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MICOLE
Multimodal collaboration environment for inclusion of visually impaired children

Specific targeted research project

Information society technologies

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Summary

This report describes a field study that has been conducted in five different countries (Sweden, Scotland, Finland, Austria and France) of visually impaired children's situation in their school (Task 3.1). Furthermore, this report describes the activities and results from the Prototyping Workshop that was performed by representatives of the partners in this WP in order to design collaboration support (Task 3.2)

User requirements study in the visually impaired children's context
The aim of this investigation is to accumulate knowledge about how visually impaired children collaborate in school with peers and teachers and to what extent the visually impaired children are engaging in group work in different countries. The interaction between the pupils and their teachers and the interaction between peers are important for learning in school. It has been increasingly noticed that collaborative learning has certain benefits due to the fact that the pupils learn through a dialogue with their peers and construct their own knowledge by doing tasks together with others. A field study was conducted in the different countries and the techniques used were interviews with teachers, interviews with visually impaired pupils and their peers and observations of actual group work in the schools. The results show that there are some big differences in the education between countries. However, there are also many similarities regarding aspects of collaboration that the visually impaired children engage in in their school work in different countries.

Design of collaboration support
Based on the results from the field studies in different countries, a Prototyping Workshop was held in Stockholm where the school situation for the visually impaired pupils in different countries were addressed. The problems that had been found in schools regarding the interaction between visually impaired pupils and teachers and their peers were collected and discussed. Different haptic and auditory applications developed within the MICOLE project were assessed during the workshop. New designs for supporting the specific aspects regarding collaboration and interaction among teachers and pupils found in the field studies were formulated.

1 Introduction to collaborative support for group work

The conversation between student and tutor and between pupils is an essential part of the learning process. This learning process should be discursive, adaptive, interactive and reflecting. Communication as a concept is used and defined in a lot of different ways with focus on aspects such as sender and receiver of messages, encoding-decoding, attribution of meaning, evoking of response, conveying meaning and so on. The visually impaired pupils that are the main user group in MICOLE do not have access to visual input like mimics and gestures when communicating with peers and teachers. However, haptic and auditory feedback together with talking verbally in shared collaborative interfaces could compensate for some of the information that these pupils otherwise not have access to. A social psychological definition of communication is formulated as follows
(Cherry, 1957):

> "the psychological signals whereby one individual can influence the behaviour of another "

Theories about groups often categorise the functions and activities that groups do in order to fulfil the goal of the group. It is interesting that a common denominator in many theories about groups is the emphasis put on the importance of both task and production on the one hand and maintaining and managing social relations on the other, in order for the group to attain its goals. According to the task circumplex model a formal group has three functions that are to produce, give members support, and maintain the group (McGrath, 1993). It will be important that the systems developed in MICOLE can efficiently support both solving tasks, learning and social interaction in order to support good inclusion of the visually impaired pupil in the collaborative learning process. One definition of what a group is has been formulated by Schein (1965):

> "a psychological group is any number of people who a) interact with one another, b) are psychologically aware of one another, and c) perceive themselves to be a group"

In order to cooperate, groups and individuals have to coordinate their activity through communication. The components that are important for coordination are activities, goals of activities, actors and interdependencies. Interdependencies that are of importance are shared resources, to synchronise simultaneous activities and to manage processes where one activity has to be finished before the next activity can start. Underlying processes to coordination are decision-making, communication and perception of common objects like physical objects or shared databases. In this work package it is important to investigate how those aspects are manifested in the group work in schools. Malone and Crowston (1990) define coordination as follows:

> "The act of managing interdependencies between activities performed to achieve a goal."

Groupware are systems that support distributed or co-located cooperation, coordination and communication, and this concept is used in the area of

computer supported cooperative work (CSCW) (Sauter et al., 1995). A frequent way of classifying these systems is in terms of their ability to support groups whose physical proximity varies along two continua of time and space (McLeod, 1996). In the time continuum there is groupware that supports synchronous and asynchronous work and in the space continuum groupware can support different degrees of distributed or co-located work. In the case of the pupils´ group work in the school the field studies in this work package have shown that group work in the school is mostly co-located and often but not always synchronous. This means that the group sits down and work together at the same place and work at the same time. However, some group work that is done over a longer period of time in the school is asynchronous because pupils sometimes sit together and work but sometimes work individually during the project period.

In the area of computer supported cooperative work (CSCW) people's level of awareness of others activities has been identified as important for cooperation in groups. The concept of awareness is generally used in terms of, individuals' perception of others' activities and the status of others' work-processes. When people that cooperate do not have the opportunity to get this kind of information, if they for example work in a distributed way, studies have shown that they do not reach the same quality in joint projects (Kraut et al., 1993). Awareness is necessary for all kind of cooperation but it can vary due to what degree of focus the cooperation has (Gaver et al., 1991). When working closely together in order to solve a task, individuals get a large amount of information about status in the work process and thereby get a high degree of awareness. A lower degree of awareness characterises cooperation where a main task is divided into subtasks between individuals. Apart from this, co-located individuals have general awareness of events going on in the surrounding context. In the case of visually impaired and sighted pupils collaboration in school, this general awareness has to be transmitted through other senses than vision which limits the information that the visually impaired pupil gets compared to the others. This might make it harder for the visually impaired student to obtain awareness. However, a shared multimodal interface, that represent group activities and objects in complementary ways, that both sighted and visually impaired pupils can use, might give mutual awareness.

2 Objectives of this work package

The objective of this Work Package is to investigate the specific issues of collaboration in cross-modal interfaces in order to gain knowledge about how visually impaired and sighted children can interact and learn on equal grounds. Another objective of this Work Package is to make a mapping of problems in interaction between sighted and visually impaired children in collaborative situations in their environment in the field.

In this first year, these objectives were addressed in Task 3.1 (User requirements study in the children's context) and in Task 3.2 (Collaboration support). The aim of Task 3.1 was to conduct a field study in order to explore situations involving collaboration among visually impaired and sighted children in their environment when learning at school or playing with friends. The techniques used were primarily open-ended interviews and observations. The aim of this assessment of the problem

space was to derive hypotheses that would inform WP4 in the specification of the interface prototypes (Task 4.1), and that would form the topics investigated in empirical studies year two described in Task 3.3.

Activities have also been performed the first year to address the plans in Task 3.2 (Collaboration support). The aim in Task 3.2 was to design tools to support collaboration in order to investigate the possible ways of representing information in a multimodal way so that blind and sighted children can work together. The ambition was for this process to be iterative in order to improve the tools continuously so that they finally fulfil the children's needs.

3 User requirements study in the visually impaired children's context, Task 3.1

Royal Institute of Technology, KTH has been involved in planning and leading the WP3 parts of the joint WP2/WP3 work meetings in Dublin in December and in Glasgow in May. This was part of the co-ordination work that was done in order to get the field study started at the different locations in which the study ran in parallel. Representatives from all partners have been present at those meetings and all partners have presented their ongoing work at these meetings continuously.

The field study that the partners in WP3 took part in was designed which means that methodology and procedure was formulated and decided on. The interview guides for the interviews with teachers and children were developed as well as an observation guide and a consent form. Different partners made local modifications to these guides so that they worked in the settings in each country.

3.1 The field study performed by KTH

A field study was performed by the researchers at KTH in schools in Sweden. Teachers in four schools have been interviewed, and both visually impaired and sighted pupils have been interviewed in three of these schools. The interviews covered issues concerning collaboration between the children during school work, different kinds of group work, their information handling in school, their communication with other children and the teacher and finally some questions about games and play.

Furthermore, the children's group work in school was video recorded and observed at three of these schools. The recording of naturally occurring group work group took place in class while the children did their regular schoolwork that was planned by the teacher. A full day of unstructured observation was also performed of a school day in one of these integrated classes that were included in the field study.

Contacts were made with four schools in the Stockholm area. Teachers and pupils in three of these schools agreed on letting us interview both the teacher, the pupils and make observations of and to video record group work. In one school only the teacher was interviewed. However, further contacts might make it possible to also interview pupils and to do observations of collaboration in that fourth school.

In total five teachers/personal assistants were interviewed in their schools. In one of these interviews both the teacher and the personal assistant were interviewed at the same time. Three blind and three sighted children were interviewed in the ages of 11 to 13 years. All visually impaired children are pupils in integrated classes in Swedish schools. All children that were interviewed were the only blind child in its school class.

Observations of group work that was naturally happening in the school work and that was planned by the teachers were made of three collaborating groups. Two of the groups contained three pupils and one group contained four pupils.

3.1.1 Results from interviews with teachers and personal assistants

3.1.1.1 General information

All the teachers and assistants had only one visually impaired student in their classes. Most teachers and assistants had in average about 20-25 pupils in their class. There was one exception in one school were the pupils in different ages were together in bigger classes with about 50 students. But this big class was divided into smaller groups. The pupils that the teachers and assistants had were in grade 6, 5 and 4.

Two of the visually impaired pupils were born blind whereas two had some sight left. All of these pupils used Braille except one pupil that did not want to use it. This pupil had some sight left and was according to the teacher very eager to fit in among her peers and she avoided as much of the special equipment that she could in order not to seem different from the rest of the pupils.

Examples of other equipment that the teachers and assistants said that the pupils used were Minilogg, Abakus, personal computer, Perkins system, internet, special rulers, tactile maps, rubber drawing pads, wax ropes, clay and all sorts of hobby material like pieces of cloth,wood and paper. The teachers and assistants also had access to Braille writers in school.

All pupils have a person that functions as a personal assistant but these have different training and education. Some have training in teaching pupils with special needs but one teacher did not have such training.

The teachers and assistants said that all visually impaired pupils had a personal computer at school and all pupils except one have internet access.

Regarding special training for the children apart from the ordinary school the pupils go and train certain things such as handling information in the computer, using tactile maps, reading Braille and using an ordinary keyboard.

3.1.1.2 Group work

According to the teachers and assistants the all the pupils engage in the ordinary group work in school. The most common number of pupils in each group is 4-5 pupils during a group work activity. The different types of group work are for example longer projects on specific topics, laboratory sessions in natural science such as chemistry or physics and problem solving in math in groups

When the teachers and assistants were asked to describe how a typical group work is done some of the teachers and assistants responded that the pupils get the task either in text to all the students or that just one student gets the text and then reads it for the other group members. Then the group typically divides the work among the group members and each student searches for information. Finally the students combine all the different information that they have collected. In some group work activities one pupil writes whereas the others give suggestions along the way of for example a laboratory session. All teachers and assistants except one said that the visually impaired students present the group work in the same way as their peers. One teacher said that her pupil couldn't handle presenting in front of the whole class. This student instead presents the work separately in front of the teacher, the personal assistant and one other pupil. In general the teachers and assistants claim that both the visually impaired and the sighted students in a class with one visually impaired student become very good at explaining things verbally. This was something that even the pupils' parents had recognised when comparing with all the kids in a family according to the teachers and assistants.

One teacher said that the other pupils regard the computer that the visually impaired pupil has access to as an asset. The teacher claims that this makes them wanting to work with the visually impaired pupil. The group then goes to the work place of the visually impaired pupil and gather around the computer and work there.

3.1.1.3 Difficulties due to visual impairement

The difficulties concerning doing group work specifically for the blind child due to the visual impairment was something that was discussed with the teachers and assistants. A general problem that was mentioned was that reading takes too long time for the visually impaired child and that reading Braille and discussing at the same time is sometimes too cumbersome to manage for the pupil that then misses some of the things that happen in the group work. A big problem for one visually impaired pupil was that he did not have access to internet at his computer whereas the sighted pupils had that. One teacher brought up the problem that she perceived that the visually impaired pupil sometimes have problems following the mimics and gestures of the others and that the pupil therefore misses social cues. This can sometimes have negative consequences for the visually impaired pupil when engaging in group work in the school. Another problem was that in chemistry and physics pupils get help from the others to understand processes but these are still hard to understand and abstract phenomena are generally hard to understand.

3.1.1.4 Pedagogical practices

The teachers and assistants had tried to include outdoor activities in group work and generally had good experiences from that. One example brought up was that some project work was done outdoors such learning the names of different plants and how they are built. One teacher said that using the concrete outdoor context as a resource was an explicit aim in the education.

Generally the teachers and assistants had noticed that modelling in any material was usually better for the visually impaired pupil than drawing. They had noticed that the visually impaired pupil was not able to draw correctly and one teacher discussed whether there is any good reason at all for the children to learn how to draw a picture correctly. The teachers and assistants were not sure that it was meaningful for the visually impaired pupil apart from getting the ability to show others a correct drawing.

Generally the aims pedagogically with the group work activities were that all pupils including the visually impaired pupils should learn how to work together in groups. It is formally stated in the school curricula. All pupils should also learn and practise how to present work in front of others.

3.1.2 Results from interviews with visually impaired children

3.1.2.1 Computer use

All visually impaired pupils have access to computers in school and at home. All children except one have access to internet at school. The pupils use their computers continuously at school for writing and reading and for doing math. Many pupils also do their exams at their computers. All interviewed pupils use Braille and have computer systems that they can write texts with and read through Braille.

At home the children use the computers for chatting with friends, listening to music and playing games.

There is no general use of the internet among the pupils in order to get information that they need for school tasks. One pupil uses the internet very much whereas the other children get most information from their assistants.

3.1.2.2 Group work

All pupils do different types of group work in school on a regular basis. The group work can be both laboratory sessions in natural science, reading groups in English and group work in math or social science. The pupils in fact claim that they do different kinds of group work in all topics in school. The pupils also do longer projects in school that can last for several weeks. One example was building a shop and planning the expenses and the layout of the shop and so on incorporating math tasks in different ways.

All children thought that it was harder to work in groups with too many people involved. They all thought that a good number of people were between 2-4 pupils. The reasons for not liking large groups were that it was hard to follow the discussion and the others activities. One pupil said that all the others could see what everyone is doing but that this was not possible for her. This was especially true in larger groups than three to four persons. A pupil felt that a problem with large groups was that there could be disagreements about how to do the work and that it was generally hard to make consensus decisions on different aspects of the work.

The presentation of the group work is a large part of the task in school and all the visually impaired children were very good at that and found that part one of the easier and most fun. The children explained that it was no problem to present information in front of the classmates and that they just talked about what the group had done and sometimes even showed pictures. One pupil said that if she held the picture in the wrong position the others just asked her to move it so that they could see. The presentations are of different kinds, it can be a poster, a verbal presentation or even a theatre performance in front of the class.

3.1.2.3 Difficulties with group work

The children were all very good at explaining their part in the work process in a typical group work that they had just done the same day. All children were also very good at understanding what happened during the group work and none of them felt totally left out. But some problems were acknowledged. One child did not find the task in a natural science laboratory session very rewarding because she felt that it was too much of the understanding of the chemical process that she had to understand by feeling the substances which was very hard, whereas the others could see it very easily. So she did not think that she learnt very much from the exercise. She thought that the most important then was to just get through it. One pupil got responsibility for writing more than the other on his Braille computer and he did so but when the text from him and the other pupils in the group should be collected it was problematic. The reason for this was that the sighted students only saw a small portion of the text at a time in the Braille display which made it very hard for them to understand whole sentences. The time they had for this part was too little and this had the result that they did not finish in time. One child did not like to get the task of collecting information or writing reports because she felt that this was cumbersome for her. Another pupil said that someone else usually takes notes because as she states ”the others can not see what I write” and she finds that a problem.

One of the visually impaired students thought that group work was rewarding but two of the children said that they actually did not like group work so much. One child thought that she got to do less work than she wanted when she did group work than if she worked by herself. But the children did find positive aspects of group work such as that it was more fun to solve a task in dialogue with others, that it therefore could be easier to solve tasks because each child did not have to do everything by him or her self. One pupil said that one thing that was fun with group work was to get to know other pupils better that she had not talked to so much before.

3.1.2.4 To produce illustrations

Most of the children were not very fond of drawing. One child found drawing quite rewarding but this child had some vision left and could actually see some lines in a magnifying glass. The other two children thought that it was too hard to get the drawing right and also that it was not so meaningful for them. One child explained that it is easier to use material that she can make something three-dimensional with because that is easier for her. This pupil found it hard to show the same thing in two dimensions than in three dimensions.

All children liked to build things in other materials and also found group work that involved that kind of activity the most rewarding. Such materials could be clay but also wood or paper and all kinds of other materials. One pupil remembered a park that they had done from leaves and gravel and so on that they found outdoors. Another pupil remembers a shop that they built in a cardboard box that she found very fun. Another example was an electrical circuit that also had a quiz incorporated in it with questions that should be answered correctly in order for a buzzer to make some sound. This pupil was so proud over this work that she showed it to her mother during a meeting with the teacher.

3.1.2.5 Outdoor activities and play

The group work is not always done within the school building according to the children. Sometimes they go outside and either collect material from the nature like leaves or grass or they use the outdoors for going a path with a number of stops where a question is placed that they have to answer. The blind children found the outdoor group work activities very positive. This is interesting in the light of the reports from some of the children that said that they are very much alone and not doing anything during breaks. The other children play different ballgames or do other physical games that are too fast for the visually impaired children to join.

One activity that one visually impaired pupil liked to do during breaks with others is a game where some children are on top of a small hill and the other children try to take them down and get on top of the hill themselves. This game was very physical and the pupil liked it a lot.

3.1.3 Results from interviews with sighted pupils

3.1.3.1 Computer use

The sighted children have access to computers in school and at home. It does not seem to be the case that they use the computers very much in school. The pupils feel that the teachers want them to use books in order to search information rather than using the internet. Most sighted pupils are aware of the fact that they have access to internet in the school.

The pupils use the computers at home for surfing the internet playing games and chatting with friends. One of the older pupils say that he uses internet daily in order to chat with friends.

All sighted pupils do group work in school about one or two times a week. The size of the groups is two to five persons according to the sighted pupils. The sighted pupils mention that they do shorter group work in English, longer project on a specific topic that lasts several weeks, group work in geography, history and laboratory sessions in natural science.

The sighted pupils said that it was a common strategy to divide the work during group work so that everyone gets to do a part each. However when doing laboratory sessions in natural sciences most work is done jointly.

3.1.3.2 Group work

All sighted children generally liked to work in groups much more than working individually. A positive aspect of group work mentioned was that it feels as if the work is made faster. Generally the pupils thought that the tasks tended to be more fun when they were supposed to do group work. They also thought that it was nice to divide the workload between a number of people so that they did not have to do all the work themselves. These pupils also thought that tasks were easier to solve and finally that it is fun to talk and discuss with peers during the schoolwork.

However a problem that was acknowledged was that it can be hard to work together if the group is too large. The problem then is to agree on things and that some pupils get too little to do and just sits inactive. Another problem that all pupils mentioned was that group work is not positive if they happen to be in a group of people that they do not like or have problems working with. Finally the topic and the task are important in order for the group work to be fun and interesting. One pupil felt that if he was not so good at the subject then it could be better to work individually so that he could do the work in his own tempo and focus properly.

3.1.3.3 Group work with a visually impaired pupil

One of the sighted pupils thought that it was sometimes hard to work with the visually impaired pupil because the text that explained the task had to be read aloud a number of times. The sighted pupil thought that this might mean that the visually impaired pupil had to hear the task several times in order to fully grasp it. One other problem was that if a poster had to be made the visually impaired pupil used clay instead, which the sighted pupil found a bit difficult. This pupil said that it was not a problem to work with the visually impaired pupil when writing a text, they then used to have one sighted pupil that was writing and the others including the visually impaired pupil were verbally saying what should be written.

One pupil thought that it was good to work with the visually impaired pupil because that pupil had a lot of knowledge on different topics like how engines work. This sighted pupil also said that another advantage was that they had access to the visually

impaired pupils computer directly. Furthermore, the visually impaired pupils assistant was always available to the group with the visually impaired pupil which resulted in them getting a little more support. A problem that this sighted pupil had noticed when working was that it took a long time for the visually impaired pupil to write on his Minilogg (Braille computer). The sighted pupil had noticed that the visually impaired pupil liked presenting group work and was good at explaining things which was positive.

3.1.3.4 Outdoor activities and play

The pupils sometimes did group work outdoors and found this very rewarding as they got to move around and because it was a nice change compared to sitting in the classroom.

The favourite games during breaks were bandy, football and basketball among the boys. The girls played a ball game that was called Ching. The pupils are not allowed to be indoor during breaks and therefore do not play board games or card games.

3.2 The field study performed by University of Glasgow, UGLAS

This report details the results from a study carried out at the Royal National College for the Blind (RNCB) in Hereford in England. The RNCB is a specialist school that caters for students of ages 16 and over who have a range of visual disabilities. It provides training and learning facilities for a wide range of late school level and higher level education for its students, as well as offering practical skill training.

The study was conducted through 3 interviews, a focus group containing 4 participants and 4 demo sessions. The goals of the interview were to extract information about how visually impaired people access and information in their everyday lives in work and play settings. All participants involved in the study were students or worked at the College, and were blind or visually impaired. The goal of the study was to find out how objects and accessible technologies were used in everyday life for working, playing and communicating. The results will be fed into future prototypes for the MICOLE project to provide useful interfaces, improve interaction and display information in an appropriate form.

"If there's one thing I've learnt about not being able to see, it's that you've got to be very persevering with everything. You have to learn so much before you can do anything"

A quote from one participant in the focus group study

3.2.1 Access Technologies and Computer Use

3.2.1.1 Access Technologies to Printed Material

Before access to computers became commonplace, access to information for a blind person was very restricted. Any sort of information such as books or letters had to be transcribed and printed through raised dots that could be explored and understood through the fingertips. For some materials such as books, audio versions are available, but again these must be specially recorded. Any sort of textual information required knowledge of Braille, which can be difficult to learn. Brailing of non-textual information such as tactile images and diagrams is not necessarily a straight forwards process.

These techniques were used successfully for many years to provide visually impaired users access to a large repository of information. However, while these techniques might be sufficient for access to static information such as books, the large amount of time and effort to record the information in a different format means that they are poor methods for any information that may change regularly. The introduction of access technologies for computers has revolutionised how visually impaired people access information.

3.2.1.2 Computer Access Technologies

Computers played an important part in the lives of all those interviewed. They were used in both their working and social lives to allow users to browse information and communicate. In their working lives computers were important for tasks such as word processing and to a lesser extent databases. Audio games were available from the point of view of entertainment, and communication technologies such as email and MSN Messenger were a popular tool for collaboration and communication. The Internet played an important role in work (for research), entertainment (for games and news and sports information) and communication.

When a visually impaired person uses a computer, specialist accessibility may be required. For input (information entry and navigation) for blind users, the standard desktop metaphor is not appropriate. They are not use to using a mouse, and the two dimensional spatial layout would prove difficult to navigate. The keyboard however allows a blind user to jump straight to menus that can be navigated using the arrow keys. For familiar applications, series of keyboard shortcuts can be memorised that will allow the user to navigate quickly through a series of options. The fixed layout of the keyboard allows the user to locate the appropriate keys quickly through touch for text entry. Specialist keyboards also exist that allow users to enter information through key chording. These devices are often combined with dynamic Braille displays to allow input and output on the same device.

There are different output technologies available for computer access depending on the user's visual impairment and ability to read Braille. For those with some vision, a screen magnifier may be enough to allow the user to access information. For those with less or no sight, screen readers are an important tool for browsing and accessing

information. The screen readers (such as JAWs) will read out the text on the screen in a linear fashion. It can be adapted for specific applications for example to indicate links in a web browser. These are commonly used tools that work with a wide range of (but not all) applications. Alternatively, if the user can read Braille, a dynamic Braille device can be used for accessing the text on the screen. Similarly to a screen reader, these devices will display the text on the screen through a line of Braille arrays of up to eighty at a time. They are often used in conjunction with screen readers which may not always read out all the necessary text in an application.

Specialist programs also exist (such as the Duxbury Braille program) for the creation of accessible information.

3.2.2 School and University Education

Participants were asked to initially reflect back on their school days and how they coped with learning the information presented by the teacher. With the various ages of the participants, there seemed to be a large difference in experience between those that experienced school before computer use became widespread and those that had access to computers through their studies.

There were also differences reported in those that attended mainstream education and those that attended a specialist school for the visually impaired. In mainstream education, access equipment is available, but there is a great emphasis on the teachers to make their classes accessible to both the sighted and visually impaired children. Problems can occur during lessons that rely on students having access to the material on the black board.

3.2.2.1 Different Subjects

The subject studied can also have a large effect on how easy it is for a visually impaired person to learn. Maths for example was found difficult by all participants interviewed. It is a subject that requires understanding of complex formulas and visualisation of shapes, angles and data through graphs and tables. Many of the participants reported difficulty in comprehending the presented the information. It is difficult to say whether the dislike for maths was due to this or a general lack of interest in the subject.

English and languages and geography were subjects that were noted as popular. English teaching is based mainly on textual information and can therefore be easily conveyed to the visually impaired learner through some sort of Braille or speech interface. This relatively straightforward transition from traditional lessons may explain the popularity of English in this study. A talking dictionary seemed to be a common piece of technology that allowed students access words and learn spelling. Games were available to aid learning that would challenge a student to spell a word or solve an anagram. This functionality can be provided purely through audio as easily as through vision. Learning foreign languages should share many of the benefits of learning English in that the information can be presented to a user in the form of text. However, there is the added problem of different representations of Braille characters.

Different language use different character sets and symbols such that a Braille pattern in one language does not necessarily correspond to the same letter in another Braille language.

Geography presents different challenges in presenting the information in an understandable manner. Of particular interest for this study is map browsing for geography. Maps can be conveyed to users through raised paper using lines (to delineate roads or borders etc.), and different textures to convey information about an area of the map. This allows a user to build up a spatial representation of area. Different maps containing different levels of detail can be used to indicate different features on the map. Participants stated that they would use maps to get a general overview of positions of objects relative to each other, but would not feel comfortable navigating a new area after map exploration alone.

Music was mentioned as a popular university subject as well as a hobby. Music technology lends itself to non-visual teaching as much of the skill is in listening to a sound or piece of music and making adjustments on what you hear. There were a number of interesting challenges mentioned however. The technology may change relatively quickly which is difficult is you must navigate through a piece of hardware or software through memory, touch and sound. In this situation the lack of overview of the technology can be prove difficult. Further, there is no access to certain displays that can be used for comparisons. For example, there is no way to compare levels of sounds other than audio, when a sighted person could quickly check several LED displays at once for volume and make comparisons visually.

One participant was studying fitness coaching. This involved examining the motions and performance of a client (during weight lifting for example) through touch alone. The instructor would place his or her hand on the appropriate joint and could measure the movements of the client to check whether he or she was over extending or not. The course also required building and checking of a performance history for the client that proved challenging as paper and pen form filling would be required.

3.2.2.2 Technology in University Organisation and Administration

Computers also played an important part in the organisation of the Hereford RNCB. Information about basic services and administration such as lunch menus or changes to lecture times could be distributed to the students in an accessible form such as email. There was also web access available to a dynamic ‘electronic board’ where users could visit and explore at their leisure any information left by the college on the board. The advantages of a web accessible board of traditional boards are that it can be accessed from any networked computer on the campus using standard accessibility tools such as a screen reader. It can also be thought of as dynamic as it can be rapidly updated with new information.

3.2.3 Games and Hobbies

This section of questions was developed to find out the interests of the participant outside of a work setting. As the MICOLE project is aimed towards providing

accessible interfaces for children and the majority of participants were older than the target age group, participants were asked to think back to their interests in childhood as well as talking about their current interests and hobbies. Again, the effect of rapidly changing technology must be considered when the current interests of visually impaired children are considered.

3.2.3.1 Tactile and Auditory Games and Hobbies

Audio and Braille books have been used by the visually impaired for decades. The text information is easy to translate into an accessible form (as discussed above) and equivalent information in a different modality can be presented to the reader through raised paper, speaker or computer system.

The majority of participants interviewed had an interest in board games and card games. One interesting aspect of such games is that in general, very little change is needed to make a standard board or card game accessible. These games are usually cheap to manufacture and low-tech, so in this instance (without the availability of sensing equipment or speakers in the game) static tactile presentation of information becomes very important. Raised dot printed material stuck to the board, cards and dice can allow players to read important game information without obscuring the standard print for sighted players. This offers a very cheap and effective way of allowing a blind player to participate in a game and even compete against a sighted player. Games such as monopoly, scrabble, chess, connect 4, snakes and ladders, and solitaire, along with several types of card game (eg. dominoes and beetle) were mentioned by participants. Often, specially adapted versions of particular games are developed to handle problems specific to one game or one type of game. For example, many of the accessible games have squares into which pieces can be fixed, allowing for tactile exploration of the board without moving the pieces. The accessible version of scrabble requires the user to read raised dot Braille characters on the letter squares, and therefore allows the board to easily rotate such that each player can access the Braille from the correct orientation. In games involving players placing or controlling multiple pieces (such as chess or connect 4), it is important that the user can maintain an overview of the game and in particular which pieces are theirs and which are the opponent's. Each team of pieces may have subtly different shapes or tactile properties. For example, in connect 4, one set of pieces will be a solid circle, and one will be ring shaped allowing a player to quickly identify each through touch alone.

These types of game are interesting as they incorporate many of the aspects important for the project. Players must maintain an overview of the state of the game, sometimes keeping track of and developing strategies for multiple different interaction pieces. External memory issues become important in this instance. They may need to collaborate or compete, and take part in activities such as turn taking, and simple changes allow equivalent information to be presented in different modalities depending on the player's preference.

Lego was also mentioned as a popular toy when participants were younger. It is inherently tactile, with standard sized unit pieces that can be identified through touch. Each piece attaches solidly to other Lego blocks to allow for easy tactile exploration

of the object being constructed. Each standard piece can be categorised by the number and configuration of bumps that can be felt on the top and visual feedback is not required to fit blocks together to form complex shapes.

Puzzles and quizzes can take many forms that allow them to be accessible. Tactile versions of traditional puzzles are available. For example, tactile jigsaws allow players to explore raised images on the pieces such that the pieces must be complementary shape and be continuous in height if they are to fit together. An accessible Rubiks cube can has been developed that replaces different coloured squares with different tactile symbols. A popular tool discussed for both learning and entertainment was a talking dictionary. This is an electronic device with keyboard that allows user's to access a database of words and meaning. The user is challenged to spell words, or to solve puzzles (such as solve an anagram). The majority of quiz questions contain only textual information that can easily be transcribed to raised paper Braille. Alternatively quiz games are a popular format on television, and shows such as "Who Wants to be a Millionaire" were discussed by participants as being particularly accessible. The different formats of these games lend themselves to tactile or auditory presentation in different circumstances.

To some extent, TV and film can be considered accessible as it is possible for a visually impaired user to follow a program or narrative through listening to the audio track. However, much of the time, information crucial to the program is presented visually only, which can confuse someone who does not have access to the visual channel and may cause them to lose interest in the narrative.

Several participants took part in or followed sports. It has been popular for even sighted people to follow a game such as football non-visually for many years. Radio commentaries already provide in depth descriptions of the action on the pitch allowing a user with no visual information to follow the game. Participating in sports presents different challenges. One participant interviewed was a keen footballer, involved in training and playing blind football. Here, a bell is placed in the ball allowing players to listen for it and track it. Traditional skills such as teamwork and ball control are important, but there is the added dimension of insuring your own safety and your opponents safety while navigating the pitch. Awareness of surroundings is important to avoid collisions and to successfully complete passes. This involves a lot of verbal communication on the pitch with team mates and opponents.

Two interesting activities discussed by one participant each were war games and ornithology. During war games, the participant would recreate historic battles on physical models of maps. Awareness of position of the armies on the field was important as well as awareness of the 'lie of the land'. Tactile maps would allow exploration of the field, while the participant would collaborate with sighted friends to manoeuvre pieces around the map. Ornithology involved listening and recognising bird sounds. The participant made themselves aware of the prominent species or bird when visiting a new area, and would prepare by listening to the different bird calls through an audio tape. The different species of bird can then be detected and identified through the distinct bird call.

3.2.3.2 Computer Games

The development of non-visual computer games is an emerging field. Games have been developed that take advantage of 3D sound (or stereo panning) and to a lesser extent tactile feedback technologies to present information to users. A common type of game involves identifying a particular sound from a library of sounds (which the user can listen to beforehand and access during the game), and trying to localise the position of that sound in space. Much of the time, this will also involve navigating an avatar to move the sound to a particular relative locale. A common task would involve listening and identify a monster sound to their left or right, and neutralise the monster by navigating until the sound is central before performing some action. One relevant feature of these games is that greater realism might be possible. Realistic sound reproduction through replaying a recording can produce very high quality effect. Producing photo-realistic graphics is now not an issue. One participant reported getting a shock when her phone rang while exploring a particularly tense audio, mistakenly connecting the phone ring to an event within the game.

Dynamic objects within the game add an extra layer of complication to the environment. The user is now not in complete control of the environment and must be made aware of any changes. This would be particularly important when two or more players were competing in or collaborating in a shared environment. Many competitive non-visual games use turn taking to simplify this process. One example would be an online card game where only one user could perform an action at any one time, allowing the other users to follow the progress of the game more easily.

Some traditional games were considered to be playable although they may be considered to relying heavily on graphics. In particular, some football games provided detailed in game commentary that allows a visually impaired player to follow some aspects of the play. One specific game - Mortal Combat - was considered playable as it gave auditory information about which character the player had chosen before the match, auditory information whenever a player performed an attacking move, and informed the players who had won at the end of the match.

3.2.4 Communication and Collaboration

Communication and collaboration was considered an integral part of all participants' college lives. Many courses required students to share information they may have researched or documents they had created. All collaboration reported in this study was either verbal or text-based. Communication through speech was considered to be the most important method of sharing information. When a visually impaired person needed to perform a non-accessible task (such as gain information from a diagram or fill in a paper form), they would collaborate with a sighted peer. With the advent of new technologies, it is now becoming easier to share documents through email. All participants discussed email as a useful method of sharing work with colleagues or submitting assignments to tutors.

The only instance of non-text based collaboration was in development of accessible tactile diagrams. If a diagram was being converted from visual to tactile form, one

participant would collaborate with a sighted peer to ensure that the tactile version conveyed the information in a useful form.

Several communication technologies played an important part in participants' lives. Telephone and Braille letters have been an established method of communication for a long time. New computer technologies greatly simplify some communication. Email is accessible using a screen reader or dynamic Braille display for output and the keyboard for input. MSN messenger was highly praised by all participants who had used it. Navigation of the interface could be performed through keys alone using a screen reader (such as JAWS) to provide information about any messages sent or the status of contacts.

3.2.5 Observation of Demo Study

3.2.5.1 Technologies

This pilot studies introduced participants to two pieces of haptic technology; the PHANToM force feedback device from SensAble technologies and the VT Player mouse developed by Virtouch.

3.2.5.2 Task

Participants were initially given a physical model of a simple maze built on a large flat surface with Lego blocks attached representing walls. They were asked to explore and familiarise themselves with the maze through touch.

They were then presented with the equivalent 2D virtual maze that could be explored using the above haptic technologies. The 3 three possible exploration conditions were
1. Phantom – the users were constrained to the path with explicit wall collisions presented through force feedback.
2. VT Player – the user navigated their cursor by moving the mouse. Information about the user's local context was displayed using the two tactile arrays on the mouse with pin up representing a wall and pin down representing a corridor. The user's current position in the tactile array (always the same pin) was represented by a cursor the pulsed up and down. Although the user's cursor was constrained by the walls, no explicit collision information was presented to the user. Collisions had to be inferred by the information (or lack of change of information during movement) on the tactile arrays.
3. Combination of the Phantom and VT Player – The user navigated the cursor as in the Phantom condition and felt wall collisions through force feedback from the device. Additionally, the user rested tow fingers from their non-dominant hand on the tactile array of the VT Player mouse. Information about the user's local context was then presented though these arrays as in the VT Player only condition.

Participants were asked to explore the maze fully and discussed how closely they felt the virtual maze resembled the physical maze. It was important to see whether the participants could maintain a sense of their position within the environment.

A further informal study presented the user with different simple shapes of maze (ie. A square and a cross) and ask the user to identify the shape of the maze.

3.2.5.3 Observational Results

The Phantom received a positive response from all participants. Users were able to able to navigate the virtual maze through continuously pressing against the walls. Their familiarity with the Lego maze and shape of the walls allowed them to maintain a sense of position within the maze. The Phantom was seen as a very intuitive interaction mechanism for this task as it allowed users to navigate paths freely and explicitly indicated the constraining walls through force. One participant said the Phantom gave a 'good overview' of the maze which was surprising given the single point of contact. This was possibly due to the speed of navigation possible with the device, and the fixed frame of reference for the movements. Participants were also able to determine the shape of the square and cross maze using the Phantom.

Some participants were initially positive about the VT Player mouse. However, when asked to perform a task, none of the participants could use the mouse in this context. Without the explicit feedback from wall contacts, participants struggled to detect when they were moving against a wall. Users could not use the system to navigate or maintain a sense of position within the maze, and when asked the shape of the square or the cross maze, no participants answered correctly. There are a number of potential reasons for this. As stated above, none of the participants were familiar with a mouse. The tactile arrays bore some resemblance to Braille cells. Users would run a finger back and forward over the two cells to try and detect patterns rather than maintaining static contact with one finger on either array. The fact that there were more pins in the horizontal direction than the vertical direction seemed to affect the navigation. All participants demonstrated a characteristic movement pattern of repeated left-right motions without exploring in the vertical. Participants did not seem to be able to extract the intended meaning from the pin arrays, with one participant describing the feeling as a "tactile mess".

Not surprisingly when combining the two devices, users tended to ignore the feedback from the mouse and use only the force feedback from the Phantom.

3.3 The field study performed by University of Linz, ULINZ

An extra meeting involving UPMC, ULINZ together with KTH was organised in February in Paris where possible collaboration about the field study was discussed. The questionnaires that the three partners would use were discussed and reviewed. As the teaching situation is different in the different countries, the questionnaires was decided to be slightly different but they were cross reviewed in order for them to be coherent with each other (between KTH, ULINZ and UPMC).

Both ULINZ and UPMC participate in the field study on collaborative work of blind children coordinated by KTH. Their interviews with blind pupils and teachers that teach blind pupils, address the following subjects:

1.General information
2.Group work
3.Problems when learning Mathematics

An interview study has been performed by ULINZ with four blind pupils and two teachers. Two of the blind pupils are 13 years old and two pupils are 16 years old. 3 pupils went to integrated schools and 1 pupil went to a school for visually impaired.

3.3.1 Results from interviews with visually impaired students and teachers

3.3.1.1 Interview 1: visually impaired student

General Information

Student A is a 13 year old girl and is in her 7th year of education. She is the only blind person in her class. A doesn't get additional training in a school for blind pupils. For school, she is working with the computer. She has her own laptop, which she takes with her to school. At home, she has a desktop computer in addition, which she uses mainly for doing her homework.
On the computer, she uses a Braille display. Since she also gets the books from school as computer files, this is her main source of information. But she also has books in Braille at home for herself, or she might order them from the library. She doesn't have any problems with reading Braille, she finds it quite easy.

Group Work

Recently, they had to work in groups on a project in biology. Her group (consisting of 6 people) had to design a poster about pets, and later they had to present the information they had found. So they searched for information on and for pictures about this subject. They decided together who would do which part of the project. A got the task to search for texts. For this, she mainly used the internet and books. Usually, she doesn't have any problem with finding information, only if there is no other source but blackprint books.
For the presentation of the poster, they divided up among themselves the information they had gathered, so each one of them would present a small part of the whole project.
A enjoyed the project mainly because of working together with others. Searching for texts she considered to be rather boring. But she wouldn't change anything about the way they have worked on the project.
In her class, they do not work in groups very often. If they do, they mainly stay in the classroom. Sometimes they might go to the corridor, so then A takes her laptop with her.
When A and her friends are not together, they still keep in contact via phone, text messaging, or writing e-mails. From these tools, A likes communication by means of her cell phone most.

Learning Mathematics

In maths, A gets the school book already prepared so that she can read it. If there is any additional material, either her maths teacher or her personal teacher for the blind prepares it for her. She gets this material either on computer, or, if there are important graphics, she might get a foil where she can touch and feel the image.
She doesn't know any specific Braille-notation for maths, and she is not sure what system they use in school, either. But she is used to that system and uses it also for her homework or when she is writing only for herself.
As mathematical software, she uses the calculator in Excel.
Now, she only works on the computer, but in primary school, she used the typewriter. She started using the computer approximately in her 5th year of schooling. It's not difficult for her to use the computer, and she can also easily make an ink-print output for her teacher when she hands in her homework.
Her parents can't help her anymore with maths because the level is getting higher and higher. In math, she doesn't work together with other pupils, either. As to what problems she has in maths, she mentioned working with graphics (e.g. drawing graphics). The only problem she might have during lessons is that the other children are very loud so that A has difficulties in understanding the teacher, although she is sitting in the first row.

Games

She likes playing games with her family. The games she mentioned are the card game UNO and ludo (both in blind edition).

3.3.1.2 Interview 2: visually impaired student

General Information

Student B is a 13 year old girl in the 7th grade. She is the only blind person in her class. She doesn't go to a specific school for blind pupils, but she gets additional training in how to use the white cane for example.
She uses her laptop for school. Additionally, she also has a desktop computer. She is working with the Braille display and, in addition, sometimes with the voice output. Now she doesn't have any problems with reading Braille anymore, although especially in primary school she found it quite difficult.

Group Work

A recent group work in school was in geography. B was working together with 3 other students. They had to find out certain information from the atlas – for example searching some cities. Then they had to write down some information they had found out.
In each group, they had a spokesman who decided what each one had to do and who would also present the results. B had the task to write down the information that the others found out. She also looked up certain information for herself in her Braille atlas, but her atlas didn't contain enough information.

For this special task, she didn't use anything else but her atlas and the computer. For other subjects, she uses basically only her schoolbooks and for maths additionally Excel as a calculator. She is fine with these tools, she only wished her atlas would contain more information. The difficulty in connection with other forms of media was the problem, when there was no sound or any spoken information on TV.
The group work in geography was presented as a report by the spokesman of their group, so B didn't have to present anything. When asked what she liked most about this group work, B said she didn't enjoy it so much, because the others were not really conscious of her and often left her out. But still she didn't consider this group work as boring. If she was allowed to decide for herself how she would like to organise the group work, she said she would like to gather more information herself; when writing down the information, she would prefer using only keywords instead of writing down every detail; and she would like to be the spokesman herself, or at least be allowed to read out the results.
An other group work she is really looking forward to is participating in the work for the student magazine. She hasn't done this work yet, but she was promised that she will be the one to correct the spelling of the others because she is really good in doing that. Sometimes they also have to work together in German lessons. One time, they had to analyse a text from physics, because their German teacher is also their physics teacher. They split up the text and analysed it that way.
When she is not together with the others, she mainly keeps contact by means of the phone or by chatting on the computer. She hasn't chatted very often so far, but when she did it, she really enjoyed it a lot. She also likes using the phone, although they do not call each other very often. She rather mentioned how much she liked it when one of the girls picked her up and they went for a walk.

Learning Mathematics

Her maths book is already prepared so that she can read it. As far as she knows, this is done by the school. Additional information is prepared mainly by her personal teacher for the blind and only sometimes by her maths teacher. She doesn't know a specific maths notation for the blind, but she can read the one used in school. As additional software, she uses Excel and a maths-trainer on her computer. Now she receives almost everything on computer, and she herself also works on the computer. She uses the notation she has learned in school. When she hands in her home-exercise, she makes an ink-print output. With her home-exercises, her father can help her. She doesn't work together with other pupils.
The major difficulties B has in connection with maths is to imagine what she is learning about and to keep this picture in mind. Additionally, it's difficult to remember everything during a certain exercise (like also the beginning of the calculation or the whole formula she has to work on) in order to have an overall picture. It's also difficult to draw graphics – generally, geometry is quite difficult for her.
With her teacher, the main difficulty is that to her it seems that the teacher is swamped with teaching an integrative class, so often he is impatient. Additionally, it's difficult for her that the teacher writes everything on the blackboard.
When talking about the teacher, she also mentioned her chemistry teacher who gave tries many things to help her to picture what they are learning about. E.g. she also got a model of an atom so that she could touch and feel. She enjoys these lessons very much.

Games

B likes to play. On the computer, she enjoys playing Pinball where she can work with the sound effects. She also likes to play cards, also together with sighted ones; she enjoys playing “Who wants to be a millionaire?” Some time ago, she has even designed a quiz-game herself. She Also enjoys playing domino (especially designed for the blind).
She recognizes that other children in her class play often with their mobile phones where she can’t participate.

3.3.1.3 Interview 3: visually impaired student

General Information

Student D is a 16 year old young man and is in the 10th grade. He goes to a school for sighted children, and he is not only the only blind person in his class, but also in his whole school. He doesn’t go to any school for the blind. He has a laptop for school, which he uses almost for every subject. Additionally, he has a desktop computer at home. He uses this computer only for his work for school. With the computer, he always uses Braille and has no problems with it, but finds it rather easy. At the beginning, he had problems with the shorthand notation, but he is fine with that now, too.

Group Work

A recent event when D has worked together with his class mates was in religious instruction. The class was divided into groups of 4 to 5. They had received some texts they had to work on. The teacher gave them some work assignments. After the work, they discussed the results in class. The teacher chose somebody for each assignment to report on what they had found out.
In the group, they decided together who would work on which point. The most difficult task for D was finding the Bible scriptures on the computer, because the computer could perform the searching only very slowly.
D didn’t have to search for texts since they were given, but for additional information he used his encyclopaedia on his computer.
For other tasks, he has additional to his computer an atlas and also a calculator, but now he uses only the calculator on his pc. He has difficulties with searching the internet for information, but he thinks he has only difficulties due to lack of practice.
When asked what was the most boring part for him in that group work, D mentioned again the problem he had when looking for Bible scriptures since the computer was so slow. He mentioned the general problem that if a (school-)book is quite long, Word has problems with handling the size of the document which makes the computer rather slow.
D prefers it when (like in German lessons) the subject is free to be chosen by the student. Then he likes to search for information in his encyclopaedia. He also enjoys having swell paper graphics; e.g. he mentioned that in physics, he received some graphics when they were learning about optics. This was very helpful for him in order to picture what they were talking about.

Generally, if they have group work in school, they stay in the class room and don't go anywhere else.
When he wants to contact somebody from his class after school, he usually uses the phone.

Learning Mathematics

In maths, D has his own teacher. He is separate from his class in these lessons.
The maths book is prepared for him by the job market service in Vienna. The formulas are written in a Braille maths notation, but he doesn't know what it is called. He doesn't know any notation by name.
As mathematical software, he uses MuPAD. He finds this software very helpful, for example when he has to work with equation systems.
If there is any additional exercise, he receives it from the teacher on a floppy disk. D himself is only working on the computer and he uses the notation from school. When he has to hand in his home-exercises, he usually uses the ink-printer in his class to make an output for his teacher. Otherwise, he might hand in his work simply on a floppy disk.
In maths, D has to work basically on his own. His parents can't help him anymore, although they used to. Now the level of maths is too difficult for them. And since he is not together with the others, he can't work with them, either. He used to be together with them in the "Unterstufe" (grade 5 – 8), but it is easier for him now with having a teacher on his own. The teacher has a general training for being a teacher, and now she has taken some courses to be familiar with the special needs D has, especially for the software he uses.
Now he is fine with maths. But in the lower grades he had a few problems. At this time, he didn't use the computer, but he was working with books embossed in Braille, and he himself would also work on paper. This was difficult for both the teacher, who couldn't read Braille, and D himself, who had some problems with finding the needed information.
When he started using the computer in the 8th grade, things got easier, and now with the personal teacher, it is even better.

Games

He likes playing on the computer. He mentioned a game where he has to guess words. He also likes playing Battleships. He can also play this together with others in his class.

3.3.1.4 Interview 4: visually impaired student

General Information

Student S is 16 years old, male, and goes to 4th class of Hauptschule (8th year of schooling). His ability to see is around 10%. He goes to a school for blind children. His class is very small and consists of children of different ages and different visual capabilities.
S has a computer both in school and at home and hopes to get a laptop very soon that will make learning easier for him, since the laptop means more flexibility. For school,

he works almost only with the computer, because it is much easier for him to have the books stored on computer than to carry the folders that get really big when written in Braille. At home, S uses the computer almost only to do his homework. He prefers being outside with friends to spending time indoors.
He uses Braille and has no difficulty with it unless the text gets long (7 – 8 pages) when it's more difficult to concentrate. He finds it really helpful though if the text is written in shorthand.

Group Work

One recent event when they had to do groupwork was to compose a presentation for biology. S was working together with another boy. They had to gather information on drugs. Mainly they were working with the Internet where they found 4-5 websites. Together, they divided the chapters found on the Web among themselves so that each of them was working on his own chapters. S liked the work and found it very interesting.
Since both of the students can see a little, they could choose if they wanted to present the information on a poster or verbally. They chose to relate everything to the students because there are some in the class who can't see at all. Otherwise, for them it would have been very difficult to follow along.
For the presentation, each one of them presented the part he had prepared.
S would have preferred to present them also real drugs or e.g. a real hemp leaf so that everybody would know what he was talking about – "of course not to taste, but to feel". He also wanted to present pictures of real "drug stiffs" – but this was not possible because of the blind students and because also the teacher forbid it. But he would have really appreciated it. Now instead, they made swell paper graphics, showing the blind students a simplified version of different leaves.
The only thing he didn't like was that especially younger students would ask the same questions over and over again which made it very annoying for him. But besides that, S enjoyed this group work.
He also likes other times when they are working together. This can be both in school when they take turns reading or filling out clozes in English, but also outside for sports (he likes a lot playing football) or working in the school garden which they do about twice a year.
For keeping contact with other students, he prefers using his mobile phone (also for sending text-messages), because it is always handy.

Learning Mathematics

S has his maths book on computer, already prepared so that he can read it in Braille, but he is not sure who prepares the books: it might be the computer itself with a conversion-program.
He understands the maths notation in the book very well (mark: 1 on a scale from 1 to 5), although he is not sure about how it is called.
For mathematical software, he uses Excel. When he gets additional information from the teacher, it is usually on the computer. Only sometimes (for example in German lessons) he gets papers printed in Braille.
He can read maths on the Braille line, but he is not sure what the system is called.
For maths, he is only working with the computer. When S is writing something for maths (also his home-work), he uses his own notation. The teacher doesn't care as

long as the calculation part is ok. This is also how he hands in his home-exercises, and additionally, he has to print it out as an ink-print – output.
He is very good in maths so he doesn't need help from his parents, although they would be able to do so. Basically, he is working on his own, since in his school, there are only a few students, and there is nobody at the same level like he is.
The only problem he has in maths lessons is the way the book is written: when he wants to find an exercise with a specific number on a specific page, the search function will give him immediately the right page, but it might take very long to find the exercise, since the search function will yield all these numbers on the page; so if exercise no.3 is at the end of the page, and there are many caculations before that exercise, the student will have to go through all digits "3" before actually finding exercise no.3. It would be very helpful for him if the exercises were marked as such.
With the teacher, S has no problems related to his disability. The teacher is very helpful and understanding. Upcoming problems are rather general ("She wants me to do caculations in the way she has it in mind although my way would be much easier for me.")

Games

S likes playing football which he does also at school.
At home, he prefers going out with his friends, but he might also play at home with the Playstation, playing carraces or fighting games. The normal version of these games is okay for him, but he would prefer if the text on screen was written with more contrast.

3.3.1.5 Interview 5: teacher

General Information

Teacher S is 40 years old, female. She got training as a teacher for children aged 10 – 14, and additionally as a teacher for the blind. Half of the time, she helps blind pupils who are integrated in classes with sighted children, the other half of her time she teaches in a school for the blind. In this school, they have 3 different stages: primary school, "Hauptschule" (secondary school, age 10-14) and remedial classes for children with additional handicaps. S is teaching those aged 10 – 14. Since there are only a few blind children and children with visual impairment, respectively, the class (consisting of 8 children) is mixed in age. Also as far as their visual abilities are concerned, they are mixed. Only two of them are practically blind, the rest of them can see more or less well. Their visual impairment is due to different reasons: albinism, premature birth, defect in the retina and others. Only the two blind children use Braille.
The blind pupils who are integrated in general classes also use Braille.
In the school for the blind, they also use software and special machines to magnify written documents and books. Additionally, each child has a desktop on his/her own.
S is the personal assistant for student D who is integrated. D doesn't go to a special school for the blind. In the school for the blind where S teaches, the children don't have a personal assistant but each teacher is responsible for all students.

Group Work

Since the children are mixed in age, group work is often difficult, so they work a lot on their own. Still, they also work sometimes together. If so, they need a lot of support from the teachers to guide them through the different steps of the work. Mostly, the children search for information on the internet.
Group work is done mainly in geography, German and biology lessons. Group work is only performed in school.
The main pedagogical goals of group work are to enhance teamwork and the social aspects of working together. It is important that work sharing is fair: everybody should work approx. the same amount. It is also beneficial that they can try out several abilities and so find out about their strong points. Additionally, they learn how to help each other since everyone of them has different disabilities. In fact, they complement each other very well.

Mathematics

The maths books are prepared by the "Lehrmittelzentrale des Bundesblindeninstituts in Wien" (LMZ des BBI) (Institute for the Blind in Vienna, Centre for Teaching Materails). S is familiar with the Marburg maths notation and knows it very well (mark 1 on scale from 1 to 5). Only if the mathematical requirements are getting higher, she has to look up different expressions.
The blind students get the materials mainly on the computer, sometimes they use the Braille books. Especially if the students are younger, they use more books. But these books are very difficult to handle since they are very big.
In maths materials, they use the Marburg notation. Mostly, the children hand in the home exercises printed out in Braille. They have to use the Marburg notation as well.
As far as S's students are concerned, they can't get help from their parents. Their background is rather simple, so they mainly get help in the after-school care club. But the pupils can't really work together.
The main difficulties in maths that blind students might have are the following:

- mostly, they are lacking spatial imagination
- geometry is in the curriculum, but do the children really need it? Mostly, they have many difficulties with geometry. Usually, S lets them draw graphics on the draftboard.
- cancel down: for sighted pupils, cancelling down is rather straight forward. For blind ones, the teachers have to be inventive to show them a system that helps them to imagine the concept.
- to divide: pictures showing the concept of dividing are lacking, so many blind pupils have difficulties in that area.
- they can't understand structures, because in their world everything is linear.

S didn't mention any particular problem in connection with exchanging mathematical documents among the pupils.

3.3.1.6 Interview 6: teacher

General Information

Teacher T is male and 54 years old. He has a training as primary school teacher, teacher for handicapped children and as a teacher for the blind. He is the teacher for the blind for two students A and B. These students are in two different schools. In each case, the student is the only blind student in the class consisting of 24 and 17 pupils, respectively. T is responsible only for the blind student in the class, helping her with the difficulties she might have in the lessons.
A is completely blind due to a hereditary sickness on the mother's side. B still can distinguish between light and darkness and might perhaps be able to distinguish some colours.
A and B both use Braille. As technical aid, they both have a laptop, and additionally both at home and in school, they have a desktop computer. Beside the computers, they have an ink-printer, a scanner, a Braille printer both in school and at home and a Braille typewriter.
A and B don't go to a special school for the blind. They are in the school for sighted children, having T as their personal assistant. But they might go to summer camps for the blind, if it is their personal decision.

Group Work

A and B work together with the other children like in non-integrative (mainstream) classes; but of course, the other children have to be conscious of A's and B's blindness.
T mentioned several projects or group works A and B had participated in:

1) theatre performance of "Romeo and Juliet"; A participated as well, and she only needed help to find her place on the stage. So she would put her hand on somebody's shoulder who would lead her over the stage. A is so independent, that the others in her class would sometimes forget that she is blind, so on the stage, it happened sometimes that they forgot her on the stage, but then they realised it and somebody led her to her place again.
2) In drawing lessons, A is able to make pictures where they can express passion and emotions. They can also make pictures which they can feel. For these activities, they usually need help.
3) Outside school, A loves to go skiing and riding the horse with the help of others.
4) B participates in making a pupils' magazine. Her task is to correct the spelling of the other articles, because her orthography is very good.
5) In a theatre performance, B is the prompter.
6) In school, they have group work in physics, German, physical education and music lessons.
7) Outside school, they participate in "Adventsingen" (singing advent songs at Christmas time in church or from house to house), music concerts or (as already mentioned) in theatre performances.

The most important goal of the group work is the idea of teamwork: the children should learn how they can work together and help each other. In A's class, this works very well, she is independent, has confidence in herself and is well integrated in her

class. B has more problems: other children in her class are jealous of her, having the impression that B is somehow preferred by the teachers or has some advantages in performing tasks ("She doesn't have to know how to spell, she can just use the spelling function on her laptop",….). According to T, this is to a great part also to be ascribed to B's parents, who didn't allow her to go to the school where she had her friends (because of political and other reasons), and only after a few years did they allow a change of school (at T's urging). But because of this, it was very difficult for B to build up friendships, so somehow she is singled out in her community.

Mathematics

The maths books are prepared by the institute for the blind in Vienna. Additional information is prepared both by the maths teacher and T. T knows the maths notation very well (up to the 8th grade). In primary school (1st to 4th grade), T starts with using the Braille typewriter and then step by step passes into using the computer. Graphics or other information might sometimes be presented on swell paper graphics or foils.
T has simplified the maths notation in the book, since this was too complicated.
When the students hand in their homework, they do it on computer. Only at the beginning of primary school, they hand it in on Braille paper. A and B use the notation they also use in school.
According to T, it largely depends on the parents if they can help their children with school work, especially maths. A's parents are very dedicated to helping their daughter. Of course, as the level in school gets higher and higher, it is more and more difficult for the parents to help.
A and B don't work together in maths with other children.
T mentioned the following problems in connection with maths:

1) It is difficult for them to draw graphics, so he only lets them recognize the elements, they do not have to draw.
2) Often, the exercise in the book can only be understood by looking at the picture; these pictures are often too complicated to be described verbally.
3) In geometry, the exercises are often too difficult to be pictured only in the mind; but drawing the graphic for the blind student is almost as difficult as imagining it.
4) Equations are sometimes very long, so that they can't be read in one; since the Braille display can only show 40 characters at a time, it might well be, that the equation is split – perhaps right in the middle of an expression which makes it difficult to get an overall picture.
5) If the teacher doesn't make it correctly, it is very easy to mix up an exponent 2 with a "b". Of course, this might also happen with other signs.

3.4 The field study performed by University Pierre et Marie Curie, UPMC

3.4.1. Interviews with the teachers

Eight teachers participated in this study, among which two taught in secondary school with the one blind person in integration and six in specialized establishments.

Three professors gave courses to the secondary school, two only for the pupils who are in secondary school, two had class of the primary school at the secondary school and the only one taught in primary.
Among these teachers, two are visual impaired people: one blind people and the second partially-sighted teacher.

The interview with the professors lasted per each, approximately, one hour and taken were on them temporary workers free. They could be realized according to the available funds and the preferences of the teacher in the surrounding wall of the school or within the university Pierre and Marie Curie. During these interviews we let us be tried hard to intervene to prolong speech and reflection of the professors thanks to “reformulations”.

We wished to begin the peer the teachers interview notably to be able to ask them for the opinion on the wire netting of interview overturns raise to them, namely if one the important question, their opinion on the formulation it of the questions was missing.

3.4.2 Interviews with the pupils

Twelve pupils contributed to the project Micole, among which three pupils in the common school environment and five of the level 4-5 in specialized school.
Among these pupils two are partially-sighted persons, Braille user and ten blind persons with or without visual rest.
Lasted of the interviews was spread out between a half-hour and liter of an hour; they were individual and taken on temporary workers of course or during playtime (break). They took place in a place convenient to stake in exceptional confidence of busy peer boss and the other pupils (free classroom, library, etc.).

A quite particular attention was required to consider the teachers recommendations to accommodate the interview to the rhythm and to the vocabulary of each pupil.

3.4.3 Analysis of the teachers interview

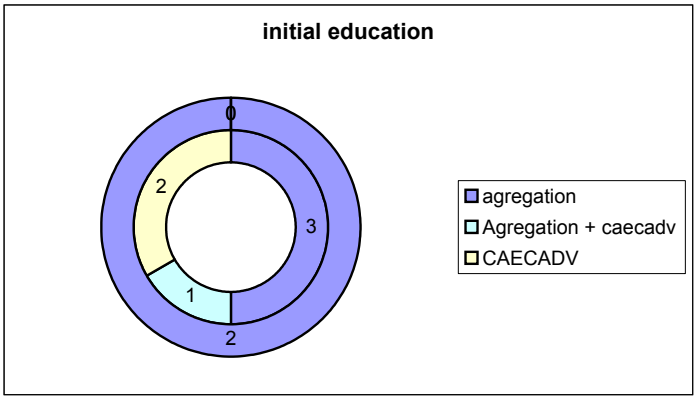
For this analysis we shall use the recapitulative chart of the interview.
We shall divide this analysis into three subsections, corresponding respectively in:
- The teacher's knowledge and customs (way of education, knowledge of the Braille, use of software, choice of the mathematical code).
- The difficulties which are confronted the teachers; whether it is at the level of the education of the mathematics either by the use of material.
- The group work (group work in class, parental help).

Points put in highlight

3.4.3.1 Knowledge and customs

The trainings in the field of the visual deficiency of the teachers teaching in specialized establishments can be: diplomat trainings specialized in the visual

handicap as the CAEGADV (Certificate of capacity in the general education for blind and visually impaired) the CAPA-SH, (Vocational training qualification for the Assistive Technologies) and the 2CA-SH (Complementary certificate for adapted teaching and schooling of pupils in situation of handicap) a personal training with the Braille learning in a autonomous way.
As for the teachers teaching in the common environment and having only a bind pupil per year, this training contents itself very often with what can bring them their pupils. So, guides as the "guide Handiscol" for the teachers welcoming a pupil presenting a visual impaired pupils and daily trainings can be proposed to them, however these trainings are more of the order of general information than forming true trainings as such.



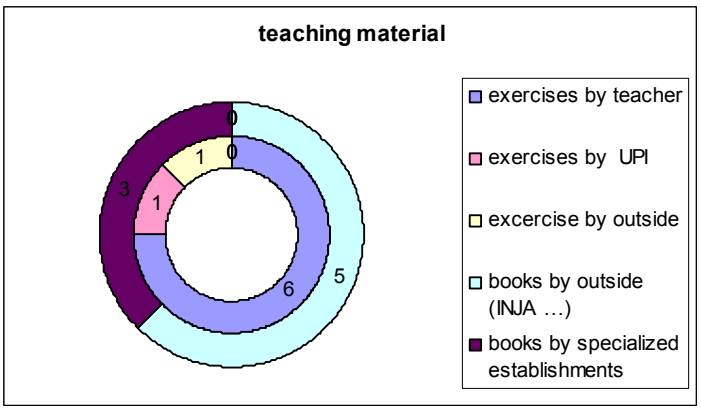
Outside circle: in inclusive education / inside circle: specialized education

Not breaking the rule, the training of the teacher of our study is very different according to types of establishments: the first ones having a knowledge of the Braille, the mathematics Braille and some technical helps for the visual impaired people, contrary to the second who often have no "time" to put a lot to know a little better the domain of the visual disabled.

This lack of training and knowledge of the Braille in the common school environment can have three consequences:

· It obliges the professors to appeal to outside bodies

For the preparation of their mathematical materials (control, courses, graphs). The teachers in specialized establishments prepare by them self the exercises, appealing to the outside or internal bodies only for the transcription of books.

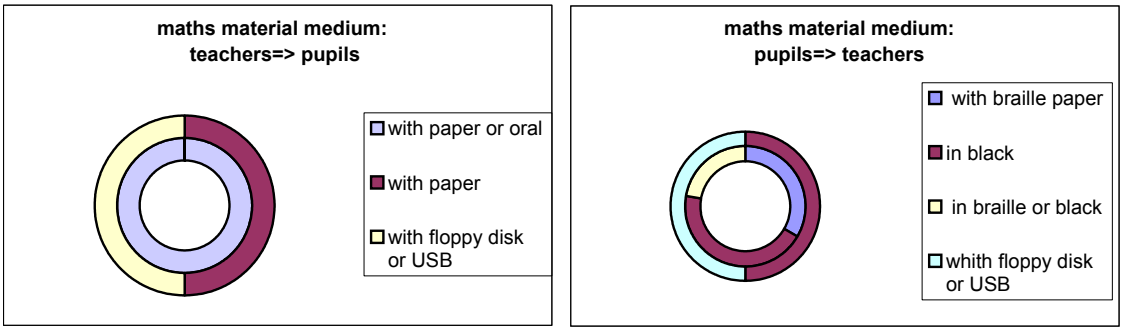


Outside circle: in inclusive education / inside circle: specialized education

This demand of transcription for any material notably has for consequence to have still no documents in due course. « They need to re-transcribe them of 10 workdays and it is far too much, we send them fortnight before and we advance more or less fast with the class then from time to time texts arrive and they are not any more completely of current events ».

→ Future software should be able to suggest to the teachers realizing them exercises then sending them by network or by key USB to the student.

As regards the courses and the exercises as well as the depiction of the pupils the Braille knowledge for the teachers influences the support of the mathematical material whether it is in the direction a teacher = > pupils or conversely:



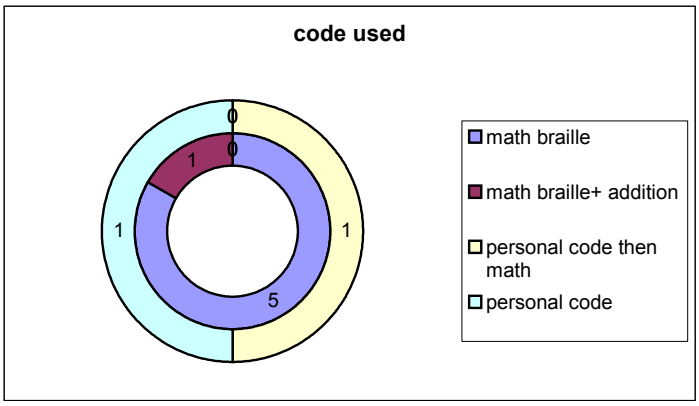
Outside circle: in inclusive education / inside circle: specialized education

Very few interviewed teachers use computer means to give the courses and the exercises to the pupils, preferring the paper or the oral by speed, custom, misses computer tool for raise to them or preferably. This last reason is, indeed, explained by some teachers by the importance to learn to build a document in Braille « the Braille presentation paper is important, it is not the same that in black, it is necessary to master it ».
As regards the depiction of the pupils, the choice of support has them often possible in institutes welcoming only visual impaired persons, teachers reading all the Braille.

The orientation of the choice is then made according to the preference of the teacher, the available computer tools, by simplicity or pupil preference.
« For the younger indeed it is with Perkins Brailler, the pupils of level twelve with Scientific orientation, use Perkins or then computer. They choose themselves, for the greater part they use Perkins »
« Lack of experience of the pupils with the computer ».
« The reading on floppy disk can raise problem to have incomprehensible signs »
As for the pupil's homework in integration class, they can be realized by three different manners according to tools in ownership of the pupils: by floppy disk or key USB, in printed black, but also in handwritten black. This last one is written by the visual impaired pupil or by one of her classmates, what has for consequence the impossibility of the visual impaired person to read again or the dependence in a third.

→ Future software should allow it could re-transcribe or it would send to black or to Braille the document easily from the teacher to the pupil and conversely.

Some tools used by the visual impaired pupil do not allow in teacher to be able to read quickly and correctly the reasoning and the exercise « the professor on my screen reads things which he does not understand ». For reduce this difficulty the teacher and the pupil at the beginning of the year can agree for the creation of a particular code, mixing the black writing with the Braille (ex: the star for multiply), replacing the mathematical Braille current. This new code can have notably as repercussion a possible neglect of some signs and this fact engender difficulties for the official exams (HIGH SCHOOL DIPLOMA) as well as for the university future.



Outside circle: in inclusive education / inside circle: specialized education

In the field of the special education every professor puts a sense of honour in the fact that their pupils use only the mathematical Braille in rigour « As I say to my pupils when you will be brilliant in mathematical you can give your recommendations and modifications for the mathematical Braille but not at the moment seen whom we are vulgar user we make with the fact that we have:. The code mathematical Braille current. » « In mathematical that arrives that there is who invent the own code, but we always put back him on the good way ».
However one of the teacher use with these pupils besides the notation "Antoine", the abbreviations not existing either in the Braille, or in the Braille abbreviated, to simplify some mathematical formulations: « it is more small shortcuts for the editorial staff of problem of mathematics ... numeric Application for example write it « a.n. ».

→ Importance that the experimented pupil can have access to the automatic insertion of the mathematical signs, and to add the possibility of using the Braille abbreviated for the formulation of the answers.

3.4.3.2 Difficulties met

Difficulties for the education of the mathematics
The question « do you meet difficulties to teach the mathematics to the blind children? » triggered deep reactions with the teaching professors in specialized establishments:
« I would not say difficulties. There is nothing indisputable »
« It is not a difficulty but it is necessary to pass by the language a lot. »
« I think that to be visual impaired does not necessarily add difficulties »
« Effectively he can have the other difficulties but there no more »
« Not really and then the mathematics it is always mathematics which we teach to blind pupils, to smith … »

Once these sentences thrown to re-center our choice of vocabulary, three complications were put in highlight:
Two of these complications emanate from the blindness in her even to know difficulties of apprehension and realization of graphic and geometrical element (curve or table), as well as for the reading and the calculation of algebraic expression (the linearity of formulae, location inside the calculation and the calculation in him even). The last one, as for her ensues from both complications coming to be described. So, the visual impaired persons put more time than sighted for the reconnaissance of a formula, a graph. The eye allowing a global vision while the tactile reading is very sequential and asks for a work of synthesis. This third complication is more of the order of a request i.e. a need of supplementary time, her that even who was recognized for the signing of exam.

For the first two difficulties of the solutions, ideas, were emitted or already realized by professor in class:

- Accompany the figure, the table, with a text or a descriptive speech.
- To have a Braille computer in several lines to be able to show a table, or a graph almost in their totality.
- To have the relief figures so that the pupils can touch the object and of this fact indeed show this one.
- To have the Braille computer multi-lines to be able to put the operations in column or have the notion to go to the line.

Finally, in a general way, the teachers teaching in specialized establishments use to counter the complications which they can meet:

- The word, the stake in word of the mathematical terms: « it is which operation which corresponds in « of » in my sentence five of minutes? (Answer of the pupil): to multiply »,
- The reference to the concrete, to the examples and the notions which speak to them: « we change explanations because we do not use the same notations and then he the same did not live there also, it is necessary to put itself in their

place, it is necessary to find examples which are convenient for them » « I avoid making too mathematical mathematics, I make mathematics in a literary way I try not to use too much the mathematical language ».

As regards the specific difficulties of the teachers working in the common school environment, they are also two orders:
Difficulties in particular for the geometry and the graphs: for their realization, their visualization (problem to position precise points, to gripping of a complex figure or a graph).
The second as for her is the consequence of the number of pupils in classroom: « when we take care about one pupil 25 others make “fiesta” ».

→ Future software has no instructive vocation, the role to teach being totally to the teacher we shall set of this analysis.
- The importance of the terminology employed notably for the possible taken out in screen readers
- The necessity of realizing a help for graphs, figures (this falling part in our partner of the Project MICOLE), this help could indeed integrate according to the desire or the need of the pupil and the teacher, a descriptive textual part of the graphic element.
- The importance of a help for the reading and for the calculation of algebraic formula, with a need to be able to reach permanently the first operation or the instruction, possibility according to the level and the choice of the student to be able to arrange his operation in column or on-line.

Difficulties bound to the materials

Some technical helps even if they are very competent in different spots can have gaps for the others. So screen readers are very appreciated and used for the reading of a text or the navigation in a computer, a web page but are useless for the reading of a graph or a geometrical and still insufficient figure for the reading of algebraic formula. Indeed, they do not read correctly some mathematical signs notably reading and by way of example "hyphen" for the minus sign.

As regards the software (Readmath in particular), three big complications were quoted:
- The problem of the calculator not integrated into the software, engenders one waste of time and a cognitive effort for the pupil. So, it requires that the pupil goes out of his calculation, goes to the calculator, face his calculation and returns in its exercise to note the result with his memory to him report.: « the problem of the calculator it is obliged to close the document, to open "Jaws" to calculate, to remember results and re - go into the problem. »

- The systematic return in the literary Braille in every space, what obliges the pupils to put back the mathematical sign permanently: « they write with the standard Braille and when we want to pass in the mathematical Braille they have to put the point six and three, the problem it is that as soon as they put a space it is more good they go back in the normal code ».
However this problem of space and on returning to the literary Braille is understood by the mathematical Braille he even so, this one not requiring a space, this last one in certain software implies the end of the code squall mathematics.

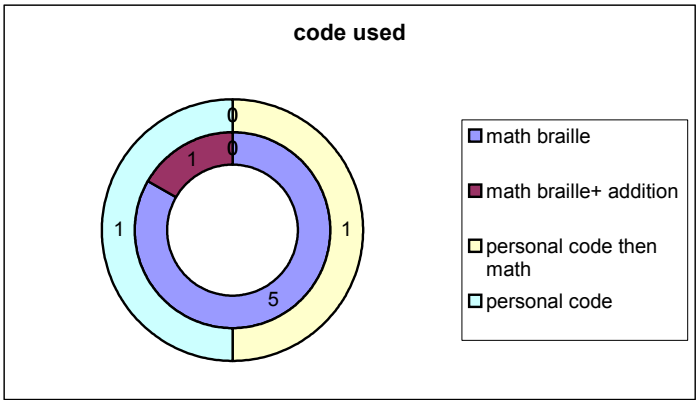
- Most of the Braille computer are not provided with screen with liquid crystals to see in black the contents of the Braille computer, returning of this fact the reading for the complex teacher and long for the pupil. Indeed, this one is obliged to close the current document to be able to re-transcribe it.: « to verify what he wrote or it had to re-transcribe but he could not write any more at the same time or I asked him) to read again ».

→ The software integrates a touch function allowing to stay in a mathematical Braille, to add it a calculator or what this one is very easily accessible and places the result automatically in the current exercise.

3.4.3.3 The collaborative work

The group work includes the homework at the house by means of a member of the family and the work with binomial or with group inside the class.

As regards the work at the house:



Outside circle: in inclusive education / inside circle: specialized education

The teacher of integration did not know how to give us their opinion onto the parental implication of the personal homework of their pupils. This being able to be explained by the level of the pupils, indeed, they are respectively in ten and twelve level, the teachers considered certainly that they ask for no more help to their family.

The answers of the teachers in specialized establishment were especially centred on the quality of the parent assistant. So, the majority of the parents can have difficulty in helping their child for the mathematics homework: knowing little or not the complete Braille and of this fact in no way the mathematical Braille. This lack of parental investment for the learning of the Braille can have the second consequence besides the absence of help; the great majority of the professors we one so, clearly said as they did not prefer that the parents intervene in duties. This being explained by a significant difference between the explanations of the teachers and those of the parents:

« The help can go against the explanations of the teachers, because the parents do not use forcing the best way of explaining, they try to make cross methods which can be destructiveness for the pupil »
« Generally I prefer all the same that they made in class because it is not ten thousand manners to work and to explain »
« I do not know how the parents explain it but several times the pupils return with homework and it is rather false »

This reserve that the professors for the personal homework can have can to listen that the education method of the mathematics for the brailed users is different from that to teach to sighted people by:
The necessity of employing specific and inherent mathematical Braille signs (such as blocks for the division).: « we spoke with a pupil who writes in black of four ninth of X, we see at once how's that spells and in Braille, it is necessary to say 4X on 9 because if we put 4 divided 9X seen the priority of the operations 9 and X multiply, then the one who is going to dictate he has to say that 4 and X are a part of the same block may close the block to reopen the block for new of the bottom. »

The rigour of the mathematical explanation and the terminology (structure of identical sentence to finalize a problem, use terms of numerator and denominator for the fractions): « I especially noticed that to teach Braille users required a lot of precision to be much more precise on the mathematical terminology, the mathematical precision that serves especially for be best understood. Thus I tried hard to be even more precise with Braille users, on the structure of the sentences, to be thrifty in the expression of the theorems ».
This rigour in the terminology does not insinuate a radical change of vocabulary and the not use of term such as the high or the bottom of a fraction but indeed a quite particular instigation on the employment of mathematical name to show well the correlation between the term and the writing: « it is necessary to adapt itself but especially not to change vocabulary because when a blind pupil speaks with one sighted people they have to understand) absolutely, thus it is necessary to explain also the high and the bottom of a fraction ».

→ Remarks: use good terminology for the explanation of the mathematics to know the necessity of having a quite particular rigour in uses it terms for the functions of the software.

The work in small group

The small group analysis being developed in the part 3.5 for « The analysis of observation of a collaborative work », we invite you to refer there. These below us remind you only the conclusions of the teacher's interviews on this subject:
The comments of the teaching teachers in a specialized establishment describe this work as:
- A work in binomial either with the totality of the class,
- The pupils explain their progress of thought, their result either help one of his school friends.
The teacher take the children participate in the course and leave an important place on second thought personal aloud. However there does not seem be of idea of the group of collective purpose, mutual and constructive exchanges.

To resume for the teachers, this work could be more qualified as « individual work in group ».
As for the teamwork in class of integration this one does not seem to be a part of the methodology of the professors, it can be explained, also, by the lack of tools their allowing to take the pupils work together.

→ For the work in small groups the software should be able to propose various windows. Windows for the discussion what would allow the pupils to give and to modify them works together as well as windows for the order, the functions of every member and finally a window for the final paper.
This tool should be able to have a pleasant visual interface for the sighted pupils, with a good transcription of the black in the Braille and conversely for sends it to network to the various members.

3.4.3.4 Summarizing

It seems that the development of a working environment which would facilitate the access to the textual mathematics as well as their manipulation, should allow, according to the analysis of the teachers interview, to have the following various features:
Features:

- Integrate a touch function allowing to stay in a mathematical Braille, or another codes than " the space " to cross of the Braille mathematics in the literary Braille (double space, doubles line feed for example),
- A means of re-transcription or sending in black or Braille of the document easily of the teacher to the pupil or conversely,
- That the experimented pupil can have access to the automatic insertion of the mathematical signs,
- The possibility of using the Braille abbreviated for the formulation of the answers,
- The integration according to the desire or the need of the pupil and the teacher, the descriptive textual part of the graphic element (for the co-workers working on curves and graphs),
- Be able to reach permanently the initial operation,
- Have the possibility of arranging its operation in column or on-line,
- Have an integrated calculator or what this one is very easily accessible and places the result automatically in the current exercise,
- Propose (for the group work) various windows; notably a window of discussion allowing the pupils to give and to modify their works, windows for the order and the functions of every member and finally a window for the final paper.

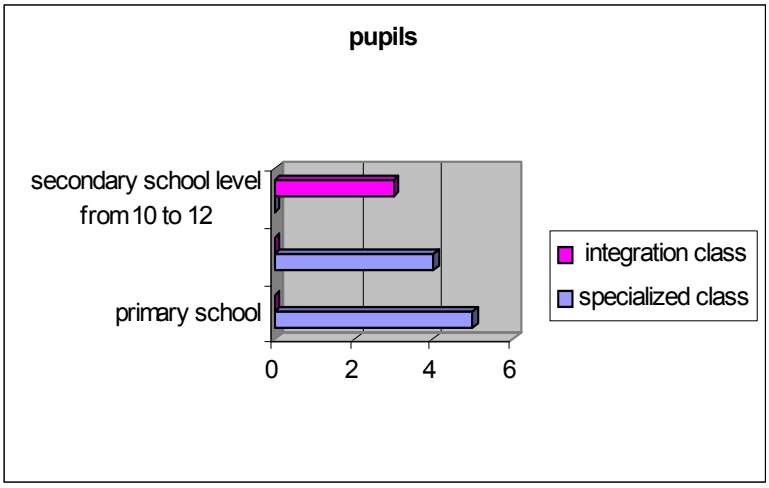
Counsel and request for software intended:

- That it have a pleasant visual interface for the sighted teachers, with a good transcription from the black to the Braille and conversely for the sending and the recovery in network of the exercises.
- The importance of the terminology used notably for the screen reader and the functions and the helps of the software.

3.4.4 Analysis of the pupils interviews

This part will follow same as those used for the analysis of the teacher's interview namely:
- Knowledge and customs of the pupils (classroom level, Braille knowledge, use of software, choice of the mathematical code).
- Difficulties whom they are confronted whether it is at the level of the mathematical learning either by the use of material.
- Group work (group work in class, parental help).

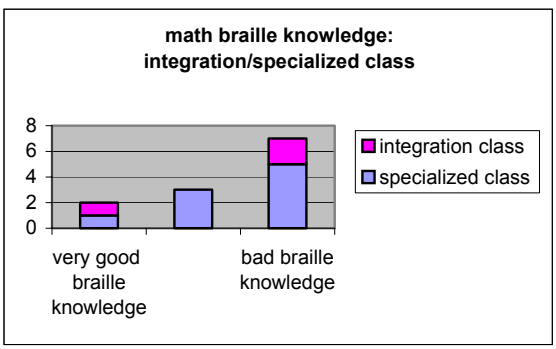
Before any thing, we present you the population of pupils: they are twelve pupils, among whom nine in a special school and three in integration.
Pupils' proportion in school / secondary school and primary is described on the graph below.

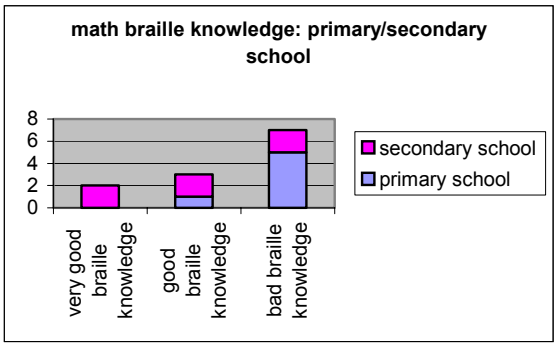


Points put in highlight

3.4.4.1 Knowledge and customs

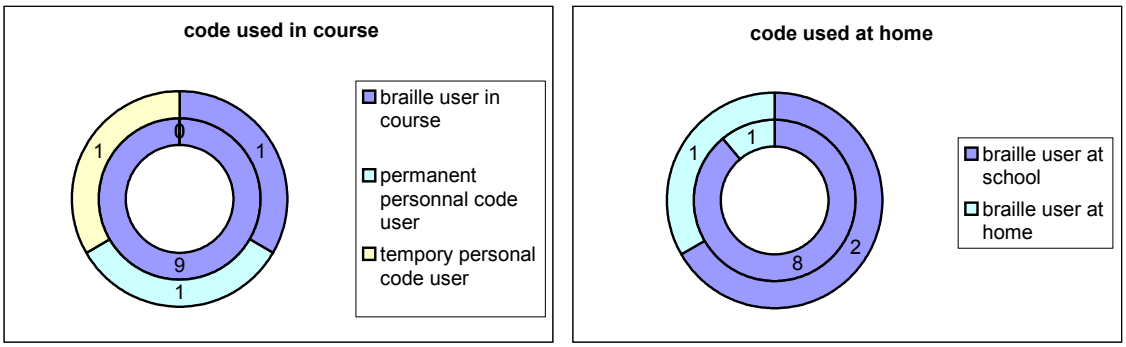
The level of the pupil's knowledge of the mathematical Braille normally keeps pace with the level of learning and the school level of these last ones: the pupils in junior forms having a less big experience and a custom of the mathematical signs. Nevertheless with the same years of training the differences inter-individual exists, those can be explaining with the facilitated of learning, in degree of the partial sighted (the pupil using then his visual rests in depends on the Braille) etc.:





The mathematical Braille code is taught, for the pupils schooled in a specialized class, by the teachers, according to the needs of the course, allowing a relatively slow and spaced out learning, and thus a good acquisition.
For the pupils in integration classroom the UPI responsible for the biggest, for the smallest the auxiliary of school life or the professor of CLISS can play this teacher's role of Braille math.

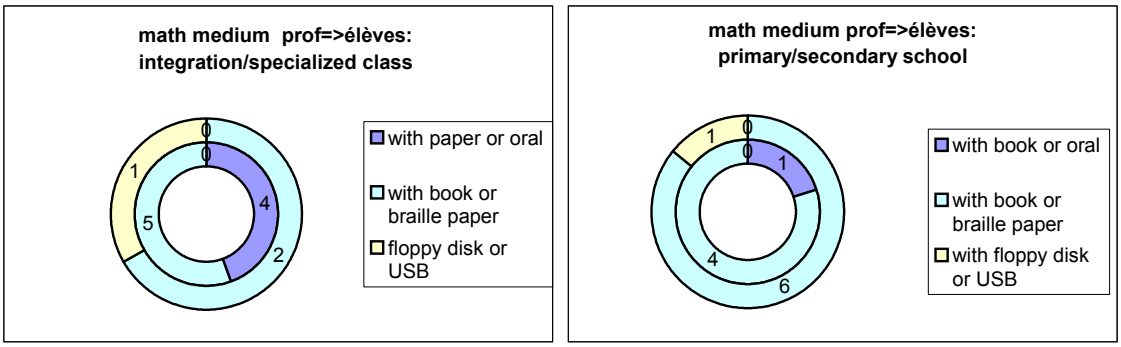
This Braille knowledge is going to influence the choice of use the mathematics Braille code or a personal code, whether it is within the school, in common environment, or to them house. This use of a particular code enters teacher and pupil is not realized in specialized establishments as we were able to see it in the interview teacher analysis.



Outside circle: in inclusive education / inside circle: specialized education

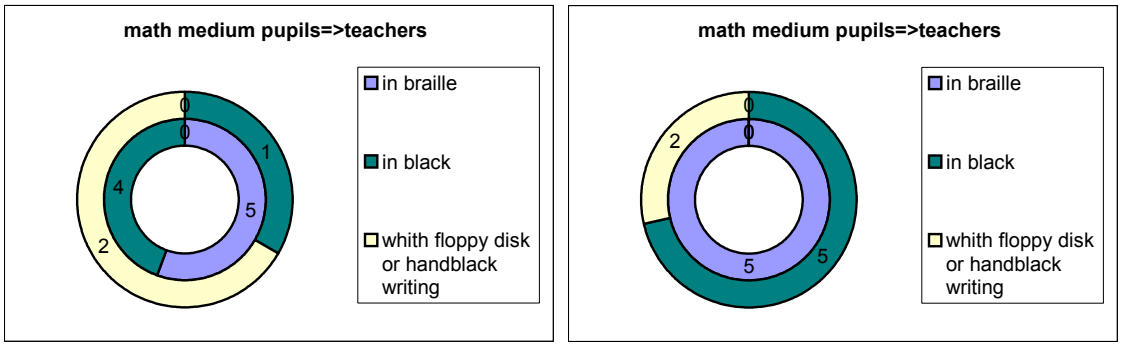
The proportion of the pupils using another code than codes Antoine, is relatively weak, it corresponds that has two pupils on twelve. This choice of a personal code ensues from a need of simplification and from speed in the writing: « from time to time when I am at home I change little to simplify ».
The glance concerned the use of the personal code with the teacher, changes from the pupil to the other one. The one considers it as a means to reduce the difficulties which he can have: « we made a small code to us, to simplify because otherwise it was too complex », the second pupil has he examine this use with much more drop and consideration of the echoed for his future: « it is just necessary to agree with the professor at the beginning of the year and then that passes, normally, but it is in no way a good method. »
As for the support for the homework and the controls, we wished to make a comparative degree, a specialized school environment and a common school but also between the primary school and the secondary school. So, the pupils of the primary give to their teacher by Braille paper, nobody still not mastering at this age the computer tool, and not using in class that of Perkin.
For the secondary school the support varies of the printed or handwritten black and the floppy disk or the key USB. The return in handwritten black is specific at the secondary school in common environment, this one is made by the visual impaired people (then not being able to read again) or thanks to the help of a third (responsible for UPI or classmate): « I look to him onto floppy disk I tap the computer and here is

it is the simplest, is I ask somebody who copies out him in black for me but check it is not very practical all the same



Outside Circle: class of integration Outside Circle: primary & secondary school

The choice of the material for the personal work differs according to the age of the pupils. The pupils in primary work at home with the same material as in classroom to know the cubarithme and the Perkins, this being able to be explained by one not or badly knowledge of the computer tool either by exercise of training to master the presentation in Braille paper (cf interview with the teacher).
For the oldest, the choice for the work of the mathematics is normally the Braille computer (most part of screen reader as we have already mentioned it not reading correctly all the mathematical signs). Nevertheless the screen reader is used when the professors and the pupils built up to themselves their own code or for the partial reading of the exercises notably for the instruction or for the second reading of the courses.
Some students prefer, also, to continue to work with Perkins, rather than with computer tools (Braille computer). This choice is then explained by the teachers by ease to be able to read the table in its totality without having to go to the line: « in twelve level for example I have 11 pupils among whom six Braille users and all work on Perkins it is for the tables to have all the picture for example five lines which they can have of a single paper rather that with the Braille computer which is single line ».



Outside circle: in inclusive education / inside circle: specialized education

→ To have in exit the screen reader for the personal work
Have the possibility of having Braille computer with several lines.

The use of material for the personal work brings us to speak about different known software and or used by the pupils. Two softwares were mentioned by the pupils:

· Bramanet: translation software of mathematical in Braille working only with Word97 (cf 1.2.2. For the state of the technical art of the helps for the mathematics),

· Readmaths: software under BACK and Windows 98 / XP allowing to transcribe in black and to shape the mathematical formulae squalls.

Five pupils use the Readmaths software, among which one having chosen Readmaths having used previously Bramanet. This change of software was to realize in unhappiness and by the obligation, this last one working only under Word97 « I use Readmath it is not the one that I prefer but, before I used bramanet and I really found this software extraordinary, it had a reversible method which readmath we does not have could ask to the Prof. to make us cross the courses in black and we had them in Braille it was really very well (…) Something which had seduced me at once in bramanet it was the integration of an abbreviated code it is very practical ».

The daily use of the software Readmaths by the pupils allows them to be of check critical in the practice of the software; they then quoted us some one of its advantages and its disadvantages:

- Advantages:
  - « It takes care a great deal of mathematical codes »
  - « It also has a system to realize tables of variation »
  - « The automatic insertion of the signs »

- Disadvantages:
  - The access to the calculator which makes waste time and which asks for an cognitive effort to the pupil: « the calculator, to have access to the calculator I have to take out of my document that I made the calculations that I remember me there and that I turn back into my document »
  - The transcription « I transcribe I cannot modify any more my text, the problem can being it is that readmath does not make the transcriptions by him even
  - The problem of compatibility with Braille computers of the other company «It accepts no other tactile computer which results from another company")
  - « No reversible method (: Prof. to give the course in black and we had them in Braille)
  - The problem of the spaces which indicates to the software that the mathematics Braille code finishes and goes automatically to the literary Braille « We have to put a sign 6 3 and thus if you forget it is not well re-transcribed because as soon as you make entrance it is necessary to put back points »

→ To conceive a software with an integrated calculator so allowing to decrease the charge cognitive but also to reduce the time of calculation.

- To facilitate the transfer of file from the teacher to the pupil and conversely
- Look for the change of code for the end of the mathematical Braille.

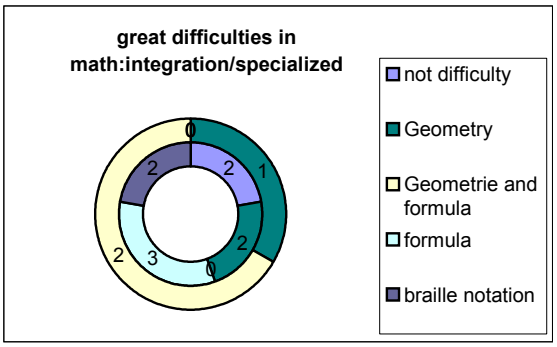
3.4.4.2 The difficulties met

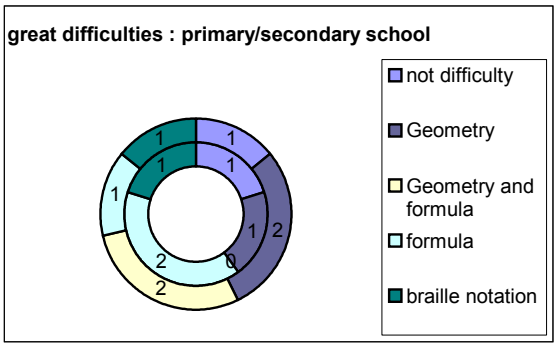
Difficulties for the mathematics learning

Two pupils following a specialized schooling we tell us to have no difficulty in mathematical, these two persons being respectively in class of level 5 and the level 8.

«For the multiplication: no, additions, subtractions: no the divisions: no the geometry figures: no … No that goes ».
The difficulties described as for them by their school friends can be included in three big domains:

- The Braille code
- The geometry
- The algebraic expressions





Outside circle:classe of integration

Outside Circle: primary school / secondary school

One of these difficulties is the use of the mathematical Braille code; the pupils having mentioned this problem indeed describe this code like a complex code, with very similar signs. « It is just on the notation I never manage to remember for example the parallel sign » « notations finally with codes of the signs which I do not too much manage to retain ».

The geometry is a part of big difficulties with which are confronted the visual impaired persons. The interviewed pupils not breaking the rule, they are confronted with the reconnaissance of figures and graphs, with the work on this one (position a point, for a graphic calculation): « I have difficulty to representing the graph I sets a lot of time to understand for what the exercise asks, when it is necessary to calculate diagrammatically or to see diagrammatically something I also have difficulty » « of moment or in the figure it has too many things that still go but as soon as there are many things I do not manage to find a way inside ».

In these difficulties for the geometry can be allied by the difficulties for the algebraic expressions. These are not obviously of the same order for the pupils in primary as in secondary. The primary are indeed, confronted for the location of the operations « Yes I have difficulties for some exercises as the divisions or the decimal numbers sometimes, it is necessary to put the comma under the comma …, and then the divisions it is hard also to put it and to calculate because I do not really know where to put the other cubes ».
The oldest as for them meet problems with the length of formulae and the calculations, imposing efforts mnemonic for this recollection of the terms and the intermediate results of the calculation « When I have big and complicated calculations, in more I have no calculator adapted then it is very difficult for me for the moment, fortunately I have a good memory ».

As regards the linearity of formulae this one does not seem to put more difficulties than that to the students, these last ones being in the habit and knowing for some that this "formulation": « indeed for me it is not in floor it is on-line, thus it is just another system of representation we become used bit by bit in fact, and sight that I began very early it became an automatism rather quickly (…) The fact of learning the mathematical normal Braille and the mathematics it is the same thing in fact, me I do not know two different systems, finally so just a little because I studied it at the beginning but, I think that it is not more complicated than to learn the mathematics for sighted. Later I think that those who can have difficulties it more a problem of methodology than adaptation ».

→ Importance for the young pupils to allow positioning them algebraic expressions in column and to allow decreasing the charge mnemonic during complex calculation (fast access to a calculator, to highlight the terms for the simplification).

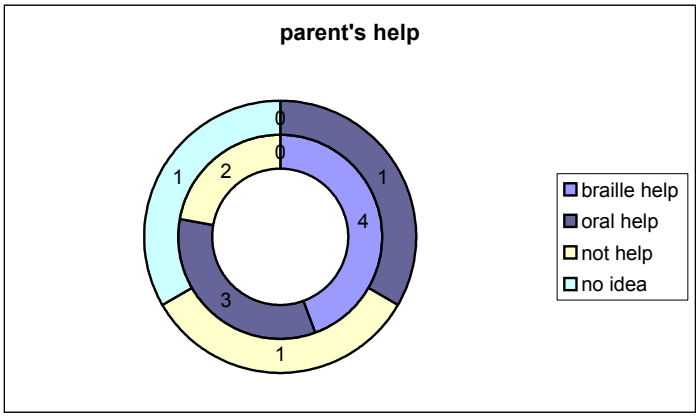
Difficulties meet in uses of materials
The difficulties meet in uses of materials can be moved closer to the disadvantages of the mentioned software higher namely:

- The access to the calculator which makes waste time and which asks for a mnemonic effort to the pupil.
- The problem of transcription where the pupil is obliged to go out of his document to be able to transcribe it, which could not any more then modify it.
- The difficulty and the latency period to obtain the teacher papers (in class of integration).
- The problem of the spaces which indicates to the software that the Braille code mathematics finishes and hands on automatically to the literary Braille.

A last difficulty mentioned, this one coming from the fragility of paper to draw. These transparent and virgin paper, can have squared to make things easier the location of points, however these last ones seem to be very fragile not allowing then to realize a curve. « There is some squared paper but to my opinion it is much more fragile either we have anymore of tactile sensation or if we support too hardly it tears then I do not use it any more ».

3.4.4.3 The group work

The parental help:
few parents knowing the Braille and of this fact the mathematical Braille, only four pupils can have a reasoning help also and on the writing and the reading of the mathematical help: « my mother helps me a little; she knows a little the Braille … She gives me examples to the oral and then I work with my Iris ». Nevertheless, even with Braille knowledge this help is essentially by the oral. The pupil reads then the text in Braille, or for those who possess an Iris read with in the small digital window, the parents helping afterward of different way: giving example, putting on the track, giving the answers for example.
Nevertheless, a quarter of the parents not knowing the Braille do not put a lot into the help for the personal homework « They are not propped in mathematics or in Braille moreover » Quite as in this person comment the few nearly of help can be explained only by not Braille knowledge.



Outside circle: in inclusive education / inside circle: specialized education

→ Importance to have a good transcription Braille = > black so that the parents can read what their child writes during their exercises.

Group work in classes or outside

The group work being developed in it left 3.5 we shall mention in this part only the conclusions and the big sentences of the pupils illustrating them.

The pupils in integration tell us that they working in group only outside of the courses and describe this like a dual work consisting essentially in a help of understanding and or for the note: « somebody takes all the notes, they take notes in black and after I made re-transcribe (…) Like that I am sure to understand the questions because often the papers are not very well adapted thus the advantage it is that somebody can explain me the instruction ».

However the teamwork as such does not seem to be a part of customs of the pupils in class of integration, this one being able to be considered as a supplementary problem to be managed: « I do not see the interest there, seen the problems met already with the professor I think that with two three pupils that could only worsen things ».

For the pupils in specialized school only one conceives the group work correctly i.e. a division of ideas, a confrontation of points of view and a division of spots.: « We put in common our ideas, we agree and then we work, there is one who written and then the other one speaks or explains to him ».

For six other pupils the group work can be more represented as an individual work realized in a collective time, this work which can describe like the an help of a school friend that is to explain its reasoning or to put it on tracks to resolve the problem, the calculation … « With my classmates, we explain like that between us, each explains something to a whom check did not include and then Here we are, but we work especially in dual».

This group work, this mutual help, takes place orally by ease, speed or by not mastery of the computer tools: « by speaking, but it is true that we could use our Iris it is enough to connect them in network, but one does not make to it very often that made waste time».

→ To be able to work in a fast way: by network, Internet.

3.4.4.4 Summary

According to the analysis of the pupils, the future software should allow to have these various features:

- Be able to work in a fast way: by network, Internet,
- A good transcription braille = > black, black = > Braille,
- Be able to position them algebraic expressions in column,
- Allow to decrease the mnemonic charge during complex calculation (fast access to a calculator, to highlight the terms for the simplification),
- To Facilitate the transfer of file from the professor to the pupil and conversely,
- Look for the change of code of the end of the mathematical Braille,
- The automatic signs insertion.

3.4.5 Summary of the interview of the professors and the pupils

Before summarizing the features hoped by the target population, we wished to add the advices given by teachers and pupils in the end of the interviews So the last formulated question was: « if you had an council to give us, which shall be it? », few pupils answered almost all the professors looked we an advice:

« Not to ask them to write too much, there are quite a lot of steps which they make mentally and I noticed that the fact of writing more that usually, to make more steps, or the other things hamper them more than help them and that they can have permanently the equation to be realized, to calculate in a window that they can go to verify that I think that it would indeed be ».

« that the software is attractive visually for the teacher in integration and for the sighted classmate" ».

« It would be necessary can be to think then in a Braille computers with at least two it would be already indeed but three it would be best that we can have the notion to pass in the line, so that they do not any more need to calculate the 28ièm character or the space and to put the equal below the equal ».

« Watch the understanding of the problem, the instruction and so that it is conceived in the head i.e. that the problems or exercises instruction made reference to objects which the blind persons already arrested, touched ».

« That documents are exploitable of the one or the other one than there is no problem for both, that is that I am not obliged to print the document that I can give a floppy disk or a key USB and that would end there ».

« And although there is a pleasant voice, because sighted peoples have the mouse but also the images then why to choose between the Braille computer and the screen reader. It would be necessary to make just similar that for sighted I think ».

- « It would indeed be can be not to forget the automatic insertion of the mathematical signs,».

The analysis of the inter-groups interviews going to the same sense, the advices being in agreement with the big points highlight during the interviews analysis, we can, recapitulate the list of features wished for the future mathematical algebraic expressions software:

The features:
- Integrate a touch function allowing to stay in a mathematical Braille, or another codes than spaces out it to make understand in software the end of the Braille mathematics (double space),
- A means of retranscription or of sends to black or Braille of the document easily to the teacher or conversely,
- That the experimented pupil can have access to the automatic insertion of the mathematical signs,
- The possibility of using the abbreviated Braille,
- Be able to reach permanently the first operation or the instruction
- Have the possibility of arranging its operation in column or on-line,
- Have an integrated calculator or what this one is very easily accessible and places the result automatically in the current exercise,
- Allow to decrease the mnemonic charge during a complex calculation (fast access to a calculator, highlight the terms for the simplification),
- To obtain a help on the Braille symbols allowing to look for a symbol and to insert it directly into the current work.

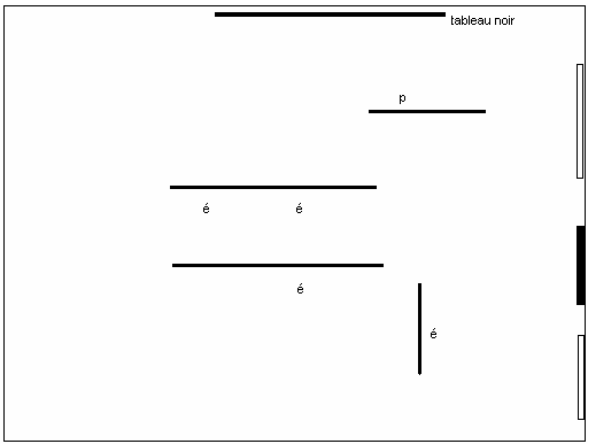
Demands and council:
- That it have a pleasant visual interface,
- A good transcription from the black to the Braille and conversely for sends it and the recovery to network of the exercises,
- Take care about the terms employment
- Do not add them supplementary steps for their usual work.

3.4.6 Analysis of observations

Following both observations were realized in a class of level 9 in a specialized establishment working at the integration for the partial sighted or the visual impaired people in common secondary school.
This class consists of four blind pupils. The teacher has for characteristic to use the blackboard during these courses. The teacher explains this use like a custom having worked, indeed, in a common school previously and by educational method to centre, structure the mathematics: « to teach blind children did not prevent me from continuing always to write in the blackboard, it is anyway structuring for the pupils » uses of the blackboard can be also interpreted as a help for the teacher, to structure his course.
All the pupils use an Iris: personal Braille assistant portable of 40 characters made by Eurobraille.The Iris contains normally: a word processor for the mathematics the Readmath software spreadsheet of data, a calculator, an administrator of files, a navigator Web a network connector Ethernet, etc.

IRIS of Eurobraille

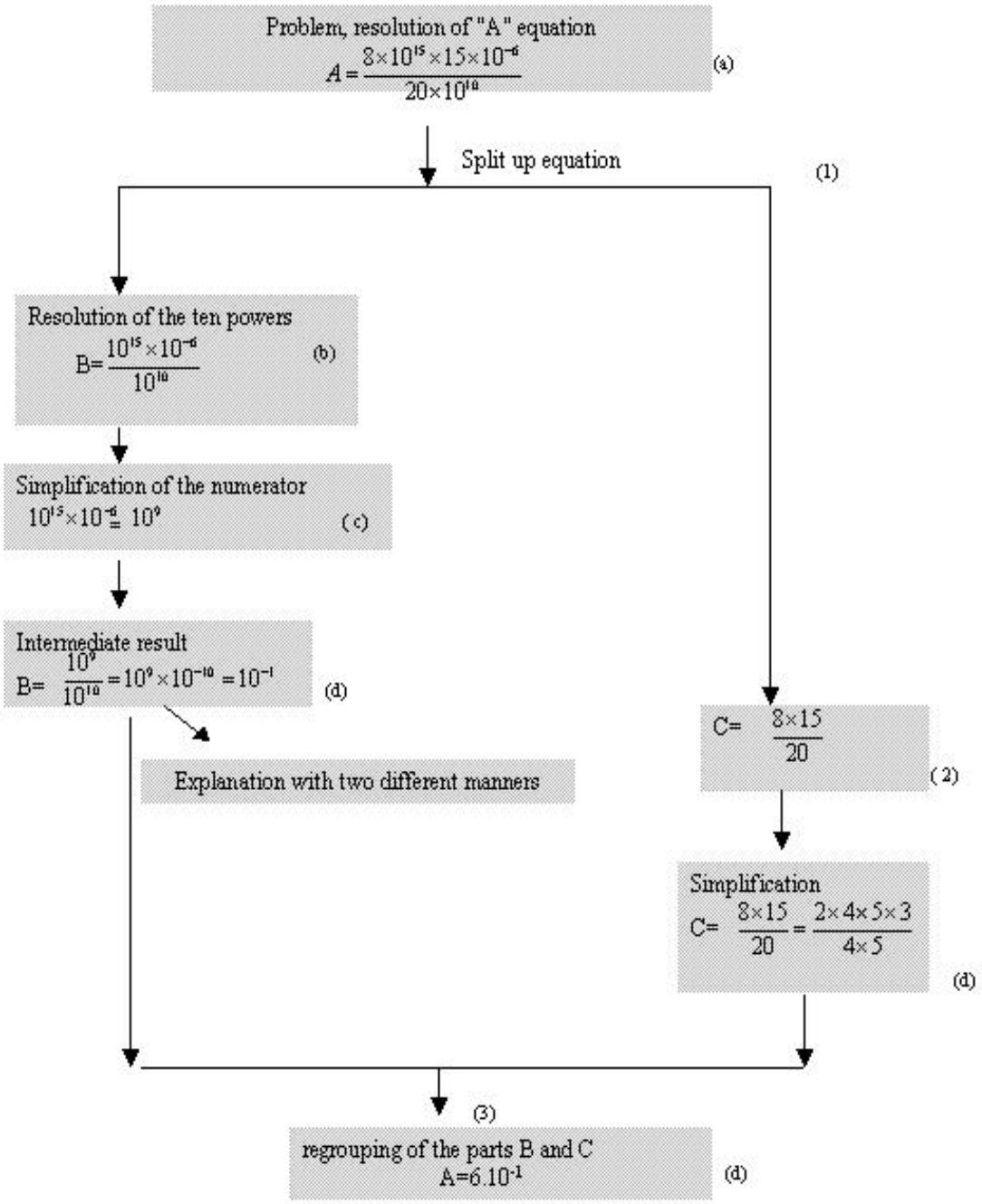
The arrangement of the class is drawn below:



These two analyses of observations are going to be presented by means of a graph. This one represents, the working methodology, the technic employees for the equations resolution.

3.4.6.1 Analysis of a resolution of an equation with powers of ten

The purpose of this exercise was to resolve a fraction with powers of ten. As you can see it on the graph below, the teacher to make understand the exercise and the various steps of calculation uses:
- The formulation of the formula with the mathematical Braille code: « we close the block we add the block 20*10^10 we close the block ».
- The divide of the equation in two under equations: that with the powers and that containing the coefficients of the 10 powers. Splitting the equation allows to simplify and to resolve part by part the expression to emphasize the characteristic and the rules of every parts resolution
- He uses a terminology mathematical $\frac{10^{15}*10^{6}}{10^{10}}$ *on the numerator in the denominator*
- The formulation with more literary terms, or explanations on the mathematical terms « we are going to simplify, we are going to emphasize the common factors, then in mathematics we tell to "to split up the fraction ».
- asks for the pupil reasoning: « how make you to calculate, simplify the powers? ».
- The teacher explains various methods to arrive at the same result: « other method we can multiply by the opposite 109*10 10 = 10 1 ».



(a):Use Braille code to express the formula " closes the block ,one adds block 20.1010"

b) : Use mathematical language : "to the numerator that gives"

(c): The professor requests from the pupils their reasoning

(d): explanation of mathematics by literary vocabulary : "one will simplify, one highlights the common factors

(1): Voluntary participation pupils

(2): the professor questions a pupil

3): the professor requests something from the pupil but this one does not answer

The participation of the pupils can be voluntary or provoked by the teacher request. The voluntary answers insinuate an understanding or at least one helped in the reasoning to be had, as for the not answer it expresses well a misunderstanding. During this misunderstanding the teacher uses of a mathematical language to explain. « I believe that you have a difficulty with 10-; then 10-1 thus 1 that means that ten once appears; and – 1 means that i) once appears to the denominator ».

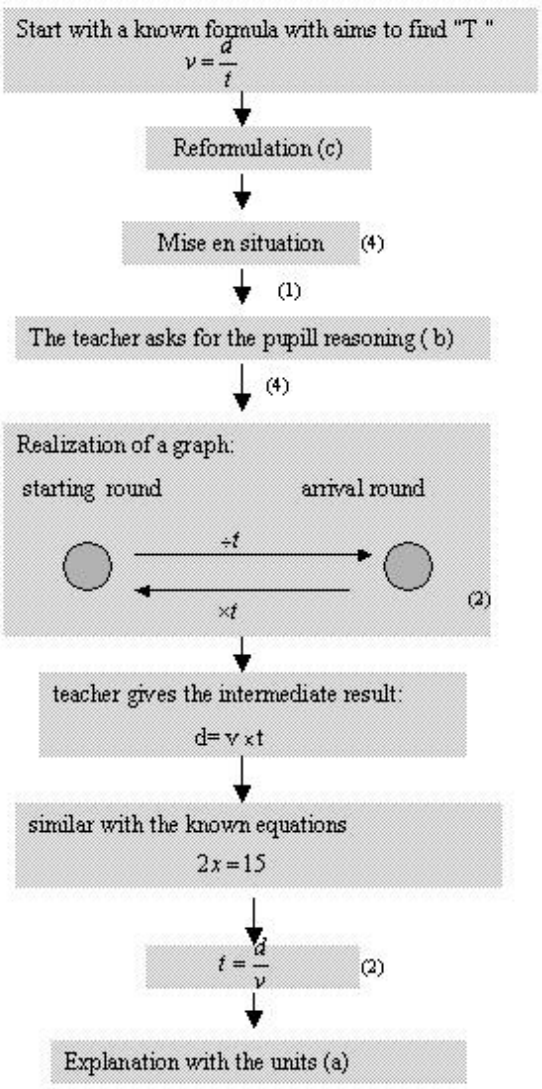
→Importance of the terms used for the functions and the helps of the software. Allow thanks to functions copy/paste to divide into several parts an expression mathematics too complex.

For the simplification, the interest to emphasize some elements coming to be to simplify with the other terms which have the same coefficient.

3.4.6.2 Analysis of a resolution of a problem with notions of time, speed and distance

The current exercise, on the resolution of a problem with notion of time, speed and distance divided into three big stages:
- The first one corresponding in search of the equation of time when we know the distance and the speed.
- The second part requires the formulation of the found solution.
-And finally, the last stage is the search for the formula t=d / v, by a different method from the “rule of three”. This under part will be inserted in the first one, this one having important only by the educational interest.

The search for the equation of time when we know the distance and the speed.

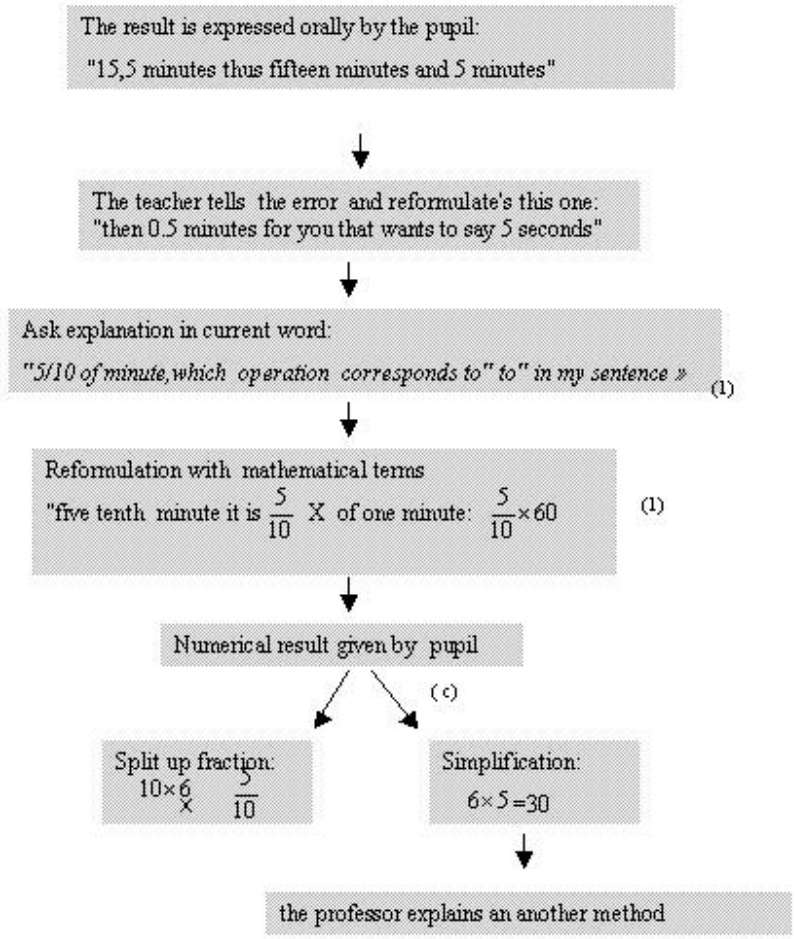


(a): teacher gives another manner of finding the result
(b): The professor requests from the pupils their reasoning
(c): explanation mathematics by literary vocabulary
(1): Voluntary participation pupils
(2): the professor questions a pupil
(3): teacher asks pupill but he doesn't answer
(4): The pupils haven't reactions

Like for the resolution of fraction with powers of ten, the professor uses for the student comprehension various methods:
- The re-formulation of the exercise by common words: « formula of mathematics v=d / t what means in brief that if we know the distance and the duration we can calculate the speed », that this not provoking answer of the pupils teacher uses then:

- To place in context so that the pupil finds that own formulation: « if you had to expose this exercise for one person outside the class how would make you? ».
- a drawing and a formulation of this one emphasizes the operations which are in it work.
- the use of type of equation already known and mastered by the pupil so that this last one can transfer these knowledge from a particular case to a majority: « what gives us as equation 12,4=0,8*t, it is the same thing as when we made: 2x=15 ».
- Finally when the pupils found formula, the teacher gives the second method to find it: « then we can find it by making the bubbles graph of departure and arrival but also thanks to units».

The formulation of the found solution



(a) Uses Braille code to express the formula

b) : Uses mathematical language

(c): The professor requests from the pupils their reasoning

(d): explanation of mathematics by literary vocabulary

(1): Voluntary participation pupils

(2): the professor asks a pupil

The teacher was already said before it, use the same means to explain and surpass the difficulties that the pupils can have. Indeed, this teacher was insistent on the explanation and the understanding of the mathematical terminology. He takes care about that the pupil can clarify his reasoning and finally he give always a second way of being able to find the result.

→For a software including educational helps, importance to insert the various manners to find a result.
- Importance to use exact mathematical terms for the screen reader.

3.4.6.3 Summary

According to the analysis of the observations the future software should allow to have these various features:
- allow thanks to functions copy/paste to divide into several parts an too complex mathematics expression.
- For the simplification importance to determines some elements by highlight the terms with the same coefficients.

Council:
- take care to use of the terms used for the functions and the helps of the software.

3.4.6.4 Useful features for the work on the mathematical formulae

The main purpose is to develop a working environment which facilitates the access in textual expression mathematics as well as their manipulation i.e. the calculation, the simplification … (The Pierre and Marie Curie university concentrates on the textual expressions; the graphic representations: graphs, diagrams, geometry being worked by the other members of the Micole project).

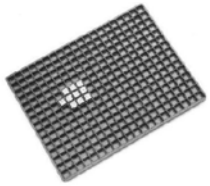
This tool will be a workplace and not a electric teacher. It will not put highlight or correct the errors.
According to the analysis of the observations it should allow:
- Every stage of calculation is arranged in a window edition in several lines or in different windows but these accessible between them by simple command.
- the field of edition allowing the student to be able to store its intermediate result will have to integrate a function to add this result directly has the end of the final sum, and to execute the jump return towards the exercise.
- the terms which were grouped together for a simplification will have to be either removed by the calculation or underlined as already calculated.
- give the possibility to the pupil to write his formula in column or on-line according to these needs.
- allow to split the numeric expression to simplify it.

3.4.7 Analysis of an observation during a resolution of problem in group

The observation of the group work in summer to realize in a level 4-5 classroom in a specialized establishment welcoming only visual impaired people.

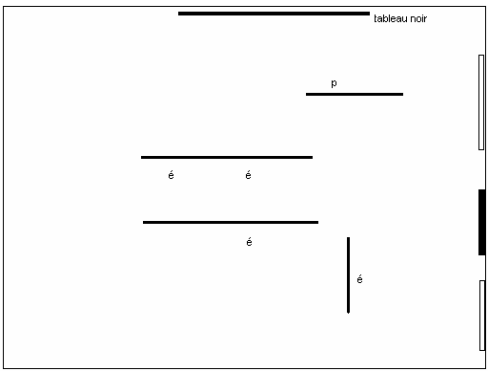
The days of the observation seven pupils were present, eighth were sick. All the blind pupils (6) and the partially-sighted persons (2) are Braille users. They use in class books in Braille, cubaritmes (plastic tray with compartments serving for the learning of the arithmetic and the algebra, which is used with relief cubes) and Perkins. (This below you can see these materials).

Hatch Perkins



Cubarithme

The arrangement of the class is described below, this one not changing during the group work the pupils staying in their usual place. During this work the professor never remains static behind his desk on the contrary he moves between the tables of the pupils.



3.4.7.1 Comparative between the collaborative work & the group work observed

As was already defined before it the collaborative work gathered the pupils in a small group to realize a common work. The “mutualization” of spots notably allowing to realize production which a single pupil would not have the capacity to do at least within the allotted time.
The group work has internal functions and laws: respect for the word of the other one, the participation of each, to speak about each in his turn, to enter the confrontation of points of view .
A distribution of spots for every member is determined either by the professor or by the pupils. These roles are the functions which a person is brought to realize in the group, with the aim of contributing to the finalization of the project.
To begin any collaborative work it is necessary to formulate this objectives so that every pupil knows the spot which he has to carry out, to describe the expected production and finally to clarify the time to realize it.

Organized by the project
During the observation the teacher gives the references of the work and asks some pupils, to read each in turn a part of the problem. The teacher makes sure while to the student comprehension on the instruction terms and then repeats the exercise objective.
The production and the time are not explicitly quoted nevertheless they are known in a implicit know by pupils because this work has to realize it in the mathematical course time. The final production will' be writing with on document per pupils.
→ Final production is individual, a copy by pupil.

Constitutions of the groups.
The group work is made not in small group but by the whole class: seven pupils. The spot to be realized is a problem with additions of decimal figures (the level 4and 5 are mixed, the level 4 not having seen the additions with commas yet, contrary in them elder pupils)
→ That is no real creation of group, the group being that of the class.

Distribution of the roles in the group
The problem resolution is made in a collective way, all the participating pupils to the identification of the problem, and give their suggestions. Nevertheless, this one was not the object between the pupils of sub divisions of spots, every points of the problem being subjected to the whole class.
→ We can speak about a group work with a " individual reflection in a joint time ».

Internal Rules of the group work
During this problem resolution the pupil investment it is good. So all the pupils intervened spontaneously, the speech being alternately made, every pupil being respectful of the word of his classmate (the pupils do not interrupt, do not laugh at the other one).
→ Good dynamics and good participation of the class, the group work rules are respected.

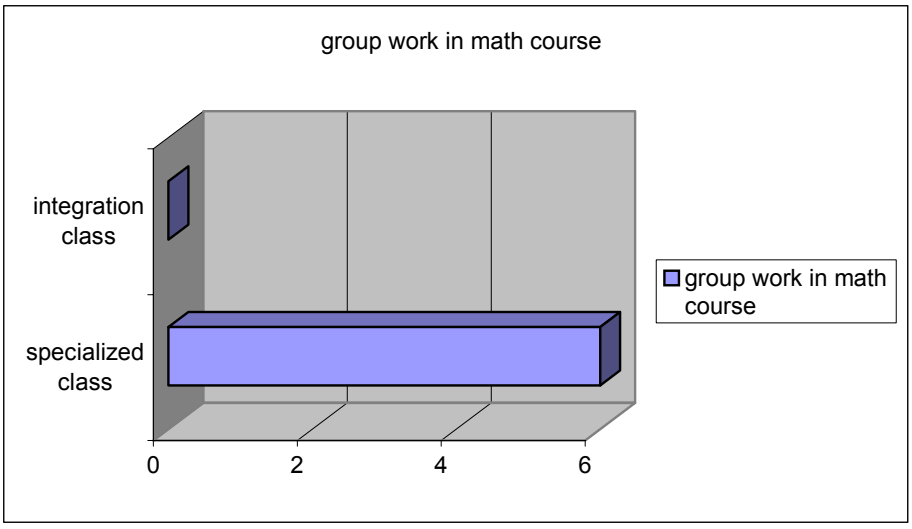
This resolution of problem cannot be qualified like a collaborative work. So besides the oral participation of every pupil, the respect for the manners of propriety of an exchange as well as the common purpose: the resolution of the exercise, this work does not include the points which are defining a group work: constitution of group, sub-division of spots.
Having only an observation of group work we cannot allow to give hypotheses at the functioning of group work in mathematical with visual impaired people. We shall also use the teacher and the pupil interviews.

3.4.7.2 Comparative between the observations and the interviews

At first we shall present a graph and a summary table of the teacher then the pupils opinions of this subject, after we shall made the comparative between them.

Point of view of the professors

	Specialized school	Common environment
Group Work	- yes sometimes for the homework, and otherwise in class not too much or just with the desk classmate. They use mutually - I make them work together for angles, for the use of the reporter I put them by binomial: one draw an angle and the other one has to measure it. **- We work together, not forcing by small group they work all together. They formulate they explain, they have to give their process to the others** - it is a raw transfer of information - the group work but I would qualify it more by the individual work in group i.e. that the strongest help the weakest by giving him indications or by giving him the answer; there is really no exchange of mode of thought of explanation … - when one work in mathematics we say all that we make orally	No collaboration Reason: - When one of his classmates is in the blackboard it is necessary to say to them that he has to say describe all that he makes because if he don't describe the blind people can't understand. - It is a very solitary girl

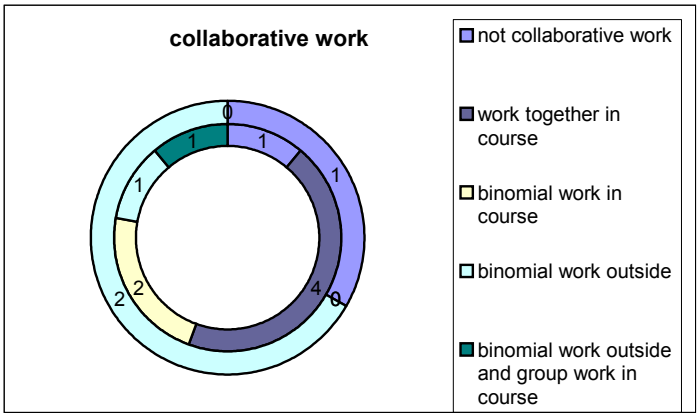


As we can notice, the group work in mathematical is more frequent in the specialized environment than in the common environment. This gap between both educational domains can be explained by different hypotheses such as the number of pupils in classroom.

But according to the comments of the teachers can we really speak about group work. Indeed they define this work as:
- A work in binomial or with the totality of the class,
- The pupils explain their progress of thought, their result, help a classmate.
The teachers ask the pupils participation during the course and leave an important place to discussion, but they don't have idea about a group conception è resume one of the teacher said: this work could be more qualified as « individual work in group ».

Point of view of the pupils

	Specialized school	Common environment
Work Group	One pupil:not group work " I don't know, it is because it doesn'tnot appear 8 pupils:Work in group or the whole class or with another classmate: **- we work by two or three after we give the result** **- to work in group it is the same thing as to work alone we can just speak louder.** - we work at the same time, we are always in small group, we work on the same problems but each on his Iris and after the teacher interrogates us **- we work on the same problem at the same time we speak slowly** **- in group we discuss and share ideas loudly otherwise we work for ourselves by writing.** **- I like to work in group because there is everybody and everybody can give his opinion** - we discuss in group so that one which has understood the lesson can explain it to the others. - we put our ideas in common, we agree and after we work, there can be one who write while the other explain or speak to him.	1-no group work reason: as we already met problem with the teacher I think that with two or three pupils things could be worst. 2-group work but only with one another classmate : - somebody take all the notes and after I made retranscribe, like that I am sure to understand the questions - I work with one school friend but rarely... But I find that useful because it allows me to understand better



Outside circle: in inclusive education / inside circle: specialized education

Going on the same way that the teachers, pupils in integration tell that work in group is only realised after school. This work is always a peer work and consists essentially in a help to understand and take notes.
As for the pupils in specialized school, only one understand the work in group as it really is i.e. sharing ideas, confronting points of view and dividing work in several task .For six other pupils the group work can be more represented as an individual work that has to be realize in a collective time, this work can include the help from a classmate.
→ group work can be define as a help and/or an expression of its point of view, its result.

Regarding more precisely the pupils and the teacher concerned by our observation (that are in bold on the preceding table) their description suits relatively well with the observation of work made during the courses : that is an individual resolution of exercises thanks to the gathering of ideas and results: « to work in group it is the same thing as to work alone we can speak just more hardly ». Nevertheless, the size of the group does not seem to influence the way to work in group: « we work on the same problem at the same time we speak slowly ».

3.4.7.3 Summary and conclusion on the collaborative work

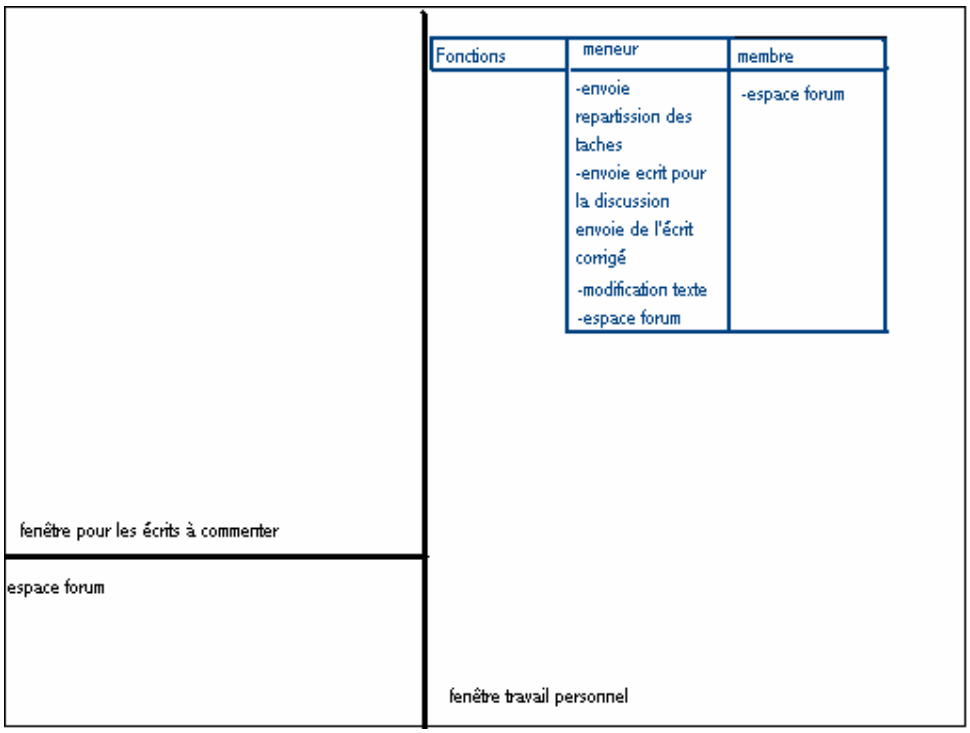
To sum up, the work « in group » that we observed and those we described during the interview does not correspond to a real group work. We can speak more of an individual work put in common with a good motivated class, and a good respect of the other opinion in order to take them in account. But is not this last point related to the visual disable. Indeed, visual impaired people prefer to speak orally in order to clarify it work.

Regarding to the group work in classes of integration, we were able to notice that it always takes place outside the classes and that it had for main purpose the explanations of the exercises and the notes taking. Those two actions in addition with the reflection of the third pupil : « as we already met problem with the teacher I think that with two or three pupils things could be worst » emphasize the lack of tools that would make able the realization of mathematics as well as the work in group.

3.4.7.4 Useful features for the group work

For the group work the software should be able to contain various windows:
- A static window where would be written the instructions of the group work,
- A window with the distribution of the tasks for every member of the group,
- a dynamic window composed of three parts:
    One half of the page, for the specific work of the person,
    One small with the forum and discussion,
One last part where the leader of the group can send his work and ask for critics, modifications and permissions.
- a window gathering the work of the group where the leader can insert the last page validated by the members.

We mean by leader of the group, the pupil having the hand on the left part of the interactive window i.e. the one who can put different papers in this part and shows his work, his ideas to the other members of the group. Indeed, we found important to have for the use of the software two different kind of user : The first one is the leader and has more possibilities than the others and the second one that only has to comment, criticize and validate the leader work. The leader has the possibility to organize the comments and the work itself, so, a single member has the possibility to arrange elements in the dynamic part thanks to the opinion given by the others. This leader can naturally modify his work in function of the needs of the group and the progression of the different members. Leader's change is facilitate and fast thanks to the forum.



Two specifics functions are needed depending on the type of school.
- Ordinary classes with pupils in integration (screen reader or projector are needed è visual impaired or sighted people need to be able to share and obtain information of his sighted classmates)
- Class specialized (Braille computer, screen reader for group games , share information with visually impaired people).

3.4.7.4 a. Specialized class

- Possibility to take the hand in order to modify the work in realisation è immediate repercussion on the screen displaying the text,
- History of the operations with the author, date and place
- Possibility of pointing an object that has an immediate repercussion on the other pupils screens.

3.4.7.4 b. class of integration

- Perfect transcription from the blackprint to the Braille and from the Braille to the blackprint (screen reader, transcription window on the two way, network cable),
- Difficulty to make graphics (calculations, drawings and map).

3.5 The field study performed by University of Tampere, UTA

UTA became engaged in this WP when MEDIALAB was not able to participate in MICOLE anymore and UTA then took over the responsibilities that MEDIALAB had in this WP. An interview study has been performed that feed data into the field study in this WP that is being performed in Task 3.1 (User requirements study in the children's context). Interviews of three visually impaired children (7-8 years old) was made by Eva Tuominen at University of Tampere.

3.5.1 Procedure and results from interviews of visually impaired pupils

The interviews were conducted at the school for visually impaired children in March 2005. Three children (7-8 years old) participated in the interviews during their one-week teaching period at the school. The children were interviewed individually, after their school day (2 boys, 1 girl). The questions concerning the group activities were a part of a larger interview. In order that the interview wouldn't take too long, only the few most important and basic questions concerning the group work were asked.

At first, children were asked if they had done any group work activities in their own schools. Two of the children answered that they had done group work. The topics in which children do group work activities include handicraft, Finnish and drawing. In handicraft, for instance, one child told that they were asked to make a village or a town from tins. The group had to first make a plan about who is going to do what. The child told that s/he wanted to build the village's shop, and it was agreed that s/he could do that.

In Finnish children mostly read together. Reading is done in small groups (three to four pupils in one group). Some topics related to science education were also

mentioned: for example one child also told that they had been exploring snow and water together in the class.

There are usually two to four pupils in one group. The teacher always decides the groups. The information for the group's work is most often searched from books or from other sources of information that the teacher has brought into the classroom. When asked what is usually the child's task in the group and what kind of information s/he collects, one of the children answered that while other children collect information, s/he usually does the drawings to the group's presentation. Drawing is also most fun with the group work. Most difficult or boring with the group work are situations when the work includes some tasks that have to be made in the book.

One child said that there hadn't been group work activities in his/her class. When s/he was asked if s/he would be interested in doing some group work, for example, in the area of nature and space, the child said that s/he would like that. Further, when asked what kind of things s/he would like to explore and investigate together with other children, s/he said that s/he had been wandering "how the rays of the sun can go to different directions since they don't warm at winter". When asked where s/he thought s/he could find and collect information about this matter, the child answered that "probably from internet".

4 Collaboration support, Task 3.2

A prototyping workshop was organised by KTH in Stockholm in late June in order to conduct design activities based on the findings from the field study. Representatives from the partners KTH, UGLAS, UPMC and UTA participated in the workshop during three days that focused on designing systems for collaboration between visually impaired pupils and sighted pupils as well as between visually impaired pupils and teachers.

4.1 Introduction to the prototyping workshop

In all the activities in this workshop the results from the field studies in the different countries were used as a base for the design discussions. The interview material from interviews with teachers and pupils made it possible to relate design aspects to real world contexts and users real requirements.

Video recordings from the field study of group work in schools were very informative and useful for the design work. They provided very detailed insights into the interaction between the visually impaired and sighted pupils and also between teachers and pupils.

4.1.1 Goal

This workshop had four main goals;

- start the design activity of WP3
- start studying collaboration in relation to design of collaboration support
- in a practical and hands-on way deliver results usable for other parts of the project

- encourage collaboration between partners in WP3

The workshop was divided into three main activities; collaboration, design and evaluation, one for each day.

4.1.2 Collaboration activity

The collaboration activity consisted of two main parts:
- create a common ground regarding what collaboration is, what it means to study collaboration and how this can be done
- discussion about how existing applications and prototypes can be used to study collaboration

At day one the topics addressed were; what we mean by collaboration in our research, what earlier research we can build upon regarding computer supported collaborative work and how we can make our existing applications in the different WPs support collaboration. Existing applications were elaborated on by the participants (Figure 1). Video recordings from the field study of group work in schools were studied and analyzed in the workshop.

4.1.3 Design activity

In the design activity, the goal was to come up with concrete design ideas on tools to support collaboration. In the design activity, a Future Workshop was used to generate the ideas and to create design solutions to the identified problems and discuss how these design solutions could be realistically accomplished in the MICOLE project.

4.1.4 Evaluation activity

The final activity was evaluation. This included two parts. On the one hand evaluation in terms of discussions with a user representative about the results from the design activity, and on the other hand evaluation in terms of moving from design ideas to research questions and experiments or studies.

4.2 The Workshop at Day 1: Collaboration

The first half of the day was spent presenting the views on collaboration from the WP leaders, showing examples of collaborative settings, studies and analyses. An informal demo session followed where the participants got hands-on experience in two different collaborative environments, one auditory and one haptic (Figure 1).

Figure 1. Workshop participants are testing existing collaborative systems. On the left a haptic application is tried and on the right an auditory system is used.

The practical part was performed by splitting up in two groups, discussing the following pre-defined topics:

- What kind of collaboration can be studied using your existing prototypes?
- What kind of collaborative research questions would be interesting to investigate?
- What activities/studies could be performed to capture these questions?
- Which are the main obstacles in doing this with the existing prototypes and equipment?
- What needs to be done to make this happen?

This provided the participants an opportunity to discuss and reflect on how applications already developed could be used to study different aspects of collaboration.

4.2.1 Results

The outcome of this first activity was perhaps not so many new ideas, but rather a heightened awareness of collaborative aspects and what is involved in studying collaboration. There was quite a bit of discussion within the two groups about what collaboration really is and what kind of collaborative aspects that could be supported using the existing applications of each partner.

4.3 The Workshop at Day 2: Design

The whole day was spent performing a Future Workshop (Kensing and Madsen, 1991) focusing on school environment for blind children. Again the participants were split up in two groups, but not the same mix as the previous day.

4.3.1 Step 1: Critique phase

In the critique phase, the participants were supposed to focus on current problems for blind children in schools (both integrated and special schools). They were encouraged

to try to be as open as possible and "think outside the box", all problems that were mentioned were written down on post-it notes (Figure 2).

After this, the groups organized the identified problems into clusters, and the presented the clusters for each other.

> - The first group made two main clusters; mainstream education and special education.
>
> - The second group used a different approach with five clusters; social relations, access to information, shared work environment, modeling, and mobility. All post-it notes were put up on a white board.

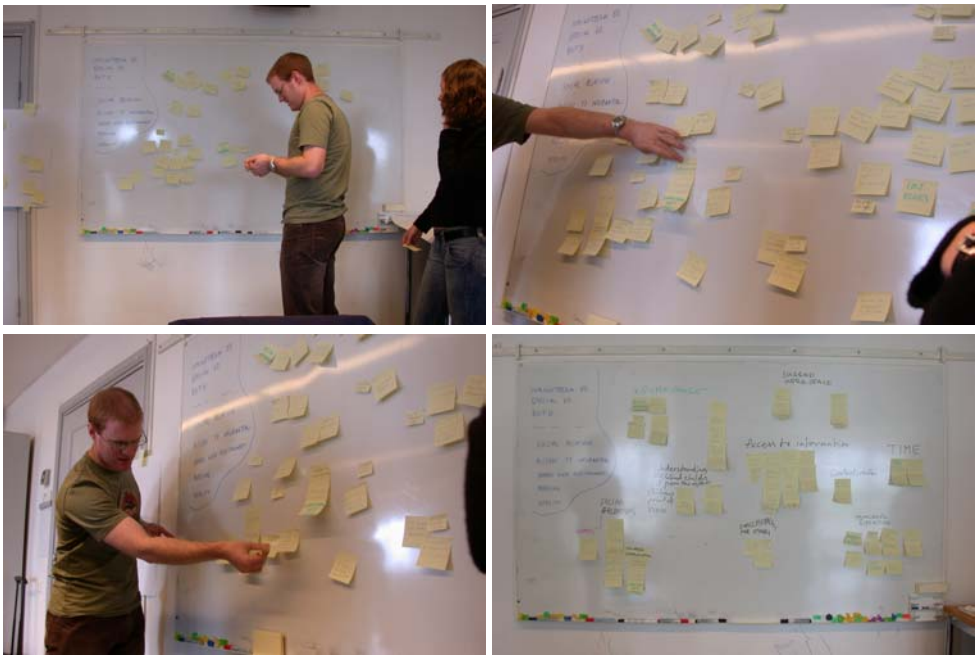


Figure 2. Participants brainstorm on current problems that the user group has. The participants then organise the identified problems in larger clusters.

After seeing and hearing about the other group's identified problems and clusters, the groups were asked to re-cluster but this time together. The new clusters, and the identified problems, were:

Social relations. No friends, at breaks no social playing, activities at breaks, exclusion, social adjustment, appropriate clothing, card games to play with, board games, non verbal communication, making faces in a friendly way, hard to see others reactions to presentation, everything isn't spoken, missing info.

Independence. Missing integration, privacy, how to be independent, computer is a resource but it's not mobile, can't sit with others because of work place with computer.

Understanding the blind child's situation from the sighted children's point of view. It can seem unfair to the sighted pupil that the visually impaired pupil has a personal

assistant which might seem like the visually impaired pupil is cheating in this way, jealousy of computer, sighted children lack interest in the tools for the blind, sighted children need to know how to communicate ideas.

Shared work space. Lack of a shared representation, shared writing, no common tools, difficult to present the blind pupils´ work/solutions, presentation of joint work.

Access to information. Black board teaching, miss a lot of information in pictures, serial presentation of information, lack of multiline display, visualisation of everything, access to non-text information, lack of overview, videos, maps, math, access to dynamic information, laboratory sessions in natural sciences, convey processes.

Content creation. Non-text creation, modeling objects for projects.

Inaccessibility for others. Not everybody can read Braille, difficult for pupils to get help with homework, transcriptions of documents of Braille.

Time. Presentation of information takes longer, can't write and read as fast as sighted children, reading Braille and discussing at the same time is hard, written instructions take a long time to read.

Teaching situation. Number of students, choosing suitable group work, as every student need time in a class it can be a problem that the blind students might need more time from the teacher, cost issues, teachers don't know how to best present information, put off a subject by poor presentation, range of different disabilities, the main teacher forgets to give the teaching material to the assistant.

4.3.2 Step 2: Fantasy phase

The second step of the design activity was the fantasy phase. In this phase, the groups were first asked to pick a couple (or a group) of problems, and make short statements and talk about how it could be solved if the. The idea was to try to turn problems that are negative into solutions that are positive. Then the groups were asked to make a couple of what-if scenarios based on these positive statements, these scenarios didn't have to be realistic, just a description of how it might be if the problems simply weren't there.

The first scenario presented was about *content creation*, how to support the creation of content for the blind child. This scenario included features like speech recognition, and a phantom to build things in a virtual space using both a library of objects and a 3d scanner to input any physical object. It should also be possible for the blind child to guide another child, or the teacher, through the created object or space. Finally, a 3d printer should be used to output the results.

The second scenario involved *blackboard teaching*. This is a common way of teaching today, and the group discussing this saw a need to lift the discussion a bit, and talk about a change in pedagogic practices, a switch from lecturing using a black board to some sort of shared interface teaching.

The third scenario presented was also about *blackboard teaching*. The idea here is to have a shared working environment, where everything is translated into an accessible form for the blind child.

The fourth and final scenario was about *navigation*, how to support way finding and exploration of unknown places. A combination of using dynamic tactile maps and some sort of sound output to guide the child, where you can search for a specific object or find a specific place.

4.3.3 Step 3: Implementation phase

Before starting the final step, the implementation phase, the groups presented their scenarios to each other. After this, the groups were asked to pick one or two scenarios and come up with a concrete and plausible solution, and describe this in as detailed way as possible (Figure 3).

Figure 3. Participants discuss design solutions in groups at several times and then consolidate results from the different groups.

Both groups chose *blackboard teaching*, and also talked about *content creation*. This involved a shared workspace, using haptic devices, having multiple representations for different input and output modalities, supporting "grasp and locate", and the possibility to follow not only objects but also gestures. The teacher writes on a smart board, an OCR software translates this into text and presents it with text, speech synthesis or Braille.

One group also discussed *navigation support*, and how to implement a system using a small portable computer, a GPS receiver, headphones or bone conductors, having a compass inside of the device and perhaps a tactile belt. This could be used to find your way around a city, and also to find a specific place using some sort of online yellow pages.

4.4 The Workshop at Day 3: Evaluation

The theme for the final day was evaluation, which in this case meant a round table discussion with a user representative. This person has been blind since birth, and is now working with international relations for a Swedish disability organisation. He is also active in the Braille authority board in Sweden.

The overall questions were:

- When can these things be useful?
- What are potential problems, and how do we solve them?
- How can we make our ideas better?

The discussion started out on a more general level, where our guest expressed a great concern that we need to address the whole school situation, not only during classes but also during breaks. There's a general lack of well being for many disabled children in their school situations and their relations with their classmates, providing means of participating in social activities is a key to solving this problem. Another important point is that "just" being blind is not so common today, we need to take into account multiple disabilities.

After this, the two groups presented the results from the implementation phase from the day before. The presentations focused on what problems they addressed (critique phase), why they had chosen this problem, the optimal situation (fantasy phase), and finally how to solve this problem (implementation phase).

Both groups presented a shared workspace / blackboard teaching scenario and solution, see above for a description of this. The main concern with this proposal was that its focus was on traditional classroom activities. What happens when you have to do your homework? Or working together with others? Do we need another approach when working together without supervision? Or when preparing something for the teacher? Another important issue is mobility. It's quite common in the schools today to have different rooms specialised for different activities, in this case the technology has to be mobile. The major positive thing about this proposal was that it took into account a situation where technology is used by everyone, and this creates changes in teaching methods. This can lead to positive things for disabled children.

The second part of the evaluation was moving from these proposals to concrete research questions and studies.

4.5 Discussion

This workshop pointed out three important aspects that we need to consider and address in the continuation of this project:

- *Shared workspace*. This was a common theme in all discussions, and was the actual use scenario that was singled out by both groups as the most interesting and most important one.

- *Construction of information*. The construction of information, both to participate in group work and to make assessment possible, is also an important issue.

- *Social support*. Supporting work in the classroom is not sufficient, we need to look at the whole social setting of the school, including breaks and even when not in school but doing school work at home. This was pointed out as an important problem during day 2, and was stressed by the guest during the third day.

In summary outcomes from the prototyping workshop were for example that it is important to provide shared workspaces that are accessible for both the visually impaired and the sighted cooperating persons. Today, group work frequently results in parallel work processes within the group because of the visual handicap.

Another requirement is to support collaboration and communication both between students and between students and teachers. Furthermore, it is important to support both browsing/exploring of information (consumption of information) and creation of information (production of information) for sharing of information within the group and for presentations of final work results.

Finally, it is as important to take social context into consideration during breaks as during classes. The social relations that are being built during breaks are important for successful group work during classes. It was recognized in field studies that some visually impaired students are not included very well in playing and gaming at breaks in school that hypothetically effect their social skills when working in groups. One must not forget that the adults orchestrate the classroom setting and there the visually impaired pupil is well taken care of. One must remember to have a holistic view of the pupils situation at school were he/she is spending much of the time during the first years in their lives.

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