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Abstract
Podcasting is a new phenomenon in Swedish schools. This paper describes a project where the main goal is to analyze if the students' interest in mathematics is affected if the mathematics is made accessible via podcasts and iPods. Teachers at eleven schools were encouraged to produce podcasts as a part of their mathematics teaching in school year eight. The results indicate an increased interest in mathematics and the learning of mathematics among the students. We also found that the technical difficulties for the teachers were underestimated in the project, and that teachers had difficulties in finding time for the production of podcasts.

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1. Introduction

During the spring of 2006 a pilot study was carried out (Gårdare, 2006) in which a teacher together with a media pedagogue were introduced to the possibility of producing podcasts as a part of the teaching of mathematics in school year 8. Teaching mathematics is a difficult endeavour. The serious problems found in the Swedish school system connected to mathematics, for instance the large emphasis on rote learning, will not be avoided simply by using podcasts. However, podcasts might offer opportunities to develop the teaching and address some of these problems, such as problems related to the low level of interest and motivation among students.

2. Project description

PIS – Podcasting In School[2] was a project that involved 11 schools and 22 teachers of mathematics in lower secondary school in Sweden. One class of approximately 25 students from each school participated. The teachers were equipped with laptop computers and video cameras. After a one-day initial training session they were encouraged to start testing on their own, and to produce short simple video recordings (podcasts) to be published on the web (for a technical discussion, see Appendix A). Examples of podcasts in mathematics from the pilot study were presented, but no other instructions concerning the content were offered. The idea behind the low level of instruction to the teachers had to do with issues of scalability, that support could be hard to offer in a large-scale implementation.

Each school in the project was expected to involve one class and two teachers. The teachers should produce podcasts with a mathematical content, and the students would be offered the opportunity to look at the podcasts on a computer and on a video iPod[3]. In some schools subjects other than mathematics were also considered. The iPods were provided to each class for half the project time, i.e. one term with an iPod and one term without.

The research dimension of the project addressed the following overarching question:

> ”Does the students’ interest in learning increase when
> you introduce *youth culture* into the school?"

Youth culture is represented by podcasting and iPods. The research design considers affordances (action possibilities) and constraints (limitations) concerning podcasting in mathematics education, in connection to interest and motivation for learning.

2.1 Research Questions

Students interest in mathematics is central in many discussions of the problems found in the Swedish school. Of course it would be very interesting to be able to measure in an exact way how students’ performance in mathematics were affected by the use of iPods and podcasts. However, as in many other situations where a new tool or a new way of working is implemented, so many things are changing that it is almost impossible to connect a change to a single variable. Therefore we focussed on student interest in mathematics, since it is reasonable to believe that an increased student interest will result in better student performance.

The main research question we formulated is:

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[2] The project was founded by Rektorsakademien, The Swedish National Agency for School Improvement, and Apple.

[3] Video iPod is registered trademark by Apple

1. How are student's attitudes towards mathematics, and motivation to learn mathematics, affected by the use of podcasts?

This question is closely related to the overarching question. In order to reach clear answers to the main research question, we needed information concerning the podcasts as well as information on how the podcasts were used by both teachers and students. Therefore we formulated three sub questions:

2. To what extent are the teachers producing podcasts, and what characterizes the podcasts in terms of what is presented?
3. In what ways and to what extent are the students using the podcasts?
4. What characterizes the mathematical content in the podcasts, and how does this affect the students' interest?

3. Theoretical framework

3.1 Interest and motivation

The importance of interest in mathematics for mathematics learning is well accepted among mathematics education researchers, especially in connection with motivation (Op't Eynde et al 2006; Hannula 2006). Motivation is often divided into extrinsic and intrinsic motivation (e.g. Ryan & Deci, 2000). Extrinsic motivation has to do with rewards of different kinds (grades, praise from parents etc.), while intrinsic motivation is connected to the learner's curiosity and interest in learning. In this study the use of podcasting and iPods will be discussed as important for both the students' extrinsic and intrinsic motivation.

One example of a quality in the use of podcasting that might affect the students motivation is that it gives the students the possibility to decide when, and to what extent, they are to be exposed to mathematics:

> "Rather than having the teacher make all instructional decisions, offering students control over the amount and sequence of instruction, including options for review, can result in higher achievement and improve student attitudes toward learning. iPod, with its virtually limitless opportunities for playback, literally places control in students' hands." (Pasnik, S. 2006)

This means that by giving the students control over their own learning environment, it is possible to achieve positive effects in relation to both extrinsic and intrinsic motivation.

In this study the iPod as a 'cool gadget' and being a part of a large project are two examples of what might effect the extrinsic motivation, and the possibilities to look at mathematics any time and new types of mathematical presentations are examples of what might effect the intrinsic motivation.

3.2 Affordances and constraints

We find the theory of affordances and constraints (Greeno, 1994) potentially helpful in the process of data analysis. In the case of the use of ICT, an affordance can be seen as a property of the particular application e.g. the use of digital media on the iPod. As such affordances are conceived as preconditions for activity and in particular for mathematical activity in the case of this project. On the other hand the affordances provided by a device or application may be seen as conditions for constraints. The existence of an affordance for some activity is not seen to imply that the intended mathematical activity will occur, although it contributes to the pos-

sibility that it will do so. The perception and motivation to engage in the activity on the part of the user becomes a key factor to consider.

3.3 Mathematical processes

In the NCTM Standards (2000) five processes, which are important in the learning of mathematics, have a central position. Here follows a short description of how the five could be addressed in a podcast. These descriptions were used in the analysis of the podcasts, evaluating the extent to which each process is present in the analysed podcasts.

Problem Solving

> *The students should be able to build new mathematical knowledge through problem solving; solve problems that arise in mathematics and in other contexts; apply and adapt a variety of appropriate strategies to solve problems; and monitor and reflect on the process of mathematical problem solving.* (NCTM, 2000).

Podcasts that are regarded as addressing the Problem Solving process should invite students to problem solving by introducing a situation and a problem that will be discussed in the class. They could show examples of problem solving (including a discussion on how to deal with the problem) or discuss strategies to solve a specific problem. A podcast that only introduces a problem and invites the students to work with it, but does not discuss possible solutions or general problem solving strategies, addresses this process only to a small degree.

Reasoning and Proof

> *The students should be able to recognize reasoning and proof as fundamental aspects of mathematics; make and investigate mathematical conjectures; develop and evaluate mathematical arguments and proofs; select and use various types of reasoning and methods of proof.* (NCTM, 2000).

Reasoning and proof in podcasts could of course be a straight forward presentation of a proof. Other ways of addressing this process in a podcast are the introduction of a conjecture that will be investigated, examples of the use of arguments and the presentation of various types of reasoning. A podcast that introduces a conjecture and encourages the students to investigate it, addresses the process to a lesser degree.

Communication

> *The students should be able to organize and consolidate their mathematical thinking through communication; communicate their mathematical thinking coherently and clearly to peers, teachers, and others; analyze and evaluate the mathematical thinking and strategies of others; use the language of mathematics to express mathematical ideas precisely.* (NCTM, 2000).

Podcasts could either invite students to communicate their thinking or show examples off good mathematical communication. In the latter the difference between a clear mathematical language and everyday language could be highlighted. Another possibility is also that a podcast contain, or invite to, the evaluation of mathematical communication.

Connections

> *The students should be able to recognize and use connections among mathematical ideas; understand how mathematical ideas interconnect and build on one another to produce a coherent whole; recognize and apply mathematics in contexts outside of mathematics.* (NCTM, 2000).

One part of this process is to recognize and use connections between mathematical ideas. This would mean that a podcast should present multiple mathematical ideas and discuss their con-

nections. The other part of the process deals with the relationship to real-life contexts. A podcast should then present an out-of-school situation or a school related situation that is non-mathematical in order to represent the process *Connections*.

Representations

> *The students should be able to create and use representations to organize, record, and communicate mathematical ideas; select, apply, and translate among mathematical representations to solve problems; use representations to model and interpret physical, social, and mathematical phenomena.* (NCTM, 2000).

Multiple representations in a podcast is one way to address this process. Presenting ideas or data using a representation to structure or model a situation is also a possible way. Important is also that a podcast could show how to translate between representations and how to select a suitable representation for a specific phenomena.

You can always discuss how much a certain presentation might affect students. For example, will a podcast where we have found the use of representations to show a geometric situation using algebra help the students to develop their use of multiple representations? Will a podcast that uses multiple representations to show how to solve a problem influence the students' awareness on representations? If a podcast presents a problem for the students to solve, will it help them to develop their problem solving skills, or can that only be done if the problem is solved in the podcast?

4. Method

The research questions in this study demand a variety of data collecting methods and analyses. Questionnaires, interviews and observation of podcasts have been used in this project.

4.1 Questionnaires

Two sets of questionnaires for all participants were used in the study[4]. In the beginning as well as in the end of the project questionnaires were sent out to each school, one version to the students and one to the teachers. We received answers from all teachers and near all students in the introductory questionnaire and about 75% of the teachers and students in the concluding questionnaire.

The questions to the students in the introductory questionnaire centred around four areas: questions on interest in mathematics, questions about previous experience of podcasts, questions about the use of mp3-players, and questions about expectations on the project. In the concluding questionnaire the students were asked questions on their participation in the project. Apart from questions on their interest in mathematics, we also asked other questions. How much the podcasts had been used, to what extent this had affected their normal mathematic activity, and what you can learn from a podcast are a few examples.

The questions to the teachers also concerned, apart from standard background information, four areas: questions about the participation in the project, questions about the teacher's own goals with the project, questions about the teacher's normal teaching and lessons, and questions about expectations on the project. The main use of the introductory questionnaire was as a background for the interviews. In the final questionnaire the teachers were asked questions on their activity in the project, on their experiences of making and publishing podcasts in the project, and on their opinions about the students' activities, motivation and learning in relation to the use of podcasts.

[4] All questionnaires can be found in Appendix A (in Swedish).

4.2 Interviews

In May we visited nine of the eleven schools, and in November four schools were visited. All schools were visited and two schools in the project were visited both in May and November. Interviews with teachers and students were carried out at each school. The interviews were of a semi-structured format using a pre-designed scheme (Kvale, 1997).

The teacher interviews ranged from 30 to 90 minutes, and in most cases one teacher from each school took part. The interview scheme concerned attitudes to mathematics and the use of the podcasts. In the section when we discussed the teacher's views on the possibilities and limitations we connected the interview question to the each teacher's answer to the corresponding question in the questionnaire.

The student interviews ranged from 15 to 30 minutes, and three or four students from each school took part. We were also very careful to explain to the students that their answers are very important for the research, and that they are one of our main sources of information.

All interviews were audio recorded and transcribed in a condensed form, followed by a complete transcription of important passages, i.e. passages where discussions clearly related to the research questions took place. The complete transcriptions were used in the analysis.

4.3 The podcasts

We have full access to all podcasts produced in the project. More than 100 podcasts were produced by the teachers. The size of the podcasts varies from about 2 minutes up to 10 minutes. By observing the podcasts and the teachers' short comments on each podcast, we characterized them in four categories: introductions to a new area, presentations of a concept, presentations of a method, or presentations of problems. Of course, this characterisation could have been made in other ways, but by using our characterisation we cover all podcasts in the project in a sufficient way.

A selection of eight podcasts was analysed in relation to the NCTM standards processes, two podcasts of each of the four types. The selected podcasts were produced at six different schools. Each podcast was examined for the presence of characteristics of the five processes from the NCTM Standards (see Section 3.3).

Eight students from one school in the project were asked to look at the podcasts and to answer a questionnaire about each podcast. The questions concerned the possible impact on students' interest, for example level of difficulty, how inspiring it is, and if you can learn the content better by using the podcasts compared to normal teaching. In addition to these questions there were open questions where they were asked to motivate why the podcast was inspiring or why they could learn specific things better from the podcast. The students were also asked when and why they would look at podcasts of the presented type. Each podcasts was graded on a scale from one to five where one would be "pointless podcast" and five "this is how a podcast should be".

5. Analysis

To find answers to the main research questions in this study, concerning how students' interest in mathematics, and motivation to learn mathematics is affected by the use of podcasts and iPods, we need information about the podcasts and how the teachers and students have been using podcasts, i.e. the three sub questions. Therefore we will in this section first treat the sub questions, followed by an analysis concerning the main research question.

In the analysis we have used the theory of affordances and constraints in order to find important issues that not only are interesting from the teachers' or students' perspective, but also indicate whether it is the podcast or iPod in itself that gets attention.

5.1 Research question 2: Teachers and podcasts

Two issues were put forward by the teachers as central affordances in the use of iPods and podcasts. The first was the possibility for students to take part of content when they have been absent during a lesson. This was seen as one of the most important aspects. In relation to this it is not surprising that the podcasts to a large extent had the same content as classroom presentations, especially in the beginning of the project. In addition, this affordance can also become a constraint. If teachers are very convinced that this is the best way to use podcasts they may refrain from trying other types of podcasts.

The second affordance focused on by the teachers was the possibility to show out-of-school situations in order to present the setting for a problem, and also the problem itself. In some podcasts the problems were solved, in other the students were given the problem as homework. The use of podcasts to present problems was in many schools something that came after a few months of testing and trying out the technical issues in the production. It seems possible that the teachers after the initial period wanted to do something more than just copying the classroom. One might argue that presenting a problem in a podcast is no different from doing it on paper or any other media. However, some new possibilities occur, e.g. visualisations of problem situations or solutions. One example from a podcast in this study is when the concept of VAT[5] (25% in Sweden) is discussed and rectangular blocks are used to show that you need to remove 20% in order to get the price without VAT. All in all we must conclude that only a small number of podcasts in this study contained something that could not be done in the classroom. Several teachers also said that they had asked the students what they wanted, and had got a clear answer that podcasts should cover the same content as normal lessons.

One of the two constraints highlighted by all teachers was that there was too little time to plan, produce and publish the podcasts. Since few teachers in the study were compensated regarding their workload, the production of the podcasts had to take place in their free time. On average, a teacher in the project was compensated with one hour each week but the time spent on the project was two hours per week. Most teachers had to carry out their normal assignment as well as taking part in the project, so it is not surprising that the production of podcasts declined radically for several teachers after some months. Some teachers could use the schools days for open-air activities to work with the podcasts, and some could use days specified for competence development, but on the whole, most teachers experienced the time issue as a significant problem. In spite of these experiences many teachers expressed an intent to continue to use podcasts in their teaching beyond the project.

The other constraint was that the teachers experienced a lot of technical difficulties, from the actual filming via the cutting and preparation of the podcasts, all the way to the final publication of the podcasts on the web. The most common problem had to do with the last part of the production, the uploading of the podcasts to the web, and the creation of an RSS-stream. It should be noted that the difficulties connected to filming and editing the podcasts were found to be much reduced towards the end of the project, but the difficulties connected to RSS and ftp remained during the whole project. Several teachers felt that they lacked a more thorough instruction concerning the last steps. In some school there were also difficulties originating in the fact that the project computers were Apple laptops (running Mac OS X),

[5] Swedish: MOMS.

while the school (and the municipality) were Microsoft Windows environments only. The problems could for instance be that the Apple computers couldn't run Windows programs necessary to access the municipality intranet.

All teachers in the project had experienced a lot of positive feedback from students and parents concerning the project. This was regarded as important, both from a more general school perspective and for more individual reasons, like the possibility to get previously not so interested students to take part of the mathematics teaching to a larger extent.

5.2 Research question 3: Students and podcasts

All students in the project have looked at at least one podcast, and most students have looked at almost all podcasts the teachers have produced and published. Some of the podcasts were looked at several times, in most cases as a preparation before a test. In the concluding questionnaire the students were asked if they during the project had spent a more time on mathematics compared to before the project. The students answered on average 3.2 on the 1-5-scale where 3 indicated no difference. It seems from the interviews and another question in the concluding questionnaire that the extra time spent on mathematics mainly consists of looking on the podcasts, i.e. they have not reduced the time for doing homework or preparing for a test.

The most common perceived affordance discussed by the students were that the podcasts could be used for reviewing before a test or when you wanted to learn more on a topic. In the concluding questionnaire 40% of the students gave a response with this meaning on the open question *why do you look at podcasts?* Similar statements were also found in interviews from many schools: "To be able to prepare for a test on the bus" and "during the lunch break we have no access to computers in school" were two statements that highlight the view that this affordance was important.

Other reasons for looking at the podcasts were also found. In the interviews many students mentioned catching up when missing a lesson. However, in the concluding questionnaire only about 8% of the students gave that answer. One interpretation is that this answer was given only by those students who really had been absent and then used the podcasts to catch up, but the reason could of course be that in reality students don't see missing a class as a real problem. The interviews with teachers and students indicate that the first interpretation is more accurate. Students also said that they looked at the podcasts because they had too, that it was homework. In this case there were large differences between the schools. In one school 65% of the students gave this answer and in another school no student at all.

The eight students in the special podcast evaluation were also very clear on what they wanted from a podcast. Criteria for a good podcast where:

i) You should learn something from it
ii) What you learn must be useful
iii) It should contain simple and clear explanations
iv) A podcast should be about 2.5 minutes. 1 minute is too short and 4 minutes too long.

They all agreed that *problem of the week* or *mathematical quizzes* should not be included in podcasts. However, on this issue we got other signals in the student interviews, where *problem of the week* was something that many students mentioned as something positive for their interest in mathematics.

One often heard affordance with portable media is the possibility to learn anytime, anywhere (Pasnik, S., 2006). In the interviews the possibility to look at the podcasts anytime, anywhere appealed to all the students, but in the concluding questionnaire only 15% of the

students claimed to have used the podcasts somewhere other than in their home or in school. More than 90% of all students said that they looked at podcasts at home and about 55% in school. The statement *anytime* seems to have a larger impact on the students who often claimed to have looked at the podcasts late in the night or early in the morning.

The importance of the iPods was a question where we found large differences between the schools. In the concluding questionnaire we asked the students if they preferred to look at the podcasts on a computer or on the iPod. The students from one school answered with an average of 1.9, ranging from 1 (much better on the computer) to 5(much better on the iPod). On the same question another school answered with an average of 4.0. Interesting here was that the arguments on the open follow up question *why* they preferred one over the other were almost the same from both schools: "It's easier", "quicker", "more fun" etc. We don't really know the reason for these large differences, but the interviews indicate that the teacher's opinion on this question impacts the students answers.

In the first half of the project there were a significant difference between the group of schools *with* iPods and the schools *without* iPods. Few students without iPods had used the podcasts at all. They were all looking forward to the day when they would get their iPods. "The day the project really will start" was an often-heard comment, both from students and from teachers in these schools. This difference was almost not mentioned in the second half of the project, maybe because the iPod, as a *cool gadget*, lost a little of it's charm of novelty when it became part of the student's normal school day.

An interesting observation concerning the students' use of the podcasts is that most students were in agreement that it was rather easy to download the podcasts to iTunes and to the iPods. Some cases of technical difficulties were found, but nothing serious, and definitely not at all on the scale that the teachers reported concerning the production and publication of the podcasts.

Interesting was also that in one class the students looked at a podcast before the teacher presented the content to the class. The students found it easier to follow the presentation and the teacher claimed that he got deeper questions from the students. Of course, this possibility exists in normal teaching also; the students can read the section in the book in advance. However, this is not common student behaviour according to the teacher. This affordance of the podcasts, that they might influence the students to look at mathematics in advance, is an important finding in this study, especially if we interpret this as a motivation to engage in mathematics to a larger extent than without podcasts.

Indications of another affordance were also found. Some students and several teachers reported on positive feedback from parents who had looked at some of the podcasts. After viewing the podcasts the parents suddenly could help their child in mathematics. It would be very interesting to interview some parents concerning this issue, but that is not a part of this study.

Among many of the students in the interviews, a perceived constraint of the podcasts was found, concerning the idea of putting a whole content area into podcasts. This had been tried in one school (not in mathematics, but in geography, concerning latitude and longitude) with very good result and positive opinions from the students. However, none of the interviewed students from other schools believed it to be a good idea. "You need someone to explain the content" was a common comment.

5.3 The mathematics in the podcasts

Eight podcasts were analysed in relation to the NCTM Standards Processes (see Section 3.3). The selection was made to include two podcasts of each of the four types: introductions, presentation of a concept, presentation of a method, and presentation of a problem. The podcasts were chosen from six different schools. A description of the eight podcasts can be found in Appendix B. An obvious difficulty in the analysis was how much to demand in order to say that a podcast addressed a specific process. We have not demanded very much in order to fulfil our criteria. If the teacher in a podcast use a basic argument like "since per cent means per hundred", we mean that the process Reasoning and Proof has been addressed. In the description in Section 3.3 we mention "the use of arguments" as one aspect of this process, and we mean that this argument is enough. Similar interpretations have been made concerning the other processes.

All podcasts addressed one or several of the processes from the NCTM Standards. In average between two and three processes were addressed, rather evenly distributed among the five different processes. One podcast addressed all five processes, even if the process Problem Solving only was present in that the students were given a problem to solve where the solution had to contain the process Connections. In general, we can say that the ways that the processes were addressed in the podcasts were rather superficial. Here follows examples of how the five processes were present in the podcasts:

- **Problem Solving.** This process was addressed by three of the eight podcasts. In one podcast a percentage problem was presented (see discussion in Section 5.1), and the solution was shown using rectangular blocks. In the other two cases the presented problems were only given, not solved or discussed.
- **Reasoning and Proof.** Traces of this process were found in two podcasts, and two other podcasts presented problems that the students needed reasoning to solve. One of the two is the percentage problem discussed above where visual reasoning was used in the solution. The other example was where the teacher used the argument "per cent means per hundred" when discussing how to calculate 3% of 300.
- **Communication.** In all podcasts the mathematics was presented using a clear and coherent mathematical language. One podcast stood out from the others since the process Communication was in the foreground. Here *patterns* as a mathematical concept was communicated in an unusual way, form an outside school perspective. The students were also encouraged to communicate a pattern of their own using a formula.
- **Connections.** This was found in three podcasts. In two of them the mathematics presented was recognised from a context outside mathematics. In the third Pythagoras Theorem was presented as an algebraic formula, but connected to the geometrical representation and to the arithmetic concepts of squares and square roots.
- **Representations.** In four podcasts representations was used to some extent. One example is where the teacher used a geometric situation (a rectangle with sides a and b) and represented the circumference using algebra.

The students' comments on the podcasts indicated that they were aware of the central meaning of the processes even if they don't have the language for it. One example is a student that wrote "You can see how mathematics can be used in real life" as a comment on a podcast that clearly addressed the process Connections where one aspect in the Standards explicitly states "recognize and apply mathematics in contexts outside of mathematics.

When it comes to the connection between the mathematical content and the students' interest, we have some indications that podcasts which addresses three or more processes are regarded as more interesting than podcasts containing only one or two. This can be seen by the overall grade the students gave the podcasts and also by the nature of the comments on why the podcasts where interesting. The three podcasts that got the highest average grade (3.75, 3.63 and 3.43) addressed respectively three, four and three processes. The three podcasts that got the lowest grades (1.75, 2.75 and 2.88) addressed respectively two, two and one process. This is not hard evidence, but together with the students' comments on the podcasts which often were connected to what you could learn (e.g. "nothing was presented" compared to "I could use this"), it seems probable that a podcast addressing several processes have a more positive effect on students' interest compared to podcasts addressing few processes.

5.4 Research question 1: Attitudes and interest in mathematics

It seems that the use of podcasts and iPods in this project have lead to a slightly increased amount of mathematics the students meet in their learning of mathematics. It seems reasonable that increased time with mathematics is connected to motivational aspects of the learning. In that case, it indicates that the presence of iPods and podcasts have affected the students' attitudes and interest in mathematics.

All students we interviewed agreed that the use of iPods was a good thing in mathematics. "Mathematics is more fun with the iPods" and "you can review in a more fun way". They also claimed that it was more fun and stimulating to look at a podcast compared to read in the book or review ones notes. They stated that mathematics had become a more popular subject in their school thanks to the project. The concluding questionnaire supports these statements to some extent (the average values given below are rather small deviations from 3). The question if mathematics is more fun when you use iPods were answered with an average of 3.6, and the question if the students are more motivated to work with mathematics was answered with an average of 3.3. The students also considered the podcasts more interesting than classroom teaching (3.3 in the questionnaire). Whether these answers are connected to a real possibility for the students to learn mathematics in a better way, or because they were the only class in their school to be part of a project where they got an iPod is of course hard to say.

Student voices concerning the content were also heard. One student was very clear on this: "If I won't benefit from the use I will not look at the podcasts." Similar statements, but maybe not so direct, was heard from several other students. In connection to the results from the special podcast evaluation (see Section 5.3) and the concluding questionnaire, it seems reasonable to draw the conclusion that what students want from the podcasts are hands-on mathematics closely related to the normal classroom activities, and that they are restrictive to unusual content.

Concerning extrinsic and intrinsic motivation, all students agreed that the iPod is a very cool gadget that definitely leads them to spend more time on mathematics. They also stated that it is not enough with an iPod, you also need to benefit from the content. It was clear that the students to a very large extent talked about extrinsic motivation using expressions like "making the course", "getting good grades", "be prepared for higher studies". They rarely talked about intrinsic motivation, even if a few students mentioned things like "mathematics is more fun", which can be interpreted as such. The last question in the concluding questionnaire was "Do you think podcasts in mathematics teaching is a good thing?". The answers (mainly Yes, with a comment) often talk about extrinsic aspects and motivation in connection to technology.

The question of the importance of the iPods in the project has no straightforward answer. When we compared the schools with and without iPods, there was a significant difference in the level of activity, both among the students and the teachers, in the beginning of the project. In the first interviews (in May) the teachers and students in several of the schools who had been without iPods meant that the project would begin after the summer when they got iPods. On the other hand, in the interviews in November, the importance of the iPods was not emphasised at all. When we then in the concluding questionnaire asked about the importance of the iPods, we also got very varied answers. In one school the students saw the iPod as very important, and answered with an average of 4.0 on the five graded scale (1 meaning "I look a lot more without an iPod" and 5 meaning "I look a lot more with an iPod"), while the students from another school answered with an average of 1.9. Our interpretation here is that the teacher's opinion on this question greatly influenced both the students' opinions and their actual use of the iPod. We know from the concluding teacher questionnaire that the teacher from the school that answered 4.0 was very positive to the idea of iPods and convinced that iPods made a large difference for the students, and that the teacher from the other school were less positive to the idea and were of the opinion that it doesn't matter if the students have iPods or not.

6. Discussion

The results from this study indicate that students' attitudes towards mathematics are affected in a positive way in this project. There are of course several possibilities for this positive effect. The students all got a 'cool gadget', they were part of a research project, their teachers (in some cases) got extra time for the teaching of mathematics and so on. However, in the interviews some other reasons were found. The possibilities to take part of the content to get a better understanding and to review the content before a test were important aspects. Especially the possibility to look at mathematics whenever you want, was highlighted by the students. This is also supported by Pasnik (2006), who means that giving the students control over the learning environment (to some extent) has a possibility to increase students' motivation. One might argue that the increased interest is a temporary situation, only while the situation is new, and that it will go back to normal after some time. One thing that supports such a belief is that the main part of the positive factors the students reported had to do with extrinsic motivation. On the other hand, several students pointed out that there had to be a gain in the learning of mathematics if they would use the podcast to any extent.

There were several effects found in the study that were caused by the specific use of podcasts, and not only by the fact that the students got a device or that they were part of a research project. One example is when the students looked at a podcast before the same content was presented by the teacher in the classroom. This lead, according to both the teacher and the students, to better possibilities for the students to understand the content and to pose more accurate and profound questions. Another example is that several teachers reported on positive feedback from parents who, after looking at some of the podcasts, experienced increased possibilities with their child's homework. However, the most prominent affordance with the podcasts concerned the use of iPods, that the students got an option to look at presentations of mathematical content whenever they wanted: in the bus, when waiting for a lesson to begin, during the lessons, at home etc.

One serious problem in the project was that many teachers experienced that they could not find enough time to produce podcasts the way they wanted. Almost all teachers raised the time issue. Of course, in a longer perspective, the production of podcasts in mathematics must be one part of the teachers' work, since we cannot assume that mathematics teachers suddenly

will get more time for mathematics just because they use a new working model. One important question in a possible future use of podcasts is to find a balance between podcast production and other parts of the work as a mathematics teacher. What can be reduced and what can be made in more rational ways? What can be removed? If podcasts should be a normal part of the job as a mathematics teacher, without an increase in workload, something must change.

Podcasts can of course be viewed on other portable devices than iPods. In a near future it is reasonable to assume that subscription to video podcasts can be done on most mobile phones. Already today this is possible with several new models. In a learning environment where a portable device for video podcasts is a normal part for all students, technical solutions and economical aspects will probably be reduced. This might open up for teachers to include podcasts in their teaching without technical knowledge, especially if suitable podcasts can be found for instance in some type of teacher community or database of podcasts.

The power of youth culture in mathematics education could also increase radically when students start to produce podcasts of their own, as a part of their learning of mathematics. We believe that this is already happening in some situations. The students use their mobile phones to film a situation in school, and then discuss it or share the situation with their classmates. An interesting future study would be to analyse the impact of such activities on the interest and motivation to learn mathematics.

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Appendix A

Podcasting & RSS

Podcasting is a technology that makes digital content such as audio and video possible to download and subscribe to. A podcast can be defined as a: “multimedia file distributed over the Internet using syndication feeds, for playback on mobile devices and personal computers” Wikipedia (2008b).

Podcasting history is relatively short and is a “new” technology using two well known techniques. Digital audio/video and RSS. The RSS is used for make content subscribable. By using a RSS-aggregator and a media player, in some software applications these two functionality's are combined, channels with various content can automatically be downloaded to the users computer.

There are different meanings of the acronym related to different versions of RSS. RSS is a family of web feeds (Wikipedia, 2008b). In RSS 2.0 the acronym stands for Real Simple Syndication.

An RSS-aggregator is client side software used to receive web content using a web feed for instance podcasts. The users ‘pull’ the content when subscribing to a feed. Aggregators can replace the need for regular checks on websites by pulling out the content. Once a subscription started, the aggregator keeps the user updated.

File Transfer Protocol (FTP)

FTP is a acronym for File Transfer Protocol commonly used protocol for uploading and exchanging files over Internet or other networks for instance uploading podcasts (Wikipedia, 2008a). There are several protocols used for transfer data from a computer to a server or vice versa. There are several FTP-clients and sever programs available for all operating systems even some web browser can be used for FTP. In this project the participating teachers have used FTP to upload podcasts and RSS-files to a web host.

Appendix B

This section contains the five questionnaires used in the study. They are presented in the original version in Swedish, but without lines for answers. Alternatives in brackets often indicate endpoint alternatives in a range. The letter Ö stands for open questions.

Introductory questionnaire to teachers

Hej.

Nu är det dags för den första enkäten till dig som deltagande lärare i PIS-projektet. Enkäten är till för att ge oss en bild av de utgångspunkter och förväntningar du har när projektet startar.

Det är av stor vikt att du försöker svara på frågorna så bra du kan. Det är dock inte meningen att det ska ta mer än 20-30 minuter att besvara enkäten.

Alla enkäter, intervjuer och observationer kommer att behandlas konfidentiellt. Materialet kommer att avidentifieras och när resultat presenteras kommer fingerade namn att användas.

Hälsningar,
Tomas, Krister, Johan och Brian.

Bakgrundsfakta

Namn: _____

Skola: _____

Utbildning _____

Antal år som verksam lärare: _____

Undervisar i följande ämnen: _____

A. Frågor som rör din medverkan i projektet

1. Varför är du med i projektet? _____
2. Varifrån kom initiativet att din skola/din klass skulle vara med i projektet? _____
3. Får du nedsättning i din övriga tjänst för att vara med i projektet? _____
4. Vilket annat stöd får du från skolledningen? _____

B. Frågor om dina mål med projektet

5. Vilka möjligheter ser du med poddsändningar i matematikundervisningen? _____
6. Vilka begränsningar ser du? _____
7. Teknikens viktigaste roll i projektet, är det att fånga elevernas intresse, att förmedla matematik på ett bättre sätt eller är det någonting annat? _____
8. Vilka ämnesområden kommer du att fokusera på? _____
9. Har du några specifika planer eller idéer för dina poddsändningar? _____

C. Frågor om din vanliga undervisning

10. I vilken utsträckning ingår följande i din normala undervisning (uppskatta i procent):
    a. genomgångar av teoriavsnitt _____

b. diskussioner om teoriavsnitt _____

c. presentationer av uppgiftslösning _____

d. elevpresentationer av uppgifter på tavlan _____

e. elevers enskilda arbete _____

f. elevers arbete i grupp _____

g. övrigt (beskriv kort dessa aktiviteter) _____

11. Vad fungerar bra i ditt matematikklassrum? _____

12. Vad fungerar mindre bra i ditt matematikklassrum? _____

D. Frågor om förväntningar och farhågor

13. Vilken effekt tror du projektet kommer att ha på dina elevers

a. lärande i matematik? _____

b. attityder till matematik? _____

14. Vilka svårigheter ser du med projektet? _____

Övriga kommentarer

15. _____

Introductory questionnaire to students

Hej.

Du är en av ca 200 elever i Sverige som är med i detta projekt. Det är viktigt att du försöker svara på frågorna i den här enkäten så noga och sanningsenligt du kan.

Vi vill att du skriver namn på enkäten, men det ska bara användas under arbetets gång. När vi skriver om projektet kommer inga namn att nämnas.

Hälsningar,
Tomas, Krister, Johan och Brian.

Bakgrundsfakta

Namn: _____

Klass: _____

Attityder till matematik

1. Hur viktigt tycker du matte är jämfört med andra ämnen? _____
2. Hur intressant tycker du matte är jämfört med andra ämnen? _____
3. Hur stor del av mattelektionen gör du annat än att jobba med matte? _____
4. Hur många minuter per vecka ägnar du åt läxläsning i matte? _____
5. Vilken nytta tror du att du kommer att ha av matte i framtiden? _____

Frågor om poddsändningar (podcasts)

6. Har du tittat på poddsändningar tidigare? _____
7. Har du laddat ner poddsändningar? _____
8. Har du prenumererat på poddsändningar? _____
9. Om du svarade ja ovan, var brukar du hämta poddsändningar? _____
10. Har du lagt över poddsändningar på iPod eller annan mp3-spelare? _____

Ungdomskultur

11. Har du en mp3-spelare sen förut? _____

Om du svarade ja på förra frågan:

12. Hur ofta lyssnar du på musik på din mp3-spelare? _____
13. Har du något annat än musik på din mp3? _____

Förväntningar

14. Tror du att du kommer att använda poddsändningar med matte? _____
15. Hur tror du att du kan dra nytta av poddsändningar med matte? _____

Egna funderingar och frågor

16. _____

Concluding questionnaire to teachers

Namn och skola.

Allmänna frågor

- Hur många timmar i veckan (i genomsnitt)har du lagt ned på podsändningarna? (0-1, 1-2, 2-3 … 6-mer)
- Har du haft någon nedsättning i tid för PIS-projektet? Hur många timmar i så fall?
- Kommer du att fortsätta med podsändningar i någon form efter projektet avslutas?

Tidigare erfarenheter

- Hade du någon erfarenhet om podsändningar innan PIS-projektet startade? (ingen alls – stor erfarenhet)
- Kände du till något om RSS innan PIS-projektet startade? (inget alls – stor erfarenhet)
- Har du någon erfarenhet av videoinstruktioner i undervisning innan PIS-projektet startade? (inget alls – stor erfarenhet)
- Hade du någon erfarenhet att stå inför kameran innan PIS-projektet startade? (ja-nej)
- Hade du någon erfarenhet av videoredigering innan PIS-projektet startade? (ingen alls – stor erfarenhet)
- Hade du någon erfarenhet av att skapa webbsidor innan PIS-projektet startade? (ingen alls – stor erfarenhet)
- Hade du någon erfarenhet av FTP-program (File Transfers Protocol, används för att flytta över filerna till webbservern) innan PIS-projektet startade? (ingen alls – stor erfarenhet)

Spela in podsändningar

- Hur många (förutom du) var inblandade i inspelningarna av podsändningarna?

- Vilken typ av videokamera användes vid inspelningarna? (mini CV, hårddisk, dvd, datorns inbyggda kamera, mobiltelefonen, annan)
- Vilket videoredigeringsprogram har du använt för att redigera dina podsändningar? (iMovie, Final Cut, Adobe Premier, Movie Maker, Pinnacle, annat)
- Andra erfarenheter kring inspelningen. Ö.

Publicera podsändningar

- Vilket program har du använt för att skapa webbsidorna för podsändningarna? (iWeb, Dreamweaver, Mozilla, annat, någon annan har gjort det)
- Vilket program/lösning har du använt för att skapa rss-flöden? (iWeb, Podcast Maker, annat, Någon annan har skött detta)
- Vilket program har du använt för ftp? (Cyberduck, Filezilla, SmartFTP, Podcast Maker, annat, Någon annan har skött detta)
- Annat om publiceringen. Ö.

Prenumerera på podsändningar

- Har du prenumererat på någon annan lärares podsändningar? (ja – nej)
- Hur var det att installera iTunes? (Mycket enkelt – Mycket svårt)
- Hur är det att prenumerera på podsändningar? (Mycket enkelt – Mycket svårt)
- Hur fungerade synkroniseringen med iPoden? (Inga problem – Fungerade aldrig)
- Har du haft några andra problem? Ö.

Eleverna och podsändningarna

- hur många av de podsändningar ni har lagt ut har eleverna tittat på? (Inga – alla)
- Hur mycket har eleverna jobbat i boken utanför klassrummet? (Mycket mindre än före projektet – Mycket mer än före projectet)
- Har eleverna tittat på podsändningar istället för att jobba i boken? Ö.
- Var har eleverna varit när dom har tittat på podsändningar? (ev flera alternativ) (Klassrummet, skolan utom klassrummet, hemma, buss/tunnelbana, vet ej)
- Hur mycket tittar eleverna på podsändningarna mer respektive utan iPod? (Tittar mycket mer utan iPod – Tittar mycket mer med iPod)
- Hur uppfattar du elevernas inställning till att använda podsändningar i matematik? (Mycket tråkigt – Mycket roligt)
- Tror du att eleverna motiveras att arbeta med matematik när de kan titta på podsändningar? (Inte alls – Väldigt mycket)
- Tror du att elevernas motivation till att lära sig matematik har förändrats under projektet? (ännu mindre motiverade nu – mycket mer motiverade nu)
- Tror du att eleverna upplever podsändningarna intressantare än vanlig undervisning? (vanlig undervisning mycket intressantare – podsändningar mycket intressantare)
- Har eleverna lagt ner mer tid på matematik under projekttiden än vad de brukar? (Nej mycket mindre tid – ja mycket mer tid)
- Hur viktigt tror du att det är elevernas egen lärare de ser i podsändningen? (Inte alls viktigt – mycket viktigt)

Concluding questionnaire to students

Pojke – Flicka

Teknik

- Hur gick det att installera iTunes (jättesvårt – jättelätt)
- Är det svårt att prenumerera på podsändningar (jättesvårt – jättelätt)
- Hur fungerade synkroniseringen med iPoden (inga problem alls – fungerade aldrig)
- Har du haft några andra problem? Berätta. Ö

Användning

- Hur många av de podsändningar läraren har lagt ut har du tittat på? (inga – alla)
  Varför har du tittat på dom? Ö
- Har du tittat på vissa podsändningar flera gånger? I så fall vilka? Ö
- Hur mycket har du jobbat i boken utanför klassrummet?
  (mycket mindre än för projektet – mycket mer än före projektet)
  Har du tittat på podsändningar *istället* för att jobba i boken? Ö
- Var har du varit när du har tittat på podsändningarna? Ö
- Är det stor skillnad att vara med respektive utan iPod?
  (tittar mycket mer utan iPod – tittar mycket mer med iPod)
  Varför? Ö
- Har du visat podsändningarna för dina föräldrar eller anhöriga? (ja – nej)
  Berätta. Ö

Motivation för lärande

- Är det roligt att använda podsändningar i matematik (inte alls – ja, mycket)
- Blir du mer motiverad att arbeta med matematik när du kan titta på podsändningar?
  (inte alls – ja mycket)
- Tror du att din motivation till att lära dig matematik har förändrats under projektet?
  (jag är mycket mindre motiverad nu – jag är mycket mer motiverad nu)
- Är podsändningarna intressantare än vanlig undervisning?
  (vanlig undervisning är mycket intressantare – podsändningar är mycket intressantare)
  Varför? Ö
- Har du lagt ner mer tid på matematik under projekttiden än vad du brukar?
  (nej, mycket mindre tid – ja, mycket mer tid)
- Hur viktigt är det att det är din egen lärare du ser i podsändningen?
  (inte alls viktigt – mycket viktigt)
  Varför? Ö
- Har du använt podsändningar i något annat ämne än matematik? Berätta! Ö

Förutsättningar för matematiklärande

- Gör podsändningarna så att du lär dig matematik bättre än vanlig undervisning?
  (ja mycket bättre – nej, mycket bättre i vanlig undervisning)
  Varför (eller varför inte) kan du i så fall lära dig bättre från podsändningar? Ö
- Kan du lära dig andra saker från podsändningar om du jämför med vanlig undervisning?
  (nej det är samma saker – ja det är helt olika saker)
  Vilka andra saker i så fall? Ö
- Tycker du att podsändningar i matematikundervisning är en vettig aktivitet? Ö

Questionnaire concerning eight selected podcasts

Frågor om podsändningar numrerade 1 – 8.

Värdera podsändningen utifrån var och en av rubrikerna:

1. Tid i förhållande till innehåll?
   1 = alldeles för kort 5 = alldeles för lång
   Podsändningens svårighetsgrad?
   1 = alldeles för svår 5 = alldeles för lätt
2. Hur inspirerande och intresseväckande är podsändningen?
   1 = tråkig och ointressant 5 = intressant och engagerande
3. Är det mer inspirerande än samma innehåll vid en vanlig genomgång?
   1 = Ja, mycket mer 5 = nej, genomgången är mer inspirerande
4. Kan du lära dig innehållet bättre via den här podsändningen än vid en vanlig genomgång?
   1 = Ja, mycket bättre 5 = nej, genomgången är mycket bättre
5. Kan du lära dig andra saker från den här podsändningen, saker som du inte kan lära dig från en genomgång?
   1 = Nej, det är samma saker 5 = ja, helt andra saker.
6. Kan det som visas vara del i en vanlig lektion?
   1 = aldrig 5 = alltid
7. Övergripande betyg:
   1 = meningslös podsändning 5 = Precis så ska podsändningarna vara.

Öppna frågor:

9. Varför är podsändningen mer eller mindre intressant än en vanlig genomgång?
10. Varför kan du lära dig bättre från podsändningen än från en vanlig genomgång?
11. Vilka saker kan du lära dig från podsändningen som du inte kan lära dig från genomgångar?
12. I vilka situationer skulle du titta på en sådan podsändning?
13. Vid vilka tidpunkter skulle du titta på en sådan podsändning?
14. Vilken skulle vara den viktigaste orsaken till att du väljer att titta på den?
15. Vilken skulle vara den viktigaste orsaken till att du väljer att inte titta på den?

Appendix C

Short description of eight podcasts

Here follows a short description of the eight podcasts that was analysed in the special podcast evaluation presented in Section 5.3.

1. The teacher discusses how to deal with a situation when you have several similar variables in an expression. He draws a rectangle on the whiteboard and then marks the sides with a and b. The circumference of the rectangle is then O=a+b+a+b which can be simplified to O=2a+2b.
2. Since percent means *per hundred* the teacher shows that 3% of 100 SEK is the same as 3/100 * 300 which equals 3*3 = 9.
3. A computer monitor has broken again and the teacher needs to buy two new monitors. He finds in an advertise that the monitors are 12.900 SEK VAT included. Now he must find the price without VAT (which is 25% in Sweden). Using coloured blocks, he shows that removing 25% of the final price is incorrect, and that you need to remove 20% in order to get the price before the 25% VAT is added.
4. Several short passages from outside school showing patterns in different situations and environments. Floor tiles, wall paper, coverings on pillows etc. The speaker voice says "patterns are everywhere". In the end the students et an assignment to create a pattern of their own, and to represent it as a formula.
5. The teacher talks about squares, square roots and Pythagoras theorem. She also shows the connection between the concepts and how you can use Pythagoras theorem to find an unknown side in a triangle. She also reminds the students that they had shown that Pythagoras theorem is valid by using paper and scissors.
6. The teacher plays a game with the person behind the camera. Bet one SEK, throw two dice and get back the sum of the dice if you guess correctly. What should you bet on? The students are encouraged to solve the problem of finding out how to bet in order to win, or to show that you can't win.
7. The teacher talks about addition of the same variable in an algebraic expression. In the equation 6x+8-2x=16 he shows that you should first deal with the x:es and then solve the equation. He also point out that when solving an equation you can only do exactly the same thing on both sides.
8. The teacher informs on the goals of the chapter *probability*. She also makes some connections to the use of probability in every day life.