Southern Regional Hub-funded project

Project Report

Supporting engagement during Active Video Watching with personalized nudges

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Published by Ako Aotearoa

PO Box 756

Wellington 6140

April 2019

An Ako Aotearoa publication. This project output has been funded by Ako Aotearoa through the Regional Project Fund.

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1 Introduction

Presentation skills and other transferable (a.k.a. soft) skills are highly sought by employers and widely deemed crucial for employability in the knowledge economy [1-13]. Research shows that transferable skills contribute as much as 85% to students' success [14]. Teaching soft skills to tertiary students in technical and business disciplines is challenging, as they are time-consuming and difficult to document [15]. The learner needs to practice under various conditions, receive feedback, reflect on it and do more practice. Tertiary teachers typically do not have enough resources to provide such support to each individual student.

Videos have become the main means for content production and consumption for the millennials and iGeneration. Video-based learning [16,17] is used in a wide spectrum of instructional settings, ranging from flipped classrooms [18], online learning and MOOCs [19,20] to informal learning using YouTube [21-23]. Videos can be a powerful method for soft skills [15,24-26], where learning requires contextualisation in personal experience and ability to see different perspectives. Although videos are a highly popular digital medium for learning, video watching can be a passive activity and may result in limited learning [17,24,27-29]. It is therefore necessary to provide support for active video learning.

Our approach is to support engagement during video watching via interactive notetaking, tapping into learners' familiarity with commenting on videos in social networking sites. In the previous project funded by the Ako Aotearoa Southern Hub in 2016, we developed AVW-Space, a Web-based platform which supports video-based learning [30-37]. In this project, we enhanced AVW-Space by introducing intelligent support for writing comments, in the form of interactive visualizations and personalized nudges.

This report is structured as follows. Section 2 introduces the AVW-Space platform developed in the 2016 Ako Aotearoa Southern Hub Project Fund grant Using Active Video Watching to Teach Presentation Skills, followed by a description of how the platform has been extended in Section 3. Section 4 presents the design and results from a study on presentation skills conducted in May-June 2018. Section 5 presents the conclusions and several avenues for future research.

2 AVW-Space

In this Section we present the first version of AVW-Space, developed in the previous Ako Aotearoa Regional Hub grant. AVW-Space is a controlled video-watching environment designed for self-study that resembles informal learning with popular social environments, such as YouTube. It can be customised by the teacher who defines a list of aspects that serve as scaffolds for learning with the selected videos. The choice of aspects should direct the student's attention on skill-related concepts and foster reflection.

Learning in AVW-Space consists of two phases.

In Phase 1, students watch and comment on videos individually, using aspects to tag their comments made anytime during the viewing (Figure 1). AVW-Space shows time-stamped comments (i.e. the time elapsed from the start of video). The student can watch the video multiple times, including rewinding or skipping parts of the video.

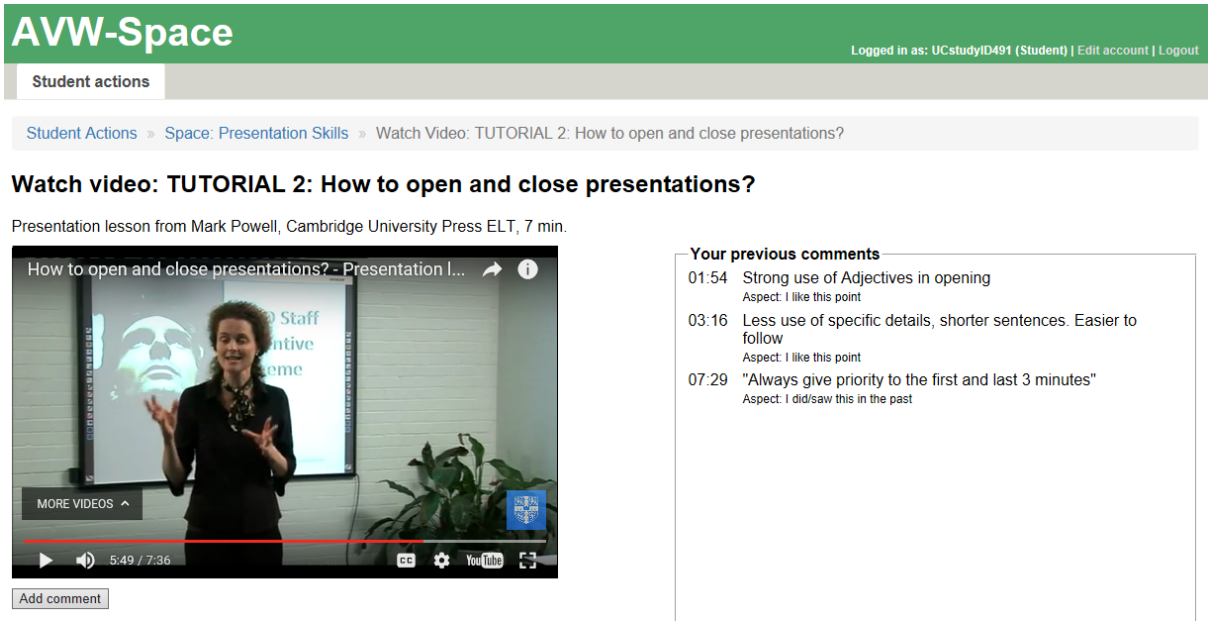

Figure 1: Phase 1

At the beginning of Phase 2, the teacher needs to review comments and approve comments for sharing. Anonymised comments are then available to the whole class. Students can browse and rate comments made by others. The students can sort the comments by timestamp or aspect, so that they can position their own comments amongst the others. The options for rating are predefined by the teacher to promote deeper reflections (Figure 2). In addition to reading/rating the comments, the students can watch the part of the video that associates with a comment.

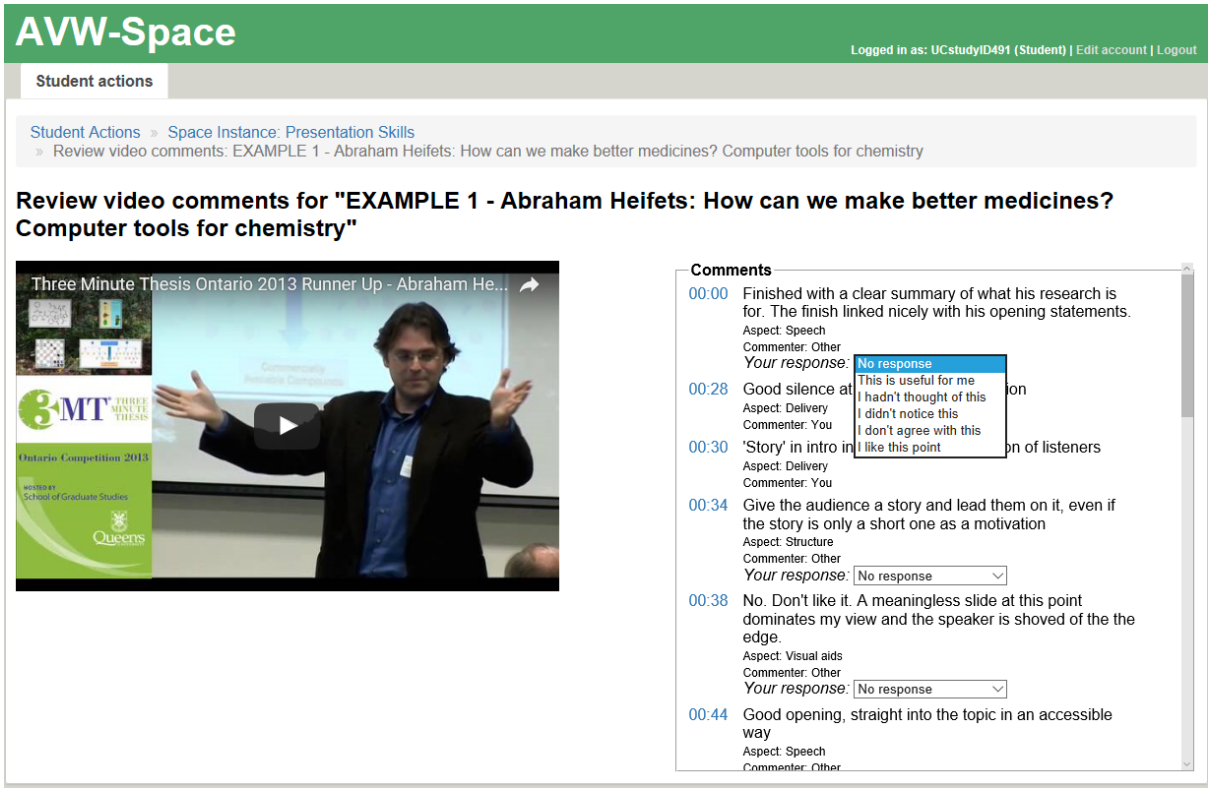

Figure 2: Rating a comment (Phase 2)

AVW-Space is a general-purpose online platform for video-based learning. We developed a space within AVW-Space aimed at teaching presentation skills. The presentation skills space contains four videos which are tutorials on presentations skills (one of the tutorials is shown in Figure 1). The tutorials are short videos (between 3 and 8 minutes) providing tips on how to make good presentations. To support students in reflecting on their past performance, we specified four aspects for tutorials:

- *I am rather good at this*
- *I did/saw this in the past*
- *I didn't realize I wasn't doing this*
- *I like this point*

When adding a comment, the student needs to specify an aspect (Figure 3).

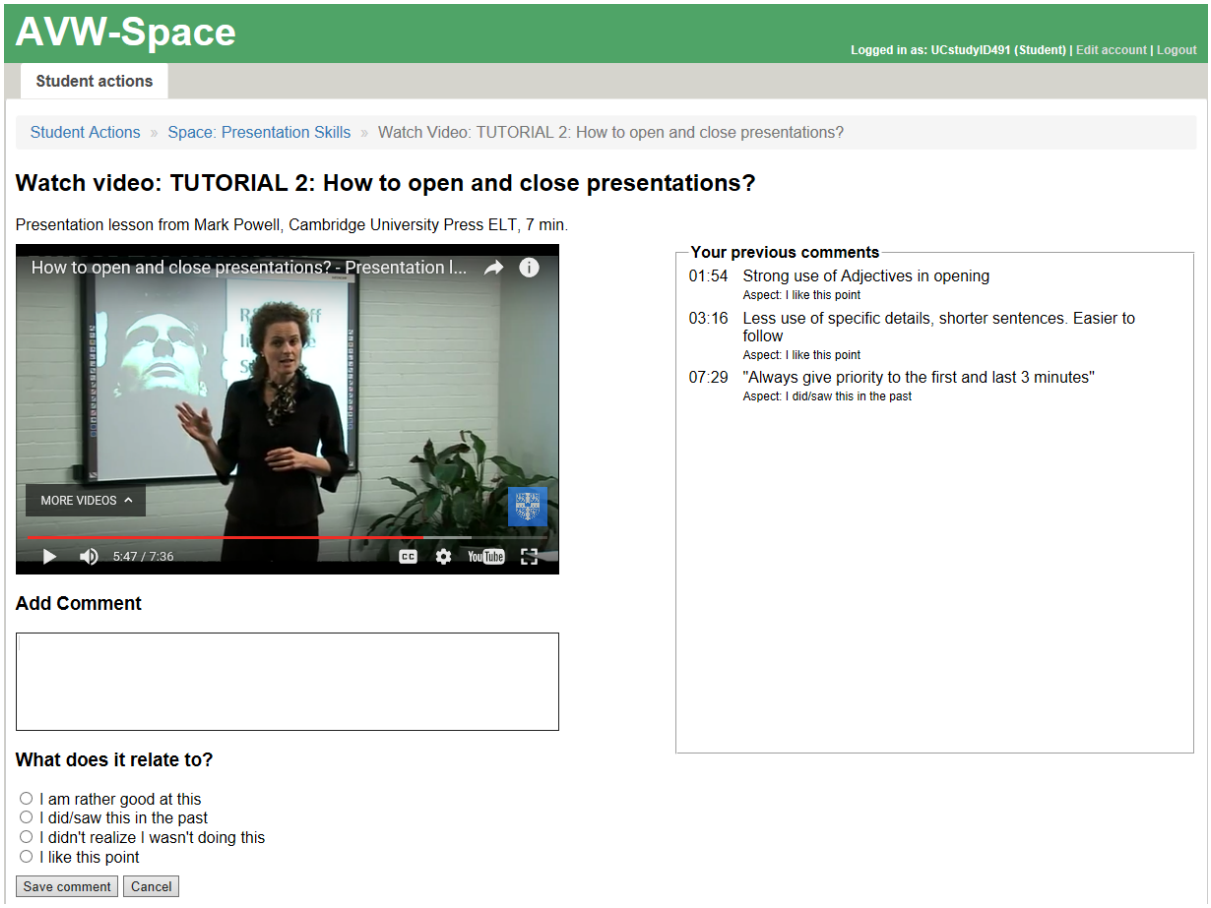

Figure 3: Entering a comment

The space also contains four videos which are examples of real presentations. The student is asked to comment on the examples in term of four aspects: *Structure, Delivery, Visual Aids and Speech* (Figure 4). The criteria for selecting the videos were: (i) appropriate content (covering opening, closing, structure, delivery and visual aids; or examples of pitch presentations); (ii) no longer than 10 minutes; (iii) balance of gender for the presenters; (iv) two popular examples and two not so popular (based on the YouTube ratings).

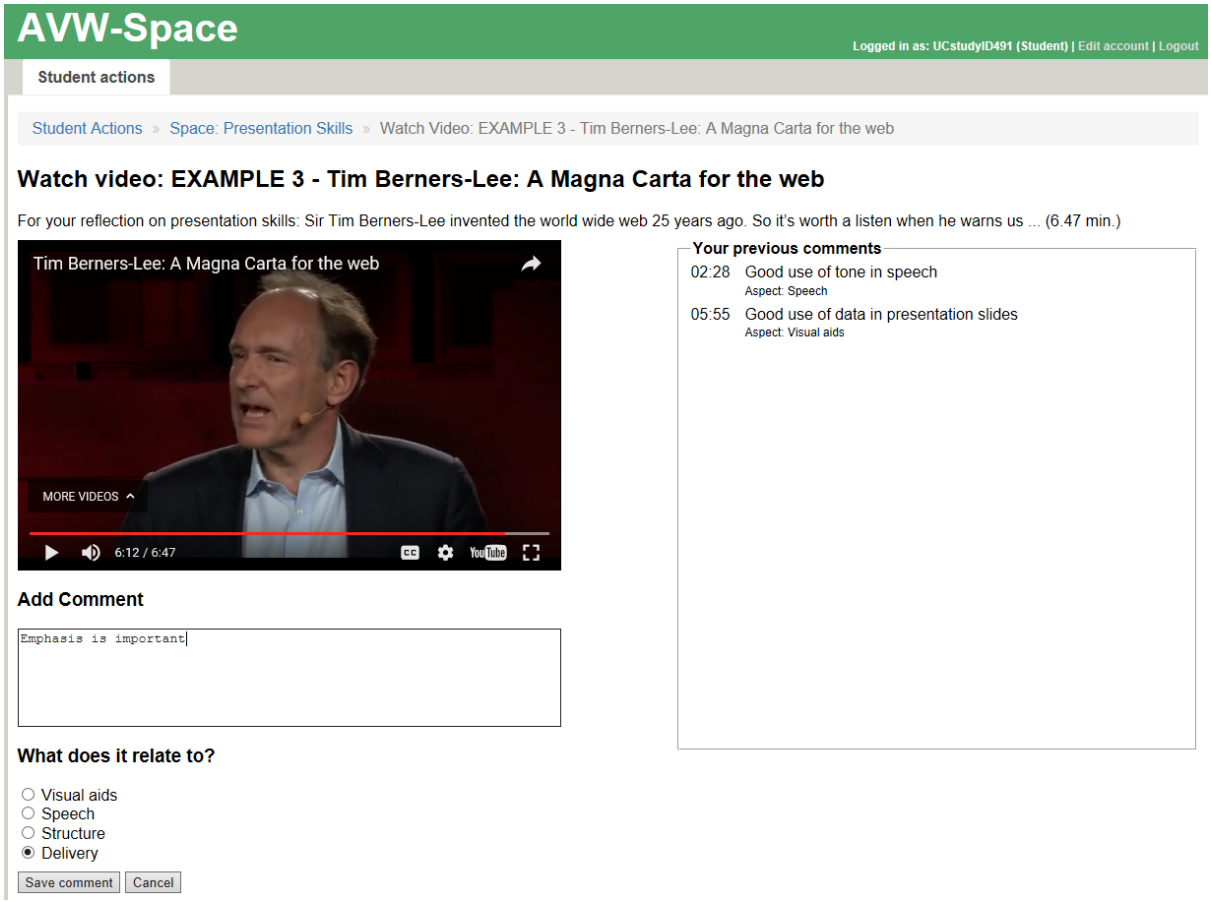

Figure 4: Commenting on an example video

After the teacher approves comments to be shared anonymously, students can view and rate comments from the whole class. There are five rating options, which also aim to focus the student's attention to comments and support learning (Figure 2):

- *This is useful for me*
- *I hadn't thought of this*
- *I didn't notice this*
- *I do not agree with this*
- *I like this point*

The first three ratings show that the student has noticed something new and useful in comments (thus indicating learning). The last two options allow the student to state their opinion about a comment.

In the previous report on AVW-Space [30], we reported on studies conducted with the first version of the platform. The initial studies showed that only constructive students, i.e. those who wrote comments and rated comments written by others, improved their conceptual knowledge of presentation skills [32-37]. Therefore, we extended AVW-Space by adding interactive visualizations and intelligent support in order to foster constructive behaviour. In this report, we present the extended version of AVW-Space.

3 Enhancements of AVW-Space

Several enhancements have been made to AVW-Space, in order to make it easier and more secure to use.

Firstly, we improved the security of AVW-Space by upgrading from HTTP to HTTPS secure connections. HTTPS connections prevent man-in-the-middle attacks where a malicious attacker can steal a user's login credentials (i.e. password) without the user knowing. This upgrade was accomplished by adding a web server (NGINX) in front of our AVW server that serves to the HTTPS URL (using an HTTPS SSL certificate acquired from a reputable authority) and routes any secure data back and forth from our internal AVW server.

Another modification is related to admin processes for AVW-Space. The administrator can now create a group of students. That way it is much easier to specify which students have access to a space instance. When the student accounts are created, the administrator can specify the group name. All accounts would be added to the group, and then later the administrator can add the whole group at once to the appropriate space.

In the following subsections, we explain how AVW-Space has been extended with interactive visualizations and personalized nudges. Please see the Manual for Instructors [31] for detailed instructions on how to use AVW-Space.

3.1 Interactive visualizations

We designed interactive visualizations which are added to AVW-Space, as illustrated in Figure 5. The visualizations are shown below the video. The top visualization is the **comment timeline visualization**: each comment is represented as a coloured dot along the horizontal axis representing the time when the comment was made. The colour of the dot depends on the aspect used by the student who wrote that comment. The legend is shown on the side.

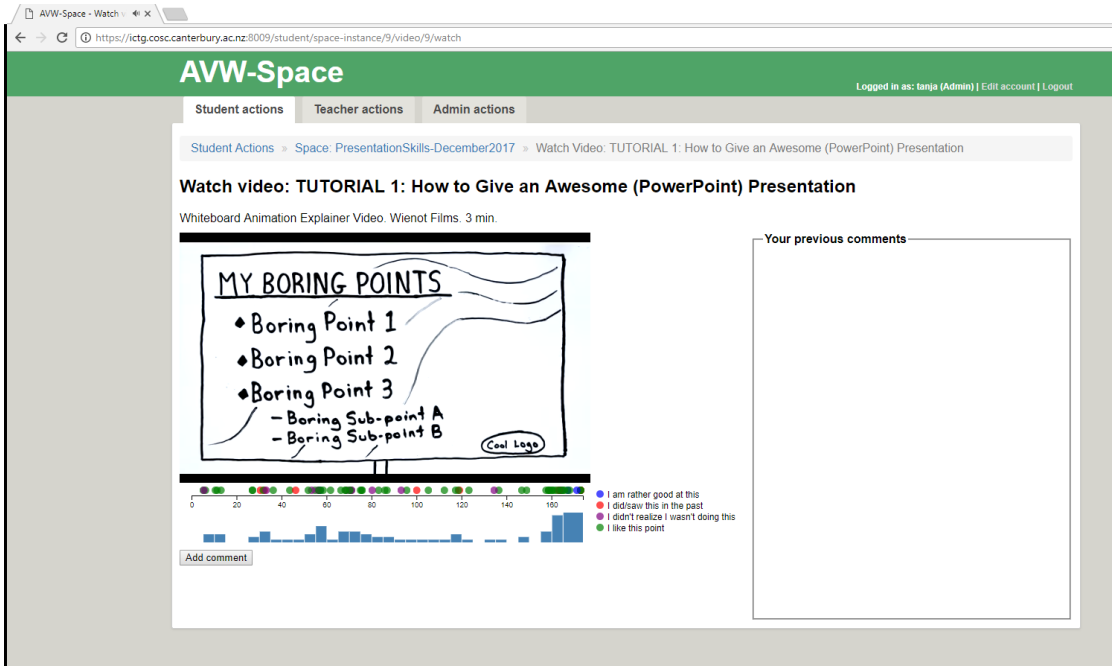

Figure 5: A screenshot from AVW-Space illustrating interactive visualizations

When the mouse is positioned over a particular dot, the student can see the comment (as in Figure 6). Dots are slightly transparent, so that comments made in temporal proximity to each other can be differentiated. Clicking on a dot begins playing the video from that point.

Figure 6: Inspecting a comment in the timeline

The bottom visualization is the **comment histogram visualization**; it shows a bar chart representing the number of comments written for various segments of the video. This visualization allows the student to quickly identify important parts of a video, where other students have made many comments. These visualizations meet two identified needs: (1) providing social reference points so that students can observe others' constructive behaviour, and (2) indicating important parts of a video and what kind of content can be expected in those parts, differentiated by aspect colours.

3.2 Learner Profile

We have designed the user profile, which contains information about the videos the student has watched, as well as information about comments written (including the aspects the students has used). The information in the student profile is updated dynamically during the session. The student profile is used as the source of information for generating personalized nudges.

3.3 Personalized Nudges

Nudges are prompts appearing next to the video (as in Figure 6). The nudges are designed so to encourage constructive behaviour (note that in the previous studies we have found that only constructive behaviour resulted in improvement in conceptual understanding of presentation skills as well as in presentation marks).

Each nudge has a title and a brief description. We designed four types of nudges:

- **No comment reminder**: this is a simple reminder encouraging students to make a comment. This nudge is offered when the student has watched at least 30% of the video without making any comments and is currently in a high-attention interval. This type of nudge is illustrated in Figure 6.

- **No comment reference point**: this type of nudge is a reminder to the student to make a comment, but this time offering an example as stimulus. The nudge is only shown if the *No comment reminder* nudge has not resulted in a comment. This type of nudge is provided when the student has watched at least 70% of the video without comments, the student is in a high-attention interval, and this type of nudge has not been issued on the current video. The comments used as stimuli for this type of nudge have been manually selected for each video from comments gathered in previous studies. An example of this type of nudge is given in Figure 7.

- **Aspect under-utilized**: a prompt to make a comment using a aspect that the student has used least often. This type of nudge is provided when the student has made at least one comment on the current videos, has watched at least 30% of it and is currently in a high-attention interval. When this type of nudge is issued, the visualizations change to only show comments made the under-utilized aspect referred to in

the nudge. For each aspect, the text of the nudge changes. For example, for the *'I am rather good at this'* aspect, the title of the nudge is "Are you good at this", and the description is "Are there any techniques in the tutorial that you feel you have already mastered?"

- **Diverse Aspects**: this nudge provides positive reinforcement, displayed when the student has used all relevant aspects on the current video. The title of the nudge is "Well done!" with the explanatory message "Great job using all aspects to comment on the video!"

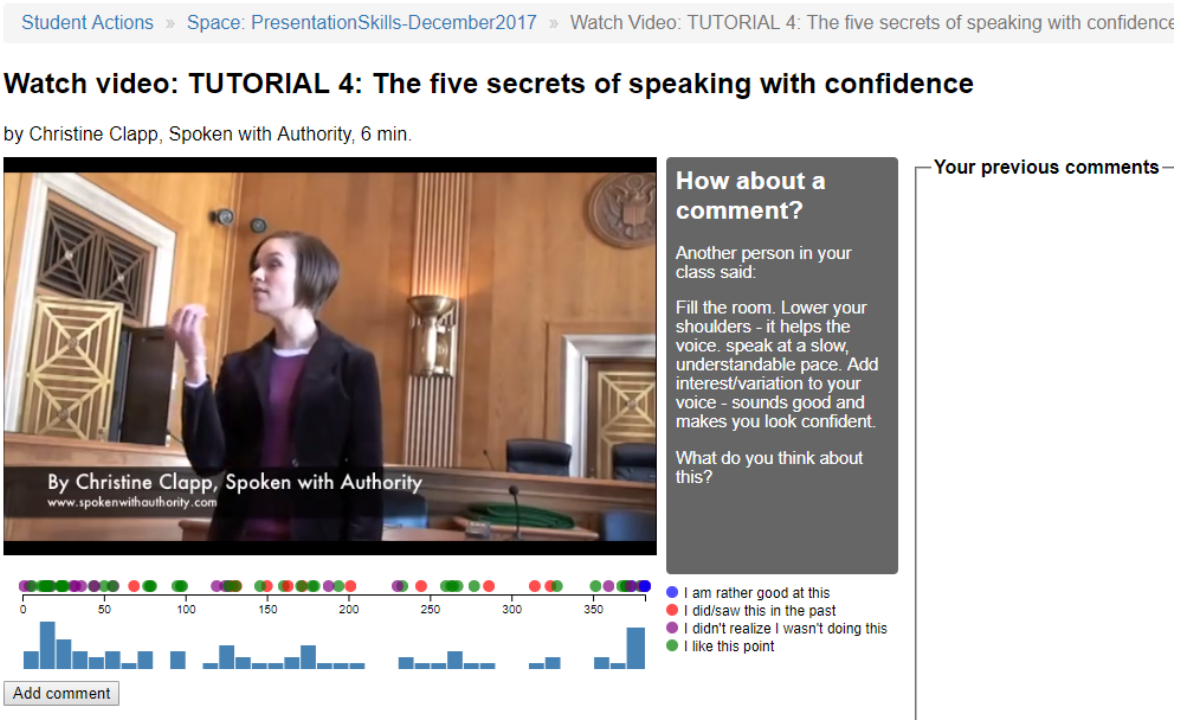

Figure 7: A nudge providing an example comment

We processed the data from previous studies in order to identify those parts of videos which attracted a high number of comments [35]. We refer to those as **high-attention intervals**. These intervals are useful for signposting, aiming to help students identify important parts of the video.

3.4 Pilot Study

We conducted a study in January-February 2018, in order to test the initial design of AVW-Space enhancements. The participants were recruited from the University of Canterbury, University of Leeds, and also via invitations sent to the members of the International Society on Artificial Intelligence in Education and the members of the Asia-Pacific Society on Com-

puters in Education. There were 38 participants who completed Survey 1; of those, 34 completed Survey 2 (23 females). Survey 2 contained questions related to the usefulness of interactive visualizations and nudges. The feedback from the participants was generally positive. However, there were a few remarks about having too many comments in the comment timeline, nudges not being visible enough, and problems understanding the visualizations.

Based on the feedback received from the pilot study participants, we made two modifications to AVW-Space. Firstly, we added an initial Welcome message (Figure 8), in order to introduce the nudges and visualizations. Secondly, we selected a smaller set of high-quality comments to be used in visualizations. This process consisted of several steps. (1) We extracted all comments written by participants in the previous five studies conducted with AVW-Space (the total of 3,310 comments). (2) We removed duplicates (there were cases when a student submitted the same comment multiple times). (3) The comments were processed semantically, using the ontology of presentation skills we developed in 2017 [36,42-44]. For each comment, we produced two measures: the number of unique domain concepts, and the domain-specific unique proportion. The latter is the quotient of the unique domain concepts divided by the word count; this measure represents the "domain saturation" of a comment. (4) We selected the "best" comments by sorting all comments by the video first, then by the number of unique domain concepts, and finally by the domain-specific unique proportion. This resulted in 651 comments, which are visualized in the comment timeline.

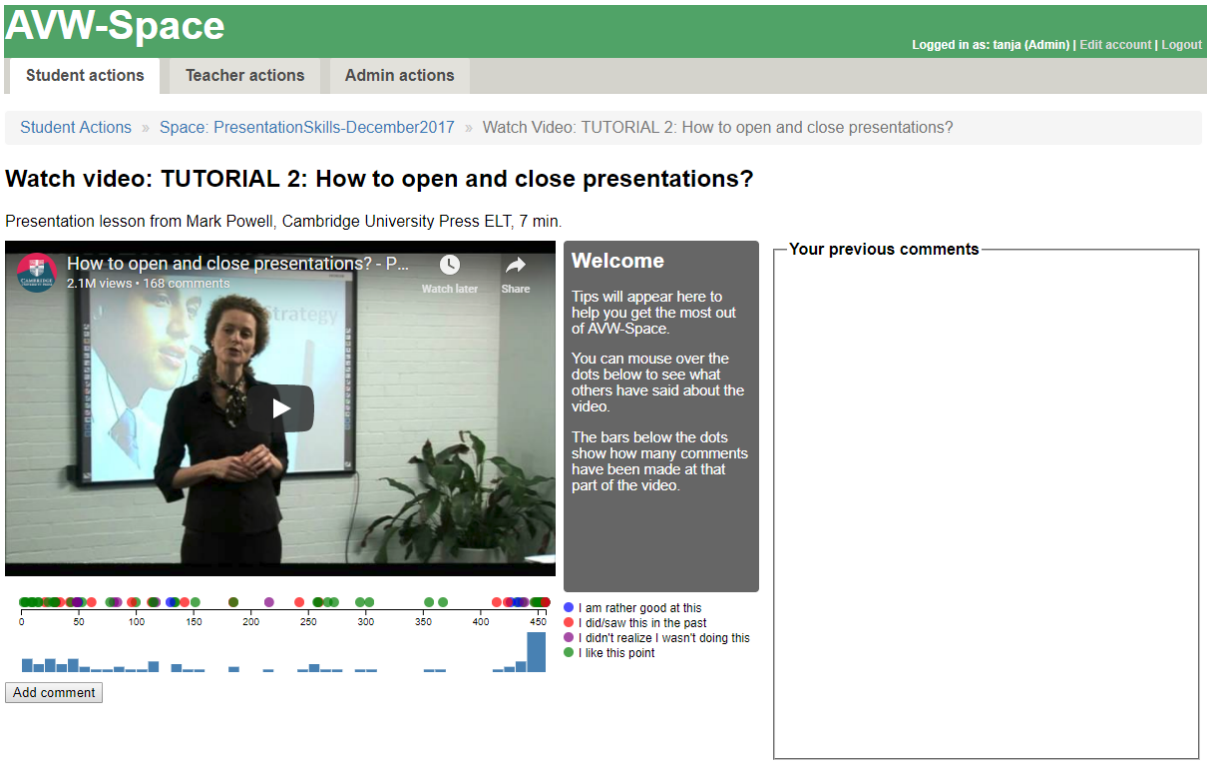

Figure 8: The Welcome message

4 Study Design

The study was performed in ENGR101, a mandatory course for all first-year Engineering students at the University of Canterbury. The students enrolled in this course were invited to use AVW-Space in order to prepare for the presentations they needed to give as a part of the course assessment.

The goal of the study was to investigate the following research questions:

1. To what extent does engagement with AVW-Space improve students' knowledge?
2. To what extent does the inclusion of interactive visualizations and nudges have an impact on the number of students who engage with the platform in the constructive way?
3. To what extent does the inclusion of interactive visualizations and nudges have an impact on student engagement?
4. Do students in control/experimental group have different opinions about the usefulness of various activities they performed in AVW-Space, and also about cognitive load?

The study started with Survey 1, which collected participants' profiles (demographic information, background experiences, motivation and attitudes using Motivated Strategies for Learning Questionnaire (MSLQ) [39]. The survey also contained three questions on the participants' knowledge of presentations (we refer to those questions as *conceptual knowledge questions*). The student was asked to write everything he/she knew about 1) Structure, 2) Delivery and Speech, and 3) Visual Aids. For each of those three questions, students had one minute to write their responses. After Survey 1, the participants were instructed to log on to AVW-Space.

Survey 2 was administered at the end of the study. This survey included the same questions on participants' knowledge of presentations from Survey 1, as well as the NASA-TLX instrument [40] to check participant's perception of cognitive load while using AVW-Space, and the Technology Acceptance Model (TAM) [41] to check participants' perceived usefulness of AVW-Space. At the end of Survey 2, there were open-ended questions on the usefulness of interactive visualizations and personalized nudges.

In order to answer the research questions, we randomly divided all participants into two conditions. The control group interacted with the original version of AVW-Space, while the experimental condition interacted with the enhanced version of the platform.

The invitations for the study were sent on 3 May 2018. Out of 1,039 students enrolled in the course, 449 completed Survey 1. Of those, 349 have used AVW-Space (we refer to the remaining 100 participants as to *Inactive*). 155 students watched videos, but have not written any comments (referred to as *Passive*). The remaining 194 students watched the videos and generated comments (referred to as *Constructive* students).

Table 1 presents demographic data about the two groups. The questions related to training on giving presentations, experience in giving presentations, using YouTube and using

YouTube for learning were based on the Likert scale from 1 (Low) to 5 (High). There were no significant differences between the two groups.

Table 1: Demographic data

	Control (234)	**Experimental** (215)
Gender - Male	164	149
Gender - Female	69	65
Gender - Other	1	1
Native English speakers	176	177
Training	1.65 (.73)	1.69 (.82)
Experience	2.17 (.79)	2.22 (.81)
YouTube	4.19 (1.11)	4.21 (1.04)
YouTube for learning	3.30 (1.14)	(3.27 (1.15)

The participants were invited to complete Survey 2 on 24 May. 263 students completed Survey 2; however, that number includes some Inactive participants. After cleaning the data, we ended up with 237 participants who have completed both surveys.

4.1 Research Question 1: To what extent does engagement with AVW-Space improve students' knowledge?

Table 2 reports the scores on conceptual knowledge questions for Surveys 1 and 2 for those students who completed both surveys. There were no significant differences on the scores from Survey 1 (CK1) between Inactive, Passive and Constructive students, showing that students had comparable levels of pre-existing knowledge. The Kruskal-Wallis test revealed a significant difference on the scores from Survey 2 (CK2), with the Constructive students scoring significantly higher than Inactive and Passive students. As in previous studies with AVW-Space [30,33-37], we found a significant increase in the students' knowledge only for Constructive students (paired t-test, t = 3.18, p = .002).

Table 2: Conceptual knowledge scores (means and standard deviations) for students who completed both surveys ("ns" stands for "not significant")

	Inactive (16)	**Passive (75)**	**Constructive (146)**	**Significant**
CK1	10.94 (3.96)	12.59 (4.31)	13.66 (5.64)	ns
CK2	12.25 (5.32)	13.16 (5.93)	15.10 (6.06)	H = 7.04, p = .03
Significant	ns	ns	t = 3.18 p = .002	

We conducted statistical analyses for the students in the experimental group, in order to identify causal relationships between CK1 (the conceptual knowledge score from Survey 1), the number of nudges received, the number of comments written, and the conceptual knowledge score on Survey 2. The path diagram (Figure 9) shows that nudges do have a significant impact on the number of comments written. CK1 and the number of comments written have significant impact on CK2. Therefore, nudges are successful in increasing the number of comments, which in turn increase the conceptual knowledge score on Survey 2. The model shown in Figure 9 has a good fit (CFI = .988, RMSEA = .052).

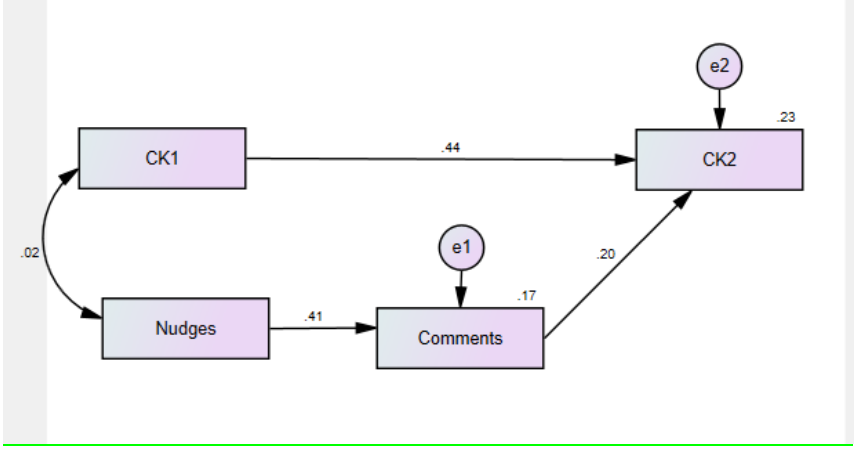

Figure 9: Path diagram for the experimental group (Chi-square = 2.551, two degrees of freedom, p = .279)

4.2 Research Question 2: To what extent does the inclusion of interactive visualizations and nudges have an impact on the number of students who engage with the platform in a constructive way?

We enhanced AVW-Space with interactive visualizations and personalized nudges, the goal of which is to foster constructive behaviour. In order to determine the effectiveness of those two enhancements, we compared the numbers of Inactive, Passive and Constructive students in the control and experimental groups. Table 3 reports the numbers of students belonging to different categories, including all students who completed Survey 1.

Table 3: The number of inactive, passive and constructive students in the two conditions

	Inactive (100)	**Passive (155)**	**Constructive (194)**
Control	53	95	86
Experimental	47	60	108

A Chi-square test of homogeneity between intervention type (control or experimental group) and behaviour type (i.e. inactive, passive and constructive) revealed a significant difference (Chi-square = 9.972, p = .007), with the effect size (Phi) of .149. The post hoc analysis involved pairwise comparisons using the z-test of the two proportions with a Bonferroni correction. The proportions of inactive students were not significantly different in the two conditions, but there was a significant difference in proportions of passive and constructive students ($p < .05$). This finding shows that interactive visualizations and personalized nudges are effective, resulting in significantly more students engaging with videos constructively.

4.3 Research Question 3: To what extent does the inclusion of interactive visualizations and nudges have an impact on student engagement?

We were also interested in what kind of differences can be observed in terms of student engagement between the two groups. Table 4 presents information about the two groups, for those students who completed Survey 1 and interacted with AVW-Space. The students in the experimental group wrote a significantly higher number of comments in comparison to the control group, as illustrated in Figure 10. There were no significant differences between the two groups in terms of the number of videos watched, the number of sessions, the number of days active or the number of ratings made.

Table 4: Interaction statistics

	Control (181)	**Experimental (168)**	**Significant**
Comments	4.28 (7.74)	6.30 (9.59)	t = 2.17, p = .031
Videos	7.03 (4.34)	7.03 (4.22)	
Sessions	2.57 (2.04)	2.52 (2.55)	
Days	2.12 (1.44)	2.11 (1.76	
Ratings Made	25.13 (57.47) n = 31	25.84 (47.46) n = 25	

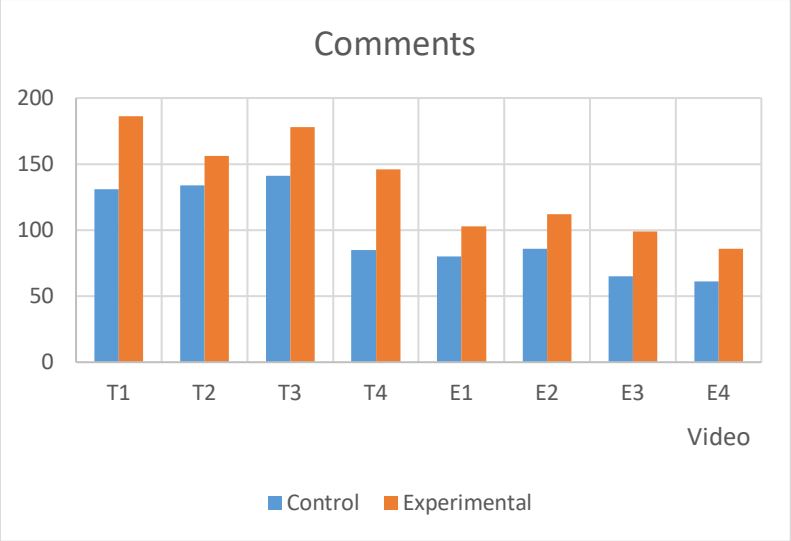

Figure 10: The number of comments per video

Figure 11 illustrates the effect of nudges; for each day of the study (shown on the x axis), the bars represent the percentage of participants who made comments on that day, out of all participants who logged on to the platform on the same day. As can be seen, the percentages for the experimental group are higher on almost all days.

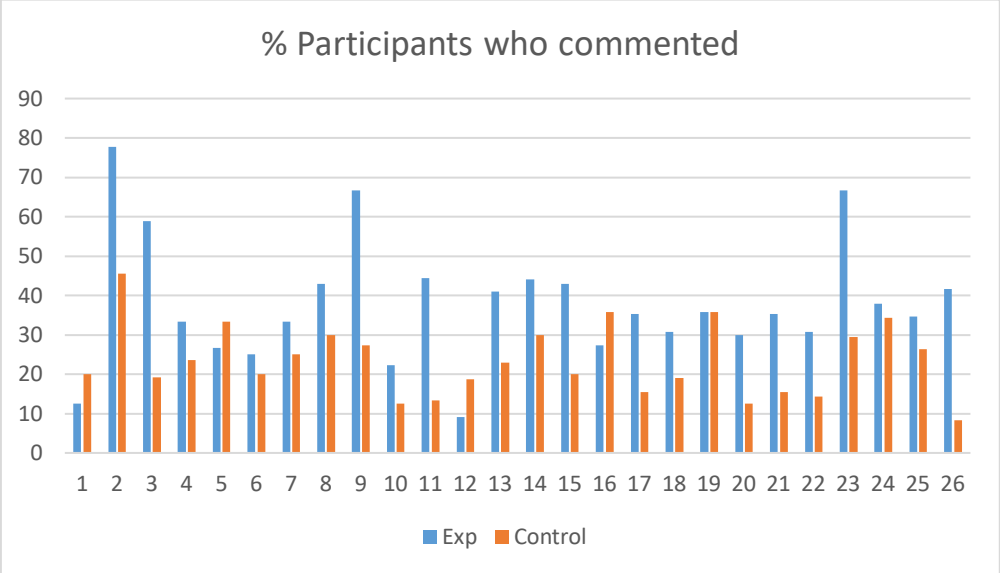

Figure 11: The effect of nudges

The comments made by constructive learners show high levels of engagement, such as remarks on important events in videos, and contain statements showing reflection and self-explanation. Some examples of comments are:

- Even this video follows the message that it is trying to show. The presentation of the video and the accompanying animation is simple, builds to a clear message and does not have boring bullet lists. It was more effective to show people how to present while doing the things you are saying.

- Spice up the opening, really grab the attention of the audience. Because if you don't get it at the start, they won't pay attention the whole way through.

- Your visual aids shouldn't contain everything you're saying, they should simply highlight the most important points covered and any information/data mentioned or referenced.

4.4 Research Question 4: Do students in the two groups have different opinions on the usefulness of AVW-Space and the imposed cognitive load?

Survey 2 contained the Technology Acceptance Model (TAM) instrument [41], consisting of ten questions. Table 5 presents the TAM scores for the two groups.

Table 5: TAM scores for the two groups, ranging from 1 (highest) to 7 (lowest)

Questions	Control (115)	Experimental (100)
TAM1: I think I would like to use AVW-Space frequently	4.31 (1.72)	3.97 (1.53)
TAM2: I would recommend AVW-Space to my friends	4.11 (1.72)	4.16 (1.65)
TAM3: Using AVW-Space would enable me to improve my soft skills quickly	3.41 (1.61)	3.27 (1.39)
TAM4: Using AVW-Space would improve my performance considering the development of soft skills.	3.40 (1.58)	3.11 (1.36)
TAM5: Using AVW-Space would enhance my effectiveness when developing soft skills.	3.43 (1.65)	3.17 (1.32)
TAM6: I would find AVW-Space useful in my studies/job.	3.61 (1.68)	3.41 (1.39)
TAM7: I would find AVW-Space easy to do what I want it to do.	3.64 (1.62)	3.47 (1.52)
TAM8: My interaction with AVW-Space would be clear and understandable.	3.52 (1.69)	3.08 (1.43)
TAM9: I would find AVW-Space easy to use.	3.30 (1.68)	2.78 (1.20)
TAM10: If I am provided the opportunity, I would continue to use AVW-Space for informal learning.	4.13 (1.84)	3.82 (1.60)

The 2-factor ANOVA revealed a significant interaction effect *Group * Category* on the first two TAM questions, as illustrated in Table 6. The scores of Constructive students from the

experimental group scores are significantly lower (i.e. better), showing that those students would like to use AWEV-Space significantly more frequently (TAM1) and are significantly more likely to recommend AVW-Space to their friends (TAM2) than the other three sub-groups (i.e. constructive students from the control group, and passive students from both groups). The same analysis revealed the main effect of Category for TAM questions 3, 4, 7, 8 and 9 (Table 7).

Table 6: Results of the 2-factor ANOVA on TAM1 and TAM2

Group		**TAM1**	**TAM2**
Control	Passive (47)	4.38 (1.93)	4.23 (1.96)
	Constructive (68)	4.26 (1.57)	4.03 (1.55)
	Total (115)	4.31 (1.72)	4.11 (1.72)
Experimental	Passive (23)	4.91 (1.34)	5.22 (1.57)
	Constructive (77)	3.69 (1.47)	3.84 (1.55)
	Total (100)	3.97 (1.53)	4.16 (1.65)
Total	Passive	4.56 (1.77)	4.56 (1.89)
	Constructive	3.96 (1.54)	3.93 (1.54)
	Total	4.15 (1.64)	4.13 (1.68)
Interaction effect group * category		F = 5.17, p = .024 Partial η^2= .024	F = 5.45, p = .021 Partial η^2= .025

Table 7: Differences on TAM scores between Constructive and Passive students

TAM Questions	**Passive (70)**	**Constructive (145)**	**Main effect Category**
TAM1: I think I would like to use AVW-Space frequently	4.56 (1.77)	3.96 (1.54)	
TAM2: I would recommend AVW-Space to my friends	4.56 (1.89)	3.93 (1.54)	
TAM3: Using AVW-Space would enable me to improve my soft skills quickly	3.64 (1.70)	3.20 (1.39)	F = 4.88, p = .028 partial η^2 = .023
TAM4: Using AVW-Space would improve my performance considering the develop-ment of soft skills.	3.61 (1.69)	3.10 (1.36)	F = 5.57, p = .019 partial η^2 = .026
TAM5: Using AVW-Space would enhance my effectiveness when developing soft skills.	3.59 (1.71)	3.18 (1.39)	
TAM6: I would find AVW-Space useful in my studies/job.	3.76 (1.79)	3.41 (1.41)	
TAM7: I would find AVW-Space easy to do what I want it to do.	3.93 (1.65)	3.39 (1.51)	F = 5.91, p = .016 partial η^2 = .027

TAM8: My interaction with AVW-Space would be clear and understandable.	3.96 (1.72)	3.01 (1.44)	F = 17.03, p < .001, partial η^2 = .008
TAM9: I would find AVW-Space easy to use.	3.56 (1.72)	2.81 (1.32)	F = 10.62, p = .001, partial η^2 = .006
TAM10: If I am provided the opportunity, I would continue to use AVW-Space for informal learning.	4.23 (1.87)	3.87 (1.66)	

Survey 2 also contained four questions from the NASA-TLX instrument [40], on demand, effort, frustration and performance related to writing questions and the same four questions on rating comments. For example, the first question asked the participant to specify how mentally demanding it was to write comments on videos in AVW-Space; the question asked the participant to think about how much mental and perceptual activity was required – thinking, deciding, remembering, looking and searching. The scales for Effort and Demand ranged from 1 (*very easy*) to 20 (*very hard*), and for Frustration and Performance from 1 (*not at all*) to 20 (*very much*). The scores for the two groups are given in Table 8.

Table 8: NASA-TLX scores for the two groups, ranging from 1 (lowest) to 20 (highest

NASA-TLX	**Control (120)**	**Experimental (102)**
Demand Commenting	8.51 (4.65)	8.48 (4.29)
Effort Commenting	7.45 (4.41)	7.99 (4.46)
Frustration Commenting	7.68 (6.05)	7.32 (5.23)
Performance Commenting	11.18 (5.02)	12.12 (4.36)
Demand Rating	8.62 (4.68)	7.05 (4.13)
Effort Rating	7.83 (4.70)	6.88 (4.11)
Frustration Rating g	8.5 (5.64)	6.75 (4.71)
Performance Rating	10.90 (5.02)	11.67 (4.43)

The 2-factor ANOVA revealed a significant interaction effect *Group * Category* on the scores for Effort on commenting, as illustrated in Table 9. The constructive students from the experimental group reported the lowest amount of effort while commenting in comparison to the other three subgroups of students.

Table 9: Results of the 2-factor ANOVA for Effort when Commenting

Group		Effort - Commenting
Control	Passive (51)	7.43 (4.34)
	Constructive (69)	7.46 (4.49)
	Total (120)	7.45 (4.41)
Experimental	Passive (24)	10.38 (4.17)
	Constructive (78)	7.26 (4.31)
	Total (102)	7.99 (4.46)
Total	Passive (75)	8.37 (4.48)
	Constructive (147)	7.35 (4.38)
	Total (222)	7.70 (4.43)
Interaction effect group * category		F = 5.89, p = .016; Partial η^2= .026

The same analysis revealed the main effect of Category (i.e. Passive or Constructive) for Demand, Frustration and Performance on Commenting, as well as for Performance on Rating, as reported in Table 10. The constructive students reported significantly lower demand and frustration during commenting, and at the same time reported higher performance on both commenting and rating comments written by others.

Table 10: Differences on NASA-TLX scores between Constructive and Passive students

Questions	**Passive (75)**	**Constructive (147)**	**Main effect Behaviour**
Demand Commenting	9.28 (4.83)	8.10 (4.25)	F = 3.69, p = 0.56; partial η^2 = .017
Frustration Commenting	9.12 (6.18)	6.70 (5.24)	F = 9.93, p = .002, partial η^2 = .044
Performance Commenting	10.53 (5.32)	12.16 (4.33)	F =4.48, p = .035, partial η^2 = .02
Performance Rating	9.35 (5.51)	12.22 (4.02)	F = 16.07, p < .001, partial η^2 = .069

Survey 2 also contained two open-ended questions on the usefulness of interactive visualizations and nudges. There were 100 responses on interactive visualizations, 85 of which were positive. Some examples of positive responses are:

- *Can see what other people are doing as inspiration*
- *See which parts of the video other people find useful*
- *To compare yourself with the rest of the class.*

- *Difficult to interpret but useful concept*
- *Extremely useful. Clear aid on what others thought about a specific point*
- *It isn't very helpful in the tutorials (I don't care what other people did / didn't know), but for the presentations it was useful because i could know what to look out for in certain parts of the video*

One participant stated, "I didn't understand them till id finished most of the videos," showing that the introduction to interactive visualizations might need to be improved.

There were 91 responses to the question on how useful the nudges were. Eight participants stated that they have not noticed nudges. There were 61 positive responses, such as:

- *Help me to be engaged*
- *To give me a little push in the right direction of what to comment on*
- *Help you along without giving the answer*
- *I found that helpful and it made the videos less overwhelming to watch*

There were 21 negative responses, such as:

- *It created subtle pressure to make comments which wasn't really useful at all*
- *They were always the same so not hugely useful*

There number of nudges we implemented is low, and that explains the comment about the nudges being the same. In future work, we will add additional nudges to AVW-Space.

5 Discussion and Conclusions

We presented the enhancements made to AVW-Space in order to foster constructive behaviour. Similar to the findings from our previous studies, the study conducted with the enhanced version of AVW-Space also found that only constructive students (i.e. those students who wrote comments) have improved their conceptual understanding of presentation skills. The findings presented in the previous sections show that the pedagogical intervention implemented in the new version of AVW-Space is effective: there were significantly more constructive students in the experimental group in comparison to the control group, while there are no other significant differences between the participants of the two groups at the start of the study. Therefore, interactive visualizations and nudges are effective in encouraging students to engage with the videos constructively.

However, not all participants engaged in such constructive learning. The participants who completed surveys but have not interacted with AVW-Space at all, or who have passively watched videos, have not improved their conceptual knowledge. This is true for passive participants in both conditions. One of the directions of future research is to further enhance nudges to be more effective for passive students.

There are other avenues for future work on AVW-Space. The current version of the learner profile includes information about how the student interacts with AVW-Space. Due to time constraints, we have not been able to incorporate information about the student collected in Survey 1 into the learner profile. In the next version of AVW-Space, the survey will be conducted directly in AVW-Space, instead of administering surveys via Qualtrics. Additional support may include visualizations of the student profile as well as the visualization of the engagement of the whole class, which will support the student in comparing her/himself to the class.

We plan to enhance the rating of comments by pointing out to each student comments which will be valuable to him/her, as well as comments of high social value (i.e. highly rated comments). We also plan to perform studies with other transferable skills in the future.

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