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MATHEMATICAL AUDIO-PODCASTS FOR TEACHER EDUCATION AND SCHOOL

Christof Schreiber and Rebecca Klose
Justus Liebig University Giessen
Germany

Abstract

Audio-podcasts offer notable opportunities for oral representation of mathematical content through digital media—not only for teacher education but also in primary schools. This article deals with the process of creating such podcasts, as well as their uses in schools, university teaching and research. We allow for various learning groups—which are made up of university students or school students—to create audio podcasts, either at German universities or schools, for the purpose of strengthening understanding of various mathematical topics. For this endeavour, learners only need a mobile recording device (i.e., smartphone or tablet). Often, learners can even use personal devices for both recording and research of the given topic (BYOD).

Keywords

Oral representation; audio-podcasts; mobile recording device; teacher education; mathematical concepts; reflection

1. Representation in mathematics lessons

Representation in mathematics lessons is a central aspect and supports competence across all school levels. This can be carried out in written, graphical or oral form (Hessisches Kultusministerium (HKM), 2011; Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland (KMK), 2005). Education standards emphasise the transfer of various modes of presentation. Thus, representations should be used in order to enable students to communicate mathematical ideas and model mathematical phenomena (National Council of Teachers of Mathematics (NCTM) 2000).

With regard to the role of 'writtenness' (in German: Schriftlichkeit; Koch & Österreicher, 1985; see also Schreiber, 2013b) in the mathematics classroom, working with the students' writing has been common practice for some time now. Some notes are used for making journals or travel diaries (Gallin & Ruf, 1998) and are sometimes even created while solving math problems. They are also used to investigate the description of previously solved problems. The investigation of inscription-based communication during the problem solving process was examined carefully in the project '*Math-Chat'* (Schreiber, 2004, 2010, 2013a).

Besides written and graphically-based modes, there has been an array of studies on the role of orality in the mathematics classroom, which are based on Pimm's (1987) work. For example, the production of mathematical audio podcasts is an innovative educational practice that focuses on the aspect of orality. Although the process of creating an audio-podcast produces a final oral product, one needs to acknowledge the fact that writing surfaces in one way or another (see 2.1). This is useful for investigating the student's learning process and the final product.

2. Audio-podcasts of mathematical topics

Podcasts range from audio or video recordings to readily available downloads and online subscriptions. This article solely focuses on audio-podcasts, in which neither images nor written texts are utilised. One may wonder how digital media can be effectively used to support mathematical learning processes, wherein representations would predominantly be oral. As such, mathematical audio-podcasts were developed to suit learners in both the school and university, while encouraging

Corresponding author
Email address: Christof Schreiber christof.schreiber@math.uni-giessen.de
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them to reflect on mathematical topics. This idea and current procedures can be explored further on the respective blog[i] about audio-podcasts.

In terms of creating audio-podcasts for mathematics, the focus lies on oral communication and representation, which means that learners are not able to use visual aids or gestures to clarify messages. In order to accurately express meaning to an audience, a speaker must first thoroughly reflect on the topic and speech. In regard to the representation of a mathematical topic, the procedure, exempt from drawing on any written or graphical elements, is of great interest. In other words, how can students explain the concepts of 'infinity', 'greater than' or 'less than' operations, such as addition, division or even geometrical objects, such as circles and cuboids, using only verbal means? Thus, diverse mathematical content can be interesting in numerous ways. Geometric topics are especially suitable, as they easily lead one to a graphical representation. Abstaining from written and graphical representation is therefore crucial. Even arithmetic routines, like arithmetic techniques or the use of short cuts, as well as pattern recognition can produce interesting results, which, in terms of representation, usually are only noted down and commented on verbally. The challenge of having to overcome the obstacle of representing something orally does not apply to philosophical topics, such as 'the special digit zero, 'infinity' or 'mathematics in day-to-day life', as these ideas can easily be verbalised. Nevertheless, these topics were tested on school students, in order to gain insight on their concepts.

2.1 Production process of mathematical audio podcasts

In order to increase the quality of the audio-podcasts, as well as deepen reflection of the individual's own knowledge, the following procedure (Figure 1) has been developed (see also Schreiber & Klose, 2017, in preparation):

Figure 1: Production steps of audio-podcasts.

Unexpected recording

The learners form small groups. Each group must answer a mathematical question to an already known topic on the spot. This means that answers are unexpected and are given without any preparation. A recording device is used to record such utterances. This first audio recording can always be listened to at a later time, thus allowing students to have the opportunity to reflect on their answers.

[i] http://www.uni-giessen.de/mathepodcast/

Script I

The learners are to plan the first recording of their podcast. Since the final audio-podcast will be published, a script must be created. Thus, they can gather information about their topic by doing research on the Internet as well as by browsing through the provided material, such as worksheets and textbooks. The learners are free to decide on how to proceed by either writing a text, just taking some notes or even adding some drawings.

Podcast—first version

At this stage, the team works independently: The students make their own decisions concerning the mathematical matter and their performance, without any intervention from the instructor. Script 1 is read aloud, while a mobile device records the utterances. The recording addresses the given question or impulse and learners should keep in mind that it can be directly published at this stage, if a high standard is reached. Furthermore, this podcast version serves as the foundation for discussion during the editorial meeting.

Editorial meeting

This meeting is carried out by the teacher and takes place with another group. Upon presenting the first podcast version to both the opposite group and the teacher, learners receive feedback. While well-explained aspects receive praise, constructive criticism is directed at overlooked or improvable points. Moreover, for the first time, the teacher now takes on an active role during the production process. The task involves giving advice on how to optimise the podcast in terms of structure, content, language and performance. The editorial meeting, in particular, does provide insight into the learners' thought processes. It enables the teacher to identify and clarify potential misconceptions as well as serves as a means to practise and improve language skills.

Script II

At this stage, each group once again works on their own script, and the advice and guidance, received during the editorial meeting, is taken into account. Before making a second script, learners are to discuss the feedback they received, share their knowledge and decide on how to realise the final audio-podcast. They may either edit the first script or, if major changes are needed, they can create an entirely new script. The second script shall be used as a foundation for recording the final audio-podcast. Therefore the group must carefully select and decide on the content they want to present to the audience.

Audio-podcast

Based on the second script, which underwent the editing process, the actual audio-podcast version is recorded. This is done with a mobile device. The audio-podcast begins with the same initial question, which was stated during the production process of the unexpected recording. This audio-podcast is then posted on an online blog and, as such, made available for the public on the Internet.

As seen in the production process, audio-podcasts fuse both modes of communication: 'writtenness' and orality (Schreiber, 2013b). Thus, mathematical audio-podcasts demonstrate how written representation can be connected to spoken representation. Each step is relevant if one aims to produce a final product of high standard, which means that the content is correct and realised according to the learner's capabilities.

We have produced mathematical audio-podcasts in different languages. Some were produced in German and various other mother tongues and languages of instruction, like English or Spanish. Audio-podcasts, called PriMaPodcasts[ii], were also recorded with primary school children. Moreover, university students, studying to become primary or secondary school teachers, also created audio-

[ii] http://www.uni-giessen.de/primapodcast/

podcasts (MathPodcast)[iii]. The podcasts are published and available to the public on several online blogs. Each podcast is sorted according to a particular category and tagged with respective keywords, allowing for easy navigation when using a mobile device. The examples differ in terms of duration, outcome, style and quality.

2.2 MathPodcasts in teacher education

The project of producing 'MathPodcasts' aims at achieving the following: It builds upon the mathematical foundation of the university students and drives them to reflect on the meaning of mathematical content in the school context. The production procedure of 'MathPodcasts' follows the above-mentioned steps.

University students often supervise and guide the production of mathematical podcasts of school students. As such, it is important for university students to have gone through the steps themselves prior to doing so in order to understand the production procedure thoroughly. In this way, they receive a better understanding of how demanding it can be for younger learners to have to explain a mathematical concept unexpectedly and without being able to draw on other means of expression besides that of orality. Similarly, university students can also relate to this. For example, recently covered concepts of a university lecture would be challenging to express orally, without the support of using other modes of expression.

Deepening mathematical content and understanding is another focus of audio-podcasts. The university students notice their increase in knowledge and are able to internalise already learnt content. The horizon of the university students' content knowledge can range from secondary school math ('What is special about the digit zero?') to areas covered during university lectures ('Explain the classification of quadrilaterals'). This fact is crucial, since university students in their first semester tend to be irritated with the syllabus. For example, dealing with new content, in order to be able to teach mathematics well, can be frustrating for those who are of the opinion that they already possess necessary mathematical knowledge and skills (Klose, Tebaartz, Schreiber, & Lengnink, 2014).

Through being part of the project, the students work out key ideas and concepts of the mathematical introduction lecture in small learning groups. This meta-cognitive activity—reflecting on their own thoughts and mathematical knowledge—allows for a better internalisation and sustainability of the learnt content. Hence it facilitates the learning process. Moreover, the podcasts are analysed by the learning group to identify the existing anchor points of mathematical conceptions, while misconceptions are corrected.

Audio-podcasts for mathematics have previously been part of different projects of the Department of Mathematics Education at the Justus-Liebig-University Giessen. This project, in particular, aims to achieve the following goals:

- Strengthening the mathematical foundation to ensure a stable course of studies.
- Expanding communication competences in regard to mathematical concepts and terminology.
- Improving the students' satisfaction by realising the relevance of in-depth mathematical knowledge for their course of study.
- Gaining insight on methodological implementation in terms of theory and application.

The students' subject-related learning processes were documented, analysed and evaluated. Some groups were accompanied during the production of the podcasts and interviewed subsequently. The

[iii] http://www.uni-giessen.de/mathepodcast/

initial results indicate a positive relationship between the frequently occurring reflection processes on the content of university lectures. Through intensive confrontation with the lecture content, students could not only understand but also remember and reproduce it better. The participants also described their increased access to the process of producing podcasts as being useful, as this method was relevant and implementable for a real-life classroom.

2.3 PriMaPodcasts in primary school

One can expect the following outcomes with 'PriMaPodcasts' (Schreiber & Klose, 2017, in preparation):

- **Learning**: As students are to refrain from using written-graphical representations, they need to replace these with oral explanations. In order to achieve this, students are required to learn how to formulate their verbal expressions as precisely as possible as well as utilise the language of mathematics.
- **Diagnosis**: The production of 'PriMaPodcasts' enables the examination of the students' state of knowledge. The state of knowledge and learning progress of one or more students can be evaluated. As the students work with previously covered topics, the instructor may receive informative feedback on the quality and effectiveness of his or her teachings as well.
- **Research**: Leaving out a particular mode of representation may also allow researchers to assess its function. As such, alternative representation means can be discussed and the success rate of the students' performances, using these alternatives, can be observed. Therefore capability for utilising the language of mathematics and its terminology can be investigated.

Using 'PriMaPodcasts' in multilingual contexts is also an aspect we have explored by having created 'PriMaPodcasts' in bilingual mathematics lessons (Klose, 2015)[iv].

Mathematical audio-podcasts of students, whose mother tongue was not German, has proven to be a research area worth investigating. For this purpose, PriMaPodcasts in French[v] and Russian[vi] were produced. Working with these recordings is promising, especially for university students who wish to teach in primary schools, as they can become prepared for the different linguistic standards that await them in the multi-cultural classrooms of Germany. Focus on these rather seldom regarded languages proves to be beneficial for university students of the respective linguistic background and provides them with the opportunity to be confronted with their individual multilingualism.

3. Different benefits for all students

As described above, students may benefit from the production of audio-podcasts, as it triggers them to reflect on topics and create a deeper understanding of the content learnt during lectures. Moreover, the use of digital media through mathematical audio-podcasts can enrich not only the mathematical classroom but also areas far beyond. Also, this method has a low threshold in terms of technological demands because a mobile recording device is the only requirement. Often learners are in possession of a device of their own (BYOD), which can be used for both recording and researching information for the podcasts. Hence this method can easily be applied to various other subjects or even customised and altered according to its purpose. At this point in time, the tool is already suitable for primary and

[iv] http://www.uni-giessen.de/primapodcast-bili/
[v] http://www.uni-giessen.de/primapodcast-fr/
[vi] http://www.inst.uni-giessen.de/idm/primapodcast-ru/

secondary schools, but can also be utilised in tertiary institutions, though the act of supporting the learners must differ accordingly.

Besides acquiring content knowledge, school students also develop media competences through the act of working with audio-podcasts. Available digital media tools, including the Internet as a platform for individual productions, can be actively used to represent the individual's knowledge.

The combination of written and oral representations not only provides excellent opportunities for the occurrences of mathematical learning, but also grants access for research on subject teaching. The transition from medial orality to medial 'writtenness' and vice versa required during the production of mathematical audio-podcasts can be a quite demanding skill for the learner. Still, achieving this skill successfully fosters the use of terminology and mathematical communication, representation as well as argumentation, which fulfils central aspects of education pedagogy and standards. Research can take place in various different ways: learning through individual research by the university students and using opportunities to create studies in areas of mathematical communication, semiotic analyses, interaction analysis and other areas. As producing audio-podcasts reduces the learners' communication means to the oral level, due to the given technical settings, the general focus of study is on investigating orality as a form of communication and representation of mathematical thinking.

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