Does tagging improve the navigation of online recorded lectures by students?

British Journal of Educational Technology *Vol 46 No 1 2015* 45–57
doi:10.1111/bjet.12121

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Abstract
Students more and more have access to online recordings of the lectures they attend at universities. The volume and length of these recorded lectures however make them difficult to navigate. Research shows that students primarily watch the recorded lectures while preparing for their exams. They do watch the full recorded lectures, but review only the parts that are relevant to them. While doing so, they often lack the required mechanisms to locate efficiently those parts of the recorded lecture that they want to view. In this paper, we describe an experiment where expert tagging is used as a means to facilitate the students' search. In the experiment, 255 students had the option to use tags to navigate 18 recorded lectures. We used the data tracked by the lecture capture system to analyze the use of the tags by the students. We compared these data to students who did not use the tagging interface (TI). Results show that the use of the TI increases in time. Students use the TI more actively over time while reducing the amount of video that they view. The experiment also shows that students who use the TI score higher grades when compared with students who use the regular interface.

Introduction

During their academic careers, students spent a great number of hours attending lectures. More and more universities record these lectures and provide them online to their students (Leoni & Lichti, 2009). Traditionally, metadata is created by dedicated professionals (Gruber, 1993); tags, on the other hand, are a form of user-created metadata (Mathes, 2004). Tags are textual keywords and phrases that can link to a number of different resources (O'Reilly, 2005). In this case, they are linking to locations within the recorded lectures. We believe that expert tagging has the potential to be a good fit with recorded lectures because most lecture capturing systems (LCS) currently lack sufficient support for students to navigate the recorded lectures efficiently and because tags have a low barrier to entry and relatively low cognitive costs for the expert (Mathes, 2004). The goal of this study is to investigate the use of tags as a navigational aid for students. In this study, we provided all students with the same set of tags constructed by an expert using a tagging protocol.

We will address the following research questions:

1. When do students use the tags?
2. Does the availability of tags increase the navigation speed of students? Do the tags help them to more quickly locate the parts of the recorded lectures they want to view?
3. Do students who use the tags score better on the exam?

Practitioner Notes

What is already known about this topic

- Students prefer to use recorded lectures.
- Students use recorded lectures mainly as part of their preparations for the exam.
- Students use their notes to find the relevant parts of the recorded lectures.

What this paper adds

- Our research analyzes the use of tags, added by an expert, as a way for students to find the relevant parts of recorded lectures more easily.
- The paper compares the use of the recorded lectures with those tags and without them.
- The paper shows that students that use the tags score significantly higher for the exam.

Implications for practice and/or policy

- The paper shows that providing tags alongside recorded lectures can help students review recorded lectures more efficiently.

We will first describe recorded lectures and tags in more detail; then, we outline the method used, the results from the study, and finally, we will discuss the conclusions.

Recorded lectures

Survey-based research conducted both in the USA and Australia with a combined total of more than 8000 respondents showed that most students express a preference for courses accompanied by online recordings of the lectures (Gosper *et al*, 2008; Traphagan, 2006; Traphagan, Kucsera & Kishi, 2010; Veeramani & Bradly, 2008). These recorded lectures were created using an LCS. An LCS consists of a dedicated capture appliance in the lecture hall, capturing audio, video and the VGA signal of the lecturer's laptop or desktop. The capture appliance can be started, stopped and monitored remotely by a system administrator. The capture appliance automatically synchronizes the recorded audio, the video and the VGA signal into a single interface stored on the server. The lecture can be viewed live or on demand by the user using a web browser.

Because they are integral recordings from live lectures, the recorded lectures in this study are usually 40–45 minutes per recording. Research on 1200 students in the Netherlands, conducted by Gorissen, van Bruggen and Jochems (2012a, b) using surveys and interviews showed that students typically do not watch the full recorded lecture from start to finish. Instead, they jump to the parts of the lecture they want to (re)view and only watch those segments. Analysis of their navigation behavior showed that it often takes several jumps within the recording to find those parts they want to review. The research also showed that students use recorded lectures primarily while preparing for exams. Students use the recorded lectures as part of their regular learning activities. One other important activity is note taking. Taking notes during lectures is considered to be a key component of academic literacy (Badger, White, Sutherland & Haggis, 2001). Lecture notes provide an encoding function: they help students learn and remember the information from the lecture. They also provide a storage function, preserving the information provided during the lecture for later use (Anderson & Armbruster, 1986). Bligh (1998, pp. 129–147) lists an overwhelming amount of research that shows that note taking aids students in their learning process, and there is strong evidence that note taking leads to higher achievement (Kiewra, 1989). Students use their notes to find the relevant part of the recorded lecture that they want to (re)view. Most LCS, however, do not offer students easy textual clues. Students are limited to using a time-based video slider or a slide-based view to find those relevant parts.

Tags

Tags became popular as part of the Web 2.0 concept, allowing anyone to mark content with descriptive terms, in essence, adding their own explicit user-generated metadata (Mathes, 2004). We can identify a number of functions that tags perform (Golder & Huberman, 2006):

- Identifying what (or who) the recording is about. This is the most common function of tags;
- Identifying what it is. For example, a question or an example;
- Self-reference. The tag identifies the tagger or begins with "my," like "myquestion";
- Refining categories. These tags do not stand alone without contextual knowledge, for example, "Question 2";
- Identifying qualities or characteristics of the resource. For example, funny, stupid, difficult; and
- Task organizing. These tags relate to performing a task, for example, "to read."

Popular sites like del.icio.us (Delicious, 2013) allowed, and still allow, users to add bookmarks to websites combined with tags. Those tags are not only visible to the users that added the bookmarks but also to other users of the site. Combined, they form a folksonomy of tags (Vander Wal, 2007), a flexible bottom-up, user-created categorical structure. Although tagging is quite common now and supported by many websites, these social tagging systems were a significant step up from the original idea of metadata and being created and maintained by professionals. Our research adds to the existing research by extending the use of tags to recorded lectures.

Method

The research questions were investigated at the Eindhoven University of Technology (TU/e) in the Netherlands. The university uses the Mediasite LCS by Sonicfoundry (Sonicfoundry). They have five capture appliances used to create recorded lectures. Currently, the TU/e Mediasite repository holds about 8000 recordings with a total length of over 5000 hours of video. All recordings are available online; students can view them in their browser, both at the university and from home. No downloadable versions of the recordings are provided. The recorded lectures created at the TU/e are typically about 40–45 minutes long, containing one full lecture each. The number of recordings per course depends on the number of lectures for that course; the average is 16 recordings for a single course, and the maximum number of recorded lectures for a single course is 54 recordings.

During a previous stage of our research (Gorissen, van Bruggen & Jochems, 2012c, 2013), we had shown that surveys were not a reliable method to collect data on students' use of recorded lectures. Instead, we choose to collect the data using logging of their actual use during a course which lectures are being recorded. Course C01 is a course at the faculty of Industrial Engineering & Innovation Sciences of the TU/e. Students who participate in the course come from a number of different departments within the university. Most of the students (66%) are from the Industrial Engineering department; another substantial group of students (23%) is from the Innovation Sciences department. The course consists of an introduction in empirical research. Students learn how to translate real-life questions into research questions, and they learn how to create and evaluate a research design. In the second part of the course, they get hands-on training using SPSS. This part of the course is taught in English and was selected for the tagging experiment because many students use the recorded lectures of this part of the course. Grading for the course is done in two parts, and grades are registered for both individual parts and for the complete course. The first partial grade (C01P01) consists of the combined result for a 90-minute written test and an assignment. The second partial grade (C01P02) consists of a 3-hour laptop test. Each

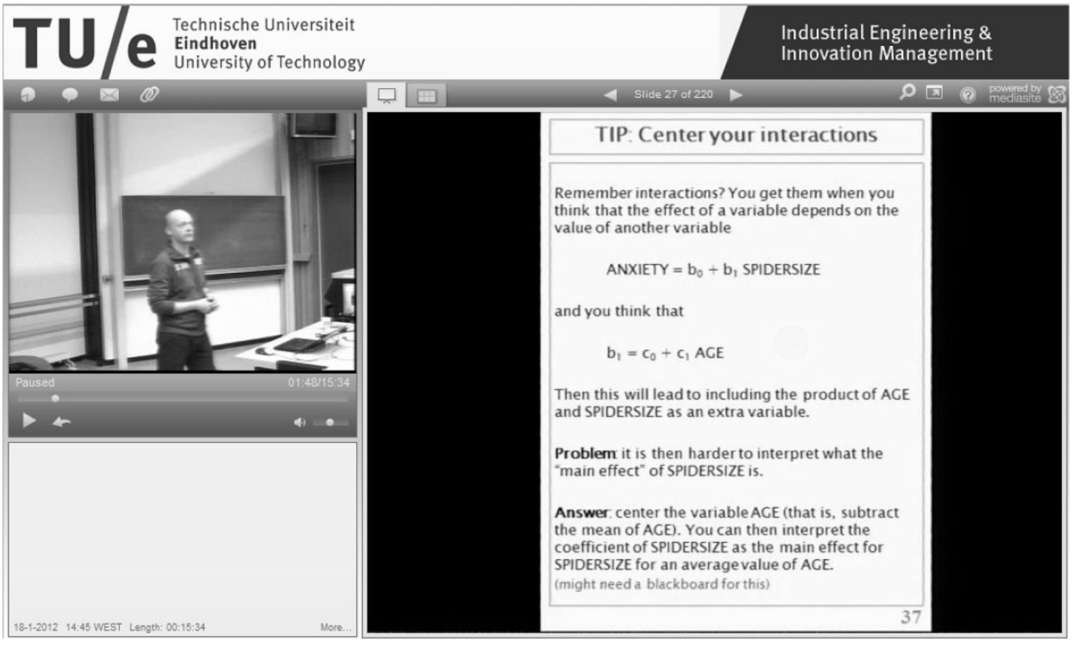

Figure 1: Example of the regular interface (RI)

partial grade (C01P01 and C01P02) needs to be 5.0 or higher on a 10-point scale. If that is the case, the grade for C01 = .5 × C01P01 + .5 × C01P02. This combined grade needs to be 6.0 or higher on a 10-point scale. Figure 1 shows an example of the browser-based player students regularly use to view the recorded lectures. We will refer to this player as the regular interface (RI).

We chose to implement the tagging interface (TI) as a separate layer on top of the RI. This eliminated the need to make changes to the existing environment, keeping the experiment restricted to just the course selected. Figure 2 shows an example of the TI. Within the TI, students have all the navigational options that the RI has, with the addition of the tags displayed on the left-hand side.

We could not allocate students to TI or RI conditions. Students were free to select the RI or the TI whenever they retrieved a recorded lecture. When students wanted to view the recorded lectures, they had to log in. The system logged which students viewed the recorded lectures and in case of the TI, the system logged which tags the students used to navigate through the recorded lectures.

To determine where to place the tags, we used signals, or signposts, provided by the structure of the lecture. Exley and Dennick (2004) describe a number of possible lecture structures a lecturer can choose from. Table 1 describes the structure types and suggests possible tag indicators per structure type.

Exley and Dennick distinguish a number of different types of statements a lecturer can use to inform students about the lecture organization: signposts, frames, foci and links. Bligh (1998, p. 84) refers to these signals as *macro signals*. *Signposts* are statements that signal the direction the lecturer is going to take. An example of a signpost is as follows:

In this first lecture I am going to talk to you about the structure of the course, the topics that are part of the exam, the structure of the exam, which is laptop based, and the best way to prepare for it. But first I am going to show you an example.

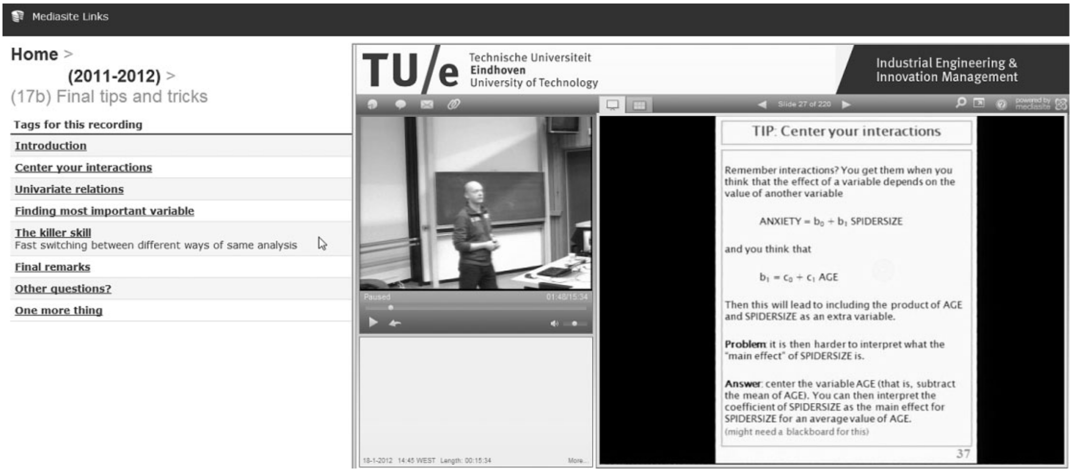

Figure 2: Example of the tagging interface (TI)

Table 1: Lecture structures

	Description	*Possible tag indicators*
Classical	Lecture is series of related entities, describing their features or properties.	Start of new entity
Sequential	Lecturer goes through a simple sequence of related subtopics that underpin the main topic and form a logical and coherent "narrative" with a specific conclusion.	Start of new subtopic
Process	Uses the sequence of components within a process (eg, in biochemistry, ecology, geology, economics) as the framework for the lecture	Start of new process step
Chronological	Uses a temporal or historical sequence to structure the lecture	Start of new time sequence
Spatial	Uses the spatial relationships between entities as a structure, for example, in anatomy and embryology, geography or architecture	Start of new spatial relationship
Comparative	The lecturer sets up a debate between competing ideologies, concepts, methods, procedures or techniques.	Start of new ideology Start of new concept Start of new method Start of new procedure Start of new technique
Induction and deduction	Induction is the process by which observations, facts and evidence are synthesized to form theories, rules and laws. The opposite process by which theories and rules are used to predict and calculate facts about the world is known as deduction. Both processes can be used to structure a lecture.	Start of new theory Start of new rule Start of new observation Start of new fact/evidence Start of new deduction or induction step
Problems and case studies	Case studies can be used to structure lectures by bringing together conceptual understanding and reasoning with real-life, relevant situations.	Start of case/problem explanation

Frames are statements that indicate the beginning and end of topics and sections. An example of a frame follows:

OK, to start off with our first topic, let's have a look at the way you can determine the size of a sample.

Foci are statements that highlight and emphasize key ideas, definitions and concepts. An example of foci statements is as follows:

Now during the exam, you will get data that has funny stuff in it. I won't tell you that that is the case; I will expect you to know that is the case, so make sure you check for that first.

Links are statements connecting to other sections of the lecture or prior knowledge and experience. Two examples of a link statement follow:

As you should remember from the first part of the course . . .

Contrary to what we did during the previous example, we now . . .

The structure of the slides also provides a signal for the lecture organization. The slides contain titles, lists of important topics, schemas with the structure of the topics, etc.

Based on these signals, we created the following tagging protocol for our experiment:

1. Examine the lecture structure (see Table 4). This gives an indication of the sort of possible tag indicators that signal useful tags.
2. Playback the recorded lecture, and while playing, listen to oral signals by the lecturer that indicate signposts, frames, foci or links.
3. Mark potential tags. Pause the recording, write down the time code along with potential tag title and a short description of the tag.
4. After completion of the tagging process, the tags, descriptions and time codes were added to the tagged player system.
5. Always add a tag at 00:00:00, indicating the beginning of the recording. This gives the student an easy way to return to the beginning of the recording.

Using the tagging protocol, the recorded lectures were tagged by hand within 2–3 hours after each recording had been created. All tags have a title (always visible), a description (visible when the user hovers over the title) and a time code (not visible to the user). Once logged in, tags could be added and edited as shown in Figure 3.

Tags were added to the recorded lectures by the main author of this article using a management interface constructed for the experiment. After a recorded lecture had been tagged, the professor for the course reviewed and approved the tags and descriptions. A total of 18 recorded lectures, each 40–45 minutes in length, were tagged, spanning the full 9 weeks of the second part of course C01.

Table 2 shows, as an example, the tag titles, descriptions and time codes used for the C01 Lecture 11b recording.

Usually, the lecture started with an introduction of the topic or a summary of the topic covered to that point. That introduction was then often followed by a demonstration of that topic using SPSS. For the C01 course, a total of 18 recorded lectures (C01P02L1 through C01P02L18) were created. Each recorded lecture is on average 40–45 minutes long. Half of all tags have been added to the first 14–16 minutes of the recordings, the rest to the remaining 25–30 minutes. The total number of tags added was 202, the average number of tags per recorded lecture was 11 ($SD = 3.6$).

Given our three research questions, we performed a number of analyses:

1. When do students use the tags?
   a. When do the students use the TI?
   b. Does the use of the TI increase over time?

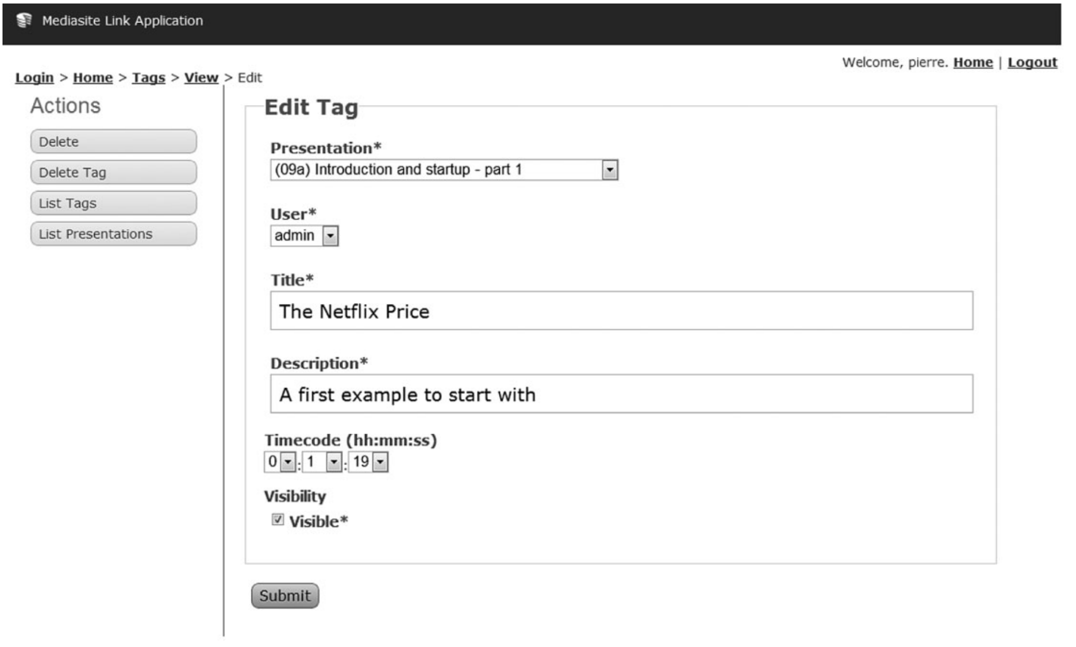

Figure 3: Adding and editing tags

Table 2: Tags for C01 lecture 11b

Tag title	*Description*	*Time code*
New variables based on existing ones	How to do this	00:00:00
Interaction variables	How to add and interpret them	00:06:00
A crude specification test	Ramsey's "omitted variable test"	00:12:22
Ensuring proper models	Creating new y variables	00:23:40
Outliers	What is it and how to take care them?	00:32:12
Weekly not-on-the-exam fact	Each last 5 minutes of a lecture	00:40:00

2. Does the availability of tags increase the navigation speed of students? Do the tags help them to more quickly locate the parts of the recorded lectures they want to view?
   a. How much video do students view per recording session using the TI compared with the RI?
   b. Do the students click more or less during a recording sessions while using the TI?
3. Do students who use the tags score better for the exam?
   a. Are the exam scores for students that use the TI higher?

Results

First, we will analyze the first research question: when do the students use the tags? During the time period of the experiment, November 2011 through January 2012, a total of 255 students viewed one or more of the recorded lectures for the second part of the C01 course. Of those 255 students, 172 students only used the RI to view the recorded lectures, eight students only used the TI and 75 students used both the TI and the RI during the timeframe of the experiment. We analyzed the use of the recorded lectures on the level of individual "recording sessions." A recording session is defined as an uninterrupted period of time during which a learner views one single recorded lecture (Advanced Distributed Learning, 2004). If a student views multiple recorded lectures consecutively, they are all considered to occur in their own individual recording session. This way a recording session can be labeled as either a TI session or a RI session.

Figure 4 shows the number of recording sessions for the C01 course for both TI and RI on a weekly basis. It is clearly visible that the number of RI recording sessions (3477 in total during the experiment) is much greater than the number of TI recording sessions (879 in total during the experiment). The graph shows a significant increase in the number of recording sessions for both the RI and TI in the last 4 weeks of the experiment, in the weeks leading up to the exam for C01.

Figure 5 shows in more detail the peak in number of recording sessions for both the RI and TI during the last 7 days before the exam. These results confirm that students most frequently view the recorded lectures during the week leading up to the exam (Gorissen *et al*, 2012b). An analysis of recording sessions per day shows that peaks in session numbers per day occur on Wednesdays and Thursdays (the lecture is on Wednesday), whereas the troughs often occur on Saturdays.

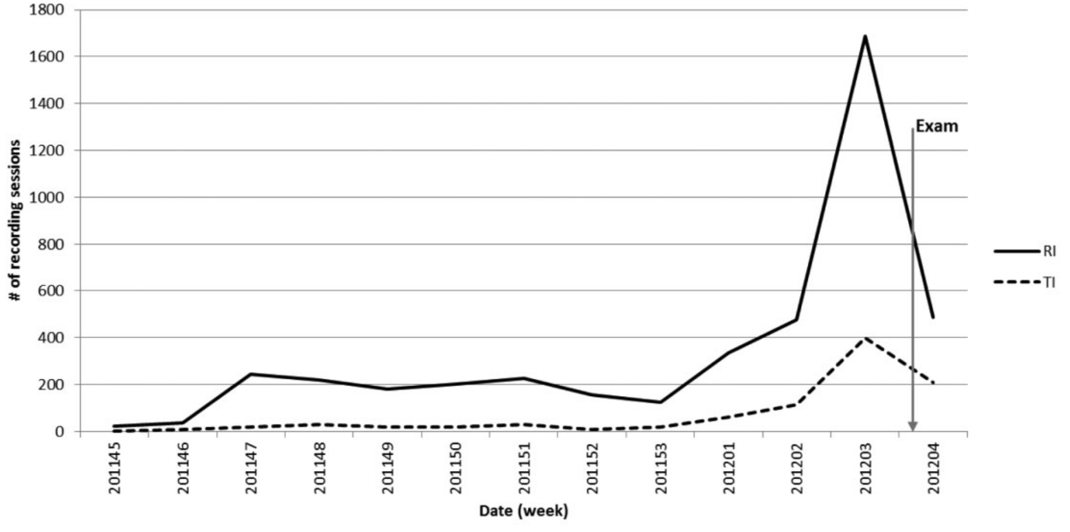

Figure 4: Number of recording sessions for tagging interface (TI) and regular interface (RI)

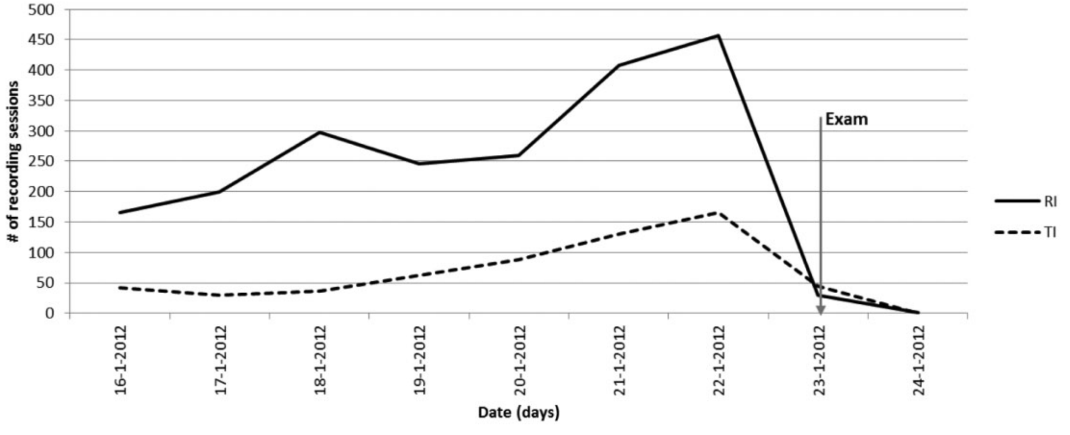

Figure 5: Number of recording sessions for tagging interface (TI) and regular interface (RI) during the last 7 days before the exam

Figure 6 shows the percentage of the total number of recording sessions where the TI was used per week. The dashed line shows the trend line. Analysis of the percentage in SPSS revealed a Pearson product–moment correlation coefficient of $r = .775$, $n = 13$, $p = .002$. The use of TI when compared with RI increased over time.

Our second research question relates to the navigation speed of students when they use the TI. Do the tags help them to more quickly locate the parts of the recorded lectures they want to view?

Figure 7 shows that although the absolute number of RI recording sessions is higher than the number of TI recording sessions, the average amount of video received during a TI recording session is higher for most of the recorded lectures. The figure shows the average amount of video (in minutes) per recording session for each recorded lecture for the RI and TI. It shows that, with the exception of the first three recorded lectures, for other recorded lectures, the average amount of received video per recording session is higher for the TI than for the RI.

We did a further analysis into the differences of navigation speed between the RIs and TIs by comparing the amount of use of the interfaces over time. Research by Gorissen *et al* (2012b) shows that students use recorded lectures more when preparing for the exams. For this course, the exam was on January, 23 2012. Figure 4 shows a significant increase of the number of recording sessions after January 1, 2012. Figure 6 shows an increase in the use of the TI over

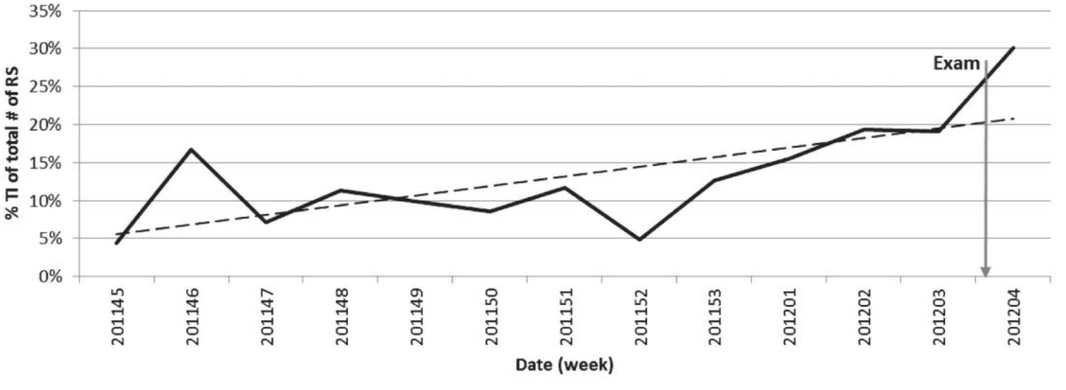

Figure 6: Proportion tagging interface (TI) of total number of recording sessions per week

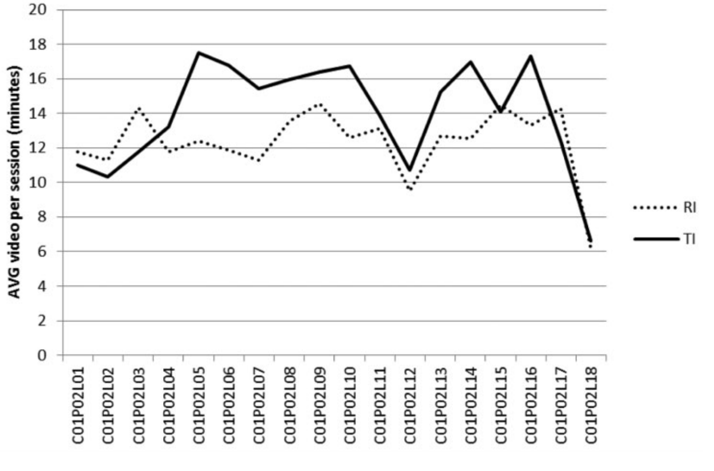

Figure 7: Average amount of video (in minutes) per recorded lecture per recording session

time. We have taken these two developments into account while analyzing the second research question. For the RI, we calculated the amount of video received per recording session of the period before and after January 1, 2012.

Table 3 shows that the average amount of video received per recording session for RI decreased from 13.07 to 12.29 minutes per recording session, a decrease of 5.9%. The students viewed less video per recording session for the recording sessions while using RI in the weeks leading up to the exam.

For the TI, we calculated both the amount of video received and the number of times a tag was clicked during a recording session, again comparing the period before and after January 1, 2012. Table 3 shows the results of that comparison.

Table 4 shows the same information as Table 3, but for the TI. It includes additional columns for the data related to the total and average times the students clicked on a tag in the TI. The table shows that the average tag click count per TI recording session more than doubles from 8.80 to 18.34. The average amount of video per recording session for the TI decreases from 20.05 to 13.20 minutes (−34.2%). Students use the tags in the TI more actively during the last weeks before the exam, yet view less video per TI recording session than before January 1, 2012.

Our final research question was whether students who use the tags score better for the exam than students who do not use the TI. Does an increased us of the TI lead to a better grade for the second part of the course (C01P2_grade)?

Because we could not allocate students to TI or RI conditions, we analyzed the data using linear regression with CO1P2 as dependent variable. To control for existing differences in exam performance, the results of the first part of the exam (CO1P1_grade) were used as a covariate. The number of sessions using TI (count_TI) as well as RI (count_RI) was used as predictor variables.

The analysis was performed using students from whom we had both CO1P and CO1P2 scores ($n = 167$). We checked for multivariate outliers using the Mahalanobis' distance (using $\alpha = .001$

Table 3: Video received for regular interface

		*Video received**	
	*RS** (n)*	*Total*	*AVG****
<January 1, 2012	735	9 606.02	13.07
≥January 1, 2012	2742	33 698.38	12.29
Total	3477	43 301.40	12.45

*Minutes, **Number of recording sessions, ***Average per recording session. RS, Recording Sessions; AVG, Average.

Table 4: Video received and tag click count for tagging interface

		*Video received**		*Tag click count*	
	*RS** (n)*	*Total*	*AVG****	*Total*	*AVG*
<January 1, 2012	142	2 847.58	20.05	1 250	8.80
≥January 1, 2012	737	9 726.58	13.20	13 519	18.34
Total	879	12 574.16	14.31	14 769	16.80

*Minutes, **Number of recording sessions, ***Average per recording session. RS, Recording Sessions; AVG, Average.

Table 5: Descriptive statistics for regression analysis

	count_RI	*count_TI*	*C01P1_grade*	*C01P2_grade*
M	12.65	3.34	7.65	5.33
SD	10.314	7.702	0.823	1.599
Min.	0	0	5.20	2.50
Max.	48	33	9.50	8.40

$n = 164$. *M*, mean; RI, regular interface; *SD*, standard deviation; TI, tagging interface.

with 3 *d.f.* and a critical χ^2 of 16.27) and removed three cases based on the results. Table 5 shows the descriptive statistics for the variables in our dataset with the remaining 164 cases. The test for multicollinearity shows both tolerance and variance inflation factor values to be close to 1.0, ruling out multicollinearity. Normal P-P plot of regression of standardized residual shows a normal distribution.

A hierarchical multiple regression was used to assess the ability of the number of recording sessions for RI and TI (count_RI and count_TI) to predict the C01P2_grade. The CO1P01_grade was entered at Step 1, explaining 19.3% of the variance in the C01P2_grade, $F(1,162) = 40.091$, $p < .001$. After entry of count_RI, the total variance explained by the model decreased to 18.8%, $F(2,161) = 19.931$, $p < .001$. After entry of count_TI, the total variance explained by the model as a whole increased to 23.4%, $F(3,160) = 16.322$, $p < .001$. The two control measures explained an additional 3.6% of the variance of the C01P2_grade after controlling for the C01P1_grade, R^2 change = .036, *F* change (1160) = 7.497, $p = .007$. In the final model, only the C01P1_grade and count_TI were statistically significant, with the C01P01_grade recording a higher beta value (beta = .44, $p < .001$) than the count_RI (beta = .194, $p = .007$).

Conclusions and discussion

In this study, we provided students with the choice to use a TI instead of the RI available to them. Both the RI and TI are used most in the weeks leading up to the exam. Although the RI is used more often than the TI throughout the semester, there is a significant increase in the relative use of the TI in time. This could be because the students needed to get used to TI, because they found the use of the TI useful and increased their use of the TI or because the topics covered in the recorded lectures were perceived by the students as more difficult, making the availability of tags to find relevant parts of the recorded lectures more useful. A next step would be to analyze the use of tags by a group of students over a number of courses to determine whether the growth in use is consistent or whether course-related criteria, like the topic of the course or the perceived difficulty of the course, influence the use of the tags.

During the first part of the semester (before January 1, 2012), students who use the TI view considerably more video per recording session than the students who use the RI. In the second part of the semester, however (after January 1, 2012), this difference is almost reduced to zero. At the same time, the use of the tags per recording session more than doubles. This suggests not only that the students use the TI more actively, but also that the availability of tags helps the students to watch the recorded lectures more efficiently.

Students viewed less of the recorded lectures when using the TI. Although this means a decrease in their time on task, the regression analysis shows that the use the TI had an, albeit small, positive influence on the predicted grade for the course, even when controlled for the grade for the first part of the course. However, of course, most of the variance in the exam results is not accounted for in the simple model tested here. Such a model not only has to include well-known predictors such as students' approach to studying, prior knowledge, intelligence and motivation (Entwistle, Hanley & Hounsell, 1979; Smith & Whiteley, 2002; Trigwell, Prosser & Waterhouse, 1999) but social-economic ones as well, as was demonstrated in the extensive literature study by Ben Youssef and Dahmani (2010) who showed that students' socio-economic characteristics like age, gender, family structure, level of parents' education etcetera have a significant influence on the students' performance and their ability to benefit from the availability of ICT during their academic career. These characteristics may have been influential in the choice of a student for the TI, although de Boer, Kommers and de Brock (2011) found no strong correlations between (preferred) viewing styles and personal traits like learning styles and short-term memory.

We were not able to determine if the tags helped the better students to perform even better or that it helped weaker students pass the course where they otherwise would have failed. In a more process-oriented perspective, the results found can be seen as consistent with results reported by Bligh (1998, pp. 129–147) who showed that note taking aids students in their learning process and that it leads to higher achievement (Kiewra, 1989). Like the notes, the tags provide students with a structured study aid while preparing for the exam. Further research along these lines is needed.

This study used expert tagging. It did not research whether the wording of the tags was optimal for students. It may be possible that the students prefer a different vocabulary or would place tags at different time locations within the recorded lecture, for example, to link the tags more directly to the notes they create. Further research needs to determine whether or not the creation of tags by students does indeed improve the speed with which students find the parts of the recorded lectures that they want to review.

Acknowledgements

This research has been funded by Fontys University of Applied Sciences. The authors would like to thank the Student Office of TU/e for their assistance in this analysis and access to the dataset.

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