Pharmacy Education (2022) 22(1) 843 - 855
https://doi.org/10.46542/pe.2022.221.843855

RESEARCH ARTICLE

The impact of video lecture capture on student attainment and achievement of intended learning outcomes

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Keywords
Digitalisation
Toxicology
Video lecture capture

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Abstract

Background: The multimedia capturing of live lectures has increased within higher education institutions, even in the pre-COVID-19 period. Despite student satisfaction, the video lecture capture (VLC) influence on students' attainment and achievement of intended learning outcomes is controversial. **Methods:** To explore the impact of VLC, a cross-sectional study across 2016/17 (n=209 students) and 2017/18 (n=206 students) was conducted in the course of Mechanistic Toxicology in Pharmaceutical Education. **Results:** The results showed that 73% and 90% of the assessed students entirely viewed the videos of theoretical (550 minutes) and practical/laboratory classes (250 minutes), respectively. VLC impacted student attainment and the achievement of intended learning outcomes on the capacity to understand the subjects and apply knowledge. **Conclusion:** The effectiveness of VLC is to be considered under the framework of constructive alignment and the specificities of the course.

Introduction

Over the last few years, the use of video lecture capture (VLC) within higher education institutions (HEIs), namely in the United Kingdom, United States, Australia, and Singapore, has markedly increased (Owston, Lupshenyuk & Wideman, 2011; Brooks *et al.,* 2014; Danielson *et al.,* 2014; Newton *et al.,* 2014; Crook & Schofield, 2017; O'Callaghan *et al.,* 2017; Witton, 2017; Edwards & Clinton, 2019; Joseph-Richard *et al.,* 2018; MacKay, 2019; O'Brien & Verma, 2019). In Europe, the implementation of digital technologies as a strategy for teaching and learning within HEIs is one of the European Commission's main recommendations (European Commission, 2014). In Portugal, some HEIs have introduced multimedia capturing of live lectures by using video technologies/platforms, such as "Panopto" platform and "Explain Everything" application.

The terms "lecture capture", "lecture capturing", "screencasting", or VLC are used to describe the multimedia capturing of live lectures in front of an audience of students. It can be performed through image and voice recording of the entire class environment, including the teacher (audio and image), learning objects (e.g., PowerPoint slides), and the audience (audio and image). The successful use of a pre-recorded 4-5 minutes video to deliver toxicology educational content in a school of medicine was described (Vo, Ledbetter & Zuckerman, 2019), and the use of videos to teach information literacy concepts in pharmaceutics (Chatfield & Romero, 2021).

Despite the increasingly high interest in VLC use by HEIs, particularly during and after the COVID-19 period, there is an open and quite inconclusive debate about its actual benefits regarding, for instance, the development of digital literacy (Tiernan & Farren, 2017) or the development of pedagogical approaches mediated by VLC (Owston, Lupshenyuk & Wideman, 2011; Newton *et al.,* 2014; Lokuge Dona, Gregory & Pechenkina, 2016; O'Callaghan *et al.,* 2017; Joseph-Richard *et al.,* 2018; Dommett, Gardner & van Tilburg, 2019). Additionally, as pointed out by some authors, there were many studies with conflicting results when trying to correlate the use of VLC with student attainment (Brooks *et al.,* 2014; Danielson *et al.,* 2014; O'Callaghan *et al.,* 2017; MacKay, 2019).

Based on a successful experience developed within an Erasmus+ project (Learning Toxicology through Open Educational Resources (TOX-OER) (Martín *et al.,* 2018), producing video lectures to be included in a MOOC) and the perceived benefits of using video lectures (Maringe & Sing, 2014), the application of VLC was introduced in Mechanistic Toxicology (MecTox), a course in the five-year integrated master programme in pharmaceutical sciences.

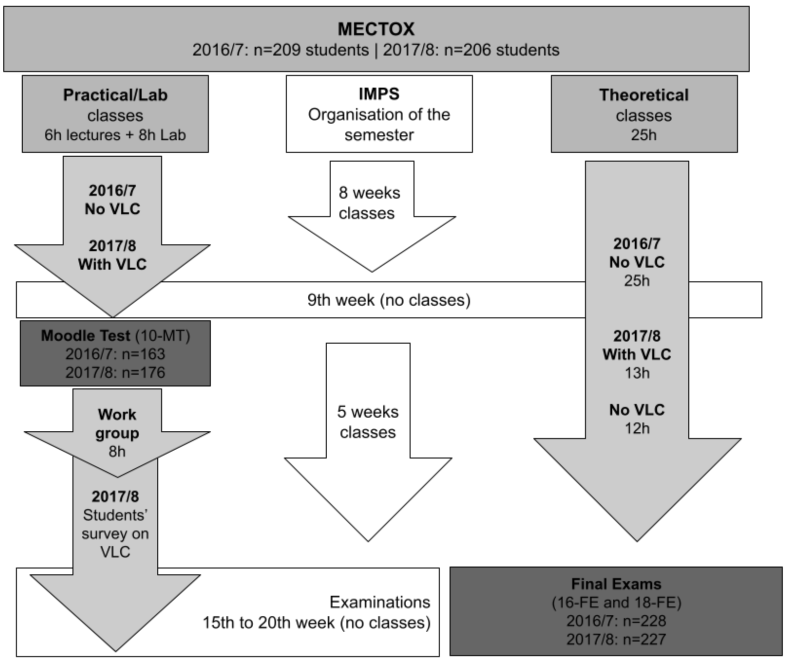
In line with previous research, it is essential to carry out further studies to elucidate the actual individual use of recorded lectures (Bos *et al.,* 2016) by exploring the extent to which VLC fosters students' academic attainment (measured, for instance, by their actual grades) and student academic achievement of intended learning outcomes.

With this in mind, this study analysed the impact of VLC by comparing students' grades across two academic years and their perceptions about the usefulness of VLC to address the following research question: how does VLC use impact student attainment and achievement of intended learning outcomes? This paper starts by introducing the intervention's objectives under the framework of MecTox and pointing out the methods used to evaluate the effectiveness of VLC in MecTox. Then, the paper presents the results, discusses the main findings, and concludes with a reflection on educational technology issues in post-COVID-19 education.

Methods

Study design

The cross-sectional study was performed in the MecTox to analyse the impact of VLC on students' attainment and achievement. MecTox assumes an outcomes-based approach to teaching and learning based on constructive alignment (Biggs & Tang, 2011). Under this framework, the systematic alignment of teaching/learning methods and activities and the assessment tasks to the intended learning outcomes have been considered in conveying VLC. The intervention aimed to improve students' grades and achievement of intended learning outcomes on memorisation skills, understanding the topics, and applying knowledge (Figure 1).



Transparent graphics - context of the study based on the Integrated Master in Pharmaceutical Sciences (IMPS) calendar; soft grey graphics - main features of the study; hard grey graphics – student assessment events

Figure 1: Study design according to the IMPS and MecTox academic calendars

Data collection

The data informing the research question focused on students' lecture video use and grades. All the data and statistics related to student use of lecture videos were obtained in the statistics module of the "Panopto" platform. Data were summarised with descriptive statistics and comparisons to determine the differences in student grades between students with VLC (2017/18) and those without VLC (2016/17). Since users' perception of the educational value of multimedia resources is essential (Ingram *et al.,* 2007), a survey was applied to students in 2017/18 to collect their perceptions of VLC when assessing its effectiveness. The survey scale consisted of eight items rated on a 7-point Likert scale from strongly disagree (1) to strongly agree (7). Factor analysis was performed, and a Cronbach's alpha score of 0.622 was obtained. When the item "the availability of videos of the practical/theoretical classes influenced me in my non-attendance in classes" was deleted, Cronbach's alpha value changed to 0.712. In the data analysis, the coded response was reversed for this item.

Data analysis

The data were analysed on SPSS version 26.0. Descriptive statistical measures such as percentages, means, and standard deviations were used to evaluate the data according to VLC use and student grades. Independent sample tests were used. The Mann-Whitney U test evaluated the differences between students without VLC (2016/17) and those with VLC (2018/19), and the Kruskal-Wallis H test assessed the differences between the groups of students with VLC clustered by the number of minutes viewed. The level of statistical significance was set at 0.05.

Ethics approval

The institutional Ethics Commission approved the study in full compliance with research ethics, norms, codes, and practices established in the European Union.

Course description

MecTox is a course offered in the eighth term (semester) of the integrated master's degree programme in Pharmaceutical Sciences. Each term has 30 ECTS credits (European Credit Transfer System; 1 ECTS = 27h of student workload) and six credits are attributed to MecTox, with two hours of theoretical classes plus two hours of practical/laboratory classes. The theoretical classes are not mandatory; they take place mainly in the form of expositive lectures in a lecture hall and are addressed to all the students (around 200) enrolled in MecTox. The practical/laboratory classes, which are given to smaller groups of 20-50 students, are mandatory and include expositive lectures, laboratory classes, and workgroup sessions. The academic teaching staff team is made up of six teachers, including the coordinator in both academic years. Each team member was responsible for specific topics in the theoretical and practical/laboratory classes.

The participants involved in the study comprised undergraduate students enrolled in 2016/17 and 2017/18 in MecTox, as described in Table I, which also displays the number of students in each academic year and their average grades.

Table I: Characterisation of the sample in the academic years 2016/17 and 2017/18

MecTox	2016/17	2017/18
Number of students surveyed	209	206
Female/Male	175/34	161/45
Part-time students	11	10
Students with special needs	4	5
Mobility students	9	8
Average mark of approved students in the 4th year of IMPS	14.3±2.33	14.0±2.3
Average mark of approved students in the ToxMec course	12.7±2.5	13.2±2.2

IMPS-Integrated Master in Pharmaceutical Sciences

The assessment tasks included group work on general MecTox topics (20%), a Moodle test (MT) on practical/ laboratory class topics (20%), and a final exam (FE) on theoretical class topics (60%). Under the constructive alignment framework, the assessment tasks were aligned with intended learning outcomes on memorisation skills, understanding the topics, and applying knowledge, indicating that each of these assessment components is structured to evaluate student achievement on the different intended learning outcomes. Over 200 students from each academic year attended MecTox, of whom 90% were assessed; among those, more than 90% were approved at the end of the respective academic year, with a final grade of at least 10 out of 20 (Table II).

Table II: Number of students in each academic year and in each assessment event

MecTox	2016/17	2017/18
Registered students	209	206
Assessed students	187	192
Moodle Test, 10th week (10-MT)	163	176
Final Exam, 16th week (16-FE)	171	163
Final Exam, 18th week (18-FE)	57	64
Extra Final Exam (Extra-FE)	7	12
Approved students	171	180

MT-Moodle test; FE-Final Exam

As shown in Figure 1, the MT on laboratory class topics was performed in the middle of the term (i.e., the tenth week, 10-MT). This test included 12 multiple-choice questions and one open question. For each student, multiple-choice questions were randomly selected from a database and aimed to evaluate student achievements in learning outcomes related to their capacity for remembering the topics. The purpose of the open question was to assess student achievements in understanding the topics. While multiple-choice questions required the students to recall concepts without necessarily understanding them, the open question required their ability to understand and interpret learned information.

The FE assessed the theoretical subjects of MecTox in the sixteenth or eighteenth week of the term (16-FE and 18-FE), giving the students two opportunities. For this study, only the grades of successful students were considered. The first section of the FE focused mainly on evaluating students' capacity to apply knowledge (e.g., the questions required their ability to use learned material in new situations), and the second section assessed their ability to understand the topics (e.g., the questions required their ability to understand and interpret learned contents).

In both academic years, MecTox lectures (25 sessions of theoretical classes of up to 50 minutes each and three practical classes of up to two hours each) were held in the lecture hall with around a 130-140 seat capacity (Figure 1). The VLC was applied in 2017/18 in all practical classes and in 13 out of the 25 theoretical classes. For pedagogical reasons, some theoretical class videos included parts of two consecutive lessons, longer than the 50 minutes planned.

The VLC was performed by the coordinator of the MecTox, who used the “Explain Everything” application on an iPad (Apple Inc) connected to a data show. During the lectures, the teacher used this application to present the pdf file interactively, namely by using tools such as a pointer, slide zooming, highlights, and drawings, among other features, to improve learning (Pi, Hong & Yang, 2017). This application offers a set of essential pedagogical resources in the classroom that a simple PowerPoint presentation does not allow. Its use in higher education has shown to increase student engagement with consequent improvement in content retention (Malin, 2014).

Videos were recorded during the live lectures, and only the teacher's narration was captured, alongside the presentation of slides, which were simultaneously projected to the students with the interactive features performed by the teacher during the lecture. At the end of the lecture, the videos were made available online as an educational/learning supporting resource. All the pedagogical and scientific materials, including the presentations supporting the lecture, were also made available on the same Moodle page for both academic years.

Results

Use of lecture videos

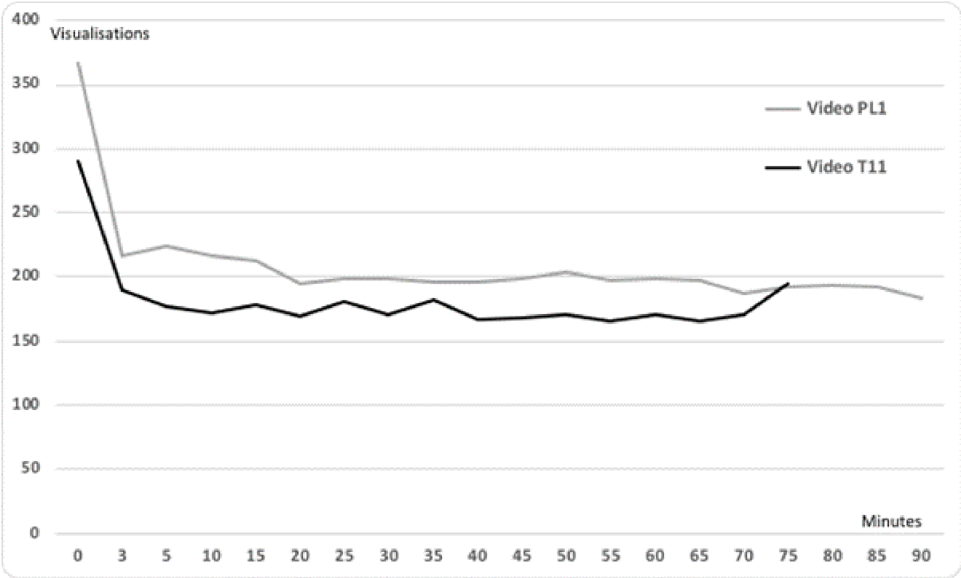
Table III presents the video length (in min), the percentage of viewers per assessed student, and the ratio of "Average of minutes viewed by each viewer" over "Minutes of video" for the 16 videos that were made available.

Table III: Viewing data related to each of the video lectures available to students

Subjects	Video Lecture	Minutes of video	% of viewers per assessed students*	Ratio of "Average of minutes VIEWED by each viewer" over "Minutes of video"
Practical/ Laboratory (PL)	PL1	90	97	1.1
	PL2	80	92	1.3
	PL3	80	91	1.2
AVERAGE		**83**	**94**	**1.2**
Theoretical (T)	T2	36	79	0.7
	T3	42	70	1.0
	T4	41	75	1.2
	T5	43	77	1.2
	T6	45	77	1.2
	T8	40	76	1.2
	T9	68	77	1.2
	T10	31	78	1.2
	T11	74	82	1.2
	T12	35	73	1.2
	T13	45	73	1.1
	T24	25	56	1.0
	T25	21	55	1.1
AVERAGE		**42**	**73**	**1.2**

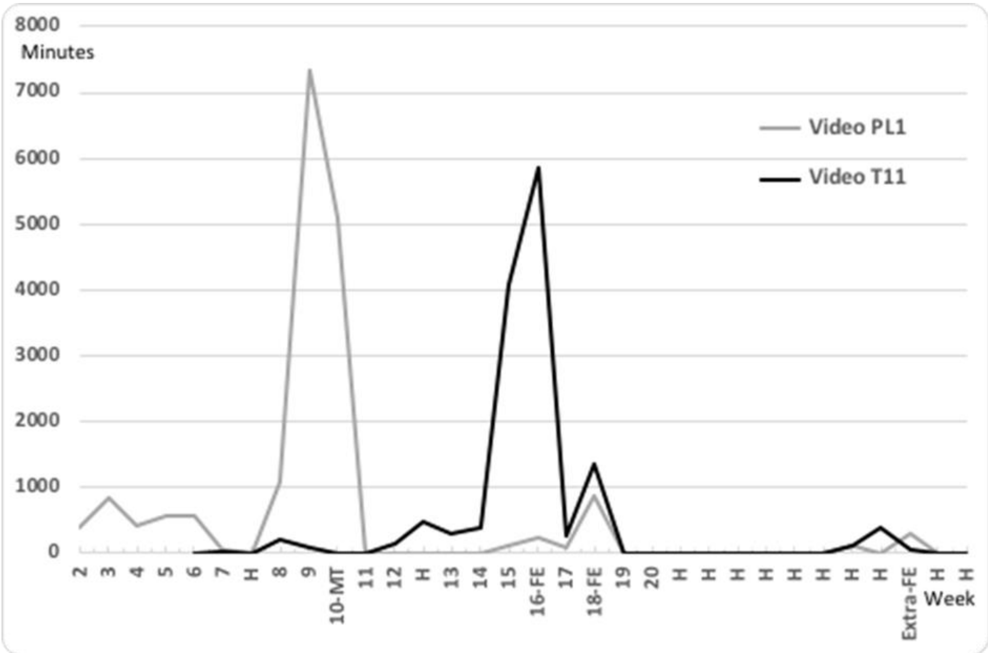
** The number of students assessed in 2017/18 was 192*

Furthermore, for the practical/laboratory (PL) videos and the theoretical classes (T) videos with the highest number of views, the number of viewers throughout the videos was monitored (Figure 2), and a calendar was obtained with the information on the number of views, the minutes of viewing, and the number of viewers throughout the term (Figure 3).



The results of the Videos-PL and Videos-T with the highest number of views are shown

Figure 2: Number of views throughout the videos



The results of the Videos-PL and Videos-T with the highest number of views are shown

Figure 3: Minutes of video viewing per semester week

Considering the three PL videos (Table III), an average of 94% of the assessed students viewed the videos, with a ratio of "Average of minutes viewed by each viewer" over "Minutes of video" above 1, which suggests that all minutes of the recorded video (250 minutes) were viewed by most of the students. Similarly, considering the T videos, 73% of the assessed students viewed the videos, with a range between 55%

for the last video recorded (T25) and 82% for the video with the highest number of minutes viewed (T11). Once more, the ratio of "Average of minutes viewed by each viewer" over "Minutes of video" was higher than 1, precisely 1.2, which indicates that each student viewed around 630 minutes of the 546 minutes of video lectures available. Hence, each student repeatedly viewed some videos.

Videos with the highest number of views in PL and T were analysed (Figure 2) to deepen the authors' understanding of this matter. The highest number of views occurred in the first three minutes of both videos. However, after three minutes, the number of views remained stable (around 200) until the end of the video, even for videos as long as 90 minutes. For the same purpose, these videos were analysed for viewing time throughout the term (Figure 3). The results confirmed that students extensively used the videos, reflecting that they were positive about the availability of lecture recordings (O'Callaghan *et al.,* 2017), probably to support autonomous learning so that they can understand and apply knowledge. The 250 minutes of video lectures on PL topics were viewed, on average, for almost 300 minutes by more than 90% of the students who attended the assessments (Table III), with more than 50, 100, and 120 students viewing at least 300, 200, and 100 minutes of the videos, respectively (Figure 3). Similar results were seen with videos on theoretical topics. The available 550 minutes of video lectures were viewed for more than 600 minutes by an average of 73% of students who attended the FE.

Figure 2 shows the standard of video views, which seems to be very consistent for the duration of the videos, except for the noticeable peak seen in the first three minutes. Interestingly, longer-duration videos resulted in better involvement of students, consistent with previous findings (Giannakos, Jaccheri & Krogstie, 2016).

Considering the periods of video lecture views (Figure 3), the highest number of minutes of viewing (more than 70% of the total) occurred two or three weeks before the assessments, i.e., 10-MT for PL1 video and 16-FE for T11 video. A possible explanation could be that students mostly used these videos as an educational/learning resource to support their preparation for the assessments (Gorissen, van Bruggen & Jochems, 2015).

It is also noteworthy that 16% and 12% of the total minutes of viewing for PL1 and T11 videos occurred during the class period. The remaining time of views was before the other assessment events (18-FE and Extra-Events). Similarly, a previous study revealed that 75% and 10% of the viewing time occurred before the exams and during the term, respectively, and that longer-duration videos resulted in better involvement of students (Giannakos, Jaccheri & Krogstie, 2016).

A scattergram that registers the minutes of the PL video viewing and the grade obtained by each student in 2017/18 shows the impact of video viewing (Figure 4).

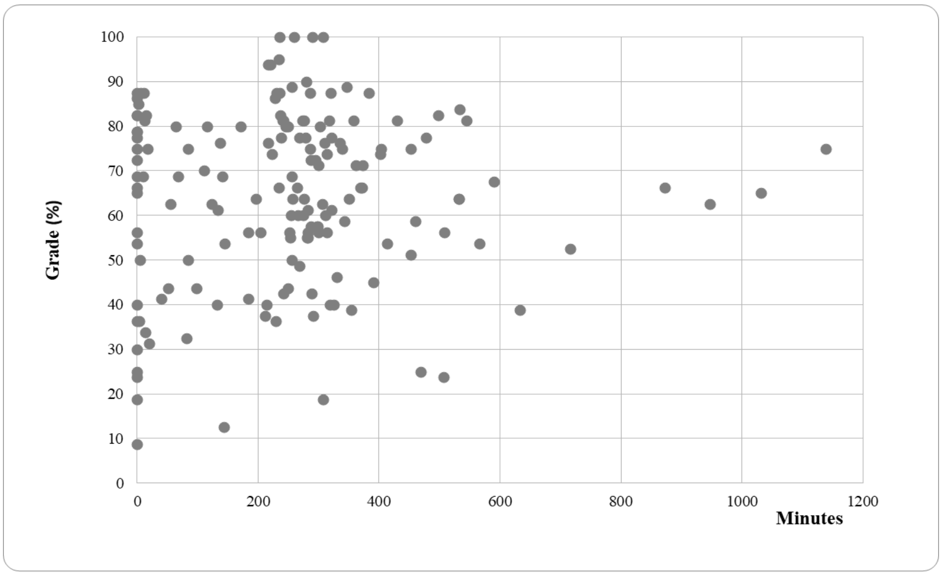


Figure 4: Scattergrams of the obtained grades (increasing order) in Moodle test in both academic years, 2016/17 (N=165) and 2017/18 (N=173)

The top ten results were obtained by students who viewed more than 200 minutes of the videos. As in other studies, there was a high dispersion of student grades over the number of viewing minutes (Williams, Birch & Hancock, 2012; Brooks *et al.,* 2014). Accordingly, the standard deviation analysis of the distribution of grades decreases as the number of minutes watched increases suggesting that grades get closer to the class average (Table IV). A possible explanation could be that video viewing supported student attainments. By looking at differences between groups of students clustered by the number of minutes viewed, the Kruskal-Wallis H test showed no statistically significant differences between the number of minutes and student grades in 2017/18 (H(3) = 1,704, *p*=0.636).

Table IV: Statistical measures throughout the samples: minutes viewed by the students 2017/18 and respective grades (10-MT)

Students grouped by the minutes viewed	N	Mean (grade)	Standard deviation	Standard error
0 - 94.9	40	59.6	22.9	3.6
95 - 255.9	39	66.2	20.2	3.2
256 - 321	40	67.3	17.5	2.8
322 - 1138	39	63.7	16.3	2.6

Considering the number of views by the students, it can be concluded that MecTox students invested a considerable amount of their study time viewing video lectures. This finding reinforces the importance of evaluating the "time on task", and the type of viewing pattern features when analysing the influence of VLC on the students' academic achievements, as previously acknowledged (Bos *et al.* 2016). It is interesting to observe that females tend to rely more heavily on digital resources than on lecture attendance. After missing a given lecture, female students will view the corresponding recorded lecture sooner than males, indicating a deeper engagement with the approach (Brady *et al.* 2013). In MecTox, around 80% of the students contributing to the clarification of the VLC use are females.

Students' attainment (Moodle test and final exam) and achievement of intended learning outcomes

Considering the study design (Figure 1) and the research question guiding the effectiveness of the intervention, the student's grades were collected for two academic years (2016/17 and 2017/18). The grades (in the percentage of the total possible to be obtained) in the 10-MT (total, obtained in the multiple-choice questions and obtained in the open question) and in the FE (in the 16th week or 18th week) were analysed. It was decided to exclude the results of both non-approved students and those that attended laboratory classes in previous years.

Results in the Moodle Test

The first assessment (10-MT) was performed by 87% and 92% of participants in the years 2016/17 (without videos) and 2017/18 (with videos), respectively. Although they could choose to be assessed on laboratory and practical subjects during their FE, most students preferred to do it in the middle of the term. A possible explanation is that they did not have other assessment events at that time and could focus on their other courses during this period. Thus, by choosing to take this 10-MT, students had more time to study the subjects and be prepared. As mentioned above (Figure 3), students in 2017/18 mostly viewed PL videos during the three weeks preceding the 10-MT.

The comparison of obtained grades in 10-MT between both academic years showed that in 2017/18, the cumulative curve of grades (in the percentage of the maximum that would be possible to be obtained) by the 176 students attending is below the cumulative curve that represents the grades obtained by the 163 students in 2016/17 despite the use of VLC. The average grade in 2017/18 (64.4% +/- 19.4%) was lower than the average grade in 2016/17 (71.4% +/- 18.7%). The analysis of the different achievements of students in multiple-choice questions and the open question allowed for a better understanding of the discrepancies in the grades obtained.

Similar results were seen in the open question for both academic years, but the video lecture used appeared to be ineffective as per the responses to multiple-choice questions. By comparing 10-MT in both academic years, students from 2017/18 (with videos) had lower results than their counterparts from 2016/17 (without videos). Comparing grade means in 2016/17 (71.4%), student achievements tended to be better than in 2017/18 (64.4%). The Mann-Whitney U test indicated that this difference was statistically significant, U(337)=10992, Z=-3,570, *p*=0.0001).

Regarding the impact of VLC on the achievement of intended learning outcomes, 10-MT grades were analysed in two parts as the assessment tasks were aligned with distinct intended learning outcomes. In the first part, a set of 12 multiple-choice questions focused on intended learning outcomes related to memorising basic concepts and toxicology contents. Comparing the grade means in 2016/17 (75.1%), student achievements tended to be better than in 2017/18 (65.5%). The Mann-Whitney U test indicated that this difference was statistically significant (U(338)=9966, Z=-4,848, *p*=0.0001). The video lecture used, promoted learning outcomes that mainly focused on memory and did not affect the students' academic achievement.

In the second part, the open question focused on students' ability to correlate toxicity phenomena. Interestingly, the results in the second part of the 10-MT were identical in both academic years. The distribution of the results was the same across 2016/17 and 2017/18, and the Mann-Whitney U test indicated no statistically significant differences U (N=338)=14671, Z=0,449, *p*=0.653).

Results in the Final exam

The effect of VLC on student attainment was also evaluated in theoretical issues in the final exams. As described in Figure 1, final exams occurred between the 15th and 20th week of the term; in this period of intensive study, students needed to be prepared for all the finals. Further, 91% and 85% of the total assessed students attended the 16-FE in the years 2016/17 and 2017/18, respectively (Table II), while 30% and 33% of the total assessed students sat for the 18-FE in 2016/17 and 2017/18, respectively.

Figure 5 shows student results in two sections of the FE in 2016/17 and 2017/18.

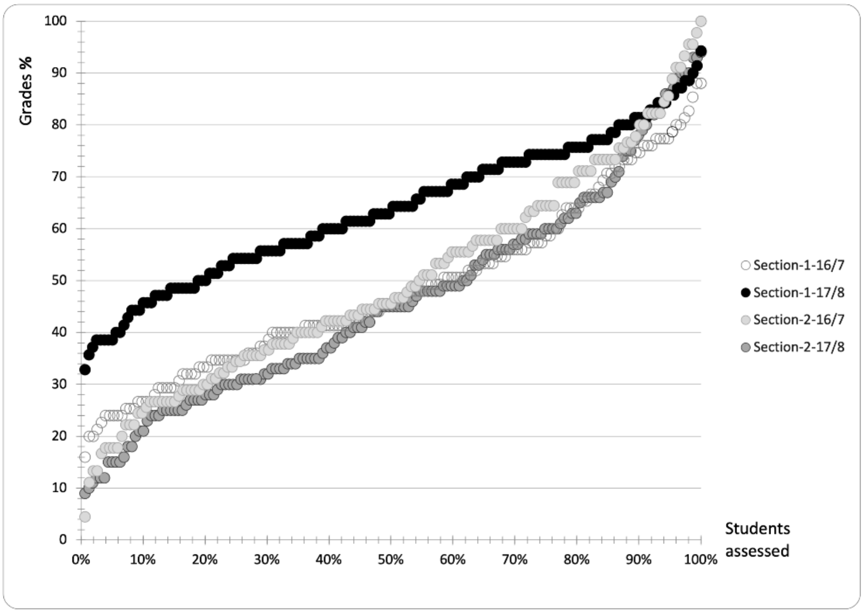


Figure 5: Scattergrams of obtained grades (increasing order) in Section 1 and 2 of the Final exam in both academic years, 2016/17 (n=152) and 2017/18 (n=159), considering the results of the students that were successful in their final grade

The content of each section was similar across both academic years, but it should be noted that in 2016/17, there was no VLC in sections 1 and 2. In 2017/18, section 1 had all the topics with VLC and section 2 without VLC (Figure 1).

Comparing student grades with VLC (2017/18) and those without VLC (2016/17), the results obtained in section 1 in 2017/18 with VLC were much better than those in the sections without VLC. By comparing the grade means in 2017/18 (63.7%), the students' attainment tended to be better than in 2016/17 (48.43%). The Mann-Whitney test indicated that this difference was statistically significant, U(311)=18199, Z=7,715, *p*<0.001, confirming that in 2017/18, students tended to attain better results.

Comparing the means of the students' grade (46.45%) and (49.9%) in section 2, in 2017/18 and 2016/17, respectively, the Mann-Whitney test revealed that this difference was not statistically significant, U(311)=10931, Z=-1,454, *p*=0.146. A possible explanation is that VLC was not available in 2016/17 and 2017/18.

Considering the high use of video lectures when preparing for these assessments, it seems that VLC contributed to student attainment. It can be concluded that the use of video lectures in MecTox supports the autonomy of students while preparing for exams, which seems to be an advantage during a time-demanding period. The literature suggests that students are expected to adapt their use of the captured content available, depending on their individual learning needs (Witton, 2017). These findings align with those of a previous study (Albon, Larson & Marchand, 2020), as student pharmacists in MecTox use VLC strategically to meet their needs in time-demanding assessment periods. A previous study reported that students studied less in a lecture capture-enabled class while maintaining similar final results (Brotherton & Abowd, 2004). Regardless of this matter, section 1 of the final exams focused on the student's ability to apply knowledge in new situations, and VLC seemed to help students in this kind of intended learning outcome.

In contrast, VLC had no impact when memory was the primary feature in the evaluation (as described in 10-MT). These results support the principle of constructive alignment as VLC use should be part of a pedagogical practice rather than a passive capture-all institutional policy (Witton, 2017). The basic concept of which lies in the idea that learning behaviour can be influenced by course design and alignment (Bos *et al.,* 2016). Hence, the benefits of VLC in contributing to the achievement of intended learning outcomes focusing on subject understanding and knowledge application makes the use of VLC effective in MecTox, corroborated by the fact that the students tended to achieve better results in 2017/18, as shown above.

Student survey: the perceptions of students on video lectures

In 2017/18, a student survey was applied after the 10-MT and at the end of the term. It focused on the use of video lectures and the perceived influence on obtained academic results and student lecture attendance. Students could use open space for any comments or suggestions (free comments) using the survey tool available on the Moodle platform, and each student could only answer once. The survey was answered by 128 students, corresponding to a response rate of 73% of those who attended the 10-MT (176).

Analysing the answers (Figure 6) which include 21 free comments, 80% completely agreed with the statements: *"I used the videos of the practical classes as study support (for example, for the Moodle test)"* and *"I believe that the videos of the practical classes helped me studying for the Moodle test"*; around 15% partially agreed, and less than 5% of the students disagreed. These results are in line with the answers of those who agreed with the statement: *"I believe that the results that I obtained in the Moodle test were influenced by the use of videos as a teaching/learning tool"*. However, only 48% completely agreed (7) with the statement in this case. This high interest of pharmacy students in audio/visual tools was previously described and is supported by the survey comments underlining that VLC is essential in facilitating the revision of the class contents. In a previous study, 140 students in a Ph.D. pharmacy curriculum considered VLC beneficial and reported using the recordings primarily to review the lecture (Maynor *et al.,* 2013). This study did not evaluate whether MecTox students switched from other learning methodologies, such as notes/book reading, exercise solving, or group discussion, or whether they used the video either as an additional resource or a complementary education/learning tool (O'Brien & Verma, 2019; Ranasinghe & Wright, 2019).

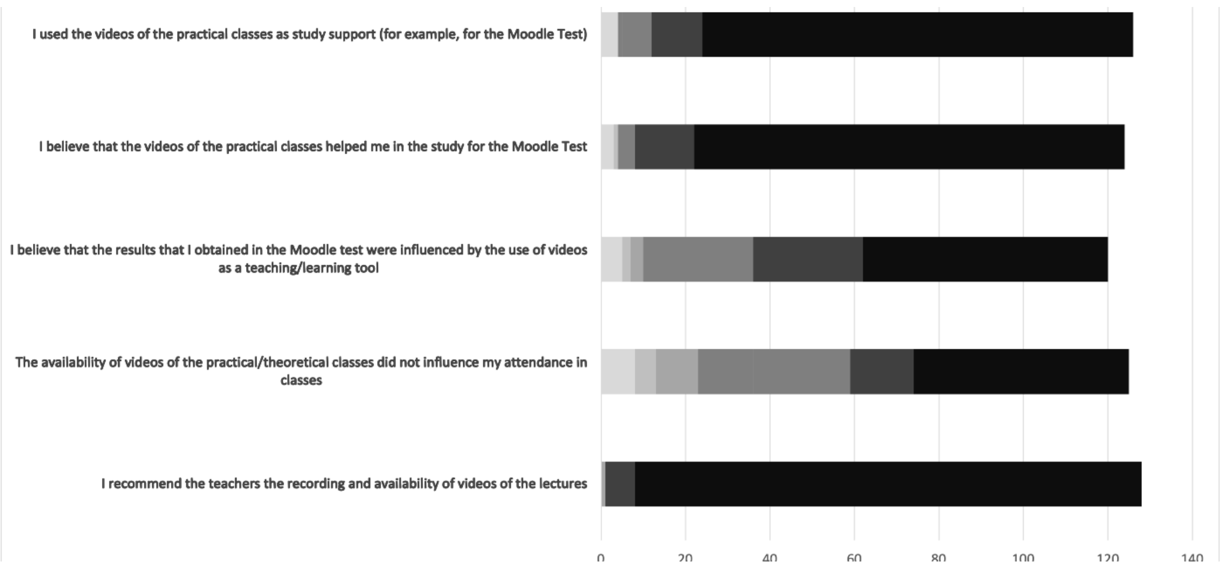


Figure 6: Student survey results

Regarding the statement *"the availability of videos of the practical/theoretical classes did not influence my attendance in classes"*, a broader spectrum of answers was obtained. Although the majority of students expressed their total agreement with the statement, 10% showed some level of disagreement, and more than 35% wavered between (3) and (5). Regarding video lecture use by students, an expected decrease in student attendance in scheduled lectures is still debatable (Toppin, 2011; Asarta & Schmidt, 2015; Persky *et al.,* 2014; Howard, Meehan & Parnell, 2018; Nordmann *et al.,* 2019). A study in pharmacy schools in the United States (Persky *et al.,* 2014) reported that one of the main reasons for students skipping a class was the provision of a digital recording of it. However, besides the fact this study did not monitor the presence of students in live lectures, it was the teachers' perception that the number of students in the classroom was in the expected range.

Additionally, in response to the survey, some students indicated a tendency to reduce their interest in live classes, but around 50% indicated that they were interested in video use and practical/theoretical classes. The analysis of the comments about the VLC showed that students perceived its importance to support the interaction between students and the professor, as students are not stressed about taking notes. This challenges the concerns raised about the impact of lecture capture on teaching, as it can reduce the interaction between the teachers and students (Joseph-Richard *et al.,* 2018; Dommett, Gardner & van Tilburg, 2019). Thus, the most interested students, who were already determined to attend classes, might be expected to use video lectures as an additional learning resource and not as an alternative to live classes. Also, those who missed classes reported using videos as an alternative, possibly reflecting the trend that those students with the lowest attendance in classes resorted to the recordings more frequently (Groen, Quigley & Herry, 2016). The analysis of the survey 21 free comments also highlighted that VLC was vital to part-time students or those who could not attend the class for any other reason.

Finally, students were unanimous about the importance of VLC, with 99% expressing their strong agreement with the statement: "I recommend to the teachers the recording and availability of videos of the lectures". These results align with previous findings (Witton, 2017; MacKay, 2019) as VLC increases student general satisfaction and is perceived as helpful for their overall learning. In summary, the analysis of 21 free comments about the VLC highlighted its importance:

- To part-time students or those who could not attend the class for any other reason;
- To facilitate the revision of the class contents;
- To support the interaction between students and professors, as students are not stressed about taking notes in this situation.

Implications for practice

This study could demonstrate the strong affinity of students for VLC and the positive impact VLC had on students' attainment and achievement of intended learning outcomes. In MecTox, VLC had positive effects on students' attainment when the assessments occurred in a time-demanding study period, in particular. A fine-grained analysis focusing on the achievement of learning outcomes revealed that the effects on the achievement of intended learning outcomes might be related to the moment when the specific learning outcomes were assessed. Indeed, if the VLC affected the abilities to understand and apply knowledge assessed in the FE, the question is whether memorisation skills (assessed previously in the 10-MT) might have been improved by the intensive use of VLC throughout the term. The extent to which the students were able to understand and apply knowledge may lie in the fact that they remembered the essence of knowledge to be applied.

The enforced shift to blended learning prompted by COVID-19 as of March 2020 had direct consequences on teaching and learning. This shift addresses the innovation capacity and the resources for teaching and relies on academic teaching staff commitment. As the analysis on the use of technology in education showed encouraging results in student attainment and achievement, higher education systems and institutions should actively reduce the digital divide between higher education students by creating a shared understanding between teachers and students on how to use it (MacKay, 2019) while promoting its use to improve student learning (Cilesiz, 2015). The analysis of the effects of VLC provides new insights into teaching and learning in pharmacy education with consequences on post-COVID-19 education. The effect of educational technology on online teaching and learning contexts underlines the use of VLC as a resource to support learning and the preparation for the assessment. This study also encourages the adoption of VLC in other teaching and learning approaches as far as fitness for a purpose is critically analysed.

While adopting a constructive alignment framework, it would be appropriate to recommend using VLC considering student needs, the educational design, assessment components, and the course intended learning outcomes. Other benefits reflected in this study include, for instance, increased student satisfaction with VLC (students were less stressed taking notes in lectures and felt that the availability of video lectures improved their performance and understanding of the content and clarified issues by providing them with the possibility to check missed or complex topics in the respective videos); active control over learning (student interaction with the video platform increased their flexibility in the learning process); and enhanced quality of the interaction between students and teachers because videos could clarify fundamental concepts before conversations.

Generalisations should be avoided because VLC must be integrated as a pedagogical approach using its main advantages feasibly combined with other teaching and learning methodologies.

Conflict of interest

The authors declare no conflict of interest.

Availability of data and materials

The datasets used and/or analysed in this study are available from the corresponding author on reasonable request.

Source of Funding

The work was supported by UIDB/04378/2020 with funding from FCT/MCTES through national funds.

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