

Elsa Foisack,
Ph.D., senior lecturer
School of Teacher Education
Malmö University
Malmö, Sweden
20/01/2008

Learning mathematics in a bilingual context - sign language and spoken/written language

The question why many deaf pupils have difficulties in learning mathematics is of great importance. International research shows that deaf pupils achieve much lower results on tests in mathematics than hearing pupils do (Frostad, 1996; Nunes, 2004), but we know very little about why it is so. In this paper I will focus on the language situation for deaf people and if the way deaf pupils express themselves in sign language influences their concept formation. My topic Learning mathematics in a bilingual context refers to the situation for people who do not hear or have difficulties in hearing spoken language and therefore use sign language for direct communication, in this case Swedish Sign Language (SSL) as well as a spoken/written language, Swedish.

In Sweden sign language has been recognized as a language only since 1981 and research in sign language as a language has been going on only since the 1970's at Stockholm University, research that is now of crucial importance internationally (SOU 2006:29). Sign language is a language that has been developed by deaf people in the need of direct communication and has always been in use. It is a gestural-visual language and it has no written form. Sign language users are considered to be a minority group in the hearing society and so there is a need for competence in the language used in the society. The degree of the hearing loss limits the use of spoken language, but for the use of written language there are no limitations. According to the late recognition of sign language as a language in Sweden, as well as in most other countries, Swedish only was the official language taught in the schools for the deaf and hard of hearing until the curriculum of 1983 prescribed the languages to be Swedish Sign Language (SSL) and Swedish (Skolöverstyrelsen, 1983). Since then the bilingual approach has been in development in the schools for the deaf and hard of hearing in Sweden.

In a School for deaf and hard of hearing pupils in Sweden the sign language environment is crucial. Swedish Sign Language is taught as a separate subject and has a bilingual approach

with the two languages Swedish Sign Language and Swedish (Skolverket, 2000/2002). The basic objectives are however the same as in all schools in Sweden. In the syllabus for the schools for deaf and hard of hearing in Sweden (Skolverket, 2000/2002) there is a general text on bilingualism from which the following quotation is taken:

Learning occurs through both languages. Bilingualism is therefore important in all school subjects, not only in the two subjects Swedish and Swedish Sign Language. Every subject has subject-specific concepts and a terminology that the pupils do not meet in other subjects. As a consequence it is every teacher's obligation to make sure that the pupil masters these concepts in both languages.

Concerning mathematics there are a great amount of well defined subject-specific concepts and related terminology in spoken/written languages that pupils in school need to master. The quotation above shows that an equivalent terminology for mathematics in Swedish Sign Language should be used, a terminology that need is in need of development.

I will bring up theoretical issues of importance to my research, findings and suggestions to further research in the area.

Theoretical issues

The children I study are pupils in Schools for the Deaf and Hard of Hearing in Sweden. I will mainly refer to the study I reported for my Ph. D.-exam and those pupils were in fourth grade, 10 – 11 years old. In my approach to study learning my focus is on Cognitive Education and theories developed of Feuerstein (Feuerstein et al., 1991) concerning mediated learning, about the importance of qualitative aspects on teaching. Theories by Feuerstein are closely related to those of Piaget, but the uniqueness is in the connection to how learning is developed in a social context influenced by Vygotsky. For assessment Feuerstein has developed a dynamic approach to reveal the learning potential of the individual. Interaction is crucial but the purpose is for the individuals to understand and solve problems on their own.

In analysing the pupils' use of sign language in my research study, I used the four characteristics of sign language (Bergman, 1979): *iconicity* developed out of visual aspects, for example triangle and cube; *simultaneity* using both hands at the same time showing two separate one-hand signs; *movement*, for example moving the hand away from your body

telling I-GIVE and moving the hand towards your body telling I-GET; *spatiality* not linear like spoken languages, but “painting” an imaginary picture or movie.

Studying learning mathematics my focus is on literacy and numeracy explained by Nunes and Bryant (1996), on developing basic arithmetic explained by Marton and Booth (1997) and the concept formation of numbers according to Fuson (1992).

Deaf and hard of hearing pupils learning mathematics

Mathematics is not only one out of several subjects in school; it is a way of thinking necessary in everyday life. In its broad sense mathematics is constantly becoming more and more important in our society. Nunes and Bryant (1996) use the expression numeracy for mathematical literacy, which they consider to be of equal importance as literacy in the sense of language competence. They define numeracy as the ability to use mathematical concepts and to think mathematical in different situations. In a broader context of literacy it is defined as to be able to cope with any situation and to understand and to use information of different kinds. According to Nunes and Bryant (1996), numeracy has to be developed by every child in three main steps. First you need to be logical, second you need to learn conventional systems and third you need to use your mathematical thinking meaningfully and appropriately in situations.

Research has been conducted at Oxford University (Nunes, 2004) on teaching mathematics to deaf children on coordinating logic with mathematical conventions for representing information. An intervention programme is constructed taking in account findings that deaf children have strengths in spatially presented information and that they are weaker when information is presented sequentially. Illustrations to support the problems to be solved were used as well as the use of content-free materials to express and act out what happens in the problem. The pupils showed considerable progress in their mathematics learning through out the year of the study.

Out of Marton and Booth (1997) I find great importance in explaining learning simple arithmetic defined in three main steps: Modelling, counting strategies and number facts. Modelling is when children use objects or their fingers to model problems. The next step, counting strategies, is when children may count silently or aloud without using any objects.

The third step, number facts, is when children simply know out of the addition and subtraction tables. By using the relevant combinations of numbers, they can solve the various problems they meet.

What strategies children use at the second step are qualitatively different and are of great importance for the teacher to verify, since they may not lead to the third step and to develop mathematical thinking. In my own research I identified strategies used by the pupils expressed in sign language. Here are some examples of strategies taking advantage of the nature of the sign language from my findings. I found pupils' use of distinct rhythmic movements to express repeated addition to be of good help. For numbers in Swedish Sign Language one hand is normally used. I noticed how pupils used one hand for a number they wanted to remember and kept signing with the other. Pupils would also use both hands representing one factor each to express multiplication, i.e. the number of girls by one hand and the number of apples by the other hand. Pupils used the space in front of them to explain the problem by placing the boys to one side of them and the girls to the other. I noticed pupils using "double counting" to keep track in the following way i.e. solving $2 + 5$. 2 was signed by one hand and 5 by the other, then they counted up by one hand from 2 to 3 and down by the other from 5 to 4. Next counting up by the one hand from 3 to 4 and down by the other from 4 to 3. Then counting up from 5 to 6 and down from 3 to 2, from 5 to 6 and from 2 to 1 and finally from 6 to 7 and from 1 to 0. And by having nothing left, the answer was to be 7. Pupils were also using the commutative law, i.e. when solving a problem like $2 + 5$; they would switch to $5 + 2$. Double counting is a strategy noticed to be used frequently by deaf children. Frostad (1998) points out the importance of keeping attention to it, since it is not a strategy leading to the use of known facts. That is however the strategy of using the commutative law.

Basic concept formation of sign-language users has become a great interest of mine, since I have realised its importance in developing mathematical thinking. I will explain it by describing aspects of concept formation of the number three. Mathematically Fuson (1992) has identified seven different contexts in which you operate. Those are sequence (1, 2, 3 ...), counting (three elephants as well as three ants), identification (the number three), cardinality ($2 + 1$ as well as $4 - 1$), ordinality (the position on the number line), measuring (3 cm) and non-numeric (Solvägen 3). Only when you can use all of them and switch between them automatically, you master the concept. That conclusion is of importance in identifying the pupils' knowledge of number concepts.

My concern is that by using different modes of representation, you have a wide range of expressions and actions in developing thinking in mathematics. In language you can use the sign for three, fingerspell three by using the hand alphabet, say the word three or write it. Of importance in expressing mathematics are also non-verbal representations like using three objects, three fingers arbitrary or three content-free objects. For sign language users you realise by this description the difference in using two spoken/written languages from using a signed and a spoken/written language in a bilingual setting. In the use of sign language it was possible to analyse whether the pupils used their fingers as an abstract symbolic expression for the number three or concretely as three fingers. When solving the first problem one of the pupils, Olga was thinking and the showing the number sign. When asked how she solved the problem, she used the number signs and thereby showing that she was thinking in wholes and parts of the whole. Ines, another pupil started out showing the number signs and then counting the fingers of the signs one by one. Olga showed a symbolic expression, while Ines did not, since she used each of the fingers of the number sign as an object to be counted.

Does the way deaf pupils express themselves in sign language influence their concept formation? That is one of the research questions in my theses (Foisack, 2003) and here are my conclusions. In my study I found the pupils use all of the four characteristics of sign language as follows: *Iconicity* by using fingers for the numbers 1-5, *simultaneity* by signing one number in each hand, *movement* by showing the action in the problem and *spatiality* by localizing the objects of the problem in the space in front of them or on the table. Pupils using the characteristics of sign language consciously succeeded better in solving the problems. Using the structure of sign language in mathematics was helpful when describing the problem. The visual aspects of sign language may hamper concept formation in mathematics. For the last point I refer to the iconicity of sign language. It may cause that abstract representations are not developed. It can however also be of good help, for instance by keeping numbers in vision as explained earlier.

The study was set up so that the pupils were asked to solve certain problems out of the research question how deaf pupils express themselves and act when confronted with a mathematical problem. To reveal the concept formation, the solution of a problem presented was discussed in four different ways: in sign language with no material available, with paper and pencil, with learning materials i.e. Centimo, Cuisenaire-rods and buttons, and with real

objects i.e. apples to count and shelves and pencils to measure. In analysing the data, I notice how the pupils solved the problem at the different levels of abstraction. The ultimate goal was to solve the problems without any materials, the most abstract level, even though my focus of research was on the process. One of the seven pupils in the study solved all the tasks presented without any materials and could explain his way of solving the problems using all different materials, while the other pupils needed more or less of mediation to understand and to solve the problems presented. An important finding was to what extent the pupils used the knowledge they gained from using one kind of material to using another and from solving one problem to another.

Conclusion

From my research study I want to bring up two concluding statements. The first one is the importance of a more developed terminology in sign language and the second is finding alternative methods for teaching mathematics to deaf pupils developed out of a bilingual perspective. The spoken/written language is used by the majority and therefore necessary to all members of the society. Sign language users are a minority and therefore not always in focus. But for direct communication, sign language is necessary if you don't hear spoken language and for developing concepts it is crucial to use your first language – the language you use for thinking. Research concerning deaf children solving mathematical problems in sign language that Pagliaro and others are doing in the USA (Ansell & Pagliaro, 2006; Lang & Pagliaro, 2007; Pagliaro & Ansell, 2003) will certainly bring new knowledge to the issue.

My suggestion for further research includes both aspects. By now we know that direct communication in teacher – pupil as well as in pupil – pupil situations are crucial in learning mathematics. Since sign languages are not international but national, a more developed terminology in the Swedish Sign Language (SSL) has to be done in Sweden by people competent in mathematics education as well as in SSL. Experience and knowledge internationally should possibly contribute to the work, i.e. research done in the USA (Lang & Pagliaro, 2007).

Concerning alternative methods the intervention programme used in research at Oxford University (Nunes, 2004) in teaching mathematics to deaf children showed significant improvement in learning mathematics. Illustrations to support the problems to be solved were

used as well as communication supported by use of content-free materials to express and act out what happened in the problem. I find the intervention programme used to be in accordance with my own research on forming concepts by deaf children. It would be interesting to try it out on Swedish pupils in the school for the deaf and hard of hearing. It has been developed out of recent and well established research on how deaf children learn, and it gives the teachers opportunities to communicate with the pupils with the purpose of helping them to develop logics and mathematical thinking. Further more it brings up the question of the competes of the teachers, another important area for future concern and research.

In this paper the question why many deaf pupils have difficulties in learning mathematics has been illustrated by focusing on the language situation for deaf pupils. Possibilities to improve the communication by developing the mathematics terminology in sign language and by trying out more effective ways of teaching and learning have been illustrated and are here by suggested to be in focus in further research.

References

- Ansell, E. & Pagliaro, C. M. (2006). The relative difficulty of signed arithmetic story problems for primary level deaf and hard-of-hearing students. *Journal of Deaf Studies and Deaf Education* 11(2), pp.153-170.
- Bergman, B. (1979). Dövas teckenspråk – en inledning. (Sign language of the deaf – an introduction.) *Forskning om teckenspråk III*. Stockholms Universitet: Institutionen för lingvistik.
- Feuerstein, R., Klein, P.S. & Tannenbaum, A. (Eds.). (1991). *Mediated Learning Experience*. London: Freund.
- Foisack, Elsa (2006). *Divisionssagor – ett sätt att komma igång med divisionsbegreppet*. (Division stories – a way of getting started with the concept of division.) Örebro: Specialskolemyndigheten.
- Foisack, Elsa (2003). *Döva barns begreppsbildning i matematik*. (Deaf children's concept formation in mathematics). Malmö: School of Teacher Education, Malmö University.
<http://hdl.handle.net/2043/1004>
- Frostad, P. (1996). Mathematical achievement of hearing impaired students in Norway. *European Journal of Special Needs Education*, 11(1), 66-80.
- Fuson, K.C. (1992). Relationships between counting and cardinality from age 2 to age 8. In J. Bideaud, C. Meljac & J-P. Fischer (Eds.), *Pathways to number. Children's developing numerical abilities*. Hillsdale, NJ: Lawrence Erlbaum.
- Lang, H. & Pagliaro, C. (2007). Factors Predicting Recall of Mathematics Terms by Deaf Students: Implications for Teaching. *Journal of Deaf Studies and Deaf Education*, published 7 June 2007, 10.1093/deafed/enm021.
- Marton, F. & Booth, S. (1997). *Learning and awareness*. Mahwah, NJ: Lawrence Erlbaum.
- Nunes, T. (2004). *Teaching mathematics to deaf children*. London: Whurr.

- Nunes, T. & Bryant, P. (1996). *Children doing mathematics*. Oxford: Blackwell.
- Pagliaro, C. M. & Ansell, E. (2002). Story problems in the deaf education classroom: Frequency and mode of presentation. *Journal of Deaf Studies and Deaf Education*, 7(2), pp. 107-119.
- Skolverket. (2000). *Grundskolans kursplaner och betygskriterier*. (Syllabuses and criteria for grades for the compulsory school.) Stockholm: Fritzes.
- Skolverket. (2006) *Läroplan för det obligatoriska skolväsendet, förskoleklassen och fritidshemmet, Lpo94*. (Curriculum for compulsory school system, the preschool class and the leisure-time centre) Stockholm: Fritzes.
- Skolverket. (2000/2002). *Specialskolan. Kursplaner och betygskriterier*. (The special school. Syllabuses and criteria for grades.) Stockholm: Fritzes.
- Skolöverstyrelsen (1983). *Läroplan för specialskolan. Kompletterande föreskrifter till Lgr80*. Stockholm: Liber.
- SOU (2006:29). *Teckenspråk och teckenspråkiga. Kunskaps och forskningsöversikt*.
- Specialskolemyndigheten, SPM (2006). (National Agency for Special Schools for the Deaf and Hard of Hearing). *Årsredovisning 2006*. (Yearly rapport 2006). Örebro: Specialskolemyndigheten.