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*Bilingual forms of teaching and learning have become common practice in Germany. However, the idea of teaching mathematics bilingually has not been totally accepted yet. The on-going study aims to investigate how young learners taught bilingually use and develop mathematical language in both of their target languages, with a focus on the usefulness of the communication tool PriMaPodcast. Parts of the research project and the interactive process of producing mathematical audio podcasts are presented.*

**Keywords**: Bilingual learning, mathematical language, audio podcasts.

## LEARNING MATHEMATICS IN BILINGUAL SETTINGS

Content Language Integrated Learning (CLIL) stands for a concept related to teaching and learning in two languages. As such, a combination of subject content learning and foreign language acquisition takes place. The extent to which it puts more emphasis on the subject-based components or the language dimension of learning, may vary from one country to another (European Commission, 2006). Bilingual teaching and learning settings have meanwhile become common practice in Germany, yet they are seen far more in secondary than primary education (Elsner & Keßler, 2013). Internationally, there seems to be no clear preference of any particular subject. Besides the social sciences, Geography, History and Economics, Mathematics is included in official recommendations on CLIL provision (European Commission, 2006).

In Germany however, the idea of teaching Mathematics bilingually has not been greatly accepted (KMK, 2006; Viebrock, 2013), neither in secondary school nor in primary education. Pertaining to primary education, concepts and materials required to facilitate mathematical learning in two languages have not been extensively developed nor become available (Küppers, 2013). As said by Rolka (2004) the exclusion of Mathematics depends on certain attitudes of mathematics teachers in Germany who appear to believe that language use has been reduced in this school subject. Yet the German syllabus of teaching mathematics demands the development and implementation of process and language oriented competences such as reasoning, communication and representation. Many show concern for having to learn a technical language for Mathematics, which other subjects do not require.

All these considerations raise the question whether it is really effective to learn mathematical language in two different languages. If so, how would bilingual learners use and develop mathematical language in order to explain mathematical content in both languages of instruction? In the next section some characteristics of mathematical language will be explained further.

## CHARACTERISTICS OF MATHEMATICAL LANGUAGE

The acquisition of mathematical language goes beyond the learning of terms and vocabulary (Maier & Schweiger, 1999; Pimm, 1987). Based on Halliday's (1978) idea of mathematics register, Schleppegrell (2007) outlines some characteristics of mathematical language. First, there are multiple semiotic systems such as symbols, oral and written language and visual representations. These systems combined are necessary for the learner to construct meaning. Moreover, there are linguistic features of mathematical language, which include technical vocabulary as well as grammatical patterns. Technical vocabulary does not only consist of mathematical words (e.g., *sum*), but also of words that are not solely mathematical. The latter refers to words of multiple meanings depending on

the context (e.g., *product*). As mathematics uses many words that are part of a child's everyday language, technical vocabulary needs to be used in meaningful grammatical patterns in order to be acquired. It typically comes along with 'dense noun phrases' (e.g., *the length of...)* as well as 'being and having verbs', which construct different kinds of relational processes (attribution and identification). While attributive clauses are non-reversible and refer to objects and events (e.g., *a sphere is a solid shape*), identifying clauses define technical terms and are reversible. Schleppegrell lists 'conjunctions with precise, technical meaning' (e.g., *if, when, therefore*) and points out the differences of their use in mathematical and ordinary everyday language. Moreover, the notion of academic language becomes increasingly more important for teaching and learning mathematics. Interdisciplinary language is characterized by precise and elaborated vocabulary and complex sentence structure, but in a more functional manner: It is this academic language, which affords the participation in teaching activities (Cummins, 1984; Schleppegrell, 2012).

There are multiple discourse practices in a mathematics classroom as learners and teachers bring various perspectives to a situation during interaction. Academic mathematical Discourse practices aim for learners to become mathematically literate and refer to practices that generalize, abstract or make claims (Moschkovich, 2007). Different language activities such as discussing and hypothesising are in accordance with the acquisition of a mathematical language, which is "more broadly conceptualised" (Morgan, 2005, p. 103). A communication tool, which implements different discourse practices, will be presented in the following section.

## PRODUCING AUDIO PODCASTS FOR MATHEMATICS

In order to investigate how young learners use mathematical language to express meaning, they get to produce audio podcasts (Klose & Schreiber, 2014). Audio podcasts have been a popular medium for several years now. They can also be used for educational purposes such as in teaching Mathematics. Schreiber (2013) calls mathematical audio podcasts produced by primary school children "PriMaPodcasts". By creating audio podcasts for mathematics, the focus is on oral communication and representation, which means that the learners are not able to use visual aids or gestures to bring their message across. To express meaning accurately to an audience, the speakers need to reflect thoroughly on their topic and speech first. On the one hand, the learners have to discuss, research and accumulate mathematical content in a precise and orderly manner. This may foster their mathematics skills. On the other hand, they have to use language consciously in order to transmit their messages. This might support their communicative competence and skills. By producing PriMaPodcasts the students undergo an interactive process.


**Table 1:** Production Steps

The production steps, as summarised in Table 1, are the following:

1) **Unexpected Recording.** The students split into groups of three and answer a mathematical question unexpectedly, e.g., *'What is symmetry?'* or *'What is so special about a square in comparison to other quadrilaterals?'* A voice recorder records their response. It is interesting to observe the kind of mathematical concepts and mathematical language the learners are able to verbalise in this way.

2) **Script 1.** To plan an audio podcast, the students need to create a script. They are free to decide the format, structure and amount of detail they want to include. At this point, they can gather more information through resources such as the Internet, textbooks and given worksheets.

3) **Podcast- First Version.** Based on their script, the children record their first podcast version.

The procedure, material and media used by the groups are of importance as they have an influence on the quality of the first recording.

4) **Editorial Meeting.** Upon presenting the first podcast version to another group and their instructor, the creators receive feedback. After reflecting on it, they can make amendments to improve the quality in terms of content, style, language and performance. The editorial meeting does not only provide others an insight into the learners' thought process but also enables the instructor to clarify misconceptions.

5) **Script II.** The children revise their script of step 1 and enhance it. Despite receiving feedback and suggestions to improve the podcast in terms of content, language and style, the students themselves decide on the changes they wish to adopt in order to produce the final version that gets presented and published.

6) **PriMaPodcast.** Finally, the students produce the PriMaPodcast based on the second script. It will be published on a blog on the Internet. The advantage of publishing the PriMaPodcast in a blog is the ability to categorize all submitted podcasts into main-topics and sub-topics respectively to provide a clear overview. PriMaPodcasts have been produced in various languages: German, English, Spanish and Turkish. PriMaPodcasts recorded in bilingual learning settings are available in this blog: [www.inst.uni-giessen.de/idm/primapodcast-bili](www.inst.uni-giessen.de/idm/primapodcast-bili)

In order to investigate the mathematical conceptualizations of young bilingual learners in Germany, we expect them to produce PriMaPodcasts in both languages of instruction (English and German). The overall research questions of the PhD, which have not been fully addressed up to this point in time, are:

1) How do bilingually taught young learners use mathematical language in both target languages (English and German) if asked to present mathematical content?

2) To what extent does their mathematical language develop throughout the entire procedure of producing PriMaPodcasts?

## METHODOLOGY

The following research design (see Table 2) was created to investigate the use and development of mathematical language of young German bilingual learners. Before the study, the communication tool PriMaPodcast and its different steps of production emerged during a pilot study at a bilingual school in Frankfurt a. M. Up to now, two rounds of data collec-

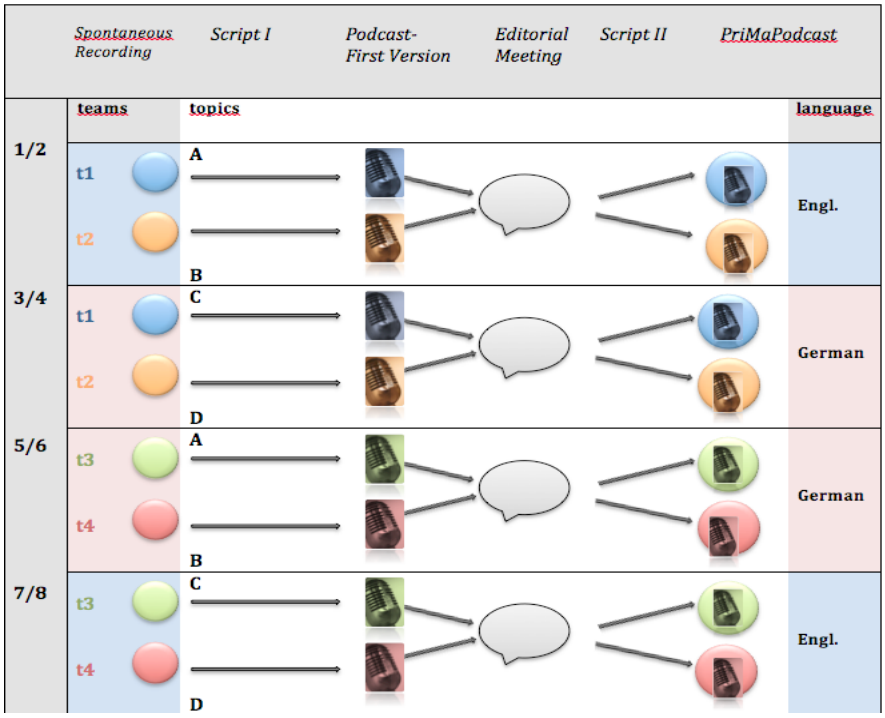


**Table 2:** Research Design and method of data collection

tion have been carried out. Each time, twelve bilingually taught students of grade 4 were grouped in fours. The groups produced two PriMaPodcasts about two different topics, one in German and one in English. All in all, a total of eight PriMaPodcasts with four different topics in two different languages were developed. In order to capture the different procedures of each team, the entire organisation process was video recorded. The mathematics teachers of both classes did a survey with regards to their personal models of bilingual teaching and learning. The learners' ways of interaction will be examined by the 'interaction analysis' (Krummheuer & Naujok, 1999), which is explained for simplicity by the following English empirical example that depicts the production process.

## EMPIRICAL EXAMPLE

The example of the pilot study presented here deals with the question of 'What is symmetry?' Three 4th graders (aged 9 to 10) produced the following PriMaPodcast in a bilingual mathematics classroom in Frankfurt. The transcripts below refer to the following recordings: the unexpected recording, the first podcast version and the final version. All citations of the transcripts are marked in squared brackets <like this>. The following analysis is based on the principles in Schleppegrell (2007) as outlined before. Some of the applied transcription rules are:

| | |
|---|---|
| . .. ... | Pause: . 1 sec .. 2 sec ... 3 sec |
| (4sec.) | Pause with given duration from 4 seconds onwards |
| Text written in *(italics)* | Describes actions for example *(whispering)* or *(incomprehensible expressions)*, ended up with % |
| Bold | Emphasis |
| b l o c k e d | Stretched pronunciation |
| / | Pitch inclination |
| - | Pitch stays constant |
| \ | Pitch declination |
| # | One utterance is followed immediately by another |

### Unexpected Recording

01 Student 1: Explain what is symmetry ... uhm symmetry is w h e n . things are . mh l i k e . mh the same looks like the same on both sides

02 Student 2: Symmetry is uhm l i k e w h e n . it's uh s o m e when it's both the same *(he is mumbling)* be that's what . Kilian said it's . the same

03 Student 3: *(is speaking low)* I don't know what symmetry is\ *(is breathing out)*%

04 Student 2: Yes a symmetry is would be like uhm . a h o u s e and the neighbour has also a house that looks . the same . just the same .. b u t uhm not everything can be symmetry...

05 Student 1: When you draw a picture and . and you wa and you m have a .. mirror it looks symmetric

06 Student 2: Yes like u h m .. m h h how I can say that . symmetry is symmetry *(Student 3 is laughing)*% . like u h like this . like uh a blue order from the same market uhm . yes#

07 Student 3: #the same colour

Student 1 reads out the task and continues giving an answer in <01>. By using an identifying clause combined with the conjunction 'when', he tries to define the technical term 'symmetry'. He talks about things that are the same and emphasizes this fact in the following. Then he reformulates this statement, by saying that something is "the same on both sides". It is difficult to analyse the concept of symmetry he has got in mind because his explanations remain unspecific; technical terms are not used. Moreover, he seems to be uncertain about the topic, which is signalized by having used fillers (mh, l i k e) and pauses. In <02> student 2 alludes "both" to the two things being the same. In doing so, he adopts the grammatical pattern of student 1 and also refers to his answer. In between, his mumbling of words indicates that he has no specific idea yet. Student 3 in <03> answers with a complete sentence and admits to not knowing what symmetry was. Then student 2 makes another attempt by giving an everyday example in <04>. The unknown things are replaced by two houses. He emphasises again that both houses look "the same". Therefore, he begins his statement with an attributive clause. Then he makes a restriction, claiming that "not everything can be symmetry". Being a second language learner he used the noun 'symmetry' instead of 'symmetric'. Student 1 in <05> seems to think of an approach to connect symmetry to mirroring. By using the conjunction 'when' instead of 'if', he tries to describe this procedure. However, he only names two parts of construction, 'drawing a picture' and 'having a mirror'. By having both components, he suggests it would look symmetric. Even though one could understand what he meant, this explanation remains incomplete. Student 2 in <06>

continues with a statement that causes student 3 to laugh. While pondering on an explanation, he simply states "symmetry is symmetry". This attributive clause defines symmetry by itself, which expresses his inability to find a better explanation. Next, he refers to something blue that comes from the same market. This aspect might indicate a translation movement. Student 3 in <07> seems to know what his peer means and puts emphasis on the same colour. At this point the recording ends. The boys seem to have reached a conclusion despite having incomplete statements. They use some grammatical patterns of the mathematical register but they do not use much technical vocabulary and precise explanations. The pupils research their topic and create a script. This serves as basis for their first podcast version.

**Podcast – First Version**

01 Student 1: Symmetry are things l that look same

02 Student 3: Symmetry means you have a line in the middle and both sides need to are the same like/

03 Student 2: A star has a symmetry . the flag of Great Britain has a symmetry a plane has symmetry - a pentagon a hexagon the White House has symmetry a flower a triangle a guitar a butterfly . uhm . symmetry has also a strawberry a ball . uhm . then underwears has symmetry and p a n t s and the f a c e #

04 Student 3: #and scarfs

05 Student 2: Yes . scarfs and glasses has symmetry .. *(is speaking low)* that's it%

In this version student 1 starts off with a general statement about symmetry by using an attributive clause in <01>. This statement is comparable to the first utterance of the unexpected recording. The emphasis again is on the sameness of things. Student 3 seizes the idea of having "a line in the middle" in <02> which generates two equal sides. This idea, described by a common expression, seems to relate to the line symmetry. In order to express meaning, an identifying clause is used. However, the exact aspect of symmetry and the objects referred to have not been explicitly conveyed yet. Only in statements <03>, student 2 presents some examples concerning line symmetry by using common words as well as technical terms, e.g. "hexagon" and "triangle". It appears that he forgets to mention one example, which student 3 adds in <04>. Student 2 repeats the suggested word and names another example in <05>. In contrast to the unexpected recording, the statements are now better conceived and more structured, except for the rather informal beginning and end. In the editorial meeting the peers praise the chosen examples. The boys receive constructive criticism to improve their script in terms of content, style and language.

**PriMaPodcast**

01 Student 3: What is symmetry

02 Student 1: Symmetry are things that look same on both sides . when you have a mirror and put it in the middle . of a symmetric thing and it looks same . on both sides it is symmetric ... A mirror is like a line o of symmetry

03 Student 3: These . there are lots of things . that are symmetric\ but not all things are symmetric\ these things are not symmetric\ a radio a door a piano a crane an ocean a sea a river\ these things are symmetric

04 Student 2: Clothes a tie glasses pants and underwears shapes a star the flag of Great Britain a triangle a hexagon a pentagon . nature for example butterflies flowers and strawberries\ . music a guitar/ a violin\ . electricity a plane even words can be symmetric otto

Student 3 reads out the question in <01>. Student 1 gives a definition by using an identifying clause, similar to the beginnings of the other recordings: he equals symmetry with "things that look same on both sides" in <02>. Then he returns to the idea of mirroring which was originally uttered in the unexpected recording. The instruction on how to mirror is more detailed than before. Moreover, the technical term "line of symmetry" is used for the first time. In his explanations student 1 relates to general 'symmetric things'. Before these things are further explained by giving lots of examples in <04>, student 3 emphasizes in <03> that "not all things are symmetric". Having taken up the idea of the unexpected recording, he names seven things, which are not symmetric. He leads over to student 2 who reads out the examples of symmetry in <04>. Some of them, which are presented in the first podcast version, are not mentioned here any more (e.g. the 'White House' or 'a scarf'). Another difference is that the examples are classified into categories like 'clothes', 'shapes' or 'music'. Thus, they are more structured. A new example of symmetry is highlighted in the end: words like 'OTTO' can be symmetric, too.

## CONCLUSIONS

As presented in the empirical example, the production of PriMaPodcasts makes it possible to investigate the bilingual learners' use of mathematical language. Each stage of production allows the mathematical language of the group to develop and become more specific as seen in the transcripts. The implementation of mathematical discourse practices, such as explaining and defining, enable the learners to express and discuss their mathematical thought processes. Moreover, the reflection on certain content deepens the students' mathematical understanding. The interactive procedure corresponds with the requirement of a mathematical conceptualization, by going beyond the stringent learning of technical terms and vocabulary. Thus, learners are groomed to become mathematically literate.

In the context of my PhD project, the presented research framework has been implemented twice so far. The analysis of the single stages (audio and video taped) will open up various possibilities to retrack the learners' progress by producing PriMaPodcasts in German and in English. Hoping to get further insights into the learners' understanding of mathematical concepts, the project will continue. As this is an on-going PhD project, further results cannot be disclosed as of yet.

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