the expected difficulty-level of the course, the number of online lectures they viewed, the number of lectures the students attended in person and the interaction between the lectures they viewed online and attended in person. Students who attended few lectures had more benefit from viewing online lectures than students who attended many lectures. In contrast to our expectations, the regression analysis did not show a significant effect of automated feedback on student performance. Offering recordings of face-to-face lectures is an easy extension of a traditional course and is of practical importance, because it enables students who are often absent from the regular face-to-face lectures to be able to improve their course grade by viewing the lectures online.

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1. Introduction

E-learning has recently become one of the fastest-moving trends and aims to provide a configurable infrastructure that integrates learning material, tools, and services into a single solution to create and deliver training or educational content quickly, effectively, and economically (Zhang, Zhou, Briggs, & Nunamaker, 2006). In many studies comparisons have been made between the effectiveness of online (distance) learning versus face-to-face learning. Russell (1999) made an inventory of many of these media comparison studies (MCS) and concluded that generally there is no significant difference between the average performance of learners in the case of face-to-face learning as compared to learners exposed to distance learning methods (i.e. the 'no significant difference phenomenon'). However, Ross and Bell (2007) indicated that this phenomenon could be dependent on the level of learning. While they found no significant difference in performance at lower levels of abstraction between students in the traditional setting as compared to online students, students in the traditional setting outperformed online students with respect to higher order learning (i.e. applying, analyzing and synthesizing information).

Video is a rich and powerful medium in e-learning because it can present information in an attractive manner. Prior studies have investigated the effect of instructional video on learning outcomes. However, the instructional video used in early studies was primarily either broadcasted through TV programs or stored on CD-ROMs. The linear nature of such video instructions produced inconsistent results. Recent advances in multimedia and communication technologies have resulted in powerful learning systems with instructional video components. The emergence of non-linear, interactive digital video technology allows students to interact with instructional video. This may enhance learner engagement, and so improve learning effectiveness. One of the examples is the Virtual Classroom project which uses asynchronous learning networks plus videotaped lectures to evaluate the effectiveness of online courses required for bachelor's degrees in information systems and computer science. Students who completed online courses tended to do as well as those in traditional classrooms,

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even though more online students withdrew or took an incomplete grade. Carnegie Mellon University's just-in-time lecture project suggests that video-based education and training systems support the same level of teaching and learning effectiveness as face-to-face instruction (Zhang et al., 2006).

Offering online video recordings of lectures after they have been given is useful in allowing students to view lectures they have missed or to re-view difficult lectures again to improve understanding. Chiu, Lee, and Yang (2006) investigated the viewing behavior of students in a Chinese grammar course when online post-class lecture videos were made available. They divided students in two groups based on their viewing activity (top 50% and bottom 50%) and found no difference in course grades between the two groups corrected for their GPA. Additionally they found that students had a preference for recordings of their own lectures as compared to lectures of a parallel group.

Ross and Bell (2007) compared the performance of students in a quality management course who had access to face-to-face lectures as well as the online lecture video recordings to students who only had access to the online lecture recordings. Using a regression analysis they found that the course score of students in the first group with access to the face-to-face lectures was predicted positively by their GPA, negatively by their age, positively by their homework performance and negatively by the number of lectures they viewed online. For the students who did not have access to the face-to-face lectures, the course score was positively predicted by their GPA, negatively by their age, positively by their homework performance and positively by the number of lectures they viewed online.

In this study the instructional method consists of a combination of face-to-face lectures and online on-demand video recordings of the face-to-face lectures, combined with the offering of online quizzes with appropriate feedback.

1.1. Research question and hypotheses

The general research question is to what extent this blended learning configuration of face-to-face lectures, online on-demand video recordings of the face-to-face lectures and the offering of online quizzes with appropriate feedback has an additional positive impact on the performance of these students compared to the traditional face-to-face course approach.

Creating an effective hybrid course takes a lot of effort; McFarlin (2008) reported a time investment of about 16–20 h for creating a single online lecture in his hybrid course. The required time investment could therefore be an obstacle for many teachers to create a hybrid course. A less time-consuming approach is to supplement the traditional course with online video recordings of the face-to-face lectures, which have been found to reduce dropout rate (Olsen, 2003). Even though Chiu and colleagues (2006) and Ross and Bell (2007) tried to measure the effect of the number of lectures students viewed online, their studies did not include a measure of attended face-to-face lectures, which is also important in explaining course performance (Stanca, 2006; Clark & Mayer, 2008).

Another method to improve the performance of students is the use of formative assessment (Lowry, 2005). When a Virtual Learning Environment is available (e.g., Blackboard), online quizzes consisting of multiple-choice questions and appropriate feedback are relatively easy to construct.

The primary goal of this study is to assess the effect on student performance of offering online on-demand video recordings of the face-to-face lectures, while also taking into account the number of lectures the students have attended in person. Additionally we aim to investigate the effect of offering online quizzes with appropriate feedback on the performance of these students.

We posit the following hypotheses which are tested in this study:

- (1) The number of lectures students view online and attend in person will contribute positively to the course performance. However, the positive effect of viewing lectures online will be weaker for students who attend a large number of lectures in person compared to a small number of lectures.
- (2) Students who have access to multiple choice quizzes including appropriate feedback will perform better than students who do not have access to these quizzes.

2. Methods

2.1. Design

To test our hypotheses we used a between-subjects design in which students were randomly assigned to a group having access to the online lectures including multiple choice quizzes and appropriate feedback, or to a group having access to the online lectures only.

2.2. Sample

A total of 474 students (161 men and 313 women) of the course European Law finished the course exam and agreed to participate in the experiment. Most participants studied Law (392 students), while a minority (82 students) studied International Relations and International Organization.

The course European Law consisted of thirteen 90-min lectures for which presence was not obligatory. Additionally there were seven optional small-group seminars (10–25 students per group) for which students, if they decided to participate, had to prepare obligatory assignments. Successful participation in all seminars resulted in a 10 point bonus increase of the final grade (on a 100-point scale).

2.3. Measures and instruments

The prime variables of interest in this study are lecture presence, number of viewed lectures online, availability of formative assessment including feedback and course exam grade. Besides these there are a number of variables we also believe to have a possible effect on performance and should be controlled for. These groups of variables are discussed below.

2.3.1. Background variables

We assessed several background variables by means of a questionnaire which could have an effect on performance: gender, study discipline, age, number of years enrolled as a student at the university and the subject area they graduated in at High School (Ding, 2009). Van den Berg and Hofman showed a positive effect of gender on study success meaning that women are more successful than men. They concluded also to a negative effect of age which means that older students obtain less study success than younger students (Van den Berg & Hofman, 2005).

2.3.2. Prior achievement

Prior achievement was measured by obtaining all official university grades of the students before the exam of European Law and averaging these grades while taking the number of credits of each course grade into account. For example, a grade of seven for a five-credit course combined with a grade of 8.5 for a 10-credit course yields a grade point average (GPA) of eight. Additionally we took into account the self-reported number of times students attempted to pass an exam of the course European Law in the past 6 years (Hattie & Timperley, 2007; Van den Berg & Hofman, 2005).

2.3.3. Learning style

Learning style was measured using two existing questionnaires which were translated into Dutch. The first is the ASSIST questionnaire (52 questions; Tait, Entwistle, & McCune, 1998) and was used to discriminate students with a deep, strategic or surface learning style. The ASSIST questionnaire has been identified to be a valid and reliable tool to study approaches to learning (e.g., Diseth, 2001). The second questionnaire is the Index of Learning Styles (ILS; 44 questions; Felder & Soloman, 1991 – based on the model described in Felder and Silverman (1988)) and was used to score students' learning style on the dimensions sensory–intuitive, visual–verbal, active–reflective and sequential–global. The ILS was found to be a valid and reliable questionnaire to assess learning style (Felder & Spurlin, 2005; Heijne-Penninga, Kuks, Hofman, & Cohen-Schotanus, 2008).

2.3.4. Learning attitude

To determine the students' learning attitude we took into account intrinsic and extrinsic motivation which was measured using a seven-item self-constructed scale. Intrinsic motivation was measured by four questions like 'I take this course because I'm interested in the field', while extrinsic motivation was measured by three questions like 'I take this course because this course is obligatory to obtain my bachelor degree'. All questions had to be rated on a five-point scale (completely disagree–completely agree). Another seven-item self-constructed scale was used to measure studying behavior, with statements like 'I use the available time for study assignments sensibly' and 'I always study at the same place' which students also had to rate on the five-point scale. Finally we asked the students to report their exam grade goal for this course as another measure of their attitude (Van den Berg & Hofman, 2005).

2.3.5. Expectations

Expectations were measured by asking the students at the start of the course via a questionnaire their expected time investment for the course and the expected difficulty-level of the course (Heijne-Penninga et al., 2008).

2.3.6. Time investment

Time investment was measured via a questionnaire by asking students at the end of the course how much time they had invested in the course and to report the number of lectures and seminars they attended in person. In addition clicks on the online video recordings were automatically registered in the Virtual Learning Environment Blackboard to assess the number of video lectures students viewed at least once (Van den Berg & Hofman, 2005).

2.3.7. Formative assessment and feedback

Assessment and feedback are powerful factors in learning and achievement (Hattie & Timperley, 2007). To be able to establish the possible effect of the availability of formative assessment and feedback, we took into account the group in which the students were assigned. A total of 218 students were randomly given access to the formative assessment quizzes, while 256 only had access to the online video recordings.

2.3.8. Performance

Finally, the performance of students was measured by their exam grade, excluding the possible bonus points for seminar participation. Of all 1341 students, 660 finished the course exam (49.2%). This dropout rate seems high, but further inquiry at the teacher and administration of the faculty of Law revealed this being a normal phenomenon for this (rather large) course.

2.4. Procedure

All 1341 fulltime students enrolled in the second semester seven-credit course European Law from the faculty of Law and the BA International Relations and International Organization (of the faculty of Arts) at the University Groningen were invited by an announcement on the Blackboard course page and a personal e-mail to participate in an experiment to evaluate the effects of the availability of online on-demand video recordings of all lectures in the course. In order to gain (and keep) access to the video recordings during the entire lecture period, students had to agree with the informed consent and answer a number of questionnaires during the course which assessed the variables discussed in Section 2.3.

Depending on the assigned group, students had access to the online recorded lectures including or excluding quizzes. Each recording was made available after students indicated if they were physically present at that lecture.

The recordings for the group having access to the quizzes were split up in approximately four parts to facilitate the integration of the quizzes. The split points were chosen such that each part centered on a distinct subject. Every individual part lasted between 10 and 45 min, while all four parts comprised the entire lecture of 90 min. After each part, students had to answer three multiple-choice questions

about the contents of the part. If a wrong answer was given, students received specific automated feedback about why the answer was wrong. Answering the multiple-choice questions was obligatory; the next recording was only made available if all previous questions were answered (either correctly or incorrectly).

By agreeing to the informed consent students gave their explicit approval to use previous study performance as well as their course exam results in our analysis. Student activity with respect to viewing the online video recordings was gathered by enabling the statistics tracing feature of Blackboard (version 7.3).

3. Results

3.1. Scale consistency and descriptives

The consistency of all scales used in this study and discussed in Section 3.3 is shown in Table 1. Scales which were not very consistent (i.e. Cronbach's alpha less than 0.7) consisted of the extrinsic motivation scale and three out of four ILS scales (i.e. visual-verbal, sequential-global and active-reflective). Felder and Spurlin (2005) indicated that several studies found similar consistency values for the ILS dimensions, but they argued by referring to Tuckman (1999) that a Cronbach's alpha value of 0.5 and higher is acceptable for attitude assessments (like the ILS). Following their argument, we will include all ILS dimensions in our analysis as they have a Cronbach's alpha of at least 0.5. As our extrinsic motivation scale is very inconsistent, we will not include that scale in our analysis. The descriptive statistics of the other variables are displayed in Table 2.

3.2. Missing values

Inspection of Table 2 reveals that there are a number of values missing. To handle missing values, we used the multiple imputation (MI) procedure proposed by Rubin (1987). This procedure is preferred over replacing missing values by their mean or case-deletion (Pigott, 2001; Schafer, 1999). In MI every missing value is replaced by a number ($m > 1$) of simulated values representing the uncertainty of the imputed values, resulting in m multiple imputed datasets. Each dataset can then be analyzed by complete-data analysis methods, after which the parameter estimators and standard errors can be combined using simple rules to form the overall estimates and standard errors reflecting the uncertainty of the missing data (Rubin, 1987; Schafer, 1997). We generated a total of five imputed datasets using the multiple imputation program NORM (Schafer, 1999). In the following section, combined results are reported based on the five imputed datasets.

3.3. The effect of viewing online lectures

To evaluate the effect of viewed online lectures, while controlling for other possibly important variables, we entered all variables and scales from the groups discussed in Section 2.3 block-wise into a linear regression model with the exam grade for European Law as the dependent variable. Categorical variables were dummy-coded. Based on our first hypothesis we also included the assumed interaction between the number of attended lectures in person and the number of viewed online lectures by multiplying these terms in the regression.

Table 1
Consistency of scales.

Scale	N	Missing %	Cronbach's alpha (# items)
ASSIST: Deep learning	379	20	0.83 (16)
ASSIST: Strategic learning	379	20	0.83 (20)
ASSIST: Surface learning	379	20	0.78 (16)
ILS: Sensing-intuitive	381	19.6	0.73 (11)
ILS: Visual-verbal	381	19.6	0.64 (11)
ILS: Sequential-global	381	19.6	0.50 (11)
ILS: Active-reflective	381	19.6	0.55 (11)
Intrinsic motivation	459	3.2	0.88 (4)
Extrinsic motivation	460	3	0.30 (3)
Study behavior scale	460	3	0.74 (7)

Table 2
Descriptive statistics of assessed variables.

Variable	N	Missing %	Min.	Max.	Mean	Std. dev.
Exam grade	474	0	24	86	56.09	11.06
Age	474	0	20	53	23.18	3.83
Years enrolled	474	0	0	10	2.84	1.48
GPA	474	0	28	84	63.68	5.96
Exam attempts	474	0	0	8	0.47	0.94
Exam grade goal	443	6.5	5.5	10	7.01	0.84
Expected time investment (h)	343	27.6	10	300	135.00	63.86
Expected difficulty-level	436	8.0	3	10	7.70	0.97
Real time investment (h)	296	37.6	20	320	152.40	68.56
Attended lectures	306	35.4	0	13	5.17	4.95
Attended workshops	308	35.0	0	7	5.05	2.95
Viewed online lectures	474	0	0	13	7.23	4.61

Table 3
Significant linear regression coefficients.

Variable	B	Standardized beta	Significance
Intercept	–21.57		0.002**
Study discipline	3.97	0.14	0.001**
GPA	0.72	0.39	0.000**
Exam grade goal	1.78	0.14	0.001**
Expected difficulty-level	1.14	0.10	0.014*
Viewed online lectures	0.77	0.32	0.000**
Attended lectures	0.77	0.35	0.000**
Attended lectures × Viewed online lectures	–0.077	–0.35	0.001**

** $p < 0.01$; * $p < 0.05$.

The first block of variables entered in the regression analysis consisted of the background variables. Only one background variable, study discipline, was related significantly to course exam grade. In this specific case we found that Law students performed better than students of the International Relations and International Organizations track. Gender, age, the number of years the students are studying and the High School subject area had no impact on student course exam grade.

Prior achievement based on students' GPA exerted a significant effect on the course exam grade. Of course, this is an expression of the well known fact that the higher scoring students in the past will on average also perform better in future assignments (van den Berg & Hofman, 2005). The number of exam attempts had no effect on grade performance implying that students who are successful in attempt one do not obtain higher scores than students who are successful only after two or three attempts and vice versa.

Learning style as measured through the ASSIST scale into deep, surface or strategic learning as well as all ILS scales showed no relationship with exam grade.

From the three attitude variables: study behavior (intrinsic) motivation and exam grade goal only the latter was significantly related to student performance. This suggests that student's ambition level is certainly important in their study success.

The next variable block that was entered referred to students' expectations. The expected difficulty-level of the course had a significant impact on the outcome; in other words: students expecting a high difficulty-level of the course obtained higher course grades.

We observed that (variation in) self-reported real time investment did not exert significant effects on student performance.

Finally we come to the core of our study where we include the feedback (access to formative assessment), viewed online lectures and attendance in person at lectures and workshops into the model.

The results show clearly that viewing online lectures as well as attending lectures in person has a significant positive effect on student exam grade. However, access to formative assessment and the attendance of workshops has no additional impact on performance. We also observed an interaction effect indicating that the effect of the number of viewed online lecture recordings is related to the number of lectures attended in person.

All significant variables are included in the model which is shown in Table 3. The model presented in Table 3 is significant ($p < 0.001$) with $F(8, 10,958) = 14.81$. The R^2 of the model is 0.26 (adjusted R^2 : 0.25). Note that the high degrees of freedom of the F -statistic are caused by using the multiple imputation procedure and were calculated by NORM.

3.4. The effect of formative assessment and feedback

To assess the effect of the availability of multiple choice quizzes including appropriate feedback, we conducted a one-way ANOVA with the availability of the quizzes as a fixed factor. The results indicated that there was no difference in performance between the two groups: $F(1, 472) = 0.804$ ($p = 0.37$). We therefore conclude that our second hypothesis is not confirmed.

This result was also clear from our regression model; having access to formative assessment and feedback did not reach significance in the model ($p = 0.34$). Hence, students who had access to the formative assessment quizzes did not perform better than students who did not have access to these quizzes.

4. Discussion

In our first hypothesis we posited that the number of lectures students viewed online and attended in person contributed positively to course performance. Inspection of Table 3 indeed shows that this holds true, even while controlling for other possibly important variables. Furthermore, the interaction we predicted also showed up in the data. Fig. 1 visualizes the effect of the number of viewed online lecture recordings on performance moderated by the number of attended lectures. Using the SIMPLE all-in-one programs for exploring interactions in moderated multiple regression (O'Connor, 1998), we investigated the simple slopes and assessed their significance. While the moderating effect of low and medium lecture attendance was significant ($p < 0.01$), this was not the case when a high number of lectures was attended ($p > 0.7$). The direction of the interaction was the same as we predicted; the positive effect of viewing online lectures was higher when few lectures were attended. When interchanging the online lectures with the attended lectures in the interaction, similar results were acquired: the positive effect of attending lectures was higher when fewer online video lectures were viewed than when more online video lectures were viewed (also significant only for a low and medium number of viewed online lectures).

Our results showed that, while controlling for important variables like GPA and study, the number of attended lectures and viewed online recorded lectures predicted the performance of students in a European Law course. This is not unexpected as Stanca (2006) already showed that course attendance is an important factor in student performance. While Chiu and colleagues (2006) did not find a positive effect of the viewed online lectures on student performance and Ross and Bell (2007) even found a negative effect of the viewed online lectures on student performance for students who were able to attend face-to-face lectures, they did not take lecture attendance in account, which we identified as an important factor in relation to viewing online lectures. This study also showed that the influence of

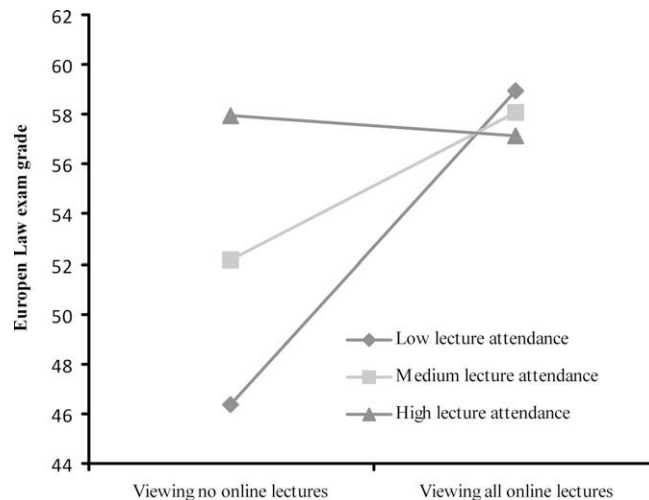


Fig. 1. Interaction effect between lecture attendance and online video viewing. Low lecture attendance is equal to one standard deviation below the mean. Medium lecture attendance is equal to the mean. High lecture attendance is equal to one standard deviation above the mean.

viewing online video lectures and attending lectures in person are approximately equal, while the interaction effect demonstrated that they can be interchanged in order to improve performance. As the video recorded lecture is essentially a ‘copy’ of the lecture, this is not a very surprising result. It is also in-line with Russell (1999) who concluded that generally there is no significant difference between the average performance of learners in the case of face-to-face learning as compared to learners exposed to distance learning methods. We do not find evidence for a level-related effect of distance-learning as Ross and Bell (2007) suggested. The tasks that the students in our setting are confronted with can be judged as of higher order but still we do not find differences in (the strength of) effects between face-to-face and distance learning.

However, experience so far showed that e-learning should come in a “blended learning approach” delivery. This means that there is a need for designing and delivering the right content, in the right format, with the right media often providing a mix of the different tools including face-to-face learning. The outcomes of this study suggest that the influence of viewing online video lectures on achievement could be viewed as an autonomous positive effect. This implies that, taking the specific context and research population of this research into account, a solely ‘distance’ approach could also have significant positive effects on student performance.

Some care is necessary in interpreting our results with respect to the number of online viewed video recordings and attended lectures. Because we were only able to register the clicks on a link starting an online video lecture, we do not have exact information about the duration students viewed the video lecture. Some students could have only viewed a small part of the video lecture, while others viewed the complete video lecture. This duration-effect could possibly influence our results. The same remark holds true for lecture attendance; some students could be present during the entire lecture, while others only were present during a part of the lecture. It would be interesting to replicate this study, while additionally investigating a possible duration-effect for online lecture viewing and lecture attendance.

The outcomes of the study are in-line with the conclusion of Mayer (2008) that instruction is most effective when available at the moment the student needs it. This just-in-time instructional support by online video lectures can be made available according to rules determined by the computer (direct instruction) or the demands of the student (indirect instruction). The first type of support seems to be more effective for beginners in the problem solving process; the second seems to be more fruitful for learners at a more advanced stage of learning to solve problems, as our university Law students are (Clark & Mayer, 2008).

It was unexpected that we did not find a significant effect of the availability of the formative assessment quizzes and feedback on course performance. It is possible that our automated feedback system did not fully anticipate the differences in ability of the students. Or, in other terms, the difficulty-level of the text and the test items have to be taken into consideration. There is evidence that the effect of feedback depends to some extent on the difficulty-level of the information. For example Clariana, Wagner, and Rohrer-Murphy (2000) report different effect sizes from feedback for easy, midrange or difficult items. However, it could also be that our study design (chosen in order to obtain as much data as possible) had a negative impact on this result. Students were only given access to the quizzes in a sequential fashion, i.e. viewing and answering questions about lecture eight was only possible after answering all questions of all previous lectures (1–7). It is likely that enforcing strict sequential access encouraged students to finish questions as fast as possible to access an online video recording of a certain lecture, in turn diminished any positive effect which could have been gained by answering the questions slower and more seriously. Another study incorporating more freedom and flexibility could provide useful in determining if there really is no effect of the availability of formative assessment quizzes and feedback, or the negative findings were due to our study design.

In this study we have explicitly tried to avoid the caveat Cox and Marshall (2007) mentioned: investigating the effects of ICT on attainment without clearly identifying the range and type of ICT use leading to unclear results. We believe that in this case we have been able to identify a positive impact of a concrete use of ICT which also could have substantial impact on the functioning of higher education institutes.

As a final remark, we would like to emphasize that offering recordings of face-to-face lectures is an easy extension of a traditional course and is of practical importance, because it enables students who are often absent from the regular face-to-face lectures to be able to improve their course grade by viewing the lectures online. Of course there is also the efficiency factor at stake here: if the effect of viewing recorded lectures online is the same as attending lectures of large scale courses, then probably using recorded lectures in combination with small scale interactive lectures or workshops would lead to better student performance and thereby student career and university efficiency.

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