IN-SERVICE TEACHERS' PERCEPTIONS OF THE DESIGN AND QUALITY OF MATHEMATICS VIDEOS IN THEIR ON-LINE LEARNING

Cornelia Brodahl & Unni Wathne
Department of Mathematical Sciences, University of Agder, Kristiansand, Norway

Abstract: *This investigation is part of a continuing education program in mathematics, directed at in-service teachers in lower secondary schools holding teacher certificates. Online mathematics lessons, offered through a distant education course, consisted of a combination of text and video podcasts. University educators' podcast development was guided by research-based design principles related to e-learning and multimedia instruction. The question arose as to whether in-service teachers enrolled in the course would perceive the podcast design as supportive for their learning. Using questionnaires, this study monitored how in-service teachers perceived podcast quality based on design dimensions. It sought to identify participants' preferences and their recommendations for video development improvement. Key factors for quality included podcast length and the speaker's narration. In-service teachers perceived the podcasts as being useful for their learning processes and indicated efficiency, enjoyment, and concentration as critical learning conditions.*

Keywords: design principles, distant education, video podcasts

Introduction

Multimedia has become an important part of higher education and multiple studies have shown that video podcasts can be highly effective educational tools in university level courses across several disciplines (e.g., Moore & Smith, 2012; Kay, 2012; Vajoczki, Watt, Marquis, & Holshausen, 2010) including mathematics (e.g., Hsin & Cigas, 2013; Kay & Kletskin, 2012; Lloyd & Robertson, 2012; Loch, Gill, & Croft, 2012). Using mathematic videos as resources serves to reinforce content by explaining the subject, demonstrating how concepts and topics relate to each other, mediate screen or black/whiteboard based demonstrations, establish real-world applications and context, provide explanations of specific procedural problems, and present overviews and refreshers of theory (Bukhatwa, Porter, & Nelson, 2013; Kay & Kletskin, 2012). The research literature provides cognitive and non-cognitive considerations and recommendations for the effective design and implementation of educational video podcasts.

Learners need learning resources that they can engage with, with the assumption that they will learn mathematics well and have a rich learning experience when they are provided with resources that they like and want to learn from. In an online course, lecturers may provide video podcasts produced for distance education that incorporate research-based design features and quality content. While instructors aim for podcasts that are of high quality, they may not know which specific aspects of the design make learners feel satisfied or dissatisfied unless the design features are communicated to learners in context of real learning situations. As learners directly respond to the design, they can indicate if the design principles are met or not, to which degree and why, and make suggestions about whether the design approach should be modified or design criteria extended. The purpose of the study was to explore in-service teachers' perceptions of the quality of a sample of video podcasts produced by university educators for use in a continuing university education program in mathematics in

which these teachers were enrolled as students. The study also attempted to identify possibilities for improving the ongoing and further development of educational video podcasts for the teaching of mathematics.

The study is part of a research and development (R&D) project, aimed at developing video podcasts for on-line mathematics lessons that currently are dominated by text information. The video podcasts were all recorded and edited using screencasting software, and contained a mix of textual, visual, and vocal instructional elements, including text, mathematics formula, calculations, drawings, paintings, photographs, graphs, diagrams and tables, and recordings of dynamic graphic, animation and voice-over narrations. They were used to supplement and reinforce portions of a lesson rather than provide a complete presentation. Little research seems to have been done in this area, especially with respect to the use of online text mathematics lessons with edited screencast-based videos embedded in a tabloid fashion.

This paper is structured as follows. Firstly, the research question is presented. Secondly, the theoretical framework is described and a literature review provided. Thirdly, the methodology of the work is explained. Then, the results are presented, analyzed and discussed. Finally, some remarks on future work conclude the article.

Research Questions

This investigation, as part of the R&D project, examined students' experiences with podcast design in a continuing university education mathematics online course. The course was directed at in-service teachers in lower secondary schools holding teacher certificates. Each online lesson contained text and video podcasts that comprised the majority of the educational content. The for-credit course was delivered entirely online, and in-service teachers were learning at a distance. Video podcasts were developed following research-based instructional design principles, standards, and models. In-service teachers engaged with the video podcasts in a natural, authentic online learning situation. This work sought to gain participant feedback about how the design quality was perceived, in order to improve future video podcasts. Accordingly, the research questions were:

1. How do in-service teachers participating in a continuing university education program perceive the quality of video podcasts with respect to particular design principles?

2. How do in-service teachers' perceptions of the quality of video podcasts help improve further development of educational video podcasts for the teaching of mathematics?

Theoretical Framework

The research literature provides cognitive and non-cognitive considerations and recommendations for the effective design and implementation of educational video podcasts.

Cognitive Design Principles

The Cognitive Theory of Multimedia Learning (CTML; Mayer, 2001) is a theoretical framework that explains how multimedia benefits learners as well as provides design guidelines for the production of educationally effective multimedia materials. The theoretical framework incorporates earlier research about human memory and learning in the field of cognitive psychology. It draws on a number of well-established theories and models including Miller's (1956) concept of chunking, Baddeley and Hitch's model of working memory, Paivio's (1986) dual-coding theory, and Sweller's (Chandler & Sweller, 1991) theory of cognitive load.

Miller (1956) proposed that chunking mechanisms (i.e., the combining of a number of pieces of information into units) can increase individuals' abilities to extract information for recall. Baddeley and Hitch (1974) proposed that the visual and verbal processing of tasks can be performed concurrently as well as separately. Paivio (1986) complemented their model, claiming that nonverbal and verbal information are stored separately in long-term memory and can have additive memory benefits for recall. Chandler and Sweller (1991), based on research exploring the architecture and capacity limits of human working memory, suggested that instructional materials should be designed to reduce demands on cognitive load associated with the processing of unnecessary information. As cognitive load theory developed and more instructional effects were identified, evidence-based recommendations for instructional designers were developed with the intention of optimizing the use of working memory, notably when processing both visual and verbal sources of information (Clark, Nguyen, & Sweller, 2006; Sweller, Ayres, & Kalyuga, 2011).

CTML is based on three principles: the dual-channel assumption, the limited capacity assumption and, the active processing assumption (Mayer, 2003, Mayer & Moreno, 2003; Sorden, 2013). Mayer and his colleagues found evidence that the use of multimedia learning material (i.e., combined visual and auditory/verbal information) can reduce cognitive load imposed on working memory. The theory states that visual and narration information is processed in two separate channels of working memory and produces visual and auditory/verbal mental representations that integrate with prior knowledge to build new knowledge. Active learning requires learners to carry out the coordination of these cognitive processes.

CTML focuses on best practices related to the use of multimedia materials (e.g., Ayres, 2015; Mayer & Fiorella, 2014; Sweller, 2004). By carefully considering many of the design guidelines for educationally effective multimedia materials and supportive research-based principles outlined in CTML (Mayer, 2014), many of the pitfalls associated with multimodal learning may be avoided. For instance, understanding that the use of two or more modalities may be detrimental to learning if the instructional design splits learners' attention, is redundant or transient, or if the presented material does not match learners' prior knowledge. After 28-years of research, Mayer summarized the main principles of multimedia instruction.

Five principles relating to the reduction of extraneous processing involve coherence, signalling, redundancy, spatial contiguity, and temporal contiguity. Individuals' learning improves when:
- extraneous words, pictures, or sound are excluded,
- cues are added that highlight the main ideas and the organization of materials,
- animation and narration are used rather than on-screen text,
- corresponding printed text and pictures are presented close together rather than far apart on the page or screen, and
- corresponding graphics and narration are presented simultaneously rather than successively.

Three principles for managing essential processing include segmenting, pre-training and the modality principle. These principles suggest that people learn best when:
- multimedia lessons are presented as learner-paced segments rather than as continuous units,

- narrated animation includes training in the names and characteristics of main concepts, and
- graphics and narrations are used rather than on-screen text.

Two principles for fostering generative processing include personalization and voice principle and suggest that people learn better when:
- conversational style is used rather than formal style, and
- standard-accented human voice is used to present narration versus a mechanical (machine) voice.

These guidelines are built upon the multimedia principle (Cowan & Morey, 2007) that indicates that people learn more deeply from words and pictures than from words alone, and the bottom line principle that indicates that people learn better from multimedia messages when they are designed in ways that are consistent with how the human mind works.

Non-cognitive Design Recommendations

Further recommendations resulting from research on university level education provide additional ways to make instruction video podcasts more sensory and emotionally interesting. These recommendations include:
- *Keep it short*. Consider the length of video clips and to keep them at the specified time or at the minimal possible length (e.g. Bergqvist, 2012; Guo, Kim, & Rubin, 2014; Medina, 2008; Sutton-Brady, Scott, Taylor, Carabetta, & Clark, 2009).
- *Talk to students fairly fast and with empathy*. Guo et al. (2014) found that video podcasts where instructors speak fairly fast, with high enthusiasm and personal feelings, were engaging. Hibbert (2014) found that the use of humor encouraged students and made the

videos compelling. To encourage students to extend greater engagement and effort, Guo et al. (2014) further recommended that a conversational rather than formal language style of voice be used. Consistent with the personalization principle of CTML, Mayer (2014) recommended narration in first (I, we) and second person (you) (Mayer, 2014).

Method

The method section describes the procedures used for initiating, structuring, planning and receiving in-service teachers' feedback about video podcasts and the resulting recommendations. The assumption is that learners will have a quality learning experience when they are presented with quality video podcasts that they like and want to learn from. The study included a community of in-service teachers enrolled in a program of continuing university mathematics education on a national basis. The program was directed at teachers with teaching certificates who already worked as teachers. In order to explore how video podcast materials produced for the distant education settings can be improved, and thus university educators' teaching of mathematics, this study investigated how in-service teachers perceived video podcasts when used in a natural, authentic, online learning situation.

The study was conducted in the first semester of a one-year study program and used mainly open-ended survey data. The study also drew on the cognitive theory of multimedia learning and as well as links to research-based principles for the design of multimedia. The successive production of 53 video podcasts was guided upon research-based recommendations for effective multimedia design including:
1. *Establishing context*. Context was explained and connected to previous

mathematical knowledge and key concepts (Bransford, Brown, & Cocking, 2000; Kay, 2014).

2. *Content weeding*. Unnecessary information was eliminated (Clark & Mayer, 2008; Ibrahim, Antonenko, Greenwood, & Wheeler, 2012; Mayer & Morano, 2003).

3. *Layout and dynamics*. Layout was planned and space organized, including the appearance and disappearance of elements, segments, and callouts (Ibrahim et al., 2012).

4. *Visuals and narrating*. Relevant and clear visuals and animations were used with synchronized narration (Mayer, 2014).

5. *Voice and pace.* Conversational, relaxed tone and relatively quick narration was used (Guo et al., 2014; Kay, 2014).

6. *Personal addressing.* Narrators addressed students with energy, enthusiasm, familiarity, and openness (Guo et al., 2014; Mayer, 2014).

7. *Guiding attention*. Critical elements and relations were identified visually and emphasized on the screen (e.g., by temporarily spot-highlighting, using different colours or contrasts, circling, sketching, calling out, or zooming: Mayer, 2014).

8. *Step-by-step*. Worked-examples were presented in a step-by-step fashion with key elements briefly explained (Kay, 2014).

9. *Video length*. Video clips were kept short (Bergqvist, 2012).

10. *Investing in editing*. Post-production included the removal of background sounds including breathing, clearing of throat, the inserting of short, silent pauses, and the hiding of pointers where not needed (Guo et al., 2014).

Video podcasts were recorded using the screencasting software *Camtasia* (v.7) and media-rich power point slides, with recordings edited before uploading and organized on the course web page. Each podcast was developed with stand-alone instructions created for and implemented in a particular online lesson, along with a PDF-copy of the power point presentation. For one topic only, two series of podcasts were offered each with a clickable, two-level, table of contents.

Throughout the semester, weekly surveys were used to provoke in-service teachers' reflections about their video podcast experiences. Continuously collecting and monitoring participants' responses improved the ongoing development of the videos and provided key data for future studies.

Participants

The analysis included data gathered from 14 in-service teachers (7 male and 7 female), over a half academic year (2013). The in-service teachers worked in schools (mainly grades 8-10) and ranged between 26.8 years to 56.1 years of age (mean = 42.2 years). Participants attended Algebra and Number Theory (15 ECTS) as the first part of the Year 1 mathematics program delivered entirely online.

Setting

The online environment for the course is considered the project setting. The course was delivered using the university's learning management system (LMS), *Fronter*. Content and activities were arranged across nine online lessons provided as a multimedial text consisting of an introduction, table of contents, learning goals, and followed by chapters of different topics in the subject area. A digital text-video format (Engebretsen, 2006) was chosen with clickable video thumbnails integrated in the body text in a tabloid fashion. Chapters included tasks and exercises as well as quizzes and surveys created in the LMS test tool and links to external resources.

Data Collection

A series of seven online questionnaires was conducted, each asking the in-service teachers to respond to two video podcasts of their choice, except for one survey addressing only one podcast. In the first part of the questionnaire, every podcast associated with a particular lesson was identified by its thumbnail, title, and time-stand. Participants were asked to determine (1) whether the content or subject area was new or known (i.e., new to me, somewhat familiar, well known), (2) degree of time spent viewing the podcast (i.e., not seen, partially seen, completely seen, seen more than once), and (3) whether they planned to review the podcast (will not rewatch, expect to rewatch later, don't know).

In part two, the in-service teachers were asked to describe the quality of each video podcast in relation to the impact of specific design features (e.g., voice and graphics, length and chunking of information) and their motivation and learning. Lastly participants were invited to suggest what could be done to improve the podcast's quality with respect to supporting the learning process. Feedback was gathered along 10 dimensions:
First impression. Consider your impression of the podcast.
Special point-out. Consider what you think is special about this podcast.
Duration. Consider the length.
Content delivery. Consider the quality of content delivery.
Dosage delivery. Consider the quantity of content delivery.
Voice delivery. Consider the quality of voice delivery.
Graphic delivery. Consider the quality of graphic delivery.
Conditions for learning. Consider the podcast's contributions to your learning conditions.
Learning process. Consider the podcast's impact on your learning process.

Potential for improvement. Consider what could be done to improve the quality of the podcast for supporting the learning process.

The LMS test module was used for collecting and processing responses. Settings required response entries for each question and the exclusion of multiple submissions. The opening time for each survey paralleled the deadline for required tests and assignments related to particular lessons. Participation was voluntary and respondents were not anonymous so that their responses could be studied over time. Permission was obtained to use participants' data for research purposes, with names encoded in numeric form.

Data Analysis

Responses to close-ended questions were organized and coded into major categories using *Microsoft Excel*. The open-ended responses were classified by coding. Coding was mainly guided by the research questions, and along the themes in the questionnaire. Coding included identifying and classifying positive and negative and statements concerning the video podcast, the integration of video podcasts in the learning process and perceived learning outcomes, and recommendations. These organized lists were exported to *Google Drive* for further formatting, reading, and analysis.

The frequency of a theme was used to identify it as a key factor for quality and, if ranked as either moderate or higher, as a recommendation for further development. Rankings of the theme's influence on learning were categorized by the researchers using the following ordinal scale (where numbers neither do indicate equal intervals between scales nor absolute quantities): 0=not identified, 1=very low influence, 2=low influence, 3=moderate influence, 4=high influence, and 5=very high influence.

Results

On average, 14 participants responded to 2.5 questionnaires (35.7%), 10 (71.4%) responded to at least one questionnaire, and two responded (14.3%) to all the questionnaires. In total, 64 video podcast responses were submitted (Table 1), with participants selecting 22 podcasts (38.6%) in total in their responses. Eight of the podcasts were considered short (1-5 minutes), nine were considered moderate (6-15 minutes), and five were considered long (more than 15 minutes). Of these five, two consisted of a series of podcasts. Overall, selected podcasts consisted of topic presentations (95.3%) and examples (4.7%). None of the selected podcasts contained worked examples. The podcast length and the speaker's narration were identified as key factors for perceived quality being ranked on average as holding "high influence" and "moderate influence", respectively.

Table 1
Frequency of In-Service Teachers' Podcast Selections

| Length | *n* | Content | | | |
		PT	PE	WE	Total
Short	8	19	2	0	21
Moderate	9	23	1	0	24
Long	5	19	0	0	19
Total	22	61	3	0	64

Note. Length: Short = 1-5 minutes, Moderate = 6-15 minutes, Long = more than 15 minutes
Key for Table 1: Presentation topic (PT); Presentation Example (PE); Worked example (WE)

Length

In-service teachers described the length of podcasts in both the short and moderate categories as "fine", "OK", "fitting", "suitable" and "tolerable", with one exception. One participant found one of the podcasts too long (8:36 min), indicating that she was familiar with the topic presented, perceived the content to be easy, and found the podcast to be somewhat boring.

In-service teachers' feedback differed with respect to podcasts categorized as long. Several of the longer podcasts were perceived as too long, regardless of whether or not the topic was known or considered interesting. For example, one presentation that was 23:48 minutes in length and only slightly segmented was reported to be too long by five out of the six in-service teachers who responded to it. "I had to rewind the podcast when slipping out of it", one of the participants complained. Another suggested splitting the podcast. By contrast, another topic presentation 21:51 minutes in length, was considered to be of suitable length by all those who responded to it.

In-service teachers appreciated the orderly arrangement of podcast collections for the two, podcast series (21:53 and 50:34 minutes respectively). They made the following comments about length: "Ok", "Fine", "OK - but too long", and indicated how they were used, "[Too] much [to watch], if you are not looking for specific themes, but good for watching the whole [series]". Thus, participants indicated that video podcasts should not be too long if in-service teachers were to enjoy them.

Narration

Although respondents were not asked directly about whether the pace of certain podcasts were appropriate, 14 (23.0%) of the total 61 podcast responses related to pace, with four of the 10 in-service teachers (40.0%) mentioning pace in at least one survey response. Slowing the pace was recommended for four (28.6%) of the14 podcast responses. In one instance, the respondent was unfamiliar with two of the topics, while in another two of the topics were "a little known". The remaining comments indicated that the overall pace of the podcast was appropriate or better (slower) than in previous podcasts. Respondents unfamiliar with the topic preferred a slower pace, sometimes in order to facilitate note taking. Responding to the participants' feedback, the narrator attempted to maintain a slightly slower pace where new, complex content was to be introduced in subsequent podcasts.

Overall, the native-speaker's narration was ranked highly for clear pronunciation, appropriate tone of voice, and proper intonation. However some critique occurred. For example, one participant commented that single words were a "distracting annoyance", "taking the focus off from learning". Three of the total responses referred to the pronunciation of the mathematical term "x^2", pronounced as "x [iː ˈɑːndə]". The narrator, coming from a certain region of Norway, pronounced the term with a non-present "r" compared to how it is spoken in the rest of the country: "x [iː ˈɑːndrə]". For that reason, pronouncing the words "correctly" was indicated as a potential area for improvement. The second criticism of the narration came from the first survey and related to parts of a screencast video where text was read out. Participants suggested, "expanding the narration beyond the text on the screen" as an area for improvement.

Other

The design and quality of the video podcasts were perceived to be acceptable and attractive and were described as "clean and organized", "neat and tidy", "clear layout, friendly and serious tone". In-service teachers' main response to the quantity of content delivery in the video podcasts was "suitable".

Participants indicated, without exception, that the use of video podcasts was welcomed, offering variety and motivation for learning. According to the open-ended questions about the learning process, in-service teachers made positive comments about using video podcasts in learning mathematics, "good for preparation of assignments", "useful as a summary", "works well as repetition", "fruitful to see examples" and "informative". More general positive comments were also provided, with these positive comments reflecting three categories related to efficiency, enjoyment, and concentration.

Efficiency. In-service teachers commented that video podcasts were effective for learning. Participants' comments included, "I like to both see, hear and record simultaneously for effective learning" and "The videos are effective for learning".

Enjoyment. In-service teachers also made specific reference to video podcasts as enjoyable. Typical comments included, "Videos are very useful and enjoyable! They facilitate learning a lot. Makes me sure that I have read is correct" and "Enjoyable to learn something new".

Concentration. In-service teachers made specific reference to video podcasts helping them maintain their focus and concentration. Participants' stated, "The videos are so interesting that I manage to stay concentrated" and "I keep concentration".

Discussion and Conclusions

In this study, we, the researcher-educators, developed video podcasts following guidelines based on research. Then we explored in-service teachers' self-reported experiences using self-selected video podcasts. In general, podcasts appeared to support the in-service teachers in their abilities to stay on task. As part of our study, we wanted to understand participants' perspectives and understandings so that we could make informed decisions with respect to ongoing podcast development. We wanted to develop video podcasts from which in-service teachers wanted to learn mathematics, which in turn, would ultimately improve the overall quality of mathematics teaching. The findings of this study are very important for the entire R&D project, and will form a basis for future project work.

In-service teachers appeared to respond fairly positively to the quality and design of the video podcasts including voice and graphic delivery, and length and chunking of information. At the same time, the in-service teachers identified and described obstacles that they experienced when using video podcasts as part of their learning including perceiving some videos as being too long, narrator mispronunciations, and the verbatim reading of materials.

Participants also encouraged specific design improvements that, from their perspective, would improve the capacity of the podcasts to provide better learning support. In-service teachers' perceptions about the quality of the video podcasts helped address certain adjustment challenges including how to keep the video podcasts user friendly thus improving further development of educational podcasts for the teaching of mathematics. We noted the following recommendations for further video podcast development:

- Keep video podcasts at the minimal length possible.
- Avoid dialectical words or phrases that may - even slightly - differ from the audience's.
- Avoid reading exactly what is written on the screen - even minor paragraphs.
- Narrate in a serious but friendly voice.

The researchers will take the recommendations drawn from the study and encompass them into the list of guidelines. These recommendations also may be of interest to other university teachers developing educational podcasts and seeking to enhance their instruction. It is also worth noting that efficiency, enjoyment, and concentration were central conditions for these in-service teachers when they learned mathematics through video podcasts.

In-service teachers' consistent responses in the subsequent questionnaires strengthen the internal validity of the study. There are similarities between our findings and previous research conducted by Kay (2014) and Mayer (2014) and upon which our podcast development was guided. These similarities in findings offer some degree of transferability and strengthen the external validity of the findings. We acknowledge that while the open questions used as part of the questionnaire allowed respondents to elaborate their responses, it also required more time to complete. This may be a limitation of the study resulting in the obtainment of a smaller number of responses or less extensive responses.

Future Work

A new questionnaire and in-depth interview was proposed to be held in the semester following this research study, focusing on participants' learning experiences using video podcasts embedded in online lessons. Questions

posed will explore why and to what degree efficiency, enjoyment, and concentration are perceived to be central conditions when learning mathematics through video podcasts, conditions that were pronounced responses in the current study.

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Authors

Cornelia Brodahl, is an Associate Professor in ICT and learning at the University of Agder and holds a Master's degree in Mathematics. Her research interests include mathematics education with digital tools. Cornelia can be contacted at: cornelia.brodahl@uia.no

Unni Wathne, PhD, is an Associate Professor in mathematics education at the University of Agder. She is interested in and does research on teaching and learning mathematics in all phases of education. Unni can be contacted at unni.wathne@uia.no