Examining the Use of Worked Example Video Podcasts in Middle School Mathematics Classrooms: A Formative Analysis

Étude sur l'utilisation de podcasts d'exemples pratiques dans des classes de mathématiques à l'école secondaire de premier cycle: une analyse formative

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Abstract

Video podcasts allow students to control when, where, and what they learn, as well as the pace of learning. Considerable research has been conducted in higher education on video podcast use, but not in middle schools (grades six to eight). This study investigated the use of worked example video podcasts in mathematics classrooms with students 11 to 13 years old. One hundred thirty-six pupils individually watched video podcasts designed to teach basic mathematics concepts. Students were positive about the quality of worked example video podcasts and appreciated the step-by-step, easy-to-follow explanations, diagrams, and being able to control the pace of learning. Learning performance increased significantly after using worked example video podcasts. There were no gender or grade level differences in attitudes toward worked example video podcasts or learning performance.

Résumé

Les podcasts vidéo permettent aux étudiants de contrôler quand, où, et ce qu'ils apprennent, ainsi que le rythme d'apprentissage. Un grand nombre de recherches ont été menées sur l'utilisation de podcasts vidéo dans l'enseignement supérieur, mais pas dans les écoles secondaires de premier cycle (classes de sixième à huitième). Cette étude a examiné l'utilisation des podcasts vidéo d'exercices pratiques dans des classes de mathématiques avec des élèves de 11 à 13 ans. Cent trente-six élèves ont regardé individuellement des podcasts vidéo conçus pour enseigner des concepts mathématiques de base. L'évaluation des élèves a été positives quant à la qualité de podcasts vidéo et ils ont apprécié les explications par étapes et faciles à suivre, les schémas ainsi que la possibilité de contrôler le rythme de l'apprentissage. La performance d'apprentissage s'est améliorée de manière significative après l'utilisation des podcasts vidéo. Il n'y avait de pas de différence selon le sexe ou le niveau scolaire dans les attitudes envers les podcasts vidéo ou dans la performance d'apprentissage.

Keywords: middle school; secondary school; mathematics; video podcasts; online videos; video clips; impact; learning; attitudes

Mots-clés: école secondaire de premier cycle, enseignement secondaire, mathématiques, podcast vidéo, vidéos en ligne, clips vidéo, impact, apprentissage, attitudes

Introduction

Video podcasts are audiovisual files that are shared in a digital format over the Internet using personal computers or mobile devices (McGarr, 2009). Key benefits of using video podcasts in educational settings include improved learning and study habits (e.g., Heilesen, 2010; Jarvis & Dickie, 2009; Leijen, Lam, Wildschut, Simons, & Admiraal, 2009; McCombs & Liu, 2007), positive student attitudes toward learning (e.g., Dupagne, Millette, & Grinfeder, 2009; Hill & Nelson, 2011; Vajoczki, Watt, Marquis, & Holshausen, 2010) and increased learning performance (e.g., Crippen & Earl, 2004; Griffin, Mitchell, & Thompson, 2009; Traphagan, Kusera, & Kishi, 2010; Vajoczki et al., 2010). However, the main advantage of video podcasts is student control over when and where they learn (e.g., Hill & Nelson, 2011; Jarvis & Dickie, 2010; Winterbottom, 2007), what they need to learn (e.g., Fill & Ottewill, 2006; Heilesen, 2010), and the pace of learning (e.g., Chester, Buntine, Hammond, & Atkinson, 2011; Fill & Ottewill, 2006; Griffin et al., 2009).

Worked example video podcasts provide step-by-step explanations of specific procedural problems. This type of podcast is particularly useful when students are beginning to learn fundamental concepts. Limited research has been conducted on worked example video podcasts (Crippen & Earl, 2004; Loomes, Shafarenkob, & Loomes, 2002). The main objective of this paper is to explore and evaluate the use of worked example video podcasts in middle school mathematics classrooms.

Literature Review

Worked Example Video Podcasts

Worked example video podcasts provide step-by-step explanations of specific procedural problems, often found in more formal subject areas such as mathematics or science (Atikinson, Derry, Renkl, & Wortham, 2000). This form of teaching and learning is becoming more prevalent in the domain of education as reflected by a recent grant of seven million dollars from the Gates and O'Sullivan foundations to the Khan Academy (http://www.khanacademy.org), one of the largest and best known, non-profit depositories of worked example video podcasts (Watters, 2011). However, based on a detailed review of the research (Kay, 2012), just two peer-reviewed studies, both targeting higher education students, have examined worked example video podcasts. Loomes et al. (2002) explored the possible benefits of worked example video podcasts but did not formally examine their impact on student attitudes or learning. Crippen and Earl (2004) observed that undergraduate chemistry students had positive attitudes toward worked example video podcasts and higher test scores.

Worked example video podcasts in mathematics have not been researched in higher education or middle school environments. Nonetheless, the benefits of using written worked examples are well established (Atikinson et al., 2000; Clark & Mayer, 2008; Kirschner, Sweller, & Clark,

2006; Renkl, 2005; Zhu & Simon, 1987). One of the main advantages, particularly for novice learners, is to moderate cognitive load (Kester, Lehnen, Van Gerven, & Kirschner, 2006; Sweller, 1988; Sweller, van Merriënboer, & Paas, 1998). When approaching an unfamiliar problem, a well-presented worked example can offer sufficient scaffolding to prevent a student from being cognitively overwhelmed. Ideally, extraneous cognitive load (processes that do not support learning) is minimized and germane cognitive load (processes that directly support learning) is maximized. Video podcasts add an additional level of control over cognitive load by allowing students to stop, rewind, and play explanations when needed.

It could be argued that the use of passively presented worked examples is overshadowed by a constructive-based approach to learning where students are encouraged to explore in a more open-ended environment and test "what if" scenarios in order to build knowledge (see Kirschner et al., 2006 for a review). The constructivist approach is widely embraced by many educational communities; however, Kirschner et al. (2006) provide substantial evidence that direct instruction through the use of worked examples is significantly more effective when students have a limited understanding of concepts to be learned. On the other hand, more knowledgeable students may not find worked examples especially helpful because explanations are considered too slow and simple (Clark & Mayer, 2008).

In summary, the use of worked examples is a potentially promising teaching approach to assist novice learners in understanding and solving procedural-based problems.

Video Podcasts in Middle Schools

An extensive review of the research (Kay, 2012) revealed only three peer-reviewed studies examining the use of video podcasts in middle schools, none of which used a worked example format. Cihak, Fahrenfrog, Ayres, and Smith (2010) reported, in a small case study, that video podcasts delivered through a mobile device helped four autistic students develop independent transition behaviors in school. The results were based on observational data from the researcher and the classroom teachers. Boster, Meyer, Roberto, Inge, and Strom (2006) observed that third and eighth grade students who watched social science and science video podcasts scored significantly higher on tests than their peers who did not watch video podcasts. Finally, in a follow up study focussing on mathematics, Boster et al., (2007) reported that sixth and eighth grade students who viewed video podcasts performed significantly better than control groups who did not view the video podcasts. None of these studies explored student attitudes toward video podcasts.

Video Podcasts - Higher Education

Because research is limited on the use of video podcasts in middle schools, it is necessary to draw on research conducted in higher education to examine the potential range of benefits that might emerge. Since 2006, research on the use of video podcasts in colleges and universities has grown rapidly (e.g., Heilesen, 2010; McGarr, 2009). The majority of studies, though, have examined video podcasts in the form of lectures or supplementary materials, as opposed to worked-examples. The research suggests that students find video podcasts enjoyable to watch (e.g., Winterbottom, 2007); satisfying (e.g., Traphagan et al., 2010); motivating (e.g., Hill & Nelson, 2011); intellectually stimulating (e.g., Fernandez, Simo, & Sallan, 2009); and useful, helpful, and effective with respect to improving learning (e.g., Holbrook & Dupont, 2010; Lonn

& Teasley, 2009). Students also appreciate control over when and where they learn (e.g., Hill & Nelson, 2011; Jarvis & Dickie, 2010), what they need to learn (e.g., Heilesen, 2010), and the pace of learning (e.g., Chester et al., 2011; Griffin et al., 2009). Finally, the use of video podcasts has resulted in significant gains in skills (e..g, Alpay & Gulati, 2010; So, Pow, & Hung, 2009), test scores (e.g., Crippen & Earl, 2004; Traphagan et al., 2010) and grades (Vajoczki et al., 2010; Wieling & Hoffman, 2010). Regarding gains observed in skills, test scores, and grades, none of the studies compared the use of video podcasts with other teaching methods. In summary, previous research in the domain of higher education suggests that video podcasts are readily accepted by students and have a positive impact on learning. It is unknown whether this pattern of results is applicable to worked example video podcasts in a middle school milieu.

Individual Differences and Video Podcasts

Considerable research has focussed on gender differences and computer-related behavior (see AAUW, 2000; Barker & Aspray, 2006; Kay 2008; Sanders, 2006 for detailed reviews of the literature). Overall, there is a repeated pattern of small, but statistically significant differences in computer attitude, ability, and use that often favours males. Therefore, it is reasonable to examine gender differences in any new computer-based technology to determine the impact of potential gender biases. Only two studies have looked at gender differences and the use of video podcasts. Bolliger, Supanakorn, and Boggs (2010) reported that female higher education students performed better than male students after using video podcasts. On the other hand, Chester et al. (2011) observed no significant gender differences with respect to attitudes toward or use of video podcasts for university students. No studies have looked at gender differences and video podcast use in middle schools.

A second variable that has received attention is the impact of age on computer related behavior. Bollinger et al. (2010) observed that graduate students were more motivated to use video podcasts than junior or senior students. Chester et al. (2011) added that while there were no age differences in attitudes toward video podcasts, higher education students who viewed video podcasts were significantly older than students who did not watch them. It is reasonable to speculate that video podcasts may more effective for older, more mature students who can handle the responsibility of self-guided learning. Age or grade level and video podcast use has not been examined to date, so it is unknown whether the results observed in higher education or with other technologies are applicable to younger students using worked example design.

Purpose of the Study

The purpose of this study was to evaluate student attitudes and learning performance regarding the use of worked example video podcasts in middle school mathematics classrooms. Four key research questions were addressed:

1) What are student attitudes toward worked example video podcasts?;

2) Does learning performance change as a result of using worked example video podcasts?;

3) Are there individual differences in student attitudes towards worked example video podcasts with respect to gender and grade?; and

4) Are there individual differences in student learning performance with respect to gender and grade when worked example video podcasts are used?

Method

Sample

The student sample was selected from a small community of approximately 85,000 people located in Ontario, Canada. One hundred thirty-six middle school students (72 boys, 64 girls) from grades six (n=29), seven (n=47), and eight (n=60), ranging in age from 11 to 13 years, participated in the study. Data were collected from eight different mathematics classrooms. One hundred thirty students completed the attitude survey and 136 students participated in pre- and post-tests.

Video Podcasts

Development of video podcasts

An experienced teacher developed three mathematics worked example video podcasts covering exponents (grade six, 7 min 29 seconds), the circumference of a circle (grade seven, 2 minutes 21 seconds), and multiplying monomials (grade eight, 5 minutes 14 seconds). These problems were then recorded using a screen capturing program called Camtasia (version 5). Each finished recording took approximately 15 to 20 minutes to produce. All three worked example video podcasts were then loaded and organized on the respective course web pages. See Kay (2011) for links to all three video podcasts used in the study.

Problem Format

Each worked example video podcast had the following features: a clear descriptive title, a short explanation of the concept being taught, and a series of example problems solved by the teacher in a step-by-step fashion. Students could control the worked example video podcast with the pause, stop, or play button as well as a dragging tool that permitted moving to anywhere in the video podcast.

Design features

When planning and creating the worked example video podcasts, six key features were followed based on well-researched design principles. First, the problem type was selected and segmented into clear steps (e.g., Clark & Mayer, 2008; Mayer, 2005) so that the user was not overwhelmed (Ball & Bass, 2000; Greer, 1997). Second, key elements were written down as needed in order to reduce the cognitive load of students (e.g., Clark & Mayer, 2008; Kester et al., 2006; Sweller, 1988). Third, clear visuals were used when necessary to illustrate key aspects of problems (e.g., Atkinson, Derry, Renkl & Wortham, 2000; Clark & Mayer, 2008; Rittle-Johnson & Koedinger, 2005; Tarmizi & Sweller, 1988). Fourth, important elements were highlighted in order to focus student attention (e.g., Jeung, Chandler, & Sweller, 1997; Willingham, 2009). Fifth, a relaxed, conversational, engaging voice was used to create the impression that each student was being addressed personally (e.g., Atkinson, Mayer, & Merrill, 2005; Clark & Mayer, 2008). Finally, the length of worked example video podcast was kept to a minimum to address issues of limited attention span (e.g., Medina, 2008; Renkl, 2005; Tapscott, 2009).

Procedure

At the beginning of class, students from grades six, seven, and eight completed a pre-test to assess their knowledge of the concepts being covered by the video podcasts (exponents, circumference, or multiplying monomials). They then watched their assigned worked example video podcast for as long as they needed. This process usually took no longer than ten minutes. After watching the worked example video podcast, each student immediately completed a post-test (identical to the pre-test) to assess their knowledge of the concept presented to them. Students were then asked to fill in a survey about their attitudes toward worked example video podcasts. In order for the data from surveys and pre-post test scores to be included in this study, students had to return a signed parental consent form. Participation in this study was voluntary, anonymous, and in no way impacted a student's grade. The survey questions about worked example video podcasts are presented in Appendix A.

Data Sources

Background information

Students were asked their gender and grade. More detailed information was not collected in order to preserve the anonymity of the students.

Survey Data

Students were requested to fill in a 17 item, five-point Likert scale, assessing overall attitude (1 item), quality of explanation (5 items), learning features (3 items), pace of learning (3 items), engagement (2 items), and potential purpose for using worked example video podcasts in the future (3 items). The internal reliability of the entire scale was 0.84. However, because this is considered a formative study, all items in the scale were analysed individually in order to gain further insights into the use of worked example video podcasts in middle schools.

Open-ended response question

Students were asked one question about whether they thought they could learn from worked example video podcasts. These qualitative comments were reviewed and categorized by theme. The coding scheme is presented in Appendix B.

Performance

Students were given identical pre- and post-tests targeting the concept addressed in the video podcast for each grade (exponents, circumference, and multiplying monomials). Differences between pre- and post-scores were used to measure learning performance. Note that the study was not designed to compare the use of worked example video podcasts with any other method of teaching. Rather, the assessment of learning performance was used to determine if viewing worked example video podcasts had a significant impact on short-term learning.

Results

Attitudes Toward Video Podcasts

Explanations

Eighty-percent of the students agreed or strongly agreed that the worked example video podcasts were easy to follow with problems that were well explained in a clear, step-by-step manner. The majority of students (79%) also believed the worked example video podcasts helped them understand the problem or concepts better. Some students were confused by some of the steps presented (18%), although 60% of the students experienced no confusion (Table 1).

Learning features

Almost 70% percent of the students agreed or strongly agreed that the writing on the worked example video podcasts was clear. Over 70% of the students agreed or strongly agreed that diagrams or pictures presented in the worked example video podcasts helped them understand better. Finally, just over half the students agreed or strongly agreed that good tips were provided to help solve the problems in the worked example video podcasts (Table 1).

Table 1: *Middle School Students Attitudes Toward Video Podcasts (n=130)*

Item	Mean	*SD*	Disagree[1]	Agree[2]
Overall				
1. Overall, I liked using the clip	4.03	(1.00)	8%	77%
Explanation				
2. The clip was easy to follow.	4.10	(0.92)	5%	80%
3. The problem was explained well.	4.06	(0.95)	8%	80%
4. All steps were explained clearly.	4.08	(0.97)	7%	78%
5. I was confused by some steps.	2.27	(1.22)	60%	18%
6. This clip helped me understand.	4.15	(0.95)	6%	79%
Learning Features				
7. Writing in the clips was easy to read.	3.88	(0.99)	11%	68%
8. Diagrams helped me understand.	4.02	(0.97)	8%	72%
9. Good tips were provided.	3.55	(1.01)	12%	52%
Pace				
10. The clip was too long.	2.62	(1.16)	45%	21%
11. The clip went too fast for me.	1.97	(1.06)	72%	9%
12. I used pause feature to stop the clip.	1.48	(1.00)	88%	8%
Engagement				
13. The clip was boring.	3.21	(1.22)	29%	41%
14. Like better than using a textbook.	4.42	(0.98)	6%	86%
Future Purpose				
15. Clips would be helpful for homework	3.53	(1.31)	19%	57%
16. I would use this clip to review for tests.	3.61	(1.26)	17%	58%
17. Clips would be helpful for extra help.	3.28	(1.27)	26%	45%

[1] Both Disagree and Strongly Disagree
[2] Both Agree and Strongly Agree

Pace

Most students were comfortable with the length of the worked example video podcasts; however, 20% percent agreed or strongly agreed that they were too long. Over 70% of the students agreed or strongly agreed that the worked example video podcasts were not too fast. Finally, less than 10% of the students used the pause feature while they watched the worked example video podcast (Table 1).

Engagement

Forty-one percent of the students agreed or strongly agreed that the worked example video podcasts were boring, 29% thought they were not boring, and 30% were neutral. Almost 90% of the students agreed or strongly agreed that watching the worked example video podcasts was better than using the textbook (Table 1).

Future use

Almost 60% of the students agreed or strongly agreed that the worked example video podcasts would be helpful for homework or reviewing for tests. Forty-five percent of the students agreed or strongly agreed that the worked example video podcasts would be useful when they needed extra help and did not have time to meet the teacher (Table 1).

Learning Performance and Video Podcasts

Independent t-tests, run using SPSS 19.0, revealed that learning performance scores increased significantly for grade six ($p < .001$), seven ($p < .001$), and eight ($p < .001$) students. The average percent increase for all three grades was 66%. The effect sizes for these gains, based on Cohen's d, are considered large for all three grades, with changes ranging from two to three standard deviations (Cohen, 1988, 1992) (Table 2).

Table 2: *Pre vs. Post Mathematics Test Scores with Worked Example Video Podcasts*

Topic	Pre VP Mean % (SD)	Post VP Mean % (SD)	% Chg	Sig. of t value	Cohen's d
Grade 6 (n=29)	23.4 (30.2)	84.0 (17.9)	60.6	10.9 *	2.44
Grade 7 (n=47)	17.0 (24.5)	85.1 (22.5)	68.1	15.9 *	2.90
Grade 8 (n=60)	4.1 (12.0)	71.7 (29.5)	67.6	17.9 *	3.00
Total (n=136)	12.7 (22.8)	79.0 (25.7)	66.3	26.3*	2.72

* $p < .001$

Perceived Learning Benefits and Challenges of Using Video Podcast

Students offered 129 comments about the learning potential of worked example video podcasts. Almost 90% (n=114) of the comments were positive, five percent were neutral (n=7), and six percent (n=8) were negative. Five themes emerged from the content analysis including general comments, learning, comparisons with other methods of teaching, getting support, and engagement. Each of these will be discussed in turn.

General comments

Based on the survey data, almost 80% of the students liked using worked example video podcasts (Table 2). Student comments about the general impact of worked example video podcasts were consistent with this rating. Almost 30% of all comments (n=35) indicated that students thought worked example video podcasts were useful and helped them understand concepts better. Sample comments included:

> "I actually knew what to do after [the video podcast] was done."
> "Before I didn't know how to do it at all, but now it is easy."
> "The clip helped me learn something I didn't know before."

Only one student made a negative comment, stating that the worked example video podcast "was not really [helpful], [but] it was a lot more fun to go through."

Learning

The largest content category was learning comprising over 45% (n=59) of all student comments. Students focussed primarily on explanations provided in the worked example video podcasts (n=42). Typical comments were:

> "The clip was explained well."
> "Yes, this clip would help me to learn because it was clear, explained well and
> showed you each step."
> "The person explaining was thorough."

Only one student offered a negative comment about learning explanations, noting that the worked example video podcast was "confusing and didn't completely explain [the concept]."

Some students also commented on the pace of learning (n=8) appreciating that the instructor took her time when explaining the problem (e.g., "[It moved] slowly and [was] easy to follow," "The person took her time."). One student noted that the worked example video podcast "could have gone slower."

Several students (n=5) commented that the visual representations in the worked example video podcasts were helpful (e.g., "There are pictures to help.", "It is easier to learn visually.", "The moving diagram ... guided me through the problem."). Two students added that they liked being able to control the flow of learning (e.g., "You can control if you want to stop and go back to something."). Finally, a couple of students remarked on the quality and quantity of examples (e.g., "[The video podcast] does more than one [example]. It goes from easy to medium to hard.", "It has very clear examples.")

Compare

A number of students compared the use of worked example video podcasts to other methods of teaching (n=20, 16% of all comments). Some students (n=11) felt that using worked example video podcasts was better than learning in the classroom because there were fewer interruptions, teachers did not always have the time to explain concepts clearly, and sometimes they were reluctant to ask questions. Here are some representative comments:

"During lessons there are always interruptions, so it is hard to follow."
"The teacher doesn't always have time to explain every single thing."
"Some people may be afraid to ask the teacher for help and this way they will get
the help that they need."
"It is more fun than hearing a teacher talk."

Others students (n=8) commented that they preferred using worked example video podcasts over working through textbooks. Sample comments included:

"[Video podcasts are] easier to understand than the textbook."
"Yes [video podcasts] definitely would help me because ... the textbook rarely
helps me."
"It would take me longer if I used a textbook."

Support

Several students (n=8) viewed worked example video podcasts as a good support or backup tool when they missed a few steps in class or an entire lesson, forgot what the teacher explained, got stuck on a particular question, did not have time to meet the teacher, were working at home, or needed to review for a test. Sample comments are:

"Yes [video podcasts] would [help] because sometimes I miss a few steps in
class."
"[Video podcasts] would help if you missed a lesson and needed to catch up."
"Yes [video podcasts] would really help me a lot because if I am at home I can
get help."
"Yes [video podcasts] definitely would help me because I don't have extra time
for help with teachers."
"I think [video podcasts] could come in handy for studying for a test."

Engagement

Six students commented on the engagement value of worked example video podcasts. Four students felt they were more fun (e.g., "[Video podcasts are] fun and interactive.", "[Video podcasts] were a lot more fun.") and two students thought they were boring.

Individual Differences in Attitudes Toward Video Podcasts

Gender

To assess gender differences in attitudes toward video podcasts, a MANOVA (using SPSS 19.0) was conducted using the 17 attitude scale items (Appendix A). Based on Hotelling's t (*ns*), no significant differences were observed between boys' and girls' attitudes toward video podcasts.

Grade level

To assess differences among the three grade levels (six, seven, and eight) in attitudes toward video podcasts, a MANOVA (using SPSS 19.0) was conducted with the 17 attitude scale items

(Appendix A). Based on Hotelling's t (*ns*), no significant differences were found among grade levels and attitudes toward video podcasts.

Individual Differences in Learning Performance and Video Podcasts

Gender

An independent t-test (using SPSS 19.0) comparing change in learning performance scores between boys (*M*=63.0, *SD* = 32.8) and girls (*M*=70.0, *SD* = 24.6) revealed no significant differences (*t*=1.40, *df*=134).

Grade level

A one-way ANOVA (using SPSS 19.0) comparing change in learning performance scores between grades six (*M*=60.6, *SD* = 29.8), seven (*M*=68.1, *SD* = 29.4), and eight (*M*=67.6, *SD* = 29.3) revealed no significant differences (*F*=0.68, *df*=2,133).

Discussion

Student Attitudes Toward Video Podcasts

Middle school students in this study had positive attitudes toward worked example video podcasts used to teach mathematical concepts. Both survey data and open ended responses indicated that they particularly appreciated the quality of explanations presented noting that they were easy to follow, clear, and helpful. These findings are consistent with those observed in higher education (e.g., Holbrook & Dupont, 2010; Lonn & Teasley, 2009). They may also reflect the design decision strategy used in this study as suggested by Clark and Meyer (2008), namely to break down problems into clear steps so that students are not cognitively overwhelmed.

Student ratings and comments also suggested that key learning features such as clear writing and the use of visual aids were helpful. While not directly tested, the results indirectly support the worked example video podcast design followed in this study: clear writing of key elements to reduce cognitive load (e.g., Kester et al., 2006; Sweller, 2003), using clear visuals to illustrate important concepts (Clark & Meyer, 2008), and highlighting to focus student attention (e.g., Willingham, 2009).

Based on survey data and comments, most middle school students thought the length and pace of the worked example video podcasts were appropriate. This finding is consistent with research suggesting that video podcasts should be concise in order to address students' limited attention span (e.g., Medina, 2008; Tapscott, 2009). However, twenty percent of the middle school students felt the worked example video podcasts were too long. This finding could be explained by cognitive load theory (e.g., Kester et al., 2006; Sweller, 1988; Sweller et al., 1998) and the limitations of worked examples when used with more experienced students. Pre-test scores were quite low (Table 2) indicating that most students were novices with respect to the concepts being taught and would respond better to a slower, detailed explanation. However, more knowledgeable students may have been frustrated by the slower pace and rated video podcasts as being too long.

Somewhat surprisingly, less than 10% of the students used the pause button to control the pace of learning. In addition, only two students commented that they liked being able to go back and review parts of the worked example video podcast. Previous research in higher education suggested that students like to control the pace of learning (e.g., Chester et al., 2011; Griffin et al., 2009). One possible explanation is that the pace of learning for worked example video podcasts in the current study matched most students' comprehension levels and therefore it was not necessary to stop and review misunderstood material. Future research is needed, perhaps in the form of focus groups or interview data, in order to understand control over worked example video podcasts for middle school students.

The majority of students rated worked example video podcasts as either neutral or boring in terms of engagement. Only a handful of students made comments about the worked example video podcasts being fun and enjoyable. This finding is somewhat contradictory to previous research on video podcast use in higher education classrooms where students viewed them as enjoyable to watch, satisfying, motivating, and intellectually stimulating (e.g., Fernandez et al., 2009; Hill & Nelson, 2011; Traphagan et al., 2010; Winterbottom, 2007). On the other hand, given the range and variety of technological toys available to today's students, worked example video podcasts of mathematical explanations would probably be considered less engaging.

On average, almost 60% of middle school students agreed or strongly agreed that worked example video podcasts would help them with homework or to review for tests. Almost half the students thought the worked example video podcasts would be helpful when they did not have time to see the teacher for extra help. These expectations are consistent with previous experiences of higher education students and the use of video podcasts outside the classroom (e.g., Holbrook & Dupont, 2010; Lonn & Teasley, 2009).

In summary, previous research has not examined middle school students' attitudes toward worked example video podcasts. The results in the current study strongly suggest that students appreciate good explanations, careful pacing, and memory aids such as clear writing and diagrams. They also view worked example video podcasts as potentially useful supports outside the classroom.

Learning Performance and Video Podcasts

The results of this study indicate that the worked example video podcasts had a significant statistical and practical impact on middle school students' short-term learning performance for three mathematical concepts. Students had very little knowledge of the concept being taught with a mean pre-score of 12 percent. After they watched the worked example video podcasts, their test scores increased by more than 65%. This sizeable gain can be largely attributed to the use of video podcasts as no other intervention or stimulus was used. It is possible that the priming effect of completing a pre-test could have contributed to increases in post-test scores. However, since pre-test scores were so low, it is unlikely that students understood the pre-test problems well enough to boost performance in the post-test.

Improvement in performance is consistent with gains observed in previous research studies for middle school (e.g., Boster et al., 2006, 2007; Cihak et al., 2010) and higher education environments (Alpay & Gulati, 2010; Crippen & Earl, 2004; So et al., 2009; Traphagan et al., 2010; Vajoczki et al., 2010; Wieling & Hoffman, 2010). It is important to recognize that this

study makes no claim that video podcasts work better than other forms of teaching. The primary conclusion is that worked example video podcasts were effective in helping middle school students learn how to solve procedural mathematics problems.

Individual Differences and Video Podcasts

 Previous research on differences between males and females and video podcast behavior was mixed with one study reporting significant learning performance gains in favour of females (Bolliger et al., 2010) and another study reporting no gender differences in attitude and use (Chester et al., 2011). However, research on gender differences in the use of technology in general (e.g., AAUW, 2000; Barker & Aspray, 2006; Kay 2008; Sanders, 2006) suggested that males might respond more positively to video podcasts. The current study found no significant differences between boys and girls with respect to either attitudes about worked example video podcasts or learning performance. Worked example mathematics video podcasts used in this study were essentially gender neutral. It is difficult to speculate why gender differences occur in some studies and not in others. Future research needs to investigate this issue more deeply, perhaps with the use of post-task interviews, to come up with a reasonable explanation.

Two recent studies suggested that older university students appreciated and were more motivated to use video podcasts that their younger counterparts (Bolliger et al., 2010; Chester et al., 2011). Results from the current study indicated that their were no significant differences in attitudes and learning performance among grade levels when worked example video podcasts were used. It is possible that the age range covered in this study (11 to 13 years olds) was too narrow to differentiate affective and cognitive responses to video podcasts. One can only conclude that video podcasts appear to be equally accepted and useful in grade six, seven, and eight classrooms.

Educational Implications

The current study is a formative effort to investigate the use of worked example video podcasts with middle school students, so it would be premature to make strong recommendations for educators wanting to use this medium. However, there are several suggestions that might prove useful to future designers and users of worked example video podcasts for middle school classrooms. First, clear, slow, step-by-step explanations are greatly appreciated by students at this age level, particularly when new concepts presented. Second, students also like clear writing and visuals that support the learning process. Third, short-term learning performance can increase markedly after watching worked example video podcasts, so using these tools for homework, review of concepts, missed classes, and test preparation is a promising potential option. Finally, students who struggle with other teaching methods such a using a textbook or listening to a teacher in a large class where there can be many distractions, may benefit from listening to worked example video podcasts inside or outside of class.

Limitations and Future Research

This study explored the use of worked example video podcasts to teach mathematics concepts in middle school classrooms. Efforts were made to ensure the quality of the analysis by providing a detailed description of the worked example video podcasts used, collecting data from a moderately large sample, and employing multiple data collection tools. Nonetheless, several

limitations need to be addressed to augment future research in this area. First, student behaviors while using worked example video podcasts were not investigated explicitly. Think-aloud protocols, interviews, or focus groups with a smaller sample of middle school students would be useful to understand patterns of worked example video podcast use and specific design features that might inhibit and enhance learning. Second, since this study was a formative analysis, the reliability and validity of the survey instruments were not provided. Survey items focussing on student attitudes toward worked example video podcasts need to be further refined and developed. Third, only three worked example video podcasts were used. A broader range of concepts needs to be examined in order to firmly establish the potential benefits of using this type of podcast. Fourth, the design and presentation characteristics of video podcasts were not examined. For example, it is reasonable to assume that factors such length of podcast, language difficulty, pace, choice of examples, and explanation strategy could have a marked effect on the impact of a video podcasts. Future research needs to explore the impact of these qualities. Fifth, the sample size was moderate and more students need to be assessed to establish whether the findings are robust. Sixth, there may have been a priming effect of completing a pre-test that contributed to gains in post-test scores. Future researchers might consider using parallel but not identical pre-post tests. Finally, this study looked at short-term use of worked example video podcasts. Examining learning performance and attitudes with respect to video podcasts over a three month term or a year, would provide a more realistic perspective on the impact of these tools.

Summary

The effectiveness of written worked examples has been well established in the literature; however, this approach has yet to be assessed when communicated in the form of video podcasts. The purpose of this study was to examine student attitudes and learning performance when worked example video podcasts were used in middle school mathematics classrooms. Students were positive about step-by-step explanations that were easy to follow and taught at the right pace. They also appreciated clear writing and helpful diagrams to support learning. While some students thought the video podcasts were boring, most felt that they were better than using a textbook. Learning performance increased significantly as a direct result of using worked example video podcasts. Students thought that worked example video podcasts could be useful for homework, getting extra help when they could not meet the teacher face-to-face, and test preparation. Future research needs to look at a wider range of worked example video podcasts in more depth over a longer time period.

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Appendix A: Student Survey Assessing Attitudes Toward Video Podcasts

Item	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Overall					
1. Overall, I liked using the clip	1	2	3	4	5
Explanation					
2. The clip was easy to follow.	1	2	3	4	5
3. The problem was explained well.	1	2	3	4	5
4. All the steps in the problem were explained clearly.	1	2	3	4	5
5. I was confused by some steps.	1	2	3	4	5
6. This clip helped me to understand the problem better.	1	2	3	4	5
Learning Features					
7. The writing in the clips was easy to read.	1	2	3	4	5
8. The diagram or pictures helped me understand the problem better.	1	2	3	4	5
9. Good tips were provided to help me understand the problem.	1	2	3	4	5
Pace					
10. The clip was too long.	1	2	3	4	5
11. The clip went too fast for me.	1	2	3	4	5
12. I used the pause feature to stop the clip at some point	1	2	3	4	5
Engagement					
13. The clip was boring.	1	2	3	4	5
14. I like this clip better than using a textbook.	1	2	3	4	5
Future Purpose					
15. I would use this clip to help me with my homework.	1	2	3	4	5
16. I would use this clip to review for tests.	1	2	3	4	5
17. It is hard for me to come for extra help with the teacher after the class, so these clips would be helpful.	1	2	3	4	5

18. Would this clip help you learn? Please explain

Appendix B: Coding Scheme for Learning Benefits or Challenges Using Video Podcast

Category	Description
Learn	• Students talked about learning including quality of explanations, pace of learning, visuals, control, and examples given
Compare	• Student compare the use of video podcasts with other teaching methods such as using a textbook or being taught as a class
Support	• Student s refer to being able to get help for tests or when they do not understand a concept taught by the teacher
Engage	• Students talk about being engaged or bored by the use of video podcasts
General	• Students refer to the general positive impact of video podcasts or that they understand more after using the clips

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