The Impact of Educational Microcontent on the Student Learning Experience

Jake H. FITZGERALD
School of Mechanical & Manufacturing Engineering
The University of New South Wales
UNSW, Sydney, AUSTRALIA
jake@snackapp.io

Christopher C. TISDELL
School of Mathematics & Statistics
The University of New South Wales
UNSW, Sydney, AUSTRALIA
cct@unsw.edu.au

ABSTRACT
This case study investigates educational microcontent as an online delivery mechanism for course content, specifically assessing its impact on the subjective student learning experience. Microcontent was introduced as a supplementary resource to students across three Computer Science courses at the University of New South Wales (UNSW). Content was distributed via Snack, a platform developed by the research team for efficient creation and distribution of short, "bite-sized" instructional videos. The case study suggests microcontent had significant positive impact on students' non-achievement outcomes; improving confidence, interest in subject material, academic self-efficacy and learning ability, as well as self-perception of achievement outcomes such as learning ability and academic performance. Findings support the position that microcontent is an effective supplementary tool for teachers which can engage a large student audience and positively impact their learning experience.

CCS → Applied computing → Education → **E-learning**

Keywords
E-learning, digital education, microcontent, videos, Snack

1. INTRODUCTION
This case study aims to deepen our understanding of the student experience of video as an online learning resource.

Short, online videos known as "microcontent" pervade digital education, being widely available on video hosting applications such as YouTube, massive open online courses (MOOCs) such as Coursera and EdX, and open source lesson providers such as Khan Academy. While extremely popular amongst students, the body of research surrounding microcontent's instructional effectiveness is mixed: despite the fact that video is highly accessible and enables self-paced learning, evidence suggests the risk of a passive, impersonal experience that can impede on long-term engagement and retention of knowledge [1]. With such popularity, the medium's impact on student learning remains to be more deeply understood.

To assess microcontent's impact, a case study was conducted at UNSW across three Computer Science courses. Sets of videos were introduced in a variety of contexts as a supplementary resource for students, created and distributed via Snack, an online platform developed by the research team. Student interactions with the microcontent were observed via Google Analytics (GA), and a post-intervention questionnaire probed student outcomes and perceptions of microcontent's impact on both achievement such as academic performance and non-achievement outcomes such as student confidence, academic self-efficacy and interest in course material.

The case study gives insight into microcontent's impact on the student learning experience, to better understand what role – if any – microcontent should play in modern pedagogy.

2. MICROCONTENT DESIGN
The design of the Snack platform is informed by best practices regarding microcontent. Specifically, Snack's videos are interactive whiteboard animations with background narration, engaging both visual and auditory channels to reduce working memory load and increase retention [2]. Snack limits maximum video duration to 10 minutes, catering to limited attention spans of students online [3]. The videos are also interactive, encouraging student participation by allowing spatial control of the video canvas [4].

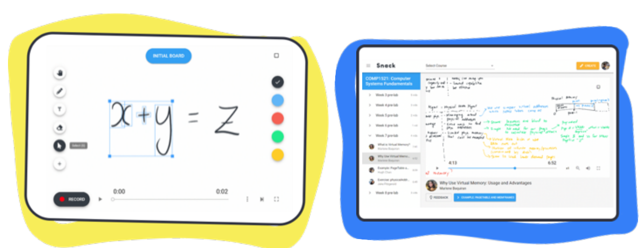

Figure 1: Snack's video creator (left) and player (right)

2.1 Modularity

2.1.1 Duration
Deteriorating student attention spans are consistently evident in studies of educational video. For example, on EdX, once a video's duration exceeded 12 minutes its average playback dropped to just 3 minutes per session [3]. Additionally, in 6.9 million EdX playback sessions Guo and colleagues revealed that median playback duration for a video of any length was only 6 minutes [1]. Subsequently, Snack enforces creation of digestible, modular chunks of content through a 10 minutes limit on a video's duration.

2.1.2 Repetition
In the context of educational video, delivery of short bursts of content followed by spaced intervals and repetition has been shown to be a highly effective way to retain new information. This retention can be attributed to Eibbinghaus' theory of spaced learning, which describes a human tendency to rapidly forget

ICMSTTL 2019 Proceedings of the 2019 International Conference on Mathematics, Science and Technology Teaching and Learning, Sydney, Australia, June 28-30, 2019, pp.17-22
doi>10.1145/3348400.3348412

knowledge after it is learnt [5]. Ebbhinghaus argued that this forgetfulness can be minimised in a compounded way by revisiting content in regular, spaced intervals.

The benefits of online microcontent therefore lie in accessibility and control, which both enable spaced learning. By giving students the ability to review microcontent on-demand and providing granular control over pace and playback, learning can be reinforced at individual levels. Snack provides the basic functionality for individual navigation in a video player, such as the ability to seek, pause, rewind and replay, but emphasises more granular controls such as playback speed, panning and zooming to give the student user end-to-end control over their learning experience.

2.1.3 Structure

Modular content requires coherent structure and ordering. Mayer and Moreno suggest that mentally organising materials into an order or "playlist" which emphasises the use of existing knowledge is crucial in video design [2]. Additionally, thoughtfully structured microcontent has been shown to decrease learning difficulty and anxiety and improve academic self-efficacy [6]. Snack therefore allows creators to seamlessly organise videos into an ordered playlist for students.

2.2 Modality

Building on Ebbinghaus' spaced learning principle is Mayer and Moreno's Cognitive Theory of Multimedia Learning, which provides a more complete description of cognitive load in the context of educational video [2]. Here, auditory and visual inputs are loaded into working memory with limited capacity, and this information is gradually processed and encoded into long-term memory which has virtually unlimited capacity. The theory posits that while each channel has limited capacity, when both are engaged simultaneously a learner's total working memory load is maximized.

Subsequently, an appropriate format of microcontent is the whiteboard video, which uses whiteboard animations with background narration. This engages visual and auditory channels in a highly complementary way, as the simplicity of the whiteboard making up the visual component removes visual noise and makes it easier for the student to follow the teacher's train of thought [2]. This is more than conjecture: Wiseman's case study showed 15% greater retention of content when whiteboard animation was added to a "talking head" video in a sample of 2000 students [7]. Furthermore, Guo and colleagues showed that whiteboard videos from Khan Academy garnered greater student playback than traditional slide/code tutorials [1]. Snack uses this popular whiteboard video format with interactive enhancements.

2.3 Interactivity

Interactive features in microcontent have a shared goal of decreasing the passivity of video. Interactivity can vary from simple features such as temporal seeking to more involved features such as embedded quizzes. Lawson et al[4] inserted eight guiding questions into their videos for one section of a social psychology class, using unaltered video for other sections as a control. They found students who answered the guiding questions throughout videos outperformed students using the unaltered video streams. In a similar study, Zhang et al [8] found students who used videos with interactive features had a more positive attitude towards the learning experience. Here, evidence suggests that viewing methods which encourage active participation and emulate a classroom environment are more effective. Snack implements interactivity by allowing users to control spatial movement (panning, zooming) on an infinite canvas and copy and paste text directly from videos.

3. CASE STUDY

3.1 Population

During the intervention semester, Snack was integrated into three Computer Science courses at UNSW. A large quantity of microcontent was produced by student tutors and consistent, course-wide engagement was observed. Details of the student populations and intervention are summarised in Table 1.

Table 1: Summary of course populations

Course	Number of students enrolled	Number of videos released	Total duration
A	707	21	1h 45m
B	564	9	1h 20m
C	356	30	2h 50m

In each population, most students were completing a degree in the School of Computer Science at UNSW. Each course was a core Computer Science unit, meaning cohorts were large and had some overlap. In each case, videos were offered as an optional supplementary learning resource.

3.2 Intervention

Microcontent was scripted and recorded by UNSW student tutors, including members of Snack's development team. In Course A, videos were tailored towards the students' weekly lab exercises and reviewed the exercise structure, common mistakes and relevant theory needed to get started. Videos were shared with students via webcms3 (Course A's LMS) and a direct link to all videos (organised into playlists) on the webcms3 main page. To increase exposure, videos were also embedded into HTML pages which contained instructions for each lab exercise. An example of this is embedding shown in Figure 2.

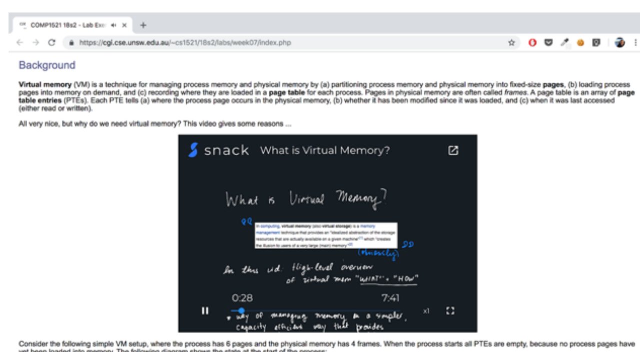

Figure 2: Course A pre-lab video embedded on LMS

In Courses B and C, microcontent was conceptual and acted as an alternative medium for students to learn course theory. Distribution was more limited in these courses, with videos being shared via forum posts, emails and social media.

3.3 Questionnaire

Our questions were designed to assess how non-achievement outcomes such as confidence, self-concept and interest in course content were affected by microcontent. Additionally, questions on achievement outcomes were included to assess self-perception of microcontent's impact on learning ability and academic performance.

The questionnaire was distributed to 1627 students across courses A, B and C. Distributing to three courses, each with its own use case for microcontent, allows for proof of translation and reproducibility: if responses are consistently positive or negative across many courses, a stronger argument can be made for microcontent's impact on the student learning experience.

4. RESULTS

4.1 Engagement

Herein, engagement is measured with two key metrics: the quantity of students reached and the quality of individual student interaction.

4.1.1 Reach

Week-by-week engagement for each course over the intervention semester is summarised in Figure 3 (source: Google Analytics).

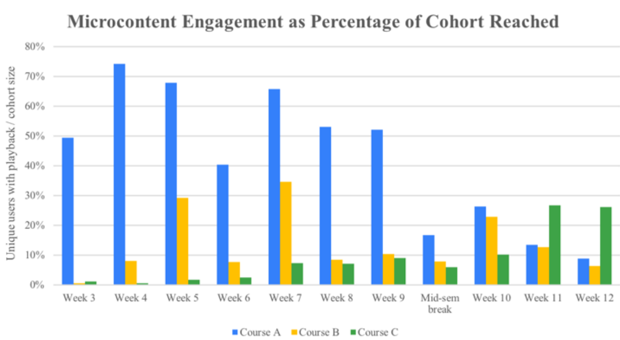

Figure 3: Microcontent reach for Courses A, B, C

As we can see, engagement fluctuated throughout the semester, with primary drivers being relevance of microcontent to assessable items and distribution methods. Accounting for weeks 3-12 where pre-lab videos were released, an average of 54% ± 11% (α=0.05) of Course A's students engaged with videos on a weekly basis. The reach of microcontent in Courses B and C were significantly lower: Course B reached 8.9% ± 5.5% (α=0.05) of the cohort, while Course C reached 8.6% ± 2.3% (α=0.05) of the cohort. In these courses, reach was hamstrung by limited distribution. Unlike Course A where videos were directly embedded into the course's LMS, Course B and C's videos were only shared via informal forum posts and comments.

4.1.2 Interactions

Interaction quality looks at how long students watched videos for, when they dropped off and how regularly they returned to watch more. Given the questionnaire is built around students' individual experience with microcontent, higher quality interactions better inform student respondents. Figure 4 shows weekly interactions for each course, represented as the average duration of playback per user. This metric accounts for longevity of student engagement and total available microcontent. Here, only the subset of students who engaged with microcontent is considered.

As we can see, playback duration was more consistent between courses. Course A had steady engagement across lab weeks 3-10, with average playback of 9.3 ± 1.2 (α=0.05) minutes per user. An average of 17.2 minutes of lab-related microcontent was released each week, meaning engaged students watched 54% ± 7% (α =0.05) of microcontent each week. Coupled with 54% cohort reach, we can conclude strong engagement with Course A's microcontent.

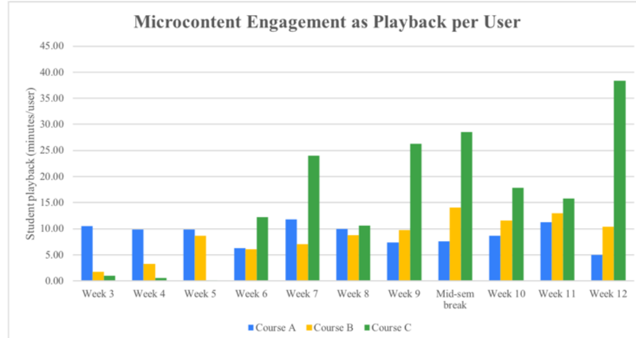

Figure 4: Microcontent interactions for Courses A, B, C

Additionally, while videos reached a smaller percentage of Course C students, individual interactions were much stronger, with a higher average playback of 23.0 ± 5.5 (α=0.05) minutes per user per week when content was available in weeks 6-12. Course B also had interactions that were equally as strong as Course A's interactions, with 8.6 ± 2.3 (α=0.05) minutes per student per week. Despite microcontent being an optional resource, engagement quality in each course was significant and warrants further analysis of impact on student learning.

4.2 Questionnaire

Questionnaire responses were collected from 177 students. 69% of respondents were enrolled in Course A, followed by 29% in Course B and 23% in Course C. Notably, 21% of respondents were enrolled in two or more of Courses A, B or C simultaneously. Gender breakdown of respondents was 24% female and 74% male, which aligns with the CSE faculty's official student breakdown of 25% female and 75% male students [1] and suggests the population is fairly represented by questionnaire respondents in gender terms.

4.2.1 Six-Point Likert Responses

The first section of the questionnaire asked a set of six-point Likert scale questions to quantitatively measure student sentiment towards Snack's videos. Figure 5 summarises responses, where a score of 6 represents "strong agreement" and a score of 1 represents "strong disagreement".

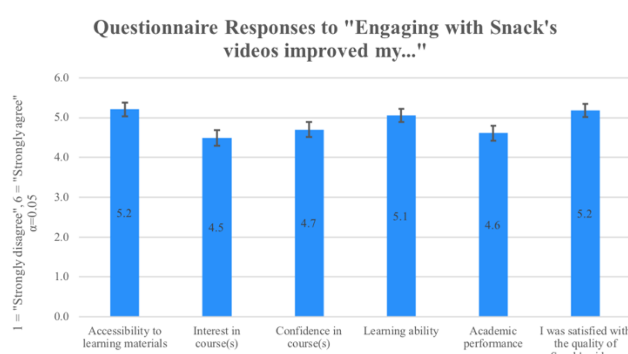

Figure 5: Six-Point Likert scale questionnaire responses

For each question, responses skewed towards "agree" and "slightly agree" categories. 90% of students "slightly" to "strongly" agreed that Snack videos made course learning more accessible, while 94% of students "slightly" to "strongly" agreed

[1] Sourced from UNSW CSE faculty's enrolment data.

that Snack's videos were satisfactory as a supplementary resource, conforming to the popularity of microcontent amongst students.

For non-achievement outcomes, students "slightly agreed" (α =0.05) that they felt more confident and more interested in course content as a direct result of Snack's videos. Moreover, students "slightly agreed" to "agreed" that microcontent improved their learning ability and "slightly agreed" that microcontent improved their academic performance (α=0.05). This suggests a self-perception of improved retention and application of material.

When segmenting responses by student engagement, those who engaged with Snack's videos more than once per week reported greater confidence, learning ability and academic performance. Between regular and irregular engagement populations, effect sizes (measured with Cohen's d value) ranged from 0.38 for difference in learning ability to 0.51 for difference in academic performance, indicating engagement had a "small" to "medium" effect size on these outcomes [9]. This suggests a causal link between regular engagement with Snack's videos and self-perceived improvements in learning.

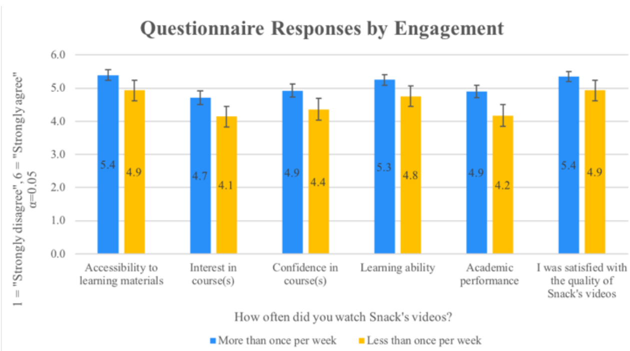

Figure 6: Questionnaire responses by engagement

Segmenting responses by gender and course drew trivial effect sizes (< 0.2) and no statistically significant difference ($p < 0.05$) for each question, suggesting this positive student perception of microcontent is reproducible across genders and cohorts.

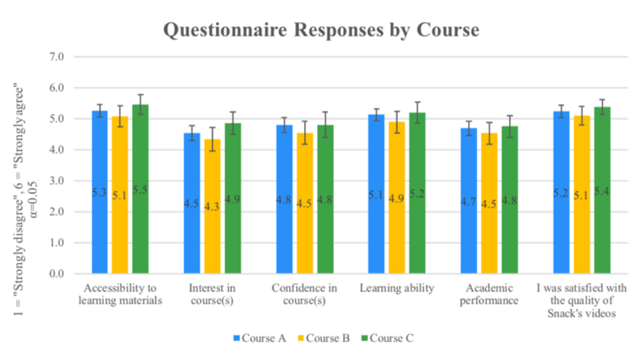

Figure 7: Questionnaire responses segmented by course

4.2.2 Open-Ended Responses

The second section of the questionnaire asked two optional, open-ended questions. Students were asked to describe the best parts of Snack's videos and to suggest improvements.

Of the 117 responses to the "best parts of Snack" question, 38 students praised the clarity of explanations in the microcontent, attributing clarity to the use of whiteboard animation and real-time code editors coupled with narration. Students stated "the dynamic nature of [videos]... with live code... was extremely helpful" and the "combination of visual imagery and live code… with narration and explanation was clear and easy to understand". This aligns with responses from a separate multiple choice question, where 83% of students claimed they used Snack's videos to "clarify points they didn't fully understand in class". It also supports literature suggesting microcontent which engages both visual and auditory modalities maximises a student's ability to digest content [2]. Moreover, 18 students enjoyed the interactive components of the Snack's videos, citing the ability to "move around the page", "zoom in on annotations", "focus on areas" and "paste code examples in real-time".

Second to clarity was relevance. 25 students liked the way microcontent was tailored towards their course, stating videos were "specifically related to course content, unlike YouTube videos". For Course A, videos were designed around lab exercises, with students stating they provided a "solid foundation for the lab… I felt less stressed as a result" and "helped [them] understand how to approach the lab". One student also found content more relatable because it was "taught by students… so it was much clearer".

Modularity of microcontent was also praised. 19 students thought videos were "concise and clear", "straight to the point", "time-cost effective" and "short and succinct explanations of big topics". Some students also claimed the videos "covered a 2 hour lecture in 10 minutes" and that they "had an easier time focusing… because the videos were much shorter in length compared to lectures". These findings support literature suggesting students prefer to consume microcontent in short, modular chunks, however they challenge some reviewed literature which suggest student focus wanes more readily when watching microcontent online than lectures face-to-face [3].

Lastly, 11 students said the accessibility of video was its best feature, stating they could "work at [their] own pace", "revisit [videos] whenever I want… it's like having an on-the-go tutorial" and that videos were "really useful and convenient for when I need to catch up". Students also enjoyed the granular control of video, citing the ability to "replay parts I didn't understand" and "rewind [videos] if necessary". At a higher level, one student claimed video "diversified methods available to [them] to learn". While most students cited interactivity, relevance and conciseness as their favourite features of the microcontent, when asked how they use Snack's videos in a separate multiple choice question (with the ability to select 1 or more option), 49% said they used videos as a "revision tool for assessments", 45% said they used videos to "catch up on missed classes" and 48% said they used videos to enable self-paced study. Accessibility and control are a crucial utility underpinning microcontent's value as a learning resource.

The second open-ended question asked how Snack's videos could be improved. The majority of responses addressed bugs and usability issues on the platform, such as problems with audio quality, latency and mobile responsiveness. These issues stemmed from Snack's lean development process, which prioritised iteration of features over robustness in the intervention semester. Majority of issues were reported by students as they emerged via a bug tracking feature and were quickly resolved. Latency was a product of high, concurrent engagement, causing servers to overload during peak traffic times (such as during a lab session). Notably, Snack had no downtime over the entire intervention semester, and many students added that these issues did not impede on their learning experience.

The second most common request was for more content, with students asking for "more videos", "more topics", "more examples" and "more revision content… covering a broader area of materials". The frequent request for "more" reveals a growing student preference for microcontent as a learning resource.

Overall the questionnaire suggests student learning was positively affected by microcontent in non-achievement outcomes such as confidence and academic self-efficacy, but also in a self-perceived learning ability and academic performance.

5. DISCUSSION

The methodological position taken in this research is that all educational experiments are biased and therefore not definitive, but can provide useful insight. When analysing a questionnaire built on experiential and opinionated data, it is difficult to draw far-reaching conclusions about microcontent's impact. Natural biases emerge in respondents. In this case, students could have been more inclined to leave positive responses due to the relatability of students authoring the microcontent, dissatisfaction with course authorities and course structure, or limitations of existing course materials.

One such bias relates to student performance. In the questionnaire, 91% of students claimed improved learning ability and 81% claimed improved academic performance as a direct result of Snack's videos. While these findings further indicate improved confidence and academic self-efficacy, they do not provide strong grounds for claims of improved performance in terms of a student's ability to retain and apply knowledge learnt from microcontent. Objective questions such as this are typically polluted by a discrepancy between belief and behaviour in respondents [10]. Here, self-perception does not match reality: analysis of past and present Course A cohorts shows no statistically significant improvement in grades and no correlation with video engagement, despite 81% of students claiming improved performance as a direct result of Snack's videos. It is impossible to know which data is limiting: the questionnaire or lab marks. In either case, findings do not provide grounds for conclusions about microcontent's impact on a student's academic performance - they only suggest a self-perception of improved learning ability.

Creation of microcontent also had limitations. The team of students developing Snack created 92% of microcontent that was distributed to Courses A, B and C. Due to inexperience, there are risks that Snack's microcontent is too leading, revealing too many hints about labs to make it easier for students to complete, influencing sentiment towards microcontent. To control this bias, a constraint was imposed by course authorities whereby videos could only rephrase text included in lab exercise instructions or lecture notes and could not contain additional information that hinted at solutions or simplified exercises. To avoid this bias in future work, microcontent could be created by teaching staff external to research and development team. Additionally, microcontent had minimal quality assurance. While videos were reviewed by head lecturers and saw many iterations, quality was not effectively measured on the student side. Quality could help better describe the nuances of engagement data, and mechanisms for measuring quality could be used in future work.

Despite minor limitations, findings on non-achievement outcomes were overwhelmingly positive. Majority of students believed their confidence, self-efficacy, interest in the course and overall learning ability was improved as a direct result of Snack's videos. These findings were translated and reproduced across three Computer Science courses, with positive experiences emerging from each course despite varying use cases and video styles (for pre-lab, conceptual and theoretical videos). While the 177 respondents made up a small portion of the overall population of 1627 students, they were shown to fairly represent the population through cross-validation of engagement data from GA and gender data from the CSE school's enrolment records. We can conclude that in the context of the subjective student learning experience, microcontent had a positive impact.

Additionally, given Snack's videos were an optional resource in each course, engagement was disproportionately high. Over the 12 week intervention semester, Snack had 7300 unique users access the site, with 36800 sessions and a low bounce rate of 6%. Almost all of these sessions converted to video playback with an average session duration of 6 minutes. With a plethora of options for online learning, students chose Snack's videos because of their relevance and adherence to best design practices.

Questionnaire responses reinforced the effectiveness of best design practices, with students praising Snack's "bite-sized" modularity and structure, its interactive interface and its multi-modal format of whiteboard animation and narration.

6. CONCLUSION

Our findings suggest microcontent has the capacity to significantly support the subjective student learning experience. Across three Computer Science courses, microcontent positively impacted student confidence, course interest and self-concept, and fostered a self-perception of improved learning ability and academic performance. High engagement and positive feedback further suggest Snack's video format has a strong pull on students, making it a potentially powerful communication tool for teachers.

This study supports microcontent's use as a supplementary resource in Computer Science education and potentially beyond, acting as an online medium to complement offline, lecture-based delivery and enable self-paced learning for students.

7. ACKNOWLEDGMENTS

Thanks to Ganga Prusty, John Shepherd, Aarthi Natarajan, Hugh Chan and the team of dedicated student developers.

8. REFERENCES

[1] Guo, P., Kim, J. and Rubin, R. (2014). How video production affects student engagement: An empirical study of MOOC videos

[2] Mayer, R. and Moreno, R. (2003). Nine Ways to Reduce Cognitive Load in Multimedia Learning. Educational Psychologist, 38(1), pp.43-52.

[3] Hazlett, C. (2018). Optimal Video Length for Student Engagement | edX Blog. [online] edX Blog. Available at: https://blog.edx.org/optimal-video-length-student-engagement

[4] Lawson, T., Bodle, J., Houlette, M. and Haubner, R. (2006). Guiding Questions Enhance Student Learning from Educational Videos. Teaching of Psychology, 33(1), pp.31-33.

[5] Elephants Don't Forget. (2018). Hermann Ebbinghaus. [online] Available at: https://elephantsdontforget.com/hermann-ebbinghaus

[6] Ibrahim, M., Antonenko, P., Greenwood, C. and Wheeler, D. (2011). Effects of segmenting, signalling, and weeding on learning from educational video. Learning, Media and Technology, 37(3), pp.220-235.

[7] Richard Wiseman. (2018). The power of acting 'As If'. [online] Available at: https://richardwiseman.wordpress.com/2012/10/10/the-power-of-acting-as-if/

[8] Zhang, D., Zhou, L., Briggs, R. and Nunamaker, J. (2006). Instructional video in e-learning: Assessing the impact of interactive video on learning effectiveness. Information & Management, 43(1), pp.15-27.

[9] Cohen, J. (1988), Statistical Power Analysis for the Behavioral Sciences, 2nd Edition. Hillsdale: Lawrence Erlbaum.

[10] Cohen, L., Manion, L. and Morrison, K. (2007). Research methods in education. 6th ed. New York: Routledge.