Extending video interactions to support self-regulated learning in an online course

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Although self-regulated learning (SRL) is essential part of learning, students often commence studies with poor SRL skills. This places much emphasis on course design to foster SRL. In online education, this is a complex undertaking. The present study examines how online technologies can be harnessed to promote SRL. This study of an online first year course (*N*=138) investigates how student use of a video annotation tool incorporating in-video quizzes can predict learning outcomes and foster SRL. The study found that students were more likely to complete the in-quiz self-assessment questions than contribute to socially-shared resources such as annotations or summaries. This finding may be a result of the higher cognitive load associated with writing tasks versus responses to in-video questions. The findings also revealed a strong positive association ($R^2=0.45$) between student completion of the in-video quizzes and course grade. It is not surprising that quiz attempts reflect performance. However, it is important to consider the interaction between the correct and incorrect responses. Above a certain threshold of positive answers, the association between incorrect in-video quiz submissions and final grade becomes *negative*. The study has implications on how analytics are interpreted and how instructors can frame feedback to foster SRL skills.

Keywords: self-regulated learning, video interactions, in-video quizzes

Introduction

Self-regulated learning (SRL), is fundamental to educational research (Butler & Winne, 1995; Panadero, Kirschner, Järvelä, Malmberg, & Järvenoja, 2015; Winne, 2017). SRL involves key processes known to effectively facilitate learning (Coulson & Harvey, 2013), and stimulate autonomy and confidence (Carey, Devine, Hill, & Szűcs, 2017). The development of such regulatory strategies, including self-monitoring, and self-evaluation have been noted to be improved through self-assessment practices (Butler & Winne, 1995). Indeed, as outlined by Sadler (1989), self-assessment is a fundamental facet of learning, as it is ultimately the individual student that must adjust any observed difference between their current performance (as revealed by the assessment answer), and the desired or required standard. Thus, the adoption of self-assessment strategies into curriculum are beneficial for productive learning (Panadero, 2017). In essence, the integration of self-assessment into the curriculum provides a scaffold for students to develop the skills needed for effective SRL (Dixon & Hawe, 2016).

While self-assessment practices have long been known to aid SRL (Sadler, 1989), their effective integration into course learning activities is still contingent on student motivation. That is, students with high levels of intrinsic motivation and course interest are likely to complete all set tasks. In contrast, students with little intrinsic motivation may require further enticement or a higher level of SRL proficiency to undertake the learning activities (Boekaerts, 2011). As education increasingly transitions towards distance and online modes, incorporating appropriate scaffolds to support SRL is now especially pertinent (Harasim, 2000; Joksimović et al., 2015). The online context and associated technical innovations have allowed educators to become increasingly creative in their approaches to prepare and design content for learning (Garrison, 2011; Goodyear, 2014). Various student-centred pedagogies (e.g., problem-based or active learning) have been shown to aid student engagement with the learning process and enhance the overall educational experience (Borokhovski, Tamim, Bernard, Abrami, & Sokolovskaya, 2012; Darabi, Liang, Suryavanshi, & Yurekli, 2013). However, motivation and self-regulation of learning remains as a challenge for many online students, often resulting in frustration and anxiety that can further lead to disengagement and dropout (Cho & Shen, 2013). There is a need for developing novel online instructional approaches that increase teaching effectiveness and improve student self-regulatory skills (Cho & Shen, 2013). One such approach gaining increasing traction is the use of video related technologies.

This study builds on an established innovative instructional approach designed to promote the development of students SRL skills through the use of an online video annotation software (Gašević, Mirriahi, Dawson, & Joksimović, 2017; Mirriahi, Joksimović, Gašević, & Dawson, 2018). While the use of video or film has a long history in education settings, the growth of online courses has seen further reliance on video as the dominant medium for content delivery and an associated rise in the number of video related tools such as video annotations, embedded discussions, quizzes and concept summaries. These video-based technologies are often used to develop SRL proficiency (Hulsman & Vloodt, 2015). The present study investigates students use of a video annotation tool incorporating in-video quizzes and annotations. Specifically, the study examines to what extent students' engagement with the annotation tool can predict learning outcomes. In so doing, we first explore how students engage with the course learning activities to regulate their learning and how they utilise the products of learning (annotations and comments) created by their peers.

Background

SRL and learning online

Self-regulated learning (SRL) is a key conceptual framework in which the construction of knowledge is developed through the use of a wide range of cognitive, physical and digital tools, where learners observe, compare and regulate their learning behaviours (Panadero et al., 2015). Zimmerman (2000) defined SRL as 'self-regulated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals' (p.14). Due to the wide range of variables influencing learning encompassed under the framework of SRL, several models have been developed to explain the concept (Pintrich, 2000; Winne & Hadwin, 1998; Zimmerman, 2000). Zimmerman (2000) developed the cyclical phases model of SRL including the three phases; (1) *forethought*, including goal setting and planning; (2) *performance*, in which learners execute the task, self-monitor and self-control; and (3) *self-reflection*, where learners assess their performance, influencing later learning strategies (Zimmerman, 2000). While similar, Winne and Hadwin's (1998) model of SRL involves a greater emphasis on metacognition and expands on the forethought phase, with four phases: (1) *task definition*, (2) *goal setting and planning*, (3) *enacting study tactics and strategies*, and (4) *metacognitively adapting studying*. In addition to these four phases, the Winne and Hadwin (1998) model includes five facets of tasks within each of the four phases; (1) *conditions*, available resources and constraints; (2) *operations*, cognitive processes and strategies; (3) *products*, learning outcomes (e.g., new knowledge); (4) *evaluations*, external or internal feedback about the interaction between standards and products; and (5) *standards*, criteria used to monitor products which can be internal or external (Panadero, 2017; Winne & Hadwin, 1998). The focus on metacognition in Winne and Hadwin's (1998) model is particularly relevant for the self-directed and complex nature of online learning environments, which often incorporate a variety of learning tools and a stronger emphasis on student autonomy (Kovanović, Gašević, Joksimović, Hatala, & Adesope, 2015; Shen, Cho, Tsai, & Marra, 2013). In this environment learners must apply metacognitive monitoring, to evaluate the effectiveness of the tools available in aiding their learning process (Mirriahi et al., 2018). This is reflected in recent studies where SRL strategies were found to be a significant predictor of academic performance (Broadbent & Poon, 2015). Broadbent and Poon (2015) noted that SRL strategies, specifically metacognition, time management, effort regulation and critical thinking, were significantly associated with academic achievement in an online learning context.

A further critical component of self-regulation is the social context in which learning is situated (Hadwin & Oshige, 2011). Socially shared regulation, the processes by which collective activity is regulated by individuals, involves the construction of common goals and standards resulting in socially shared cognition (Hadwin & Oshige, 2011). This social influence on SRL begins with observational learning, such as modelling behaviours on those of peers, social guidance, and feedback (Hadwin & Oshige, 2011). The inclusion of feedback in courses has been shown to strengthen the relationship between self-assessment and learning (Sitzmann, 2010). Self-reflection in a social context can thus provide additional opportunities for feedback from both peers and instructors and assist with task motivation and persistence (Dawson, Macfadyen, Evan, Foulsham, & Kingstone, 2012).

Research Questions

The present study adopts Winne & Hadwin's (1998) model of self-regulated learning to investigate the extent students utilise the available tools to regulate their learning processes, such as constructing or evaluating the products of learning. In so doing we extend previous research in the use of fine-grained scaffolds embedded within a learning task to promote the development of effective SRL strategies (Panadero, 2017). For the present study, the fine-grained scaffolds are operationalised through the use of in-video quizzes and the associated feedback obtained after submitting a quiz answer. Students receive detailed guidelines on how to use the features available within the online learning environment to regulate their learning. In contrast to the earlier related work by Gaševic and colleagues (2017) these activities (e.g., creating, viewing video annotations, or submitting an in-video quiz) were not graded and were established for formative purposes only. Finally, in the context of this study, students are also able to view the products of learning created by other students, thereby embracing the notion of socially shared self-regulation to examine how the social context influences an individual's self-regulation. In the first part of the study, we focus on exploring students' patterns of self-regulatory learning strategies. Specifically, we explore the extent students utilise the available features of a video annotation technology called OVAL - Online Video Annotations for Learning. The tool includes features for students to create or view video annotations, create comments on the associated videos, as well as attempt in-video quizzes as a process of self-assessment. Therefore, we defined our first research question as:

- **RQ1:** How do students engage with OVAL's features to regulate their learning strategies?

The second part of this work contributes to the further understanding of the importance of various self-regulatory learning strategies for supporting learning outcomes. The existing research almost unequivocally argues for the importance of developing robust self-regulatory learning strategies for effective learning processes (Hulsman & Vloodt, 2015; Zimmerman, 2000). In this study, we aim to explore the elements of Winne and Hadwin's (1998) COPES model (i.e., creating products of learning and evaluating learning strategies) that predict final course grade. The second research question is conceptualised as:

- **RQ2:** To what extent do different aspects of students' self-regulatory learning (e.g., creating products of learning or evaluating learning strategies) predict final course outcome?

Study Context

Course Design

The research was undertaken in a fully online first-year course in Health Sciences at a large public Australian university. The foundational human biology course runs for ten weeks where the learning tasks for each week included an introductory video by the coordinator explaining the expectations of the week and the relevance of the course topics. The content is primarily delivered in video format, with several ~10-minute videos embedded within the OVAL tool which is integrated into the institution's learning management system (i.e., Moodle), with multiple choice questions appearing at specified intervals throughout the videos (in-video quizzes). Each video contains between 1–4 quiz questions, depending on the length of the video. The completion of these in-video quizzes is optional, with students having the ability to skip each question and continue watching the video. If the student chooses to answer the question, they are provided with immediate feedback on their answer. In the first week of study, a video is provided to orient and support students in their use of OVAL. The video explains all of the functions of OVAL and students are told that the use of annotations is beneficial to their learning, however, direct instruction is only provided for the in-video quiz function. The content videos are delivered by two different academics, most as voice-over PowerPoint or a combination of face to camera with animations and voiceover, with very few external YouTube videos used in the course. In weeks 8 and 10 no videos are used to deliver content, instead an interactive (non-video) tool, Anatomy TV is used. Because of these differences, weeks 8 and 10 were excluded from the analysis. Every two weeks there is a summative multiple-choice quiz (total of 5 throughout the course), comprised of 20 questions that is focused primarily on previous two weeks but also includes cumulative questions for any of the previous weeks' content. Students have one attempt to complete the quiz, and 30 minutes to answer the 20 questions. Each quiz comprises 12 percent of their total grade, with the other 40 percent of the grade being comprised of a poster presentation.

OVAL - supporting SRL

The Online Video Annotation for Learning (OVAL) software was developed from the open source collaborative lecture annotation system (CLAS) (Gašević et al., 2017; Mirriahi et al., 2018). OVAL is an interactive video tool designed to support self-regulated learning through the use of user-annotations and in-video quiz functionality (Mirriahi et al., 2018). The software effectively allows students and instructors opportunity to annotate a video, by making time-stamped annotations corresponding to a specific point in the video or adding general comments that are not time-specific. Time-stamped annotations serve as video bookmarks, allowing users to return to a specific segment of the video for the revision of content and to encourage self-regulated learning (Dawson et al., 2012). Students have the option for annotations to be "private", and therefore visible only to the individual student (and instructors), or tagged as "public", when they are shared with peers and instructors for review and feedback.

The present study adopted OVAL to support student self-regulated learning skills in two ways. The first relates to the use of video annotations and comments to enable students to engage in the creation of shared products of learning. Specifically, as students "*operate* on raw information" (Gašević et al., 2017, p. 208), that is watching a content video, OVAL enables them to recall the information introduced in the video by labelling parts of the video they find particularly relevant (time-stamped annotations). Moreover, such created content can be made public (within the same class) and available to other learners. This way, OVAL supports socially shared self-regulation where what seems valuable to one student shapes the development of SRL for their peers, defining specific conditions for learning tasks and also providing a specific form of feedback on the content of learning (Hadwin & Oshige, 2011). The second area where OVAL aids the development of self-regulation is via the provision of the in-video quizzes. Using this form of formative self-assessment, instructors are able to define a set of multiple choice or short answer questions that appear at specific time points in the video. Students can choose to answer the question and receive immediate feedback and the video continues; or exit the question and the video continues to play. Also, there are no visual indicators where the in-video quizzes appear, so students cannot skip them by fast forwarding. By using in-video quizzes, our goal was to provide fine-grained scaffolds, defined at the task level and focused on providing formative feedback on students' understanding. That is, in-video quizzes are utilised as a tool that enables students to evaluate the effectiveness of their learning strategies, according to the external standards (Gašević et al., 2017).

Data & Analysis

The initial dataset of 148 students contained all OVAL interactions, including creating and viewing video annotations, comments, and in-video quiz attempts. For each of the in-video quizzes, we collected if students answered correctly or decided not to answer the questions. The majority of students, (approx. 80%), were part-time students (N=109) and 71% (N=105) female. The most represented age groups were 25–29 (N=24), 30–39 (N=45), and 40–49 (N=29) years. Finally, as 10 students withdrew from the course before the census date, our final dataset consisted of **138 students**. The majority of students passed the course with approximately 16% (N=22) of students receiving a fail grade. It is important to note that none of the students enrolled in the course under study had any previous experience with OVAL. To address the first research question, we provide weekly summary statistics that show usage patterns of various tools designed to support students' self-regulation (RQ1). This broad overview provides general insights into how students engaged with these non-graded activities, designed primarily to support students' operationalisation of various learning strategies, such as note-taking or self-assessment. We also provide an overview of the number of strategies each student undertook.

To investigate the second research question, we performed a multiple regression analysis with final course grade (mark between 0 and 100) as a dependent variable and metrics of student engagement with OVAL as independent variables. More precisely, we used the average number of students' annotations created and viewed per video, average number of comments created, as well as average number of quizzes answered correctly, incorrectly, or not answered as independent variables in our regression model. We also conducted model selection procedure to remove irrelevant predictors. However, given that traditional stepwise model selection procedure is sensitive to the ordering of variable execution (Field, Miles, & Field, 2012), we use *glmulti* instead - an R package for automated model selection to find an optimal regression model (Calcagno & Mazancourt, 2010). All the statistical analysis were conducted using R software for statistical analysis (R Core Team, 2014).

Results

Research Question 1

Descriptive statistics for the variables used in the study show that students adopted different strategies associated with the available OVAL features. Figures 1 and 2 show students had a relatively high engagement with video annotations in terms of both creating and viewing annotations in the early stages of the course, despite it not being a critical component of the course design. Specifically, before the teaching started, students created more than 30 annotations on average (M=32.25, SD=47.70) and viewed those created annotations more than 300 times on average (M=351.85, SD=1063.55). However, the level of engagement drastically dropped from the first week of study onwards. While there were still more than 100 annotations created and over 1000 annotation views in weeks 1 and 2, the average number of the respective activities was considerably lower (M=5.53, SD=8.09 for creation and M=16.40, SD=11.40 for viewing annotations). Table 1 highlights the number of students that were active per week of the course. While a relatively small number of students created or viewed annotations prior to the first week of the course (eight and thirteen respectively), a considerably larger number of students engaged in these activities in the first week (19 and 62 for creation and viewing of annotations). These numbers decreased throughout the course. A similar pattern was also observed in the case of in-video quiz submissions each week. Finally, a rather small number of students engaged in the creation of the video comments (Table 1).

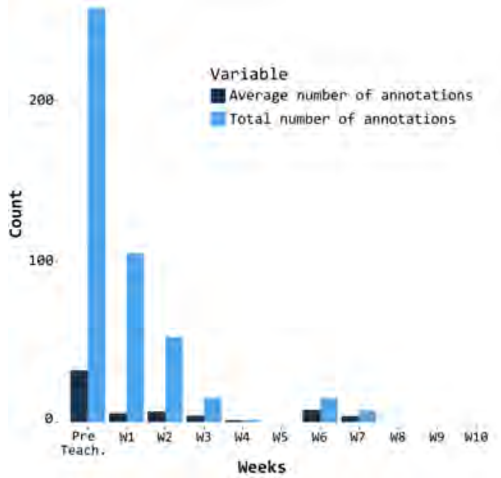

Figure 1. Overview of created annotations per week

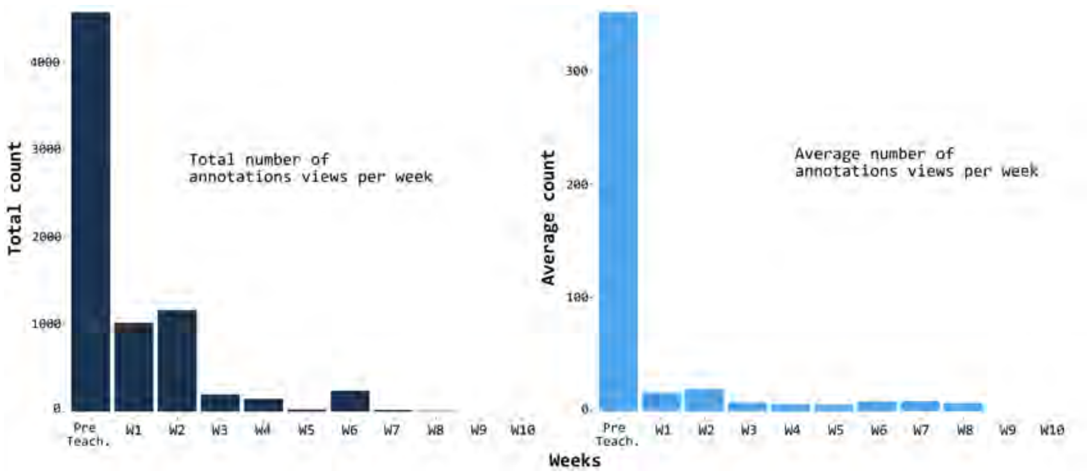

Figure 2. Overview of the total (left) and average (right) number of annotation views per week

Figure 3 further supports the statistics presented in Table 1, showing the rather substantial level of student engagement with the in-video quizzes. Overall, students seemed to have more correct answers when self-assessing the concepts learned throughout the course. However, the relatively higher number of correct answers was also followed by an increase in the number of incorrect answers. Moreover, except for week 5, which included a single video, students tended to have comparable number of submissions throughout the weeks. It is noteworthy that the number of students engaged with the in-video quizzes declined in the second half of the course (Table 1). Such decline further reflected on students' engagement with the self-assessment that was considerably higher in the first half of the course, having the peak in week 3 with more than 2,500 correct answers on in-video quizzes.

Table 1. The number of active (unique) students per week for each of the activities and the total number of unique students engaged with the given activity

	Pre	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	Total
Create annotation	8	19	8	4	1	0	2	2	0	0	0	32
View annotation	13	62	60	25	24	4	27	2	3	0	0	97

Create comment	0	3	1	2	1	0	1	0	0	0	0	6
In-video quiz	61	122	126	101	106	57	100	67	62	62	41	138

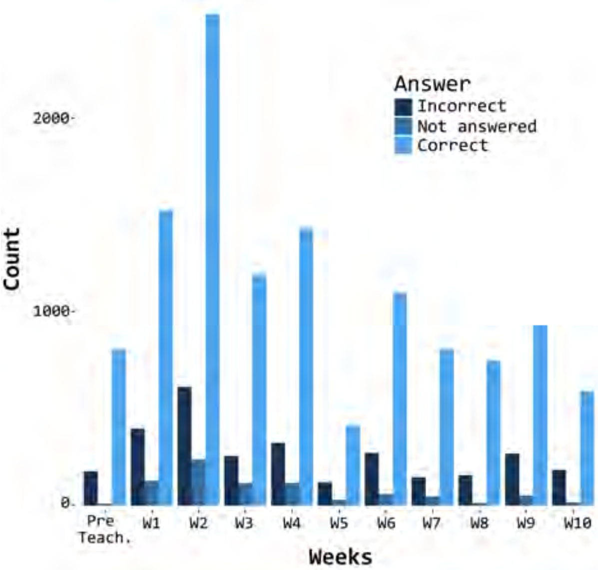

Figure 3. Total number of quizzes answered (correctly and incorrectly) or not answered.

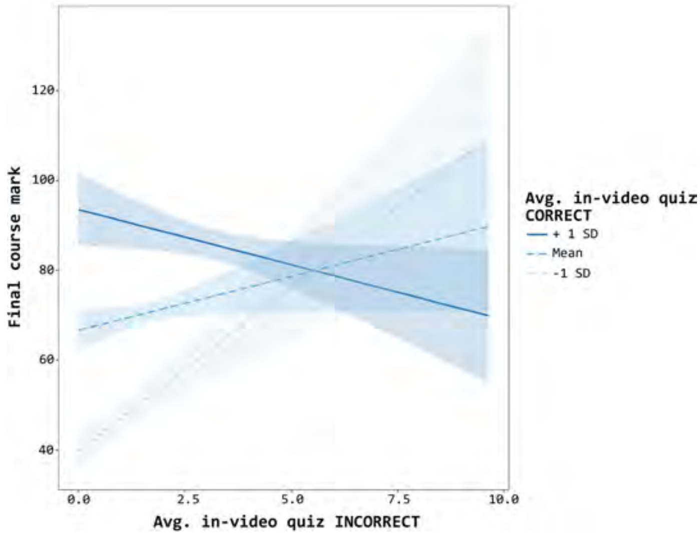

Figure 4. The interaction effect between correct and incorrect in-video quiz submissions.

Research Question 2

Although all variables were included in the initial regression model (i.e., average number of annotations viewed, created, average number of comments created, and counts of in-video quiz submissions), only the interactions relating to the in-video quizzes were included in the optimal model. After running the model selection process, the model that yielded the best fit included four variables –average number of correct in-video quizzes, the average number of incorrect in-video quizzes, the interaction between these two variables, as well as the interaction effect between correct and no answers (Table 2). The model explained 45% of the variance (R^2=**.45**, F(4,133)=28.60, p<.001) in the course grade, having almost all variables (except for the interaction between the number of correct and no answers) being significantly associated with the final course grade.

It is not surprising that the average number of correct answers to the in-video quizzes is the strongest, positively associated predictor of the final course grade (Table 2). Moreover, the effect of the average number of incorrect in-video quiz submissions was positive and statistically significant. However, it is important to consider the effect of the interaction term between these two variables (correct to incorrect in-video quiz submissions). Table 2 and Figure 4 suggest a complex association between the final course grade and interactions with in-video quizzes. Specifically, the effect of the interaction term between the average number of correct and incorrect in-video quiz submissions was strong, negative, and statistically significant. Hence, interpreting the association between the incorrect submissions and the final course grade depends on the level (or the amount) of the correct in-video quiz submissions. As depicted in Figure 4, when students have one standard deviation above the average number of correct submissions, the higher number of incorrect submissions would be associated with a lower course grade. On the other hand, for those students who have on average or less than average correct submissions, having a higher number of incorrect in-video quiz submissions is positively associated with course success. The interaction effect between the number of correct in-video quiz submissions and the average number of in-video submissions without an answer was not statistically significant. The assumptions of independent errors (Durbin-Watson value = 1.85, p=.39) and multicollinearity between predictors (VIF values in Table 2) were not violated in the regression model.

Table 2. The results of multiple regression analysis between the indicators of SRL and course final grade

Variable	R^2	B	β	VIF	p-value
Average number of in-video quizzes (correct)	.45	**4.21**	**1.14**	5.46	<.001
Average number of in-video quizzes (incorrect)		**8.04**	**0.51**	4.85	<.001
Interaction between avg. corr. and incor. answers		**-0.75**	**-1.16**	6.69	<.001
Interaction between avg. correct and no answers		-0.09	-0.05	1.61	.51

Discussion & Conclusion

Engaging with OVAL

Videos are a rapidly growing replacement to lectures in online education (Breslow et al., 2013). However, a key limitation of such videos is that the learning opportunity is reduced to a passive information transfer in contrast to more active learning processes (Cummins, Beresford, & Rice, 2016). To overcome the potentially negative impact of passive learning, the current study re-structures content videos to facilitate user engagement and support learning. Many studies have previously demonstrated that the act of retrieving information from memory is a very short-term activity. Longer term recall requires information to be regularly recalled through multiple and variable practice iterations (Roediger III & Butler, 2011). Studies have also shown that interpolating video recordings with memory tests substantially improves learning and information recall (Szpunar, Khan, & Schacter, 2013). The present study demonstrates that the inclusion of quiz questions embedded in videos can improve student academic performance. The OVAL tool and its associated features were widely used by the students. All students who completed the course attempted the in-video quiz questions. Vural (Vural, 2013) observed that online lecture videos with interactive elements such as quizzes increase engagement with learning materials and improve learning. This finding was supported in the present study.

Although all students attempted the quiz questions, the use of annotations was less well utilised (approx. 23% of the cohort). The reduced uptake in annotations may relate to the course design and instruction. While the course did not directly instruct students to use the annotation tool in OVAL, it was explained to students that it was there for them to use if they so wished. Further it was noted that the annotation process was beneficial to their learning, and instructions on how the tool worked were provided. Winne (2006) explains that an educational tool will only be adopted by students if students are made aware that the tool is useful for their learning, can be applied to their task at hand, and they have sufficient skills to use the tool effectively. While these three facets were addressed, no specific task was allocated to the use of annotations. This lack of direction or task may explain the limited use of annotation by the students. It has previously been shown that central to the scaffolding of self-regulated learning, is the integration of appropriate instructional tasks (Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013). This may explain why the annotations were not positively associated with final grade despite their use being reported as an approach to promote self-reflective learning (Hulsman, Harmsen, & Fabriek, 2009). Furthermore, the cognitive load associated with creating annotations is higher than simply completing quiz questions. The lower cognitive effort needed to answer in-video quiz questions could explain why students created a considerable number of video annotations very early in the course, which later dropped off. This trend has been noted in previous studies (Gašević et al., 2017). As the majority of online students are mature age students who work full time in addition to their studies, the effort needed to create annotations may outweigh the perceived benefits by the students (Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013).

OVAL use and predictive modelling of course outcome

While many forms of self-assessment have been shown to impact on student learning, when combined with feedback, the effect is enhanced. Indeed, the provision of timely feedback to students has been described as of particular importance (Rowe & Wood, 2007). Sitzmann (2010) conducted a meta-analysis which highlighted that the correlation between self-assessment and learning is far stronger when the assessment also includes feedback. For the self-assessment outlined in the investigated course the feedback is embedded in the questions within OVAL videos. Completion of the in-video questions provided students with immediate feedback including prompts to review sections of the video as required. Unsurprisingly, the results from the present study indicated that the correct answer in the in-video quiz is the strongest predictor of the final course grade (R^2=.45). It is interesting to note that the effect of the average number of incorrect in-video quiz submissions was also positive and statistically significant. The use of immediate feedback in this self-regulated learning tool may begin to explain why the in-video quizzes were positively associated with final course grade. The integration of immediate feedback allows the students to self-evaluate the product of their learning (i.e. their answer) against pre-conceived standards (i.e. the question). The literature suggests that students have weaknesses in judging the effectiveness of their learning (Bjork, Dunlosky, & Kornell, 2013), and self-regulated learning without appropriate scaffolds tends to result in student adoption of ineffective learning strategies (Azevedo, Moos, Greene, Winters, & Cromley, 2008). As discussed by Butler and Winne (1995), feedback from the instructor (which in this instance is embedded in the question responses) are helpful in guiding students to monitor and adapt their learning strategies rather than relying on their internal feedback which may not necessarily be adequate nor accurate. The scaffolded approach in Human Biology, where students are prompted with questions to aid reflection on their learning as well as incorporating immediate feedback, effectively allows students to rapidly evaluate understanding and determine their learning needs (Hulsman & Vloodt, 2015). When formative feedback is offered to students, despite the task not being graded, it can help promote understanding of the purpose of the learning task and act as a catalyst for SRL by affecting students' motivations, thinking, and actions and contribute to improved meta-cognitive self-monitoring and self-regulation (Dixon & Hawe, 2016).

The second part of the association between correct and incorrect in-video quiz submissions with the final course outcome aligns with the existing literature on assessment for learning. Specifically, for those students who tend to have on average or less than average correct answers on in-video quiz submissions, any interaction with self-assessment is potentially beneficial. The existing literature on assessment in general, and assessment for learning in particular, highlights the importance of providing students with the opportunity for frequent, formative testing. Indeed, cognitive psychology literature demonstrates that answering test questions at repeated intervals during an educational activity improves knowledge gain by encouraging active information retrieval, focusing attention on the content presented, promoting task-relevant behaviours, and reducing overall cognitive demand (Szpunar et al., 2013). Therefore, the results of the present study indicate that for those students who might be struggling to understand course content, it appears beneficial to continue engaging with this form of formative assessment.

The observed association between correct and incorrect in-video quiz submissions is, perhaps more complex than noted in previous research. Our findings indicate that the interaction between correct/incorrect in-video quiz answers could be detrimental to the final course outcome. Such learning strategies could be associated with a behaviour that is defined as "gaming the system". Essentially, students exploit the properties of the learning environment (feedback on in-video quizzes in this case) to obtain a correct answer instead of learning the course content (Baker, Corbett, Koedinger, & Roll, 2005; Ruipérez-Valiente et al., 2017). This learning strategy has been commonly associated with poorer learning outcomes (Baker et al., 2005). While there might be various reasons why students engage in such behaviour (e.g., students have performance goals orientation rather than focus on deep learning), what is interesting here is that gaming the system becomes negatively associated with the final course outcome after students showed a specific level of understanding of the content under study. This further suggests two plausible interpretations of the association between students' response to the in-video quizzes and the final course outcome. On one hand, it might be the case that, for various reasons, good students are not able to engage with the course at the same level they were able to early in the course. Whereas, on the other hand, it could be the case that the course content was (a) relatively easy to understand, (b) students were familiar with the content, or (c) they were simply able to guess the correct answer. Either way, this finding warrants further research and practical considerations about how to identify this particular group of students and what the feedback mechanisms would improve their learning should be considered.

Limitations and future directions

Many of the findings of the present study support that seen in the literature, however, it should be considered that this research was conducted in a single institution for a single course. Hence, a generalisation of the results beyond the current context should be made with caution. The present study demonstrated a strong positive correlation of in-video quiz questions on improving student achievement, as measured by course grade. However, the question of how, or what elements of the in-video quiz questions actually impact student achievement remains to be answered, and a number of variables should be investigated. The question arises of whether the students that are completing the in-video quizzes are conscientious students regardless, and hence are likely to engage and do well in the course irrespective. This should be the subject of future research. Additionally, it is unclear whether it is the quiz question itself that improves student performance, or if it is merely the presence of questions within a video that keep the students engaged with the video. In addition, the effect of the type of question (e.g. remember-, apply-, analyse- or understand-type questions) has not been explored in the present study. Further investigation of student motivation may also be the focus of future research. Cummins and colleagues (2016) previously identified four motivations that drive distinct behaviours of in-video quiz questions, namely, completionism, challenge seeking, feedback and revision. An understanding of student motivation may help with designing content in the future. Regardless, this study supports that learning opportunities that encourage engagement with the content in interactive ways are likely to be more effective than passive information transfer approaches (Chi, 2009).

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