Auditory material for specialised language support in mathematics education

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This paper focuses on the use of auditory material in form of radio features in mathematics education at primary school level, particularly for specialised language support. The aim of my current research is to investigate the effects of auditory material on the learning procedure and how supportive language examples can be given through auditory media, as a provided language model. This way, auditory material could be effectively implemented in teaching practice.

Keywords: Auditory learning, radio sources, design science, language support.

AUDITORY LEARNING

In order to research the effects and the use of auditory material, one has to understand how auditory learning is working. According to Baddeley (2007), in the working memory visual and auditory information are processed in different sensory channels. Auditory learning reduces sensory impressions on the visual channel, so that the auditory channel is required and therefore trained more. Acoustic information is processed through various memory processes. The echo memory saves mostly unprocessed sensory impressions for a short period of time. In a next step, the working memory with its limited capacity decodes and processes the acoustic information. It can also build temporal connections that are necessary for remembering the beginning of a sentence while hearing the end of it (Leuders, 2011). According to Leuders, an increase in efficiency of the working memory is a training effect. Since the processing of auditory information takes place in the working memory, one can also assume that the increase in auditory learning efficiency is a training effect. This is a fundamental trigger for my interest in research on auditory learning materials in mathematics education.

Another important aspect is the Cognitive Load Theory by Schweller (1994), more recently taken up by Rink (2014) in digital media research. This theory says that the capacities of the working memory are limited and should not be exhausted by extrinsic factors. One of those extrinsic factors is reading. Reading difficulties can exhaust the working memory and lead to not understanding mathematical content as well as not being able to solve mathematical tasks. Keeping mathematical concerns in the centre of learning processes while reducing extrinsic factors, is one important approach for auditory learning.

AUDITORY LEARNING MATERIAL

According to the model of orality and writtenness (Schreiber and Klose 2017, based on Koch & Österreicher 1985), auditory learning materials can foremost be categorized
as being medial-oral. If they are designed for children, they are also more likely conceptual-oral because they utilize everyday language and explain in a child-orientated and situational manner. Still, they use mathematical terms and phrases of school register. In this way, they are also characterized through conceptual-textual elements and can lead children from spoken language to written language. At best, this guides listeners to use mathematical terminology both when speaking and writing. This makes the listeners act in a more conceptual-textual way.

In education, auditory material can help to clarify mathematical terms (Leuders, 2011). Auditory support can also aid children with reading difficulties to understand mathematical contents and tasks without the need of having to read coherently and extract the meaning. This, however, does not mean that reading should be replaced by hearing. Auditory support should only be provided if needed.

Another function of the use of auditory material is the development of active listening skills. Such competence is a primary requirement for education, but it is seldom supported or even trained (Pimm, 1987). In Germany, education standards for the subject of German language make it very clear: These require, not only the competences of reading and writing, but also speaking and listening. Speaking is required to be consciously organized, while terminology is to be trained and (the use of) language is to be examined. Regarding listening, children are to listen attentively and perceptively, while registering others’ statements and constructively dealing with them. Of course, listening also takes place in the form of frontal teaching, but this kind of listening is difficult for most students. This is why supportive elements for auditory learning are necessary – both in frontal teaching and by means of group work.

**EMBEDMENT INTO COOPERATION WITH THE RADIO STATION “HR2”**

In 2015, the Institute for Mathematical Education at the University of Giessen started a project in cooperation with a regional radio station “hr2 – Hessen Radio for Culture”. This radio station developed, *inter alia*, a series of radio broadcasts on mathematical topics for primary level, collected in the multimedia offering “Kinderfunkkolleg Mathematik” (www.kinderfunkkolleg-mathematik.de). Within this collaboration project, future mathematics teachers developed auditory material for use in mathematics education at the primary level. It was an important challenge to “write for listening” without a visual representation of the subject. For example, verbal explanations were required to counter the fugacity of spoken language through linear representation or reputation. They also needed to be very accurate, so that the students would be able to deal with each mathematical topic in a very deep way. Throughout the process, the future teachers also had to reflect upon the mathematical topic as well as their own explanations, which was an advancing learning experience.

In a second step, the participants planned teaching units for performance in schools, embedding auditory educational material as a central element. This could be realised through developing listening tasks for the whole class or for working phases in smaller group. The important thing was to interrupt longer listening phases and repeat the
segments, while giving tasks in between. The auditory material could be used as preparation of a topic or as a base for discussions, as well as for explaining and deepening new contents or repeating already covered topics.

The units were realised in different schools and reflected on in the seminar, including feedback from peers, teachers and university teachers. After the reflection, the participants optimized their units and turned them in. After correcting and editing these units one last time, the units were then allocated for the download centre of the “Kinderfunkkolleg Mathematik,” as accompanying material.

**SPECIALISED LANGUAGE SUPPORT THROUGH AUDITORY MATERIAL**

As already mentioned, the learning of a language can be supported by training listening competence. Active processing is important for meaningful processing and for memorization of what has been heard. Reasonable and profitable use of auditory material is needed for these processes, for example good embedment, listening tasks or segmenting principle (Rink, 2017). With this kept in mind, teaching concepts can be developed, in which radio features or other auditory material serves as impulse or stimulus in the sense of didactical reduction. As acoustic representations are volatiley, there is the need of adding opportunities to document the content of the heard and results of the related tasks within the teaching units. By these means, specialised language support can be ensured. Following these ideas, my research can be focussed on the evaluation of auditory educational material in various settings – particularly regarding possible learning effects. The main interest of this research is the use of radio in mathematical education for specialised language support at the primary level.

Prediger and Krägeloh (2016) are referring to a model of three registers relevant for mathematical learning (everyday register, school register and technical register). This model illustrates different levels of verbal representation and how they are connected or built onto each other. Particularly interesting for my research is the question how children can be led from everyday register to school or even technical register.

School register is an important and necessary factor for successful learning in mathematics. It is a shared language basis and helps with explaining, describing and justifying (Götze, 2015). However, children do not bring this type of language to school with them. It must be learned, like registering a new language. This applies not only to children with special needs in language development but to every other child. That is the reason why they need linguistic models to develop educational language and to fill terms with representations. These linguistic models are scaffoldings onto which children can lean (Gibson, 2002). Lexical storages, which only include words, are not sufficient, as new terms must be used in whole phrases and sentences. According to Götze (2015), language acquisition is, in practice, merely a continuous learning process. There can be setbacks and sometimes children express themselves better in written language than in spoken language. This is because everyday register is predominant in spoken language and, oftentimes, deictic expressions are used. This is valid, not only for children, but also for teachers – even if they do so unaware and
unintentionally. At this point, auditory educational material could be a useful and profitable addition.

**Research questions**

The aim of my research is to find out in what way auditory learning material could be of use for language support in mathematics education. For this cause, I want to ask how auditory material, as a language model, can stimulate the development of the school register and how auditory material can support listening competence. In a second step, I want to research what a profitable use of such material could look like.

**METHODOLOGICAL APPROACH**

Regarding the data collection, I have decided to use the design research (Prediger et al., 2012), based on Wittmann’s Design Science (1995). Subject of the Design Science is the construction and research of teaching concepts, including accompanying theories. According to Wittmann (1995), this science is a practice-oriented core area for mathematical education, since it refers to the construction of artificial objects (teaching concepts, curricula etc.) and the research on possible effects in different educational settings. Innovations could find orientation in the concept of “reflective practitioners” (Schön 1987), which was developed for the training of engineers. According to this concept, practitioners are supposed to undergo a perpetual cycle of reflection, in which they repeatedly question and optimize their own actions – just as teachers have to in educational development.

**Didactical Design research**

Based on the Design Science, Prediger developed the model of design research (Prediger et al., 2012). The aim of this method is to effectively implement innovations for educational development in the teaching practice and empirical research, carried out under realistic conditions. In order to do this, one has to undergo a cycle as pictured in the following illustration.

The cycle starts at the upper left side of the illustration with the specification and structuring of the learning subject. In my case, this would be the auditory materials. Based on this, a design is to be developed for the specific learning topic – in my case, the teaching concept. In a third step, the developed design will be performed by means of a design-experiment. In this phase, I want to test the teaching concept in teaching practice, collect data and evaluate it. Based on the analysis of this data, local theories about the learning subject and the teaching concept can be developed in the last phase. The local theories are the starting point for a second round of the cycle (and after that, a few more), in which they can help to optimize the learning subject and concept. Thus, more experiments, data collections and evaluations are to follow, along with new local theories. In this way, after a few cycles, we will not have a perfect teaching concept or representative research results, but new and tested theories on the use of auditory media for specialized language support.
EVALUATION

To evaluate the data from my design experiments, I plan to use reconstructive social research methods (Bohnsack, 2010). This method aims to reproduce, by means of empiric data, how something is or was realised. I also want to refer to interpretative teaching research (e.g. Krummheuer & Naujok 1999), which examines a specific subject and interprets, not only the research itself, but also the specific situation of investigation – between the interaction partners and within their interaction.

Exemplary testing with mathematics teacher students started in February 2018 (Peters & Schreiber, in print). In summer 2018, I am going to run a pilot study, as well as prepare my main study. So, according to the plan, I will be able to present first results by the end of the year.

References


