# Investigating Engagement with In-Video Quiz Questions in a Programming Course

Stephen Cummins, Alastair R. Beresford, and Andrew Rice

**Abstract**—In-video quizzes are common in many distance learning platforms, including those from Coursera and EdX. However the effectiveness of in-video quizzes has not previously been assessed. In this paper we describe the construction and instrumentation of an Interactive Video Lecture Platform to measure student engagement with in-video quizzes. We also investigate the use of in-video quizzes as an approach to mitigate the lack of feedback available to students and lecturers in videos and traditional lectures. Finally, we evaluate the effectiveness of augmenting video with the ability to answer and receive feedback to quiz questions embedded directly within the video.

We observed that student engagement with in-video questions was consistently high (71-86%) across two cohorts ($N_1$=81, $N_2$=84) with a rate of 1 question per 8.7 minutes of video. We identified three broad levels of engagement with the quiz questions and four motivations, including challenge seeking and completionism, which explain some of the observed behaviour. The results from this investigation demonstrate that in-video quizzes were successful in creating an engaging and interactive mode of content delivery. We recommend that in-video quizzes be used to increase the interactivity of video content as well as supporting formative assessment within a flipped classroom environment.

**Index Terms**—in-video quizzes, video lectures, e-learning, teaching programming, flipped classroom

◆

## 1 INTRODUCTION

The use of video as the primary mode of content delivery is common in distance learning courses such as Coursera[1] or EdX[2]. However, the use of video in on-campus delivery is still comparatively rare. In these situations lectures continue to be a dominant content delivery approach in Higher Education irrespective of whether they are the most appropriate method of supporting students' learning. Applied subjects such as computer programming are no exception and as a result a great deal of course time is afforded to preparing and delivering lectures.

The difficulties inherent in both teaching and learning programming [1], [2], [3] mean the provision of timely feedback to students is particularly important [4]. This feedback is conspicuously absent from both traditional lectures and videos.

This paper presents an investigation into the use of videos augmented with in-video quizzes as a replacement for traditional lectures within the context of an on-campus programming course. This approach provides a number of opportunities. For example it enables students to receive immediate feedback during initial consumption of the course materials. The use of video also frees lecturer time to hold smaller, more focused teaching sessions.

The contributions of this paper include: an evaluation of the in-video quiz technique with a focus on student engagement; an analysis of student behaviour and interactions while using in-video quizzes; and finally, the design and development of an open source tool that facilitates access to

lecture videos whilst collecting substantial interaction data from users for research purposes.

### 1.1 Background and Related Work

The issues associated with lectures as a teaching and learning technique are well documented [5], [6], [7] and are exacerbated when teaching subjects such as computer programming. This is possibly due to the need to apply some programming concepts in order for students to fully understand them. The following problems associated with lectures are among the most important:

**Lectures are ephemeral:**
Lectures are rarely recorded and are therefore, by their nature, short-lived. That is to say if a student misses something or fails to record an important point during a lecture they will often be unable to acquire that information later. In addition to this, the pace of the lecture is often governed by the lecturer and this necessarily means that some students will get left behind, yet simultaneously others will become disengaged because the pace is too slow.

**Limitations of human concentration:**
It is often cited that student attention begins to decline [8] after 10-15 minutes of a lecture [7]. This suggests that in a typical 1 hour lecture students will not be able to invest their full attention on three-quarters of the content; more if you consider that the first part of a lecture is often introductory in nature.

**No feedback for students or lecturers:**
Typical lectures cannot provide an opportunity

- *S. Cummins, A. R. Beresford and A. Rice are with the Computer Laboratory, University of Cambridge, United Kingdom.*

1. https://www.coursera.org/
2. https://www.edx.org/

for every student to verify their understanding of the concepts introduced. Equally, it is very difficult for lecturers to gauge whether students have understood the various concepts discussed. This deprives the lecturer from changing pace or adding further information to support students' individual learning.

A likely reason that lectures remain so common in Higher Education is economic. Lectures are low cost because only one member of faculty is needed to teach a large group of students. In addition, since lectures are the traditional mode of content delivery there is reluctance to change because staff have already invested significant time and effort producing lecture resources. There is also no evidence that lectures are any better, or any worse, than other information transfer methods for delivering content to students [9]. That being said, it is clear that learning opportunities which encourage the students to engage with content in an active, constructive or interactive way are likely to be more effective than passive information transfer approaches as seen in traditional lectures [6], [10].

Some solutions exist for facilitating the delivery of feedback to both students and lecturers within a lecture environment. Personal Response Systems (PRS) [5], [11], [12], sometimes known as "clickers", provide an approach for embedding multiple choice questions into lecture slides and enable students to respond in real time. This allows the lecturer to give feedback to the class and also gain some understanding of how well the cohort understands the topic being discussed. Solutions, such as mJeliot, have been developed to attempt to improve interactivity in programming lectures using mobile devices [13]. The real time nature of a PRS is, however, also a core limitation of the technology. It means only students who are watching the lecture in real time can engage with the interactive elements.

It is clear that the use of video provides a solution for mitigating the first two problems with lectures [14]. Use of videos for learning can also reduce the cognitive load for students when compared to lectures if they are edited carefully [15].

Another benefit of video delivery is the ability to record the behaviour of students as they engage with the content. This is useful for enabling educators to support students and improve the content over time. A study by *de Boer et al.* suggests that some students may adjust their viewing style based on individual learning requirements and there are four types of viewing behaviours [16]:

**Linear**
    Watch everything in one uninterrupted pass.
**Elaboration**
    Watch again after an initial linear pass.
**Maintenance rehearsal**
    Selected sections watched repeatedly.
**Zapping**
    Skipping through, watching short sections only.

Students can adopt different viewing behaviours based on their individual learning need at any given time. For example, a student may exhibit a linear behaviour initially to gain an overview of the video content and then subsequently use a zapping technique to prepare for a face-to-face tutorial.

The final problem associated with lectures, the lack of feedback for students and lecturers, still affects video delivery. In fact the lack of useful feedback is worse in video. This is because the asynchronous nature of video delivery means that lecturer and student are separated by both time and space. This means there is even less chance of timely feedback which benefits the student.

A hybrid approach, and one adopted by the authors of this paper, is the idea of a Flipped Classroom [17] which is the practice of recording lectures and distributing them electronically to students to watch at their convenience before contact time. The benefit of this approach is that contact time can be used for something more interactive than content delivery.

A key limitation of content which is delivered exclusively using videos is that the learning opportunity is reduced to a simple, passive information transfer activity; much the same as traditional lectures. This may be an improvement on lectures because students control the pace and may re-watch sections. The inability for students to receive feedback or check their understanding remains a key limitation of using video delivery.

Many online learning environments provide a mechanism for administering post-video quizzes [18] in order to assess learning. This type of assessment is often useful for providing feedback to students as well as collecting usage data to support improvements to teaching materials.

A possible disadvantage of post-video quizzes is that, depending on the length of the video, it could be quite some time before the student receives feedback. The timeliness of feedback is crucial to student learning [4] and therefore waiting until the end of a video may not be the most effective approach. This could be especially problematic if the video introduces multiple concepts which build upon each other.

## 1.2  In-Video Quizzes

In order to enrich the learning experience provided by video lectures [19], we decided to trial the use of the in-video quiz approach. The approach involved presenting automatically assessed quiz questions within electronically recorded lectures and programming demonstrations. An intended benefit of making videos interactive in this way is that knowledge acquisition is no longer passive, but an active process, with an opportunity for students to test their understanding and get feedback periodically during consumption of the content.

We distinguish in-video quiz questions from a post-video quiz in a number of ways. In-video quiz questions:

- are designed to appear, and be answered, during normal video playback, with the video automatically pausing for the student to answer the question.
- should appear at appropriate times within the video content to simulate interactive discussion between lecturer and individual learner.
- provide feedback to the learner on their answer prior to the video continuing, thereby simulating a simple dialogic interaction.

It is clear that the technique of using in-video quizzes is not novel since they are used by some of the larger MOOC platforms such as Coursera [20] and have been trialled as part of other flipped classroom style investigations [21]. To the best of our knowledge, there is no academic work focusing specifically on in-video quizzes.

The ability to introduce new concepts and immediately test learners' understanding on an individual basis provides a number of benefits. One of the most important of these is the ability to quickly deliver feedback to students. This allows students to take some form of corrective action if necessary to support the learning process. The data available after students have engaged with the lecture material can also be used to improve support for individuals in face-to-face sessions, or indeed, to identify common issues that can be addressed in later video sessions.

## 2 THE INTERACTIVE LECTURE VIDEO PLATFORM (ILVP)

When we started our project in 2012, none of the existing open-source video platforms provided us with sufficient control to build in-video quizzes with fine-grained data collection. Therefore we re-purposed a number of existing open source projects to build our own Interactive Lecture Video Platform (ILVP). We developed a JavaScript library to control the playback of videos in a web browser.

A core requirement we had was to be able to capture detailed ILVP usage data. In order to achieve this, the JavaScript library we developed transmits a message to the server whenever user interaction events occur such as answering a question or pausing the video. Example messages include *"video playback paused at 30.6 seconds"*, *"video playback started at slide 6"*, and *"quiz answer entered correctly"*. In addition, the library transmits a message every 20 seconds during video playback with the current video time. This data collection strategy is sufficiently detailed that we can replay a user session in its entirety, including any non-linear playback of the video and all attempts to answer in-video quiz questions.

All students connecting to the ILVP are authenticated to the platform using a university authentication server. This allowed us to identify and track student progress. Once authenticated, students were presented with an ordered list of videos to watch. After selecting a video, the student is presented with a video playback page, as seen in Fig. 1. From this screen, students can play, pause or skip through the video using the in-built controls, or skip forward or backwards by slides, time (+/-5 seconds) or by question using controls we built for ILVP.

In-video questions are currently in one of two formats: multiple choice or text input. All questions are based on a single slide of material and are introduced by the lecturer. After introducing the problem, video playback automatically stops and the student is prompted to provide an answer. If a correct answer is provided by the student, video playback resumes. If an incorrect answer is provided, the student can choose to try again or skip the question. Once playback resumes the lecturer provides feedback by describing why a particular answer is correct. The lecturer asks the question as part of the video to increase the level

TABLE 1
Table listing the videos and distribution of questions.

| Video Number | Topic | Number of Questions | Video Duration |
|---|---|---|---|
| 1 | Prolog basics | 1 | 14m 46s |
| 2 | Solving a logic puzzle | 7 | 13m 57s |
| 3 | Prolog rules | 1 | 6m 39s |
| 4 | Lists | 1 | 11m 0s |
| 5 | Arithmetic | 1 | 19m 32s |
| 6 | Backtracking | 2 | 29m 06s |
| 7 | Generate and test | 2 | 14m 07s |
| 8 | Symbolic | 1 | 17m 34s |
| 9 | Cut | 3 | 17m 36s |
| 10 | Negation | 4 | 10m 52s |
| 11 | Databases | 0 | 5m 59s |
| 12 | Countdown | 2 | 21m 01s |
| 13 | Graph Search | 1 | 16m 56s |
| 14 | Difference | 2 | 13m 20s |
| 15 | Difference list example | 0 | 7m 34s |
| 15b | Empty difference lists | 1 | 11m 40s |
| 16 | Sudoku | 1 | 11m 57s |
| 17 | Constraints | 0 | 18m 10s |

of social presence in the video [22] because increased levels of social presence have been known to have a positive effect on learning [23].

In order to mitigate the effects of the zapping behaviour (as described in Section 1.1) and to reduce the likelihood of students missing questions, we ensured that questions are highlighted in the user interface of the ILVP and that students can navigate directly to questions within the video if they wish. This feature is highlighted in Figure 1.

All of the automatically assessed questions in the course were optional and students were not required to attempt them. Each question allowed an unlimited number of attempts.

The ILVP tool is open source and the source code is publicly available[3] along with additional technical documentation.

## 3 CONTEXT

The in-video quiz approach described in this paper was used as the primary content delivery mechanism for a second-year undergraduate introductory Prolog module at our institution and formed part of our Computer Science degree programme. It was introduced to provide students with an insight into a different programming paradigm and to enable comparison with object-oriented and functional languages introduced during the first year of study.

Table 1 summarizes the 18 videos we recorded to replace eight 50-minute face-to-face lectures. Since we were no longer constrained by lecture slots the material was divided by concept. The ability to replay videos removed the need for repetition and enabled faster delivery of the material. Material previously delivered in 400 minutes of lectures now translates to approximately 260 minutes of video. Whilst face-to-face lectures were removed in favour
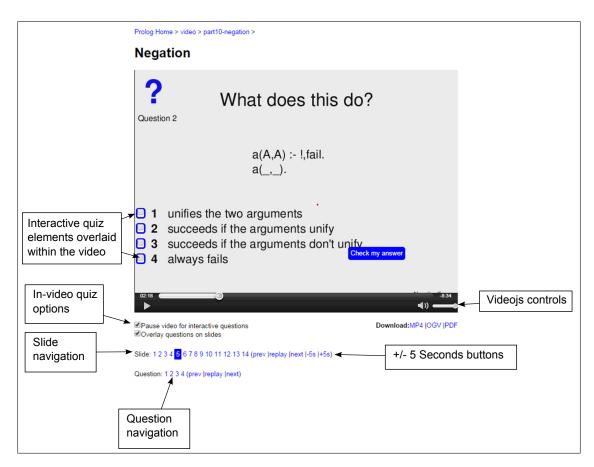
3. https://github.com/ucam-cl-dtg/ILVP-prolog

Fig. 1. Screenshot of the ILVP showing the video paused with interactive question elements overlaid.

of the videos for this particular course, the course was not devoid of face-to-face teaching. Each student received two hours of small group tutorials. Each tutorial required the student to complete preparatory work which was marked prior to the session. These tutorials provided an opportunity for students to demonstrate their understanding and receive personalized face-to-face feedback. Practical sessions were also arranged to provide students with the opportunity to practice programming and receive additional support and feedback from teaching staff.

The in-video quiz questions used as part of the course ranged in cognitive complexity according to Bloom's revised taxonomy [24], from those that required simply remembering content, to those which necessitated some application or simple analysis of ideas or concepts introduced during the video. The quiz questions we devised focused on supporting engagement with content delivered during the videos. Questions assessing higher levels of cognitive complexity (e.g. evaluate and create), were deliberately postponed until the face-to-face tutorial sessions where a member of staff can tailor the session's learning outcomes for each student. It is possible that in-video quizzes could be used to assess the higher levels of cognitive complexity, however investigation of this is outside of the scope of this study.

The data presented in this paper was collected from 2012/13 and 2013/14 cohorts of second-year computer science undergraduates. There were a total of 81 students registered for the 2012/13 cohort and 84 for the 2013/14 cohort.

The Prolog programming module is assessed in two ways. First, there is a practical exercise. Not all students attempt the Prolog exercise as they can choose between a Prolog or C++ assignment. Secondly, there is an examination which students sit at the end of the year. Since the examination covers a large variety of modules, and students need only answer questions on a subset of these, not all students attempt the Prolog question in the exam. We therefore have limited assessment data available for this module as only a subset of the cohort submit work for summative assessment. As a result, we are unable to compare student summative assessment results to their engagement with the ILVP system.

## 4 RESEARCH METHOD

The following research questions were used to investigate the effectiveness of the in-video quiz approach for delivery of the Prolog programming course.

1) How do students engage with the quiz questions embedded within video content in a programming course?
2) What impact do in-video quiz questions have on student behaviour?

Research Question 1 (RQ1) is our primary research question and aims to investigate how students engage with in-video quiz questions when they are delivered as part of a programming course. The primary reason that we are focusing on engagement is that engagement is a prerequisite for

learning even if it is not necessarily sufficient to demonstrate that learning has taken place [18]. We consider that a student has engaged with a quiz question if they have attempted it at least once.

Research Question 2 (RQ2) aims to identify any common behaviours exhibited by students who use the in-video quiz technology provided. Again the data collected from the in-video quiz system is used to categorize student behaviour.

The primary approach we have adopted for both RQ1 and RQ2 is to record the user interactions with the in-video quiz system we developed. In order to supplement this usage data we administered questionnaires. The aim of these questionnaires is to understand student perceptions of the technology as well as any behaviours observed. These questionnaires were anonymous by default, but did allow students to provide additional information to facilitate linking questionnaire data to ILVP usage data.

The questionnaire data is our primary source for being able to identify different student motivations for their usage of in-video quiz questions. In order to identify the types of student motivation, we analysed questionnaire results, both free-text and multiple choice, in order to search for themes within student responses. After identifying common themes from the questionnaire data we were then able to search for patterns within the ILVP usage logs to validate, where possible, the behaviours and motivations reported by our students.

We also analysed the in-video quiz questions in terms of cognitive complexity in order to determine whether complexity has an impact on question engagement. This analysis process involved two researchers, one of whom was the question author, assessing the cognitive complexity of each question independently using Bloom's revised framework as mentioned in Section 3. Any discrepancies generated as part of this process were discussed and resolved.

## 5 RESULTS

The online course consists of 18 videos summarized in Table 1; 16 of these videos included at least one optional in-video quiz question for students to answer. There were a total of 30 quiz questions across the 16 videos. Course materials were made available electronically, in their entirety, for the whole 2012/13 and 2013/14 academic years with no restriction on how or when students could access them.

### 5.1 RQ1 - Measuring student engagement

One of the key benefits of using video as a mechanism for content delivery is that students can consume content at a time convenient to them. The Prolog course was delivered over four weeks in October with examination of the content taking place together with all other courses at the end of the academic year in June. Therefore it is not surprising that students used IVLP most intensively during October, but also for revision over the Christmas vacation and in the run up to the exams in June.

Despite the availability of the material at any time of the day, the most popular times to use IVLP was between 10am and 11am on the days scheduled in the lecture timetable for the Prolog course. However, over half of all usage of IVLP was recorded between 2pm and midnight in October, demonstrating that students did benefit from the ability to access the content at other times of the day.

For the 2012-13 cohort, the average percentage of videos viewed was 80% (SD = 7.7%) whereas for 2013-14 it was 86.4% (SD = 6.6%). The number of students to view each video varies between the videos in both cohorts. In particular videos 1, 13 and 15b have fewer students viewing them across both years. The lower engagement with Video 1 is expected as it was introduced to the students during a face-to-face session in order to demonstrate the in-video quiz system.

#### 5.1.1 Do students answer the in-video quiz questions?

In order to evaluate the effectiveness of integrating interactive question elements within videos to test student understanding, we first need to examine if and how students interact with these questions.

Fig. 2 shows the percentage engagement of students for each question by cohort. Percentage engagement is measured by calculating the number of students who attempted the in-video questions divided by the number of students who accessed the video at least once.

On average 71.5% (SD=17.7%) of students who watched the course videos ($N$=74) also attempted the embedded multiple choice and text entry questions at least once for the 2012-13 cohort of students. The 2013-14 cohort showed a higher level of engagement with an average of 86.4% (SD=18.5%) of students ($N$=78) attempting the embedded multiple choice and text entry questions at least once.

Fig. 2 indicates that question engagement declined for the question in video 8 and the first two questions in video 9 for the 2012-13 cohort. This could be related to an increase in question difficulty; for example, the question in video 8 checks students' understanding of search trees by asking them to analyse some code for a given evaluation as shown in Listing 1. This type of question requires a deeper understanding than some of the lower complexity questions they may have encountered so far.

Listing 1. Video 8 Question 1 - 'How many times is eval(A,A) satisfied in the evaluation of eval(plus(1 mult(4 5)),X)?'

```
eval(plus(A,B),C) :-
eval(A,A1), eval(B,B1),C is A1+B1.
eval(mult(A,B),C) :-
eval(A,A1), eval(B,B1),C is A1*B1.
eval(A,A).
```

A number of questions in video 2 (Questions 5, 6 and 7) appear to have consistently low levels of engagement across both cohorts of students. On closer investigation it is evident that very few students answer these questions incorrectly when they attempt them. These questions are relatively simple to answer and are included to provide regular opportunities for students to check their understanding. These three questions in particular ask students to read a program and identify the lines of code that are responsible for different behaviour. The low level of engagement with these questions may also be the result of over-questioning as this video has the highest number of questions per minute of video (see Table 1).
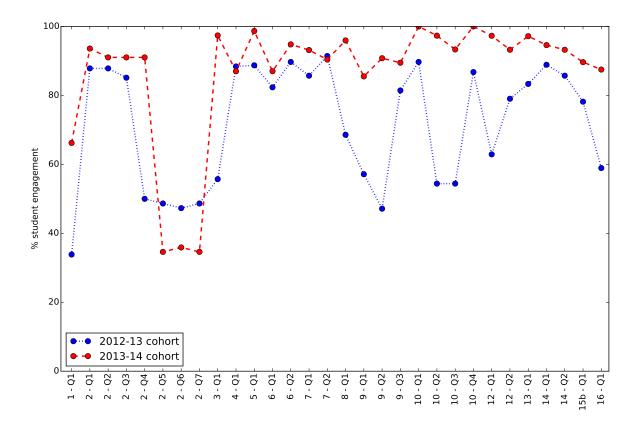
Fig. 2. Graph showing the percentage of students who attempted each question out of those who have viewed the video at least once. The questions are labelled in the form *video number - question number*.

Listing 2. Video 9 Question 1 - 'What does split/3 do?'
```
split([],[],[]).
split([H|T],[H|L],R) :- H < 5, split(T,L,R).
split([H|T],L,[H|R]) :- H >= 5, split(T,L,R).
```

Question 1 in video 9 shows a substantial reduction in engagement for the 2012-13 cohort. This is likely as a result of the type of question presented. In this particular case, as shown in Listing 2, the question is asking the student to reflect and consider what a fragment of code does before clicking a button to reveal the correct answer. This question is unusual as it does not require the student to input an answer; instead it merely reveals the correct answer during the video. It is actually the only question in the course of this type. Despite the intention behind this question, it appears as though students decided not to click the answer button. It is unclear from the data we collected whether or not students have actually thought about this problem as intended prior to continuing with the video. The data does show that they tend not to click the answer button for this question.

The perceived lack of challenge is clearly a factor that contributes to some students' decision on whether or not to engage with a question. The cognitive complexity of the in-video quiz questions varied between *Remember* to *Analyse* based on the framework criteria. The number of questions in each cognitive dimension are as follows: *Remember* (5), *Understand* (10), *Apply* (11), *Analyse* (4), *Evaluate* (0) and *Create* (0). Table 2 shows that, on the most part, students

TABLE 2
Table listing the average percentage engagement by cognitive process dimension as extended by Krathwohl.

| Complexity | 2012-13 Average % Engagement | 2013-14 Average % Engagement | Average % Engagement |
|---|---|---|---|
| *Remember* | 81.73 | 91.55 | 86.64 |
| *Understand* | 62.54 | 73.52 | 68.03 |
| *Apply* | 73.72 | 92.64 | 83.18 |
| *Analyse* | 75.73 | 94.91 | 85.32 |

in both cohorts engaged less with the *Understand* questions in favour of other questions.

A possible explanation for the reduced number of viewers using video 15b, and the slight decline in the engagement with its quiz question in the 2012-13 cohort, is due to the fact Video 15b was added late in the course in response to student questions. This is an example of Just in Time Teaching (JiTT) [25] to improve the video material in the course in response to student engagement. Incidentally, the concept added in Video 15b was actually missing from the previous five years of delivery and was only detected as a consequence of moving to a flipped classroom mode of delivery.

### 5.1.2 How many students answer the questions correctly?

The analysis of student responses to the in-video quiz questions can be useful for instructors as it allows them to engage in Just in Time Teaching to prepare for the face-to-face sessions or to improve the video content in future iterations of the course.

Through the analysis of the 2012-13 in-video quiz question data, it was noted that question 2 in Video 12 had a high number of incorrect attempts (100) versus correct ones (20). This is unusual since on average, we received 30 correct and 14 incorrect attempts per question. The most commonly observed behaviour was that students would attempt a question repeatedly until they answered it correctly. In this particular case, the students appeared to make several attempts and then give up and move on. This question was unusual as the correct answer required multiple choices to be selected. It is possible students did not consider this eventuality. As a result, we have been able to improve the material and make this expectation more explicit. The behaviour of repeatedly submitting answers to the quiz was common since there was no penalty for answering incorrectly and an unlimited number of attempts was allowed.

### 5.2 RQ2 - Investigating student behaviour

In order to understand the behaviour observed through the usage data collected we administered two questionnaires; one at the end of each academic year. The response rate was 37% (29/79) for the 2012/13 cohort and 37% (30/81) for the 2013/14 cohort. It should be noted that the 2012/13 questionnaire did not focus on in-video quiz questions specifically, therefore we focus mainly on the results of the 2013/14 questionnaire.

A majority of the respondents, 93% from the 2013/14 cohort, reported that they had watched all 18 videos at least once with the remaining 7% suggesting that they watched at least 11 of the 18 videos. This percentage is higher than the data recorded and presented in Section 5.1. The threats to validity discussed in Section 7 may explain this discrepancy.

During a practical session staff observed students watching the videos using the ILVP. Some of these students had modified the platform's JavaScript within their browser to enable them to watch the video at 1.25 speed. This feature was not initially considered, but as a result of this observation it was added to the platform. This further demonstrates that some students want precise control over the speed at which content is delivered. We note that platforms such as EdX have added similar functionality since we first built ILVP.

When asked how the students used the Prolog course videos, 56% reported that they had watched the videos from start to end at least once and then skipped through them to find relevant material as they needed it. Some 23% of respondents said that they preferred a mixed approach, sometimes watching entire videos and sometimes searching for material they were interested in. At least one respondent said that they never watched a video from start to end but instead just skipped through the videos looking for specific information.

One student reported that they

TABLE 3
Table showing the distribution of student behaviours observed.

| behaviour | 2012-13 cohort | | 2013-14 cohort | |
| --- | --- | --- | --- | --- |
| | % | # | % | # |
| No Engagement | 5 | 4 | 1 | 1 |
| Selective Engagement | 91 | 71 | 93 | 74 |
| Total Engagement | 4 | 3 | 6 | 5 |

"...watched all of them once when the course was taking place. Then I skipped over them as I needed for supervision [tutorial] work. Watched them again in the Christmas break and watched them again during Easter break (with the exception of last lecture)."

All of the respondents to our questionnaire claimed to have engaged with at least some of the in-video quiz questions provided. Some of the free text responses to the questionnaires do provide some possible explanations for students who did not engage with particular in-video quiz questions. This will be discussed in Section 6.

## 6 EVALUATION

The behaviours we identified make it clear that different students interact with the videos in very different ways, often using the material differently in order to suit their personal study regimes.

We observed that most students selectively engaged with the quiz questions, while only a few demonstrated no engagement or total engagement. These levels are enumerated in Table 3.

The motivations of students within each behaviour group shown in Table 3 are diverse. After analysing the data gained from the ILVP plus the questionnaire responses we have identified the following four motivations:

**Completionism**
Students complete the in-video quiz questions because they exist. They only consider the video complete when they have answered all questions.

**Challenge Seeking**
Students in this category only answer questions that, in their opinion, are challenging enough. They skip questions they believe are trivial.

**Feedback**
Students who aim to use the in-video quiz questions to verify their understanding of the material just introduced.

**Revision**
Students who view questions multiple times, or view them close to their examination date.

The Selective Engagement behaviour combined with the Challenge Seeking motivation is somewhat concerning for lecturers. Whilst students may believe they fully understand a concept, this isn't always true, and therefore it is impossible for the lecturer to be confident that a concept has been understood to a satisfactory level.

Two respondents suggested, in their free-text responses, that their engagement with the in-video quiz questions was

purely because they were completionists. Whilst the data we have collected shows a relatively low number of students (4-6%) who engaged with all 30 quiz questions, this perhaps is not the same metric that completionist students use to define their behaviour. One of the students who suggested their engagement was motivated by completionist behaviour did volunteer additional information to allow us to compare their usage data with their questionnaire responses. It appears that they did answer all of the questions apart from the one featured in the first lecture video which was shown to the whole class.

Another motivation, which was perhaps the most expected, is the desire for feedback. An example response is

> "They [the quiz questions] were good for verifying that I'm still following what was being lectured in the video."

This is the most commonly reported motivation in the questionnaires with four respondents mentioning it in free text entry responses. Of course, these motivations are not necessarily orthogonal. It is quite possible for students to be motivated by different things at different times or indeed have a mixture of them at any one time.

When asked to rate the usefulness of the in-video quiz questions on a five-point scale, a total of 7 (24%) respondents from the 2013/14 cohort reported that they were very useful, 17 (59%) useful, 2 (7%) moderately useful, 1 (3%) somewhat useful and 2 (7%) not useful. One respondent to the questionnaire commented that they found the in-video quiz questions useful as a means of verifying their understanding as the video progressed.

> "I think they are a great way to get involved in the material and make sure you actually understand what's going on."

This is a key motivation for using in-video quizzes rather than post-video quizzes as it provides an opportunity for faster feedback.

A majority (52%) of students thought there was the right number of in-video quiz questions distributed throughout the videos, with many (45%) reporting that they would like more. One student thought there were too many and would have preferred fewer.

RQ1 focused on investigating student engagement with in-video quiz questions. This paper has shown that most of our students do engage with a majority of the in-video quiz questions and do perceive a benefit in doing so. The various motivations and behaviours presented show that individual students make full use of their ability to engage with the content in different ways.

RQ2 focused on investigating how students behave when engaging with in-video quiz questions. This paper shows that the vast majority of students are selective over which questions they answer. Students have highlighted a number of different motivations for their behaviour some of which could be considered when designing content in the future.

We observed similar video engagement behaviours to those reported by *de Boer et al.* [16] and *Kleftodimos et al.* [26], notably the zapping behaviour described in Section 1.1. This behaviour may be triggered by the Challenge Seeking motivations reported in our study and could explain why question engagement was sometimes sporadic.

Due to the irregular distribution of questions across the different cognitive complexity dimensions, it is difficult to draw strong conclusions as to how our analysis of cognitive complexity relates to student behaviour. In particular it is difficult to judge whether our analysis of cognitive complexity matches the perceptions of those exhibiting Challenge Seeking behaviour. It is however apparent that students in our investigation prefer to engage with *Remember*, *Apply* and *Analyse* questions over those that test *Understanding*.

Based on our results, we recommend that in-video quiz questions are designed with consideration of the behaviours and motivations described in this paper. For example, in order to support those with the Challenge Seeking motivation we can attempt to include at least one challenging question per video. For those students seeking feedback to verify their understanding, we can include some diagnostic questions that identify possible misconceptions and provide detailed feedback. In terms of supporting those with a Completionist motivation, perhaps the ILVP system could be enhanced to provide a clearer indication of which questions students have answered so far and how many have yet to be answered in the course overall.

Finally, we note that our course provides an average of 1 quiz question per 8.7 minutes of video and that this resulted in mixed opinions from students with just under half reporting that they would have liked to have seen more. It may be that the rate of questioning can be increased somewhat before students believe over assessment is occurring.

## 7 THREATS TO VALIDITY

Our study was executed within a single institution for a single course, so results may not be generalized beyond the context of this investigation without further research.

It is likely that the students who were conscientious enough to respond to the questionnaire are also likely to engage with more of the content. This may therefore create a selection bias with our questionnaire results.

The two cohorts being investigated were not provided with the same questionnaire and therefore questionnaire data is limited to a single cohort (2013-14).

### 7.1 Ethical Considerations

This study was reviewed and approved by our institution's ethics committee. In our introductory face-to-face session with students, we demonstrated the ILVP and described our data collection methodology. In particular, students were shown how to opt out of the study by downloading the video files to their own computer if they wished. The usage data collected by the ILVP was not used in student assessment.

We did not request permission from students to publish their raw ILVP interaction data. Even after removing student names, there remains a small risk that one student may be able to identify the actions of another student in the interaction data, therefore we are unable to publish the interaction data recorded for this study.

## 8 FUTURE WORK

In order to investigate the effect of in-video quiz questions it may be beneficial to select a course which includes mandatory summative assessment to explore how students engage with the material when there is a strong extrinsic motivation for them to do so.

A comparative study into post-video quizzes and in-video quizzes would be useful to fully quantify the effectiveness of one when compared to the other. It may also be useful to investigate how student navigation within the videos relates to engagement with in-video quiz questions. For example, do students actively navigate around questions when they see them approaching?

Investigating the optimal number of in-video quiz questions per minute of video may be a useful topic of further investigation as student responses on this issue are mixed for our particular study.

It is clear that some programming tasks lend themselves to automated testing more than others. In addition to simple multiple choice and text entry quiz questions, it is our ambition to embed programming tasks themselves into video lectures to allow students to follow along at their own pace and see the results of program execution in real time, all within a video lecture.

## 9 CONCLUSIONS

The investigation presented provides a foundation for further work on the use of in-video quizzes within the context of a programming course. Students' perception of in-video quiz questions has been positive as has the level of engagement, which was between 71-86% across the two cohorts. We also introduced the ILVP as an example technology for improving the interactivity of videos used as a replacement for lectures.

Based on the results presented, we recommend the use of in-video quiz questions as a technique to improve the level of engagement with lecture content. The in-video quiz technique successfully meets our objective of providing rapid feedback to students as well as enabling them to engage with content at their own pace prior to contact time. The feedback that lecturer and student receive from the use of in-video quiz questions allows both to prepare for the face-to-face sessions more thoroughly. For example, as described in Section 5.1.2, we detected content that was confusing for students and were able to take corrective action.

The in-video quiz technique provides a mechanism for addressing the common problems with traditional lectures discussed in Section 1.1, especially the lack of feedback delivered to students and the lecturer. This is because the use of in-video quiz questions enables a better learning dialogue between the lecturer and the student than traditional lectures or videos allow. This is supported by the consistently high engagement with the in-video quiz questions by students.

Our course had a rate of 1 quiz question per 8.7 minutes of video. Both the analytic data and the questionnaire responses suggest that this rate of questioning is acceptable: there was a high level of student engagement (71-86%) with the questions and most students were happy with this rate of questioning (52%), although 45% did recommend including more.

We observed that different students interact with the in-video quiz questions in a variety of different ways and the motivations behind these interactions are equally diverse. We have reported four motivations which impact student decisions on whether to engage with particular questions; these include Completionism, Challenge Seeking, Feedback and Revision. These motivations should be considered when designing quiz questions to help support students learning and encourage higher levels of engagement with video content.

## REFERENCES

[1] B. DuBoulay, E. Soloway, and J. C. Spohrer, "Some Difficulties of learning to program," in *Studying the Novice Programmer*. Sussex, England: Lawrence Erlbaum Associates Inc. Publishers, 1989, ch. 14, pp. 283–299.

[2] A. Robins, J. Rountree, and N. Rountree, "Learning and Teaching Programming: A Review and Discussion," *Computer Science Education*, vol. 13, no. 2, pp. 137–172, Jun. 2003.

[3] L. E. Winslow, "Programming pedagogy: a psychological overview," *ACM SIGCSE Bulletin*, vol. 28, no. 3, pp. 17–22, 1996.

[4] A. D. Rowe and L. N. Wood, "What feedback do students want?" *The Australian Association for Research in Education (AARE) Conference. Freemantle, Australia*, 2007.

[5] Q. I. Cutts and G. E. Kennedy, "Connecting learning environments using electronic voting systems," *ACE '05 Proceedings of the 7th Australasian Conference on Computing Education*, vol. 42, pp. 181–186, Jan. 2005.

[6] D. Laurillard, *Rethinking University Teaching : A Framework for the Effective Use of Educational Technology*. London: Routledge, 1993.

[7] J. Stuart and R. Rutherford, "Medical Student Concentration During Lectures," *The Lancet*, vol. 312, no. 8088, pp. 514–516, Sep. 1978.

[8] J. Smallwood, D. J. Fishman, and J. W. Schooler, "Counting the cost of an absent mind: mind wandering as an underrecognized influence on educational performance." *Psychonomic Bulletin & Review*, vol. 14, no. 2, pp. 230–6, Apr. 2007.

[9] D. A. Bligh, *What's the Use of Lectures?* Intellect books, 1998, ch. 1.

[10] M. T. H. Chi, "Active-Constructive-Interactive: A Conceptual Framework for Differentiating Learning Activities," *Topics in Cognitive Science*, vol. 1, no. 1, pp. 73–105, Jan. 2009.

[11] C. H. Crouch and E. Mazur, "Peer Instruction: Ten years of experience and results," *American Journal of Physics*, vol. 69, no. 9, p. 970, Sep. 2001.

[12] B. Simon, M. Kohanfars, J. Lee, K. Tamayo, and Q. Cutts, "Experience report: peer instruction in introductory computing," in *Proceedings of the 41st ACM Technical Symposium on Computer Science Education - SIGCSE '10*. New York, New York, USA: ACM Press, Mar. 2010, p. 341.

[13] A. Pears and M. Rogalli, "mJeliot: a tool for enhanced interactivity in programming instruction," in *Proceedings of the 11th Koli Calling International Conference on Computing Education Research - Koli Calling '11*. New York, New York, USA: ACM Press, Nov. 2011, p. 16.

[14] S. Schwan and R. Riempp, "The cognitive benefits of interactive videos: learning to tie nautical knots," *Learning and Instruction*, vol. 14, no. 3, pp. 293–305, Jun. 2004.

[15] B. D. Homer, J. L. Plass, and L. Blake, "The effects of video on cognitive load and social presence in multimedia-learning," *Computers in Human Behavior*, vol. 24, no. 3, pp. 786–797, May 2008.

[16] J. de Boer, P. A. Kommers, and B. de Brock, "Using learning styles and viewing styles in streaming video," *Computers & Education*, vol. 56, no. 3, pp. 727–735, Apr. 2011.

[17] J. L. Bishop and M. A. Verleger, "The Flipped Classroom: A Survey of the Research," in *2013 American Society for Engineering Education Annual Conference*, 2013, pp. 5–7.

[18] P. J. Guo, J. Kim, and R. Rubin, "How video production affects student engagement," in *Proceedings of the First ACM Conference on Learning @ Scale Conference - L@S '14*. New York, New York, USA: ACM Press, Mar. 2014, pp. 41–50.

[19] J. H. Sharp and L. A. Schultz, "An Exploratory Study of the use of Video as an Instructional Tool in an Introductory C# Programming Course," *Information Systems Education Journal*, vol. 11, no. 6, p. 33, Dec. 2013.

[20] Coursera, "What are in-video quizzes? Do in-video quizzes count toward my grade?" 2014. [Online]. Available: http://help.coursera.org/customer/portal/articles/1159100-what-are-in-video-quizzes-do-in-video-quizzes-count-toward-my-grade

[21] J. Campbell, D. Horton, M. Craig, and P. Gries, "Evaluating an inverted CS1," in *Proceedings of the 45th ACM technical symposium on Computer science education - SIGCSE '14*. New York, New York, USA: ACM Press, Mar. 2014, pp. 307–312.

[22] J. Short, E. Williams, and B. Christie, *The Social Psychology of Telecommunications*. New York : Wiley, 1976.

[23] A. Lyons, S. Reysen, and L. Pierce, "Video lecture format, student technological efficacy, and social presence in online courses," *Computers in Human Behavior*, vol. 28, no. 1, pp. 181–186, Jan. 2012.

[24] D. R. Krathwohl, "A Revision of Bloom's Taxonomy: An Overview," *Theory into practice*, vol. 41, no. 4, pp. 212–218, 2002.

[25] G. Novak, A. Gavrin, W. Christian, and E. Patterson, *Just-In-Time Teaching: Blending Active Learning with Web Technology*. Addison Wesley, 1999.

[26] A. Kleftodimos and G. Evangelidis, "Exploring Student Viewing Behaviors in Online Educational Videos," in *2014 IEEE 14th International Conference on Advanced Learning Technologies*. IEEE, Jul. 2014, pp. 367–369.

**Stephen Cummins** is a Research Associate in the Computer Laboratory at the University of Cambridge. He obtained his PhD at the University of Durham in Software Engineering Education and has since worked as a Lecturer of Further Education in Computer Science and more recently as a Software Engineer at BAE Systems. He now works on the IsaacPhysics.org project researching tools to support online learning and assessment.



**Alastair Beresford** is a Senior Lecturer in the Computer Laboratory at the University of Cambridge. He obtained his PhD from the University of Cambridge, working at the intersection of mobile computing and computer security. He continues to work in the area of mobile security alongside his more recent research interests in technology enhanced learning. He currently works on the IsaacPhysics.org project, an open source platform to support the teaching of Physics in English high schools.



**Andrew Rice** is a Senior Lecturer in the Computer Laboratory at the University of Cambridge. In his current research he is working with physical scientists investigating how modern programming language theory can be used to improve computer modelling efforts. He works within the Computing for the Future of the Planet framework, investigating the contributions that computer science can make in solving issues such as over-population, global energy use and climate change.