

Video Lectures: An Analysis of Their Useful Life Span and Sustainable Production

José Miguel Santos Espino, Cayetano Guerra Artal and Sara María González Betancor

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Article abstract

The learning effectiveness of video lectures has been extensively studied by the scientific community, but research on their cost-effectiveness and sustainable production is still very scarce. To shed light on these aspects, this study has measured the useful life span and cost-effectiveness of a large catalog of video lectures produced for undergraduate courses at a Spanish university. A Kaplan–Meier survival analysis has been performed to identify factors linked to video longevity. The analysis accounted for variables such as the video production style (screencast, slideshow, chalk and talk, talking head, and on-location film) and others such as the instructional purpose and field of knowledge. The teachers involved in video production and integration have been surveyed to discover causes of video obsolescence. In addition, using life span and production cost data, the cost-effectiveness of each production style over time was estimated. The results suggest that production style affects video longevity, and in particular, dynamic visuals are more related to longer life spans compared with static contents. Screencast stands out as the most cost-effective production style, having the best ratio of life span to production effort. Some practical suggestions are provided for producing video lectures with higher longevity expectations.

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Video Lectures: An Analysis of Their Useful Life Span and Sustainable Production

José Miguel Santos Espino, Cayetano Guerra Artal, and Sara María González Betancor
University of Las Palmas de Gran Canaria, Spain

Abstract

The learning effectiveness of video lectures has been extensively studied by the scientific community, but research on their cost-effectiveness and sustainable production is still very scarce. To shed light on these aspects, this study has measured the useful life span and cost-effectiveness of a large catalog of video lectures produced for undergraduate courses at a Spanish university. A Kaplan–Meier survival analysis has been performed to identify factors linked to video longevity. The analysis accounted for variables such as the video production style (screencast, slideshow, chalk and talk, talking head, and on-location film) and others such as the instructional purpose and field of knowledge. The teachers involved in video production and integration have been surveyed to discover causes of video obsolescence. In addition, using life span and production cost data, the cost-effectiveness of each production style over time was estimated. The results suggest that production style affects video longevity, and in particular, dynamic visuals are more related to longer life spans compared with static contents. Screencast stands out as the most cost-effective production style, having the best ratio of life span to production effort. Some practical suggestions are provided for producing video lectures with higher longevity expectations.

Keywords: video lecture, sustainable education, higher education, useful life, cost-effectiveness

Introduction

Video is a resource that is increasingly used in higher education, both in online activities and as a complement to face-to-face instruction. Traditional expository instruction has been steadily leveraging on streamed video lectures and tutorials (Crook & Schofield, 2017), which have become a key resource in distance and distributed learning environments, as well as in hybrid modalities. The scientific community has paid much attention to research on how video can benefit learning within several contexts (Kay, 2012; Poquet et al., 2018). Nevertheless, research about the sustainable production and cost-effectiveness of instructional videos accounts for a relatively small number of contributions. The present observational study has the goal of contributing to this knowledge by assessing the useful life span of instructional videos used in higher education and identifying factors that are correlated to sustainability.

Production Costs and Video Presentation Format

Production of high-quality instructional videos may require considerable cost. Hollands and Tirthali (2014) estimate a range of USD\$39,000–\$325,000 for the overall production cost of a typical high-end massive open online course (MOOC), of which a large portion was taken up by video lecture production. In addition, video lecture recording and editing costs may be underbudgeted (Meinert et al., 2019). Expensive MOOC studio-recorded videos contrast with low-cost schemas (Furini et al., 2020) that deliver usable video lectures with a minimal infrastructure and production time. Efforts have been made to diminish the production cost of video lectures, for example, by repurposing preexisting video files (Nissenson & Shih, 2015) or promoting instructor self-production (Turro et al., 2010), which override the need for a costly specialized production team.

The presentation format of an educational video may have some influence in the learning process, both in the learning effectiveness and in the student's engagement (Guo et al., 2014; Ilioudi et al., 2013; Wilson et al., 2018). In addition, the cost of producing a video lecture may vary substantially depending on the chosen visualization format and the production setting. Therefore, in the design process of an educational video, it is crucial to select a set of presentation features that balances the production cost and the expected learning benefits.

Analyzing the cost-effectiveness of instructional video production has not received much direct attention by researchers. A large body of applied research is aimed at identifying features that improve the *learning effectiveness* of instructional videos (Clark & Mayer, 2016; Ibrahim et al., 2012; van der Meij & van der Meij, 2013). However, we found very few peer-reviewed studies about production factors linked to *cost-effectiveness* and *long-term reusability* (Henrich & Sieber, 2009; Hollands & Tirthali, 2014; Norman, 2017). In his review of the literature on the use of educational video in higher education, Winslett (2014) regrets the “lack of attention” (p. 500) that researchers had given to issues included cost, scalability, sustainability, and return on investment.

Useful Life Span and Sustainable Production

Beyond the concept of cost-effectiveness, *sustainable e-learning* is a term that covers multiple perspectives of sustainability in educational contexts (Alharthi et al., 2019). Sustainability in e-learning

deals with the “continuous adaptation to change, without outrunning its resource base or receding in effectiveness” (Stepanyan et al., 2013, p. 95). It also pertains to resource management, in particular, with creating reusable learning materials (Liber, 2005). One indicator of resource sustainability is the *useful life span*: how long a learning object is effectively used since it is delivered. Factors linked to longer life spans should be considered when designing the production process of learning objects.

The life span of some learning media, such as printed books, has been measured (Renaud et al., 2015). Unfortunately, the obsolescence process of educational videos has not been studied in depth. The few peer-reviewed studies that have surveyed the actual use of video in academic settings (Han & Wong, 2009; Houston, 2000; Mardis, 2009; Santos Espino et al., 2020) do not collect the age or life span of the surveyed materials.

The video medium suffers from risks of obsolescence that differ from other media. Once a video clip has been edited, it is harder to modify than other instructional media such as PowerPoint files or Web pages are. Text and pictures are easier to modify than video. Minor changes can be straightforwardly applied to online texts without the final readers noticing; but amending an audio or video recording of a human speaker to introduce new content may be challenging. This means that the useful life span of video material is more threatened by partial obsolescence of contents than that of other media.

Given the growing importance of video lectures as a learning resource, it is critical to contribute knowledge about factors that help prevent video deterioration or increase their longevity.

The Prometeo Project

In this study, we assessed the production and use of a wide range of videos produced within the University of Las Palmas de Gran Canaria (ULPGC), a Spanish university. The Prometeo Project’s mission was to produce digital learning objects for the ULPGC for use as didactic material in its degree courses. The project was active from 2008 to 2012. During that time, over 500 learning objects were produced, most of them instructional video files. Prometeo’s videos relied on various presentation and production formats, each of which entailed different production costs. The outcomes of the Prometeo Project provide us with a considerable number of video clips and usage history to analyze.

Goals and Research Questions

The main goals of this study are to assess the useful life span of instructional videos and to identify factors linked to video longevity. These goals are deployed as a number of research questions that will be investigated within the context of the ULPGC’s Prometeo Project and its associated video lectures:

1. What is the useful life span of the instructional videos?
2. Are there significant differences in the useful life span between different production styles?
3. Are there other attributes in the instructional videos that influence their useful life span?
4. What causes can be attributed to the disuse of a video?

5. Which production styles show a better balance between life span and production cost?

For the purpose of this research, the useful life span of a video will be defined as the duration from the start of the course in which the video is first used to the end of the last course in which it was used, rounded up in years. If a video was produced but never deployed as a course material, its useful life span is considered zero.

Research Method

Overview

The useful life span of the examined video lectures has been estimated from direct surveys to those teaching teams involved in the production of the videos and in their subsequent integration into college courses. These teachers have informed us which videos have been in use and, in cases where they ceased to be used, what the causes were. This information has been crossed with quantitative data extracted from the video files so that we can estimate what attributes, such as production format, are most related to video longevity and cost-effectiveness.

To proceed with this method, the following procedure was followed.

1. Video Collection and Classification

First, all videos produced in the Prometeo Project have been collected and have been labeled with their main attributes, including production style, duration, course, knowledge field, and teachers involved in the production.

2. Production Cost Assessment

As a second step, a simple production cost model was estimated for the Prometeo Project videos. For this purpose, we interviewed the original production team to build a qualitative framework that attributes a cost function to each production style.

3. Teacher Surveys

Once all videos were classified, a series of semi-structured interviews were conducted with the teachers involved in the design, recording, and subsequent use of Prometeo Project videos. The goal of the interviews was to find out the time span of each video: whether they are still in use or, if not, when they ceased to be used and for what reasons. The interviews also tried to clarify the learning purpose that the videos were aimed at.

4. Integrated Data Set

The information retrieved from the teacher surveys was interpreted and coded, to be further combined with the data collected from the video inventory, to yield a complete relational data set of the learning items, their life spans, and their learning context.

5. Survival Analysis

The integrated data set allowed to carry out a survival analysis to identify factors that have significant influence on the useful life span of the instructional videos, with a particular focus on two attributes: the production style and the learning purpose.

6. Qualitative Analysis

The teacher surveys contain nonstructured comments that offer valuable insights about video obsolescence and preservation. As a final step of this study, we gathered and interpreted this information to complement the quantitative results.

Context: The Prometeo Project

For a better understanding of this study, we will describe in more detail some characteristics of the Prometeo Project that have shaped the type of instructional content that was developed.

Project Mission and Course Selection

The Prometeo Project was founded as an institutional project in the ULPGC with the goal to produce digital learning objects, most of them video lectures and tutorials, to support official degree courses. Videos were served in streaming via a server running an in-house learning management system (LMS).

Every year, the university called for a round to select a number of courses that would be supported by the production unit to generate content. Course participation had some requirements intended to maximize the institutional impact of the investment and that are relevant to this research:

- Teachers applied voluntarily to participate.
- Priority was given to basic and transversal subjects.
- In each yearly call, courses from all main knowledge fields were selected: arts and humanities, “hard” sciences, engineering, health sciences, and social sciences.

Four production rounds were issued from 2008 to 2011. The last videos were published in 2012. The Prometeo Project was abruptly dismantled at the beginning of 2012 amid the economic crisis that was hitting Spain. After the cancellation, the video infrastructure continued to operate without maintenance, though teachers kept using videos streamed from the server, or they otherwise downloaded the original videos to migrate them to other platforms, such as YouTube.

Video Production Styles

The Prometeo Project had a production unit in charge of video filming, editing, and publishing. Teachers were free to choose which presentation style would be used for their course videos, though the options were limited to a small number of formats.

The main production styles in Prometeo Project were the following:

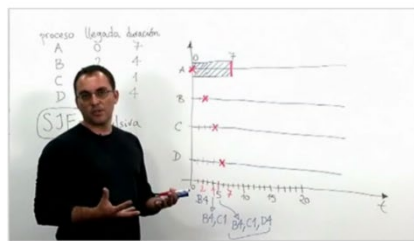
- Chalk and talk—An instructor gives a lecture in front of a large whiteboard in a studio setting. The whiteboard is used to write text, sketch schemes, or draw diagrams.
- Talking head—An instructor develops a lecture shot in frontal view. The speech is complemented with chroma-like overlaid text.
- Screencast—Many videos show recorded computer sessions with a voice-over—for example, solving mathematics exercises using a software tool or tutorials explaining how to use certain computer application.

- Slideshow—These videos use the same production technique as the screen casts, though the purpose was to record a PowerPoint-like presentation with a voice-over.
- On location—Some videos are demonstrations of real-life processes, filmed in specific locations such as college laboratories and industrial facilities.

Figure 1 depicts screenshots of each of these five production styles.

Figure 1

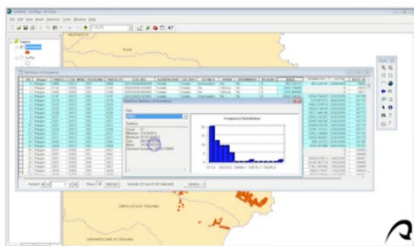
Screenshots of the Prometeo Project's Main Production Styles



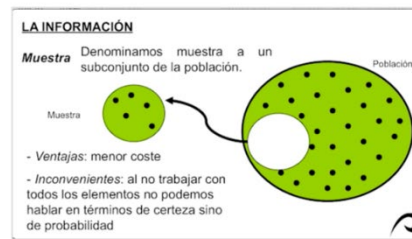
Chalk and talk



Talking Head



Screencast



Slideshow



On location

Most videos used exclusively one production style, though some hybrid instances were released (e.g., a talking head segment followed by a screencast). A minor number of videos used other styles, such as interviews and podcasts.

Video Collection and Classification

Two main sources have been used to collect video data. First was a set of work scheduling sheets of the production unit, containing all the courses, teachers, and videos in production. Second, all published video files were retrieved from the project LMS server. These two sources were crossmatched to obtain an exhaustive inventory of analyzable videos, plus a list of participant teachers.

A direct examination of video files allowed us to code basic attributes, such as duration. The production style attribute was coded according to the standard styles used in the Prometeo Project. Videos that alternate between several production styles were labeled as *hybrid*. Moreover, each video was assigned to one *instructional purpose*, chosen from these four: a *lecture* is the formal exposition of a conceptual topic by an instructor; a *tutorial* is the explanation of a procedure by an instructor; a *worked example* is a particular type of tutorial, characterized by being a step-by-step resolution of a task or problem; a *demonstration* is the live recording of a functioning system or a real-life process.

Modeling Video Production Cost

The former team leader of the Prometeo Project production unit gave information about the production process, which was supplemented with the archived work schedule sheets. In general, a video segment followed a pipeline of preparation, recording, editing, postproduction/render, review, and publishing. This pipeline was usually executed in a single batch for a set of videos belonging to the same course.

The most resource-consuming stages of the pipeline were recording and editing, whose efforts were proportional to the final duration of the published video. In addition, recording and editing costs depended on the video production style (e.g., a screencast required much less editing time than a talking head video). Time required for artwork, postproduction, and rendering was similar for each video batch and negligible when compared with the other factors. With all these findings at hand, a simple linear model of production cost has been built for each production style.

Teacher Survey

The teachers who were in charge of the courses provided us with additional information related to the actual use of the videos. The script for the interviews consisted of a structured questionnaire plus a set of open items. The open items were intended to capture spontaneous information from the interviewees. The script covered four main topics: participation in the Prometeo Project, current status of the course or subject, current status of produced videos in teaching, and teaching staff's technical competence.

For each surveyed course, at least one participant was contacted. In some cases, joint interviews were held with several participants of the same course. In all cases, answers were recorded on a per-course basis. It is important to remark that staff stability was very high for most courses, so in general, the teachers in charge of the courses at the time of the interviews were the same as those who participated in the Prometeo Project.

Two modalities were used to administer the surveys: a synchronous interview (face-to-face or via telephone) or a written questionnaire submitted by e-mail, which was used in five cases. Surveys were conducted between June and October 2016. Responses were obtained for 37 courses out of 39 (95% turnout), which covered 375 videos out of 381 (98%). A total of 38 teachers participated in the surveys.

Integrated Data Set

Once all surveys were conducted, responses were interpreted and coded into a structured database for later analysis. The following quantitative data were retrieved: course attributes (field of knowledge, stability in curriculum), instructional purpose of videos, complementary or compulsory nature of videos, video life span (starting and ending years), and videos' current validity. In addition, some qualitative information was recorded: perceived causes of obsolescence or deterioration of videos, obstacles to integrate videos in teaching, and interventions taken by teaching staff to extend video useful life.

From the video inventory and teacher survey data, an integrated data set could be elaborated for most videos ($N = 381$), providing several attributes for each item: duration, production style, course knowledge field, instructional purpose, observed life span (start/end year), current status of validity/obsolescence, and the main cause of deterioration/obsolescence (if reported).

Life Span Analysis: Method

The video life span analysis was performed in two stages. First, a nonparametric estimation was made for different subsamples, each one based on a single video attribute. A survival analysis estimates the empiric functions of density, distribution, and hazard using the well-established method proposed by Kaplan and Meier (1958). The Kaplan–Meier estimator uses a single sample of data in a way similar to a life table. Instead of people who survive or die after a treatment, we deal with the life span of videos. At any given time (t), we can count the number of videos that are known to be “alive” (still in use) and then count how many “deaths” occur in the next time interval (D). The method proceeds in three phases: (a) estimation of a hazard function for the full sample, (b) graphical plots of the survival function (Kaplan–Meier curves), and (c) nonparametric tests of equality to identify predictors for the final model.

After performing the Kaplan–Meier analysis, video duration was estimated using parametric models, using the set of parameters provided by the first nonparametric analysis. All estimations were implemented with the statistical package Stata 15 (StataCorp, 2017).

Results and Discussion

Video Demographics

The resulting integrated data set comprised 381 videos, linked to a total of 39 courses. Table 1 shows the frequencies of the five most frequent production styles, along with the distribution of the instructional styles for every production style. Other styles include podcasts (audio plus noninstructional imagery; 5 videos), Khan Academy–style virtual whiteboards (2), and hybrid-style videos (5). Just over half of the courses (21) used a single production style in all their videos, while the remaining 18 courses used two or more styles.

Table 1

Video Catalog Demographics

Production style	N	% of total	Instructional purpose (%)				
			Lecture	Tutorial	Worked example	Demonstration	Other
Screencast	105	27.6	2.9	61.9	34.3	0.9	
Talking head	91	23.9	91.2	4.4			4.4
Chalk and talk	89	23.4	44.9	3.4	51.7		
Slideshow	54	14.2	79.6	5.6	14.8		
On location	30	7.9	6.7	3.3		86.7	3.3
Other/hybrid	12	3.1	50		8.3		41.7
All videos	381	100	46.4	19.9	23.9	7.1	2.3

**Note.* Numbers in bold indicate the most prevalent instructional purpose for each production style.

Production Cost Model

The Prometeo Project data evidenced that the production cost of a video clip is strongly linked to working time. Considering all the findings and production data, the production cost of a video clip was approximated to the following simple linear expression:

$$P = K + \alpha \cdot (R + E) \cdot T$$

where P is the production cost for the video, measured in working hours, K is a fixed cost, α is a constant term that denotes team size ($\alpha \geq 1$), T is the duration of the published video clip, R is the contribution of the recording phase, and E is the contribution of the editing phase. The terms R and E vary depending on the video production style. Table 2 shows the estimated values for R and E for each production style, as well as a measure of their relative production cost. The high cost of on-location videos is due to the requirement to move a film crew to an external facility, often for a full journey.

Table 2

Estimated Cost of Production Styles

Production style	R	E	Relative cost ($R + E$)
Screencast	4.1	0.5	4.6
Talking head	5.1	2.5	7.6
Chalk and talk	5.0	1.8	6.8
Slideshow	5.7	0.5	6.2
On location	15.0	2.5	17.5

Note. R = contribution of the recording phase; E = contribution of the editing phase.

Life Span Analysis: Results

From a total of 381 surveyed videos, 362 (95%) became available to students; 19 videos were discarded by teachers before there was any chance for them to be used. At the time of the survey, a total of 198 videos (52.8% of total) were still in active use. Table 3 summarizes the average life span, taking into account the main video attributes. The observed average life span for all the videos is 5.74 years, for a possible upper bound of 9 years. (Note: life spans of censored observations have been counted as the age of each video in the last surveyed year).

Table 3

Average Life Span and Censoring of Surveyed Videos

Category	Avg. life (years)	Censoring
Production styles		
Screencast	6.81	51.4
Talking head	4.59	34.5
Chalk and talk	6.09	67.4
Slideshow	4.35	40.7
On location	6.68	78.6
Other/hybrid	6.17	83.3
Instructional purposes		
Lecture	5.30	52.6
Tutorial	6.96	47.4
Worked example	5.14	48.4
Demonstration	6.68	80.0
Other	7.10	70.0
All videos	5.74	52.8

Note. Avg. life = average life span in years; Censoring = percentage of videos still in use at the end of the observation period.

Nonparametric Estimation

A hazard function has been estimated using actuarial calculation techniques. Table 4 shows the video survival data for each annual interval. For each interval, these data are represented: lower and upper bounds of interval (*Interval*), number of survivors at interval start (*Total*), number of discontinued videos (*Deaths*), and the number of censored observations (*Cens.*). Values q_i show the adjusted proportion of terminal events (i.e., the probability of an observation that enters the interval i to stop being used in that interval). This probability is adjusted for censoring so that each censored observation is weighted as half of one finalized observation. The *Surv.* column shows the estimation of the empirical survival function S_i at the end of each interval, calculated as $(1 - q_i) S_{i-1}$. Column f is a density function that shows the probability of video end of life in the interval, calculated as $(S_{i-1} - S_i) / interval_width$. The last column, *Hazard*, is the estimation of the per-year probability of video end of life, assuming that the item has been in use until the interval start.

Table 4

Video Survival Rates

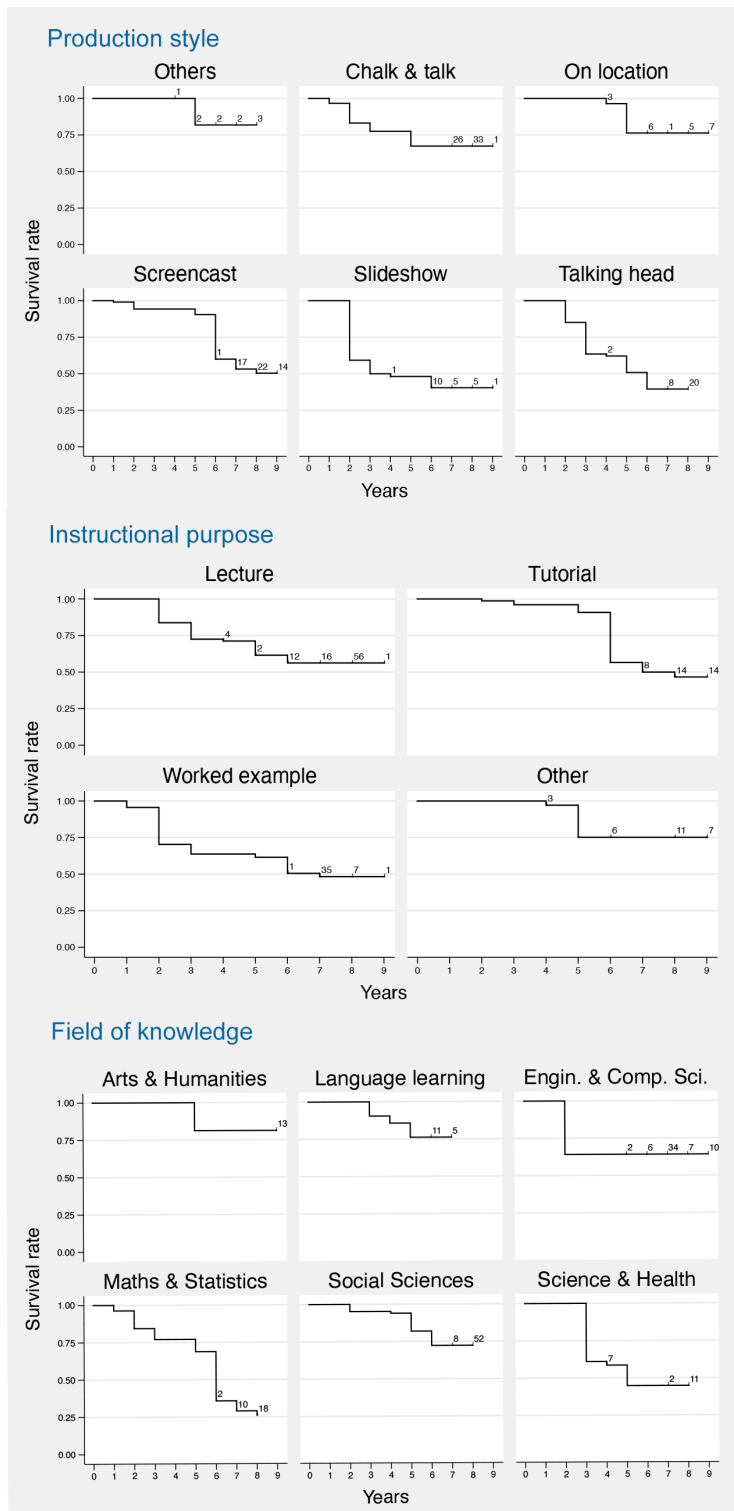
Interval		Total	Deaths	Cens.	q	Surv.	f	Hazard
0	1	362	0	0	.000	1.000	.000	.000
1	2	362	0	4	.000	1.000	.000	.000
2	3	358	0	50	.000	1.000	.000	.000
3	4	308	0	26	.000	1.000	.000	.000
4	5	282	7	3	.025	0.975	.025	.025
5	6	272	2	28	.008	0.968	.007	.007
6	7	242	19	44	.086	0.892	.076	.079
7	8	179	59	7	.336	0.598	.294	.330
8	9	113	88	2	.786	0.132	.466	.779
9	10	23	23	0	1.000	0.000	.132	1.000

Note. Interval = lower and upper bounds of interval; Total = number of survivors at interval start; Deaths = number of discontinued videos; Cens. = number of censored observations; q = the adjusted proportion of terminal events; Surv. = estimation of the empirical survival function S_i at the end of each interval, calculated as $(1 - q_i) S_{i-1}$; f = density function that shows the probability of video end of life in the interval, calculated as $(S_{i-1} - S_i) / \text{interval_width}$; Hazard = estimation of the per-year probability of video end of life, assuming that the item has been in use until the interval start.

Graphs of survival functions were used to obtain direct insight of the survival trends. Figure 2 shows the charts for the attributes of most interest in this study (production style, instructional purpose, and field of knowledge). The numbers inside the graphics show the count of censored videos having each life span length. A direct observation of these charts reveals differences between video attributes as regards video survival rate. A further homogeneity analysis of strata would confirm the existence of significant differences. Two statistical tests were applied on each attribute: a homogeneity test of strata and an equality test for survival functions. We used Peto–Peto tests, trend tests, and log-rank tests, depending on the attribute type. The following attributes failed the tests and therefore were not included in the survival model: video clip duration, visibility of speaker in video, and two cases for the role played by videos in course material.

Figure 2

Kaplan–Meier Curves for Survival Estimates of Life Span (Three Attributes)



Parametric Estimation

The nonparametric analysis provided a set of attributes that will be used as parameters in the survival model. A goodness of fit analysis was made for three different specifications of the model: exponential parametric, Gompertz, and Weibull. All three models passed Chi-square tests for unobservable

heterogeneity ($p = .000$). The best fit was the Weibull model, which obtained the largest value for log-likelihood (-153.61) and the lowest AIC (353.23).

Assuming a Weibull model, the full maximum likelihood estimates of the baseline hazard function report a statistically significant fit ($\ln p = 1.11$, $p < .001$) and a value of $p > 1$, which means that the odds of failure increase with time. In Weibull models, a positive coefficient indicates that the corresponding parameter increases the hazard rate of video discontinuation and thus decreases the video life span. The amount of this effect is calculated as $(\exp(\beta) - 1) \cdot 100$, which is the increment in the probability of video discontinuation, expressed as a percentage. Table 5 shows the Weibull coefficients for all the parameters included in the model.

Table 5

Survival Model: Parameters and Weibull Coefficients

Variable	Weibull coefficient
Course field	
Arts and humanities	-3.060***
Social sciences	-2.900***
Language learning	-1.870*
Engineering and computer science	(ref)
Mathematics and statistics	0.716
Science and health	1.580*
Subject/syllabus stability over time	-0.585
Production style	
On location and other styles	(ref)
Screencast	0.362
Chalk and talk	0.426
Talking head	1.600**
Slideshow	1.960**
Production year	0.467*
Current validity of contents	-0.238
Instructional purpose	
Demonstration and others	(ref)
Lecture	1.670**
Tutorial	2.350***
Worked example	2.800***
Role in course material	
New and essential material	1.160**
Backup/alternative material	1.700**
Actual degree of use	
Not used	(ref)
Available for students but not actively used	-3.160***
Used in some teaching activities	-4.180***
Used in many teaching activities	-3.070***

Note. (ref) = reference value for variable group. * $p < .01$. ** $p < .001$. *** $p < .0001$.

Qualitative Analysis

The interviews yielded several qualitative findings about factors that have influenced the obsolescence or deterioration of the videos. In the following lists, we enumerate those factors that have been spontaneously expressed by the teachers and that were observed in more than one course (the number of courses is shown in parentheses).

Direct causes of obsolescence:

- Video lectures did not show benefits in students (8).
- Course/topic ceased to be offered (6).
- Videos showed a software tool that became obsolete (4).
- Teacher lost access to video material (3).
- Teacher was replaced by a new teaching team that discontinued the videos (2).

Obstacles and causes of video deterioration:

- Video length is too long—need to crop/split into shorter segments (8).
- The video instructor's face does not match current teacher's appearance (7).
- Changes are needed in overprint labels, opening titles, and so on to reflect organizational changes (5).
- Evolutive changes in displayed tools require updates in video content (4).
- Some video segments became irrelevant or inadequate and need removal (3).

Most observations from the above list are well known in the practice about educational video production. It can be noted that a few causes are of organizational nature, while others are related to the contents itself.

Aversion to Younger Self-Image or Inverse Dorian Gray Syndrome

An intriguing finding is that at least seven teachers expressed some kind of rejection or puzzlement when watching their own image, recorded on the video, looking younger than their current condition. This rejection was reported as an obstacle to video use. In two courses, it became a contributing factor to video discontinuation. This aversion to watching one's younger self resembles an inversion of the Dorian Gray syndrome (Brosig et al., 2001), characterized by a rejection of the subject's own aging process.

Discussion

The survival model data show that the most influential variable in a video's useful life is the course's knowledge field. The choice of production style and instructional purpose had a weaker but significant effect on video life span. The production year has a small effect on the survival rate, which probably relates to some quality loss in the videos produced during 2011, when financial stress on the project arose.

The survival analysis has not detected a relationship between video duration and useful life span, despite known evidence suggesting that short videos are more effective and engaging. Nevertheless, one of the most reported causes of obsolescence in the teacher survey is the partial deterioration due to the loss of validity of some piece of the video content. This points to the structural complexity, rather than the duration itself, as the factor that increases deterioration. In this study, we could not delve into this matter, which can be reanalyzed in further works.

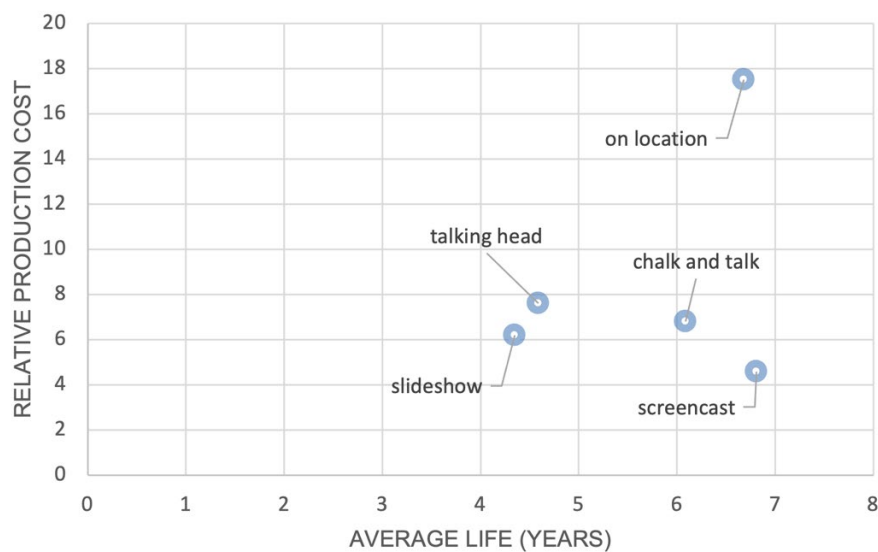
Another relevant finding is that the instructor's presence in the video frame does not show a significant effect on a video's useful life. Nevertheless, the abovementioned inverse Dorian Gray syndrome has been a cause of video discontinuation.

Influence of Production Style on Video Longevity

Figure 3 shows the relation between the average life span and the relative production cost for each main production style. For a better interpretation of the chart, it is important to recall that according to the survival model, the use of talking head and slideshow styles has a significant negative effect on video life span. Screencasts are observed to be very cost-effective, as they have a low production cost while enjoying the longest useful life. On-location videos somehow compensate for their huge production cost with a long, useful life span. On the other side, slideshows seem better for making cheap instructional content with an intended short period of use.

Figure 3

Average Life Span and Production Cost by Production Style



The comparison between chalk and talk and talking head videos deserves attention. Chalk and talk videos have a slightly lower production cost, but they enjoy a longer longevity than talking heads, even when other variables are factored out (see Table 5). Chalk and talk video longevity may be influenced by the way the content is presented: instructional content is smoothly handwritten by the instructor, in contrast with talking head videos, in which the content is displayed in discrete blocks, as in a conventional PowerPoint slideshow. Other studies have shown that handwriting is more engaging than static pictures and has some positive effect in learning, probably related to cueing effects (Fiorella &

Mayer, 2016; Guo et al., 2014; Türkay, 2016). It is possible that those positive qualities of chalk and talk videos have contributed to their relative longer life.

Suggestions for Increasing Useful Life Span

We believe that most video obsolescence factors identified in this study are addressable by proper managing of filmed footage in order to facilitate future editions. As other authors have pointed out, continuous updating of material is key for the maintainability of a teaching resource (Henrich & Sieber, 2009) and a way to make the video resources more reusable (Stepanyan et al., 2013), therefore ensuring longevity. This is in line with the findings reported in the qualitative study.

With this goal of maintainability in mind, our findings can derive some suggestions to prolong longevity so that the profitability of the production effort increases. Some of these suggestions have been acknowledged by the community or practice, such as the use of visual cues and the segmentation of content (Clark & Mayer, 2016; Ibrahim et al., 2012; van der Meij & van der Meij, 2013): this study provides additional support to their validity.

- 1. Keep editable video sources.** The organization should keep an unedited copy of every video material that needs to be durable to ease future video re-editions. If preservation is a goal, high-quality audio and video are requirements. Common storage formats lose quality and degrade with successive editions, thereby risking video longevity. Therefore, we recommend preserving primary video files using quality-lossless formats.
- 2. Avoid corporate branding in video sources.** Changes in branding are frequent maintenance tasks in multimedia learning objects (Young, 2008). For this reason, the preserved video sources should not contain corporate branding mixed in learning content. In the most manageable setting, branding items should be kept in separate segments (headers, credits, etc.).
- 3. Keep single-topic video segments.** This research suggests that videos with a complex structure are more prone to become partially obsolete. If the video lecture is decomposed in independent segments, it will be easier to rebuild a usable video material out of the segments that remain valid. It is important to note that this suggestion should not always be implemented as the *delivery* of multiple video files. It has been observed that excessive file segmentation may hinder learning in people with higher levels of prior knowledge (Spanjers et al., 2011). To circumvent this risk, sometimes it will be better to merge the valid segments into a single video clip.
- 4. Avoid excessive binding to video authors.** In the surveyed courses where the teaching team was replaced, videos were discontinued. In addition, the inverse Dorian Gray syndrome reported in this study is an indication that the product may become excessively tied to the video author shown on screen. This issue should be addressed if the institution intends to produce durable videos. Examples of policies are recording instructorless videos and decoupling the roles of writer and speaker (using actors instead of teachers).
- 5. Use dynamic, cued action rather than static, un-cued pictures.** In this survey, chalk and talk videos have longer life spans than talking heads videos, and screencasts performed better than slideshows. These findings suggest that a fluid, dynamic presentation of contents, combined with cueing (instructor's gestures or computer pointer), helps make videos more effective and engaging, thus increasing their longevity prospects.

Conclusions

The present work has contributed to increasing our knowledge about the sustainability of digital resources for learning. To the best of our knowledge, this is the first study about the longevity of video lectures and one of the first about the cost-effectiveness of educational video lectures. Thanks to this work, the influence of some video features in the useful life span of videos have been assessed, and some practical suggestions have been elaborated regarding the design of video lectures and their preservation over time. These suggestions can be directly applied in open and distributed education designs to produce more cost-effective and durable video resources. In addition, open educational repositories can increase the reusability of their video content. The full nature of an open resource is its ability not only to be freely copied by anyone but also to be easily modified.

Limitations of the Study and Further Research

This study has some limitations that impact the strength and generalizability of its findings. First, it is a regional case study with a limited social and cultural scope. Second, the characteristics of the Prometeo Project imply that all courses were on basic subjects, and teaching teams were stable and motivated. In addition, due to the standardized production method, video clips were homogeneous in several basic properties, such as audiovisual quality, duration, and aesthetics. Finally, data about the useful life span of videos have been obtained only from teachers' perspectives. Other indicators of video service life, such as the number of visualizations over time, could not be measured because video server logs were not available and some teachers had moved their original videos to other repositories, such as YouTube. In further studies, video life span may be estimated using video-watching log data.

These limitations can be overcome by conducting similar studies in other sources, especially in video catalogs with a long history and a high diversity in their video and course characteristics. For those purposes, the method followed in this article is perfectly replicable in other environments, with minimal variations.

Final Words

We believe that it is necessary to seriously consider the assessment of educational videos' longevity and to incorporate more empirical findings on sustainable production, which will add evidence-based support to the existing preservation practices and would point toward novel production methods. We encourage other researchers to apply this kind of research in other video catalogs and organizations. Future findings about instructional video longevity will fruitfully complement the well-established research about the learning effectiveness of video-based learning and will help teachers and educational organizations produce more sustainable and reusable learning materials.

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