Research in Learning Technology
Vol. 30, 2022

ASSOCIATION FOR LEARNING TECHNOLOGY ALT

ORIGINAL RESEARCH ARTICLE

Online microlearning and student engagement in computer games higher education

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(Received: 5 October 2021; Revised: 6 December 2021; Accepted: 24 January 2022; Published: 9 March 2022)

Microlearning, in which lecture recordings are segmented into parts, saw renewed focus as a means of maintaining student engagement amid the challenging conditions of the COVID-19 pandemic. While many institutions shifted to remote provision with segmented lecture recordings, there is a lack of consensus about the length that these segments should be in order to best maintain engagement. Using a self-reported system of Likert-based diagnostics, 135 videos in use at Solent University's computer games area were analysed. Ninety-four students were asked to agree or disagree with statements in the format 'I understand X', each tailored to the subject material of the video in question. Repeated questions before and after the video allowed for a change in confidence to be measured, as an indicator of engagement. The resulting 4198 responses showed an optimum range of 5–8 min overall. However, the year of study emerged as a significant factor in this regard – with an optimum range for first years at 6–12 min, and for second and third years at under 8 min. There is a need for institutional-level change in this area, as many institutions currently recommend use of lecture video segments far longer than either figure.

Keywords: remote instruction; digital learning; segmenting; chunking; pandemic

Introduction

As COVID-19 spread across the world in early 2020, many nations began restricting social gathering in an effort to slow the spread. This had a marked effect on education in particular, with countless schools and universities forced to close brick-and-mortar facilities and shift education online (Viner *et al*. 2020). For many institutions, these changes had to be implemented extraordinarily quickly (Bao 2020). Institutions had to rapidly develop guidelines for lecturers in establishing the shape and format of online provision (UCU 2020).

Maintaining engagement is a task made more difficult by distance and is a major issue for remote provision (Lee 2020). The new institutional guidelines often included a renewed focus on microlearning, sometimes referred to as 'segmenting' or 'chunking',

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Citation: Research in Learning Technology 2022, **30**: 2680 - http://dx.doi.org/10.25304/rlt.v30.2680

to address this. The process sees lecture recordings split into short videos, a technique designed to maintain student engagement by providing a series of smaller, bite-size chunks rather than very long videos (Hug 2005). Video length has previously been demonstrated to be the most significant indicator of learner engagement in online provision (Guo, Kim, and Rubin 2014).

The existing literature that studies video length in an academic setting is somewhat limited, and there is no broad consensus about the ideal length that these videos should be in order to maintain engagement. Different institutions make use of a huge range of lengths in their provision, and many existing papers address video length only as a factor when examining a different topic. Internet speed may also influence results in this area, a factor which may harm the usefulness of older data sets (Costley *et al*. 2020). Lange and Costley (2020) state that there is a need for 'multiple studies' in this area to provide additional, local data.

This paper endeavours to determine an optimal length for microlearning video resources in computer games higher education, in terms of maintaining learner engagement, with the goal of informing future teaching. While this study took place during the pandemic, the methodology used here is also more broadly applicable to remotely conducted higher education in general.

Terminology

(Newmann, Wehlage & Lamborn, 1992) describe engagement in an academic context as 'the student's psychological investment in and effort directed toward learning, understanding, mastering the knowledge, skills or crafts'. Newmann, Wehlage & Lamborn specifically define engagement level as a spectrum, rather than as a binary engaged-disengaged dichotomy. Van der Meij (2017) asserts that engagement is 'a prerequisite for learning' though Axelson and Flick (2010) argue that the causal relationship is less clear, and that engagement 'may simply be the byproduct of a learning environment that suits the student'. Axelson and Flick however acknowledge that the correlation between high engagement and learning has been well documented.

Hug (2005) represents an early description of microlearning, and by design provides a 'framework which enables various definitions'. Hug addresses length only in very broad terms, stating that there should be 'relatively short effort, operating expense [and] degree of time consumption …', with microlearning defined as more of a philosophy rather than a hard set of rules. Hug's definition describes a general principle of providing learning through multiple shorter elements, ideally interspersed throughout a longer period of time. This is as opposed to presenting the capture of a full traditional lecture, which Whatley and Ahmad (2007) suggest '… may be too long for students to usefully watch at one sitting, particularly as the visual cues and audience reaction may be missing'.

Existing literature

We identified three main bodies of literature in this area: papers which examine the relationship between length and engagement directly, papers which examine current institutional provision and papers which study other factors in microlearning but may address length. In establishing a baseline, we limited our scope to literature regarding higher education, as it became clear that video content aimed at younger learners

Citation: Research in Learning Technology 2022, **30**: 2680 - http://dx.doi.org/10.25304/rlt.v30.2680

was often significantly shorter. A study on elementary schools in the Netherlands, for example, found a remarkably short average video length of 1 min, 13 s, with some videos in use as short as 47 s (Van der Meij, Rensink, and van der Meij 2017).

Papers studying length in terms of engagement

Guo, Kim, and Rubin (2014) performed a large-scale data analysis of edX's 2012 online course provision, examining videos offered by Massachusetts Institute of Technology (MIT), Harvard and Berkeley in mathematics and science. The study identified that 6–9 min videos offered the highest overall engagement time, and that longer videos were often left unfinished. As the most detailed study in the area it has been widely cited by subsequent literature, however there are two limitations to this data set.

As the study was performed using data mining rather than with direct student contact such as a survey, the length of time a student spent watching videos in a given 'session' was used as a proxy metric of engagement, which the authors concede is an 'inherent limitation … it cannot capture whether a watcher is actively paying attention to the video or just playing it in the background while multitasking'. With this being an analysis of older data, communication with students was impossible – it therefore does not measure the student learning process directly, and acknowledges that spending time watching the video is a prerequisite for learning, but not a direct measure.

Secondly, there is the matter of the change in internet speed since 2012. In the United States, where the data were collected at the time, average speeds had risen from 14.3 to 72 mb/s by 2018, a fivefold increase since the data were collected (Federal Communications Commission 2012, 2018). This may affect the usefulness of older data for informing practice today (Costley *et al*. 2020). Speed is a factor particularly among older studies in this area (Whatley and Ahmad 2007), though it has not yet been fully explored in an academic context.

Doolittle, Bryant, and Chittum (2014) studied pacing in microlearning by dividing the same content into smaller segments for four different groups of undergraduate general health students, with a 9-min video presented in 1, 7, 14 or 28 segments. Their research found an increase in the ability of students to recall information with increased segmentation, with the 28 videos (at an average length of 19.3 s) having the highest scores. However, this extreme approach resulted in overwhelmingly negative student responses, with students viewing the technique as 'annoying'.

Ozan and Ozarslan (2016) also performed data analysis using a approach similar to that of Guo, Kim, and Rubin (2014) as part of a larger study and found that videos under 10 min in length had the greatest engagement. They were further able to demonstrate a significant drop-off in engagement in videos of 30 min or longer, though their data lacked precise groupings to draw any more detailed conclusions, as this was not the primary focus of their research.

Papers studying existing institutional use

Bao (2020) examined Peking University lecturers' transition to remote learning during the pandemic. As the first nation to be affected by the pandemic, Chinese universities had to adapt very quickly to the new circumstances. Peking University is an institution with a wide range of courses including a large number of scientific subjects, and educational provision for 44,700 students there were moved online in early 2020.

The study determined that lecturers were using videos of length 20–25 min '[i]n order to ensure that students concentrate on online study' (Bao 2020).

Rickley and Kemp (2021) took a similar approach while examining the transition to online education for a strategic management Master of Business Administration (MBA) course during the pandemic. Prior to that semester there had been no guidelines in terms of video length, and lecturers were using videos from 21 to 60 min; however, institutional guidelines in the pandemic era had this content divided into videos of 10 min length maximum, with positive responses from students.

Perry (2017) described the general trend of microlearning, with lengths ranging from 5 to 30 min, and learning media offered by the Canadian Society for Medical Laboratory Science presented at a 30-min length. Lange and Costley (2020) examined current provision at the Open Cyber University in South Korea, determining that lecture videos at the institution range from 20 to 30 min in length. Their research however is more focussed on presentation and intelligibility rather than on overall length.

Microlearning as a part of other studies

Many papers written after 2014 cite Guo, Kim, and Rubin (2014) and use their length recommendations while examining other factors (Expósito *et al*. 2020), while others simply state a length of microlearning content used for their study without further detail. For example, Ahmad (2017) studied the use of microlearning in information technology (IT) courses at Sultan Qaboos University, Oman, comparing exam results for students against those who received a more traditional delivery. The study used videos of 4 min length maximum and demonstrated a 7.46% increase in exam results for the microlearning group, but did not identify how the 4 min length was selected.

Whatley and Ahmad (2007) found that students at the University of Salford responded positively to the availability of 5–10 min lecture summary videos, however the reason given for the length studied was the difficulty of downloading longer videos at the time. This is a clear demonstration of Costley's assertion that internet speeds limit the usefulness of older data in this area (2020).

Research outcomes

In terms of optimal video length for electronic microlearning, it is clear that there is a huge disparity between lengths currently used by institutions, ranging from 5 to 30 min. The impact of video length is rarely studied directly, with many papers simply using the recommendations from Guo, Kim, and Rubin (2014), or failing to state how the length was determined while assessing another factor (Ahmad 2017). Those that study length in relation to engagement directly tend to support an optimum video length of under 10 min, though with a lack of precision, and video lengths sometimes grouped into wide ranges (Ozan and Ozarslan 2016).

Considering that length is the most important factor in determining engagement (Guo, Kim, and Rubin 2014), there is a clear need here for more specific data discerning the connection between engagement and video length in an academic context, conducted at a local level (Lange and Costley 2020).

Citation: Research in Learning Technology 2022, **30**: 2680 - http://dx.doi.org/10.25304/rlt.v30.2680

Methodology

Data were collected at Solent University from September 2020 to July 2021. During this time, all lectures in the department were conducted remotely – through a combination of pre-recorded videos and live conference calls. Recorded lectures were provided to students via Solent Online Learning (SOL) – Solent University's implementation of the Moodle learning platform. Before and after each video, students would complete a diagnostic assessment via the Moodle page, which asked them to express their confidence in the topics at hand via a Likert scale. These responses were recorded, and used to assess changes in student's confidence with the subject material on a per-video basis, as a measure of engagement with the material (van der Meij 2017).

Participants

The study recorded responses from 94 students from the Bachelor of Arts (Hons) Computer Games Design and Bachelor of Science (Hons) Computer Games Technology courses. Both are 3-year degrees. Of the students who participated, 81 were male, and 13 were female. Solent University's ethics panel cleared the study prior to data collection; as human participants were involved in the study, there were no risks to their health, financials or private data.

Modules

The five modules under study across the area are presented in Table 1.

The 17 students on CUP456 were also in the group studying CUP453, albeit at different times – with CUP453 conducted in the first semester and CUP456 in the second.

Media Design is a module centred on teaching visual communication, in which students created simple detective games using visual clues, using the Unreal Engine.

Introduction to Games Design and Prototyping saw students develop tabletop role-playing systems through frequent test play sessions and research. The module is intended to teach prototyping and iteration.

Digital Game Design and Prototyping is a rapid prototyping module where students are tasked to design and implement multiple game ideas using a game engine delivered in bi-weekly sprints.

Mobile Game Fundamentals is a programming-heavy module where students use a game engine (such as Unity) to practise mobile gestures (tap, swipe, drag, etc.) to create multiple mobile games for relevant platforms (such as Google PlayStore).

Table 1. Modules under study with student gender data.

Course	Year	Modules	Male	Female	Total
Design	1	CUP456 Media design	14	3	17
Design	1	CUP453 Introduction to games design and prototyping	25	4	29
Design	2	DAC513 Digital game design and prototyping	28	5	33
Tech	2	DAC525 Mobile game fundamentals	19	4	23
Design	3	DAC614 Experiential design	9	0	9
Totals (excluding repeated students)			81	13	94

Finally, Experiential Design is an optional module where students practise various principles of Player Experience (PX) by creating small games where the focus is shifted from gameplay to the experience on topics such as emotions, interactivity, character design, story-writing and puzzle design.

Instructional materials

Lecture segments were generally in the form of slide shows with commentary, and embedded directly on the relevant Moodle page. All videos were presented in 16:9 at 1080p resolution (1920 × 1080px).

Some modules included third-party videos elsewhere on the course pages, but these were not used for analysis, and were not visually positioned between the diagnostics used in this study. Some lecture segments were further split into parts for students' ease of navigation or other practical reasons; in these circumstances, an average (mean) length was used. Of the 140 segments studied, 135 were in the range of 2–15 min length. The remaining five beyond that range were not used for analysis as they were too thinly distributed in length to draw meaningful conclusions.

At the start of the semester, all participants watched a standardised 2-min video explaining how to fill in the diagnostic questionnaires from a technical perspective. The video indicated that the data would be used to inform future instruction as well as this paper, and encouraged participants to answer honestly.

Diagnostics

Student engagement was assessed using a five-point Likert scale questionnaire, which recorded students' self-reported confidence with the material. This approach was successfully used by van der Meij (2017) to demonstrate engagement in instructional videos, with confidence also found to be linked to subsequent student performance test scores. This broadly also follows the recommendations of the study by Fredricks, Blumenfeld, and Paris (2004), which discusses using self-report questionnaires as a means of measuring cognitive engagement in an educational setting.

The relationship between confidence and competence – and therefore engagement – has been demonstrated in other areas in the past, particularly in medical education and training (Fereday and Muir-Cochrane 2006). Clanton *et al.* (2014) studied the relationship between self-reported confidence and faculty judgement. Their study identified a significant relationship between the two, along with some smaller demographic trends such as a tendency towards lower initial confidence among younger students. Downey and Zeltmann (2009) studied the relationship between self-efficacy and competence in six IT training contexts and identified a strong confidence–competence correlation in both creative disciplines included in the study (web design and graphics), as well as in database work. Correlation was however not demonstrated in three other disciplines under study, suggesting a field-specific effect. Confidence has also been used successfully as a predictor of academic achievement in science (Andrew 1998).

The question text varied, as they pertained to the content of each video, usually a theoretical point in the lecture. A common format was maintained throughout, with students asked to agree or disagree with a statement in the format 'I understand X', such as 'I understand the relationship between tabletop role-playing games and video games'.

Citation: Research in Learning Technology 2022, **30**: 2680 - http://dx.doi.org/10.25304/rlt.v30.2680

The same questions were posed before and after each session in order to demonstrate change in the relevant area. This approach, with 'pre-test' and 'post-test' results, was used by van der Meij (2017) as a control procedure, as students may have existing knowledge of the subject. This also allowed for demonstration of change between the two data points on a per-video basis, rather than simply assessing a single value from after the training has concluded.

A total of 280 interactive diagnostics were employed, of which 270 were used for analysis after removal of the disregarded videos' questions. These were made available as embedded digital activities on Moodle, through which all data were collected.

The number of questions (two per video, both asked again after conclusion) and the order of the Likert scale options were kept consistent throughout. Five responses were available (Strongly agree, Agree, Neither agree nor disagree, Disagree and Strongly disagree) arranged in a column with 'Strongly agree' at the top. This arrangement was kept consistent in order to avoid changes in layout affecting results (Chan 1991).

Due to an unlocking mechanic used in the design of the pages – with each activity only available after completing the previous – completing the diagnostics out of order was impossible. Incomplete responses were only possible by abandoning the entire week's material half-way through, and this occurred only rarely.

Results

The diagnostics resulted in a total of 4198 student responses over the course of the year. This figure disregards students who completed a pre-lecture but not the corresponding post-lecture question (which rarely occurred).

General student numbers were also subject to an element of decay over the lifetime of a given module, as is common – with some students switching courses or leaving the university, for example.

In line with other learning technology studies researching engagement (Mango 2015; Terrion and Aceti 2011), the Likert responses were enumerated and an average (mean) was calculated. A normalised change in confidence was then calculated using the pre- and post-lecture value for each question. This was achieved using min-max normalisation.

After normalisation, a value of 0 would indicate no change in average student response, while a value of 1 would indicate all students had moved to (or remained at) 'Strongly agree' after watching the video. A decline in confidence after the video would appear as a negative value, though none of the questions in the study recorded an overall decline. In practice, all videos returned increases in confidence of ranging magnitudes between 0.18 and 0.88. Had there been any negative values to report, a range of −1 to +1 would have been used in an amended formula, with −1 indicating all students moving to or remaining at 'Strongly disagree'.

This normalisation was intended to account for variation in students' pre-existing knowledge of a subject before watching the video – as it is the overall change in confidence, as a measure of engagement, that is under study. A simpler approach such as using a raw difference in average response before and after the video would not account for this.

These normalised per-question values were collected into groups based on video length, using 1 min intervals. When a video was exactly on the division between two groups (a whole number of minutes in length), it was rounded into the upper division. The mean change in confidence for each group is displayed in Figure 1.

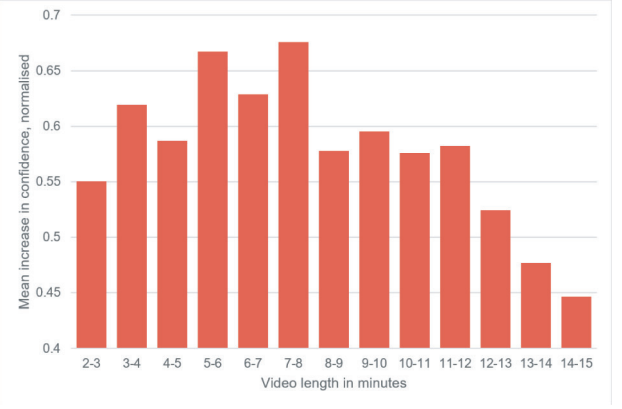

Figure 1. Normalised mean confidence increase by video length (full cohort).

Discussion

When viewing the full cohort, the data show a peak in engagement with videos in the range of 5–8 min length. This roughly corresponds with the 6–9 min peak identified by Guo, Kim, and Ruben (2014) – though our data show a weakness among shorter videos not present in the older study. As discussed later, this was an effect only present among first year students, with those in later years responding more strongly to shorter videos.

The weakness identified among the longest videos studied, particularly those approaching 15 min, may indicate that students are losing interest or struggling to keep track of the material at that length. These students may not be paying attention to the full length of longer videos, but instead watching in part or skipping through sections, before reporting only modest increases in confidence (Ozan and Ozarslan 2016).

Year of study

Students' year of study emerged as a significant factor in their reported confidence change. This was first observed when viewing module-wide averages (Table 2), as it became clear that first year students were also expressing significantly weaker improvements in confidence overall, when compared to second and third year students.

This division in confidence may stem from the shifting make-up of a course group over the first year – where unmotivated or struggling learners leave or simply fail, resulting in a higher performing group of students in the second and third years.

Paura and Arhipova (2014) identified school scores as a significant factor in dropout rates among first year engineering students – along with gender and faculty-related factors. Gairín *et al*. (2014) identified that 'students who drop out usually have a poor academic record' when analysing students of Catalan universities, an area where universities have a high dropout rate. Lack of motivation was identified as the most significant factor in that study, suggesting those that survive to study the higher years were more motivated. That study found little correlation between dropout rate and demographic profile.

In order to analyse this further, the data were split into two sections based on year of study, with first year modules separated from those offered in the second and third

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Table 2. Normalised mean confidence increase by module.

Course	Year	Module	Normalised mean (0–1)
Design	1	CUP456 Media design	0.47
Design	1	CUP453 Introduction to games design and prototyping	0.45
Design	2	DAC513 Digital game design and prototyping	0.64
Tech	2	DAC525 Mobile game fundamentals	0.67
Design	3	DAC614 Experiential design	0.63
All groups			0.62

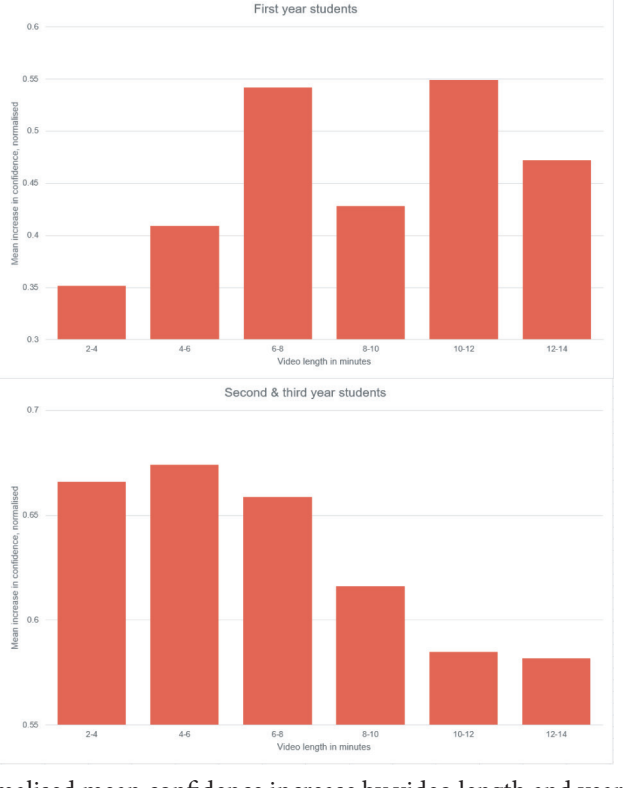

Figure 2. Normalised mean confidence increase by video length and year of study.

years. For this comparison, a length range of 2–14 min was used as the latter group did not contain any videos in the 14–15 min range. The trends are depicted in Figure 2.

The differences between the two groups were quite substantial. The weakness among shorter videos seen in the cohort overall appears to be an effect limited to first year students – with second and third year students demonstrating greater support for short videos, and much more closely aligning with the data set of Guo, Kim, and Ruben (2014).

While some prior research has shown shorter videos to be effective (Doolittle, Bryant, and Chittum 2014), this is not reflected in our first year group. Guo, Kim, and Ruben (2014) found no such drop in engagement among the shortest videos – though their study was concerned with the total amount of time students remained engaged (watching), rather than using self-reported confidence scores as a measure of engagement. Our data may therefore indicate that first year students watch the entirety of a short video, but do not feel that subject material has been covered thoroughly in such a short span of time.

Limitations

There was no way to measure directly if a student had watched the full video or had instead moved to another window or left their device, for example. This could have had an impact on the longer videos in the study in particular. While it was impossible for students to answer the diagnostics out of order, it was possible for students to delay – to perhaps watch a video and then answer the post-lecture diagnostic on a different day. This could have had an influence on their reported post-lecture confidence.

The study also did not take into account student internet speeds, which likely varied. While no students reported being unable to take part, a student with sufficiently poor internet speeds may not have been able to watch the videos at the full resolution, which would limit their ability to read lecturer body language, for example (Reamer 2013).

Conclusion and recommendations for future research

Our data identified video length as a significant factor in student engagement with recorded lectures, using self-reported confidence as a metric and broadly confirming the findings of Guo, Kim, and Ruben (2014). An optimum range in which students reported the greatest increase in confidence was identified at 5–8 min, slightly shorter than Guo, Kim, and Ruben's 6–9 min. However our data set reveals that the year of study had a significant effect, with the needs of first year students differing from others. Among our students, optimum ranges were identified at 6–12 min for first year students and 2–8 min for second and third year students.

It is clear that there is a need for more research examining segmentation in other fields and locations, as there may be additional cultural or field-specific effects that change the ideal length in different settings (Costley *et al*. 2020). Additional studies are therefore needed, examining video length at different institutions, in different fields of study and with different year groups. As the pandemic begins to ease and some universities begin to move towards a hybrid form of online and in-person provision, the relationship between students and videos in this new context also needs to be studied. The correlation between confidence and competence here could also be examined in a follow-up study as there may be field-specific effects (Downey and Zeltmann 2009).

The ideal lengths identified in this article are far shorter than the videos currently in use by many institutions (Bao 2020; Lange and Costley 2020). It is clear that there is a need for new institutional guidelines for shorter segmentation in order to improve student engagement – particularly with respect to second and third year students. These guidelines should ideally be informed by research conducted locally once it is available.

Citation: Research in Learning Technology 2022, **30**: 2680 - http://dx.doi.org/10.25304/rlt.v30.2680

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