THE INFLUENCE OF LEARNERS' LIMITED LANGUAGE PROFICIENCY ON COMMUNICATION OBSTACLES IN BILINGUAL TEACHING/LEARNING OF MATHEMATICS

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The paper is a part of a longitudinal study focusing on qualitative aspects of teaching/learning mathematics in a foreign language. Its aim is to contribute to understanding of the relationship between language and learning. The focus of this contribution is on learners' language and the interferences limited language proficiency can bring to learners' receptive and productive domains. The interferences are analysed, classified and illustrated. Possibilities to eliminate their negative influence on learning are presented. 10-11-year old children in the U.K., Germany and the Czech Republic participated in the study. Neither the teacher nor the children were native speakers of the language of instruction. The aim of the study is to increase teachers' sensitivity to the interferences, their nature and consequences.

1. INTRODUCTION

Bilingual education is a general expression used to refer to any teaching of a non-language subject through the medium of a second or foreign language. In our research, it refers to the teaching and learning of mathematics through a foreign language without any use of the mother tongue. All bilingual programmes including Content and Language Integrated Learning (CLIL) follow the same aim suggesting equilibrium between content and language learning.

Both the subject matter and the foreign language are developed simultaneously and gradually. This is why it is sometimes called *dual-focussed education*. In CLIL classes, the language acquisition naturally goes hand in hand with cognitive development, the integration of content and second language instruction provides substantive basis and exposure for language learning; the language is acquired most effectively when it is learned for communication in meaningful and significant social situations.

In the learning process, a wide range of cognitive processes is activated. Normally, this occurs in the mother tongue. In CLIL, however, mathematical understanding and thinking manifested by the language of mathematics are developed through a foreign language, and conversely, the foreign language is developed through the non-language content. CLIL provides plenty of opportunities for incidental language learning which has been proved to be very effective, deep and long-lasting, (Pavesi et al., 2001). Here, the learners' attention is focused on the mathematical content and thus Second Language Acquisition (SLA) can become non-conscious.

2. RESEARCH QUESTIONS

The teacher's task is to enable the students to develop their idiosyncratic process of knowledge building and meaning construction as well as positive attitudes (DeCorte, 2000). It is a common belief that mathematics and languages are difficult subjects. Therefore, in order to help the learners succeed, it is of the utmost importance for the teacher to examine and analyse possible barriers that might have a negative impact on learning. The CLIL teacher should be able to suggest ways to minimise these and use a variety of effective teaching strategies that would help overcome individual learning difficulties.

The aim of our longitudinal research is to analyze interferences in the interaction during CLIL lessons. We do not attempt to solve general questions of the communication between the teacher and the students; we focus on the following questions:

- Which types of misunderstandings are most connected with the use of the second language?
- How can we identify their causes?
- What can the teacher do to eliminate the negative influence of these interferences?

In this paper, we focus mainly on students' language perception and production.

3. THEORETICAL BACKGROUND

Research on CLIL in mathematics education should address the relationship between language and mathematics learning from a theoretical perspective that combines current perspectives of mathematics learning and classroom discourse with current perspectives on language, second language acquisition, and bilingual learners. Teaching and research are framed by theories of learning in general, theories of mathematics learning and, in this context, theories of SLA. In accordance with Hofmannová, Novotná, Moschkovich (2004) we believe that "theories and empirical results from linguistics, cognitive psychology, and sociolinguistics have laid the groundwork for the study of mathematics learning as it occurs in the context of learning an additional language".

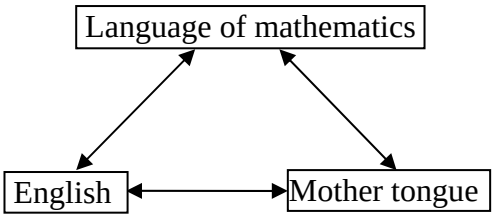
Language use makes the thought processes easier, it also has impact on perception and memory, and it facilitates mental manipulations and representations. With regard to perception of mathematics in monolingual classrooms, possible problems are intralingual whereas in learners who are functionally bilingual the difficulties are of the interlingual nature. Therefore, it is clear that the study of bilingualism is of great importance. (Novotná, Hofmannová, 2003) According to the language of instruction, CLIL classrooms can be organized in different ways: (1) the teacher is a native speaker of the language of instruction and the learners' mother tongue is different from this language, (2) both the teacher and learners are not native speakers of language of instruction. In our research we focus on the situation (2).

Learning mathematics as a discursive activity is described by (Forman, 1996). Theoretically speaking, classroom communication seems to be a simple process covering both receptive and productive skills of learners. In practice, however, the teacher and the class have to make a number of decisions in order to understand the content matter and to make themselves understood successfully. The task is not easy even in the learners' mother tongue. In a foreign language which the learners have been learning for several years only, it is even more complicated. (Hofmannová, Novotná, 2005).

There are diverse approaches to investigating language classroom, the better-known being interaction analysis, discourse analysis, conversation analysis, and variable approaches. (Walsh, 2006) From the above listed approaches, interaction analysis is most closely related to our analysis, as it does not deal only with linguistic aspects of conversation; it includes observation and/or coding instruments. However, majority of its studies do not focus on the special features of CLIL settings. The sets of keys and coding variables in various types of interaction analysis were developed for foreign language classrooms and they need to be modified for the use in CLIL classrooms. Our research attempts to contribute to this movement.

We are studying interferences that are caused by limited language abilities of participants. Under *interference* we understand any disturbance in communication. It may be for example a misunderstanding or an obstacle.[1] The sources of interferences in CLIL add two more sources in comparison with monolingual settings. To the interferences between the language of mathematics and mother tongue, these between English and mother tongue and English and language of Mathematics (see Fig. 1).

Figure 1



In (Petrová, 2005), the following obstacles that had appeared were presented and characteristics of each of them illustrated by extracts from protocols was given. They were divided into two groups: language problems (unknown terminology, language misunderstanding and mathematical misunderstandings) and communicational specifics of CLIL (ineptitude in speech and limited learners' language production).

4. OUR RESEARCH

Experiments leading to answering of the research questions were carried out in three countries - Great Britain, Germany and the Czech Republic. The aim was to teach the same topic under different conditions – different language competencies both of the learners and of the teacher – and to compare communication under these conditions. In the analysis of all practical experiments, we were looking more deeply at the influence of the language of instruction on the comprehension of the mathematical ideas as well as on the communication in the whole episode.

Experiment design

The *topic* of the teaching sequence was probability. It was presented as a problem of deciding whether a game is fair or not. The mathematical problem dealt with was a non-standard problem. The participating students had not solved similar ones before. This problem was chosen for the following reasons: (a) In order to eliminate the influence of previous experience, a common mathematical topic which the children would already be familiar with was not picked up. (b) It required calculating but not difficult mathematical operations. (c) The problem gave much opportunity to speak. (d) The needed vocabulary did not involve too many special terms and it could be visualised easily. (f) Playing the game and asking if it was fair or not was very motivating and at the same time it was based on real-life experience and investigating.

The approximately 60 minutes long teaching episode was based on playing the game[2], investigation, making graphs, calculating and answering questions, trying to change the game to make it fair and then playing another game in order to verify the new knowledge.

Participants

In each episode, the teacher worked with *groups of two or four children* aged 10-11. The reason for the limited number of participating children was our experience from the pre-experiment clearly showing that work with more numerous groups made the analysis of children's responses and the dual focus (on mathematics content and communication about it) extremely difficult. The whole session was recorded on a tape. The children were usually mixed both in mathematical abilities and in gender. At first we only worked with children whose mother language was the language of instruction (English or German) and later we worked with children who were learning in a second language. Their ability in the second language varied greatly from almost balanced bilinguals to those with a very low ability. For the teacher, it was always bilingual teaching.

The role of the experimenter and that of the teacher were merged in the person of one of authors. We see the main advantage of this organization in the direct access to the sources of the teacher's reactions and decisions in managing the teaching episode. The roles of the teacher and the teacher/observer are different; see e.g. Brousseau (2002) in (Novotná et al., 2003). We believe that merging the role of the teacher and researcher offers to us better understanding of the development of the teaching episodes.

Methods for the collection and analysis of the results

The experiments were audio-recorded. These recordings were later transcribed and analysed. At the same time the teacher's reactions and teaching strategies, and the children's reactions, answers and reasoning were closely looked at. The amount of speech of the teacher and the children were compared. The language was studied

linguistically, the mistakes and communicational obstacles were collected, classified and analysed.

In our ad hoc approach, the interactional features enabling the analysis of teacher's and pupils' interactions were defined. The dual-focus (mathematics and English as the language of instruction) was preserved. The analysis was done from the perspective of production and reception.

4. RESULTS

No major *mathematical* difficulties were encountered during the experiment. All groups succeeded in solving the problem – finding why the game was not fair and changing the rules to make it fair. The main mathematical teaching objective of the teaching sequence was fulfilled.

As to the *language used for communication*, obstacles in the teaching of those children whose mother tongue was not the language of instruction occurred. In the following text, the characteristics based on the receptive and productive nature of children's behaviour is presented. The results of the analysis and classification of interference from the perspective of didactics of mathematics in the CLIL environment are summarised. We also attempt to give hints for the teacher to avoid or minimize the influence of the detected interferences.

Learners' receptive skills

(a) Unknown vocabulary

(a1) New mathematical concept or symbol. n such case, the learner does not understand the meaning, principle, rule.

Example: There were some special mathematical terms that were new to children, such as *probability, even chance, or sum*.

Experimenter: What is the more probable … you know the word probable?
Pupil: – (Does not say anything.)
E: More probable is more likely, you have bigger chance. For example: it is more probable that you will see a dog this afternoon, but it is not very probable that you will fly to the moon next week…you have a good chance to see a dog but almost no chance to go to the moon. So, what is more probable, more likely that you will get on the two dices? The sum, the total of ten or of six? … and why?
P: (after a while looking at the diagram) The sum 6, there are more ways how to make it.
E: Yes, there are more possibilities to make six.

When preparing the lesson, the teacher should foresee what would be difficult for the learners. When introducing new vocabulary or special mathematical terms, s/he should always try to paraphrase the items, to illustrate them by examples, to use visualization, to demonstrate how they work and if necessary try to simplify. When preparing the lesson, it is highly recommended that the teacher prepares a list of key concepts and symbols with examples.

(a2) Unknown vocabulary from ordinary language. In this case, the learner does not understand the question, explanation, assignment, etc. although s/he is able to deal with its mathematical background successfully in other cases. The lack of everyday language may result in refusing to solve the problem or in misunderstanding of the task.

Example: In the last sentence of the previous example the answer of the pupil was repeated and the word *possibility* used instead of *ways*. It was a simplification, but did not lead to misunderstanding in this case. It was a brand new experience for the teacher that even with very limited knowledge of English, the communication with immigrant children was possible. The means of communication was automatically supplemented by language gestures, mimics, and pictures, repeating and showing on visual models.

When detecting this interference, the teacher is in a more difficult position. Usually, it differs from learner to learner and the teacher's help should be individualised. The teacher has several options how to react: e.g. modify formulations, simplify, use "everyday life" and visuals, and prepare written materials for learners with difficulties with language comprehension. Simplification can help the learners to understand, but the teacher must be aware of the misunderstanding that it can sometimes cause.

Language misunderstanding increases with the decreasing level of learners' language competencies. A necessary condition to succeed in cases of very limited language competencies is the presence of strong interest of the learner for the topic, practical use of the problem and activating teaching methods.

Remark: However, it is often very difficult to determine whether the learner did not understand the language itself or the mathematics in it.[3]

(b) Demands on concentration, thinking in a foreign language

This issue is discussed in (Marsh, Langé, 2000): "It is possible that the CLIL class may be perceived as 'more demanding' by the child, for the simple fact that listening, reading, speaking in an additional language is tiring until we get used to it. Therefore it is possible that the workload will feel heavier for the child, but it is up to the school to ensure that this is kept. …"

In CLIL, articulation, pace, intonation etc., are extremely important. Our experiments clearly manifest this point. Teachers have to pay attention to clarity of their speaking and adapt the pace to the level of the learners' language.

(c) Cultural interference

Another source of interferences mentioned in literature about second language acquisition and about bilingual education is the cultural dimension**.** We have not noticed this interference in our experiment. The reason could have been that the topic

was not related to a specific culture reality and also that we did not use authentic textbooks but materials that we prepared ourselves.

Nevertheless, to eliminate cultural interference it is recommended to collect information about the language environment of the learners and of the language of instruction to understand the culture differences better. When using authentic textbooks, one should realize and possibly draw learners' attention to cultural differences. (Novotná, Moraová, 2005)

(d) Verbalism and formalism of new piece of knowledge

By verbalism and formalism in this context we understand the situation when the learner knows the symbols and terms but does not understand their meaning. The new piece of knowledge is not included in the existing cognitive system, is not stable. (Hejný et al., 1990)

In our experiment, verbalism and formalism did not occur. We see the reasons for it in the following fact: The lesson was conducted in the form of a game (motivation). The teacher explained new vocabulary through exemplification, synonyms, which offered children the opportunity to create meanings of new notions and connect them with already known ones. The goal of the lesson was not to verbalize new knowledge but to create new game rules which naturally asked for relating the new ideas with the already known ones.

Learners' productive skills

In (Langé, 2002) it is stated that "limited language production of the pupils is a natural phenomenon especially by young learners". The goal of teaching mathematics through a foreign language is mainly to communicate certain knowledge, not to give enough language output. That's why we suppose the limited language production of learners is not something that the teacher should be anxious about too much.

(e) ***The limited learners' language production*** might have the following main consequences: Learners

(e1) have difficulties to formulate (correctly) an idea, pose questions and answer them, communicate clearly in the foreign language what was not understood;

(e2) make mistakes in grammar, syntax as well as use of vocabulary (in both ordinary and mathematical language);

(e3) are passive in oral communication.

Our experiments confirmed that the limited learners' language production in a session resulted in very low learners' participation in the talk and on the other hand, very high teacher's participation. The danger of presence of Topaze and/or Jourdain effects (Brousseau, 1997)[4] increases. The teacher either "helps the learners too much" or overestimates the quality of their knowledge.

(f) ***The limited learners' knowledge of the language of mathematics***

It is manifested in a similar way as in (e). Code switching and discontinuous learner's speech are the common accompanying events. Often, learners substitute the correct term by its approximation from everyday life language or from the already known, but less precise, mathematical terms.

Example: The teacher asks children to describe the graph they obtained when recording graphically the results of throwing dices. Children do not know the terms increasing and decreasing function. They replace these terms by other ones with which they are familiar.

E: Actually, yes. How does the look …does how does the graph look like?
A: eh...like a …
D: A shade.
A: No, like ….Like "I-sign"
E: Like what, like I?
A: ????? ??????(murmurs)
E: Different "Is"?
A: Yes. Going down…At first it goes down ... and then it is going … up.
D: Down and up, up and down.

The young learner speaks in short phrases and simple sentences often making many grammar, word order and usage mistakes. Mistake making is a necessary learning process and leads to language fluency. The sentences are shorter, and not as complex as adult-to-adult-speech. The teacher should rephrase and use repetition more frequently and check frequently that the learner has understood the message. Body language and visual reinforcement are emphasised when speaking to the young learner. The importance of the listening stage should not be overlooked and initially at the start of a CLIL programme the teacher produces most of the language. The teacher should know this and should not consider limited language production of his/her pupils as a sign of failure of bilingual learning.

6. CONCLUDING REMARKS

CLIL involves a number of issues. Marsh (1997) maintains that it is a motivating and challenging way of learning. By offering the target language as a tool, and giving the learner the opportunity to 'learn by doing', it is possible to reach positive and worthwhile outcomes. At the same time, it puts additional demands on the teacher related to the presence of three languages – mother tongue, foreign language and language of mathematics. In (Marsh, Langé, 1999), the following CLIL specifics are presented: the need of using a variety of media to bring the foreign language in the classroom, the role of redundancy or the ratio between teacher's and learners' talk volume, checking of comprehension or context-specific methodologies such as co-operative working styles are some of them.

The experiments showed that the teacher's limited language competence in CLIL interactions did not obstruct successful realization of the lesson. However, the preparation of the teaching episode was extremely demanding. The teacher's immediate self-reflection, analysis of setting up activities, elicitation of feelings, attitudes and emotions of pupils, focus on the use of texts and other materials and learners' production play the key role in the development of successful teaching strategies and language mastery of the teacher.

In CLIL classes, the teacher should be sensitive to the learners' needs as regards learning content, the mother tongue and the foreign language. S/he cannot prevent or at least diminish the interferences caused by the limited language skills of learners if s/he is not aware of the possibilities of their occurrence. In this we see the utmost importance of the analysis of the possible interference on the communication part of which is presented in this paper. We hope to contribute to the increasing sensitivity of teachers to these interferences, their nature and consequences.

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[1] In (Jirotková, Kratochvílová, 2004), the term communicational conflict is used. The authors speak about it when each participant of conversation understands the same word in different ways. The interference in our sense is broader, we admit e.g. the case when the participant has no idea etc.

[2] *The rules of the game:* You need two dice and some counters. Play this game with a friend. Take turns to roll both the dice and add the two scores. If the sum is 2, 3, 4, 10, 11 or 12, the first player takes a counter. If the sum is 5, 6, 7, 8 or 9, the second player takes a counter. The winner is the first to gain fifteen counters.

[3] This problem is discussed in the work of Hofmannová, M., Novotná, J., Pípalová, R. (2004). Assessment Instruments for Classes Integrating Mathematics and Foreign Language Teaching. *ICME 10, TSG 27*, Copenhagen.

[4] Topaze effect: The teacher begs for a sign that the student is following him, and steadily lowers the conditions under which the student will wind up producing the desired response.
Jourdain effect: It is a form of Topaze effect. The teacher … claims to recognize indications of scholarly knowledge in the behaviour or responses of a student, even though they are in fact motivated by trivial causes. It is a form of the Topaze effect.