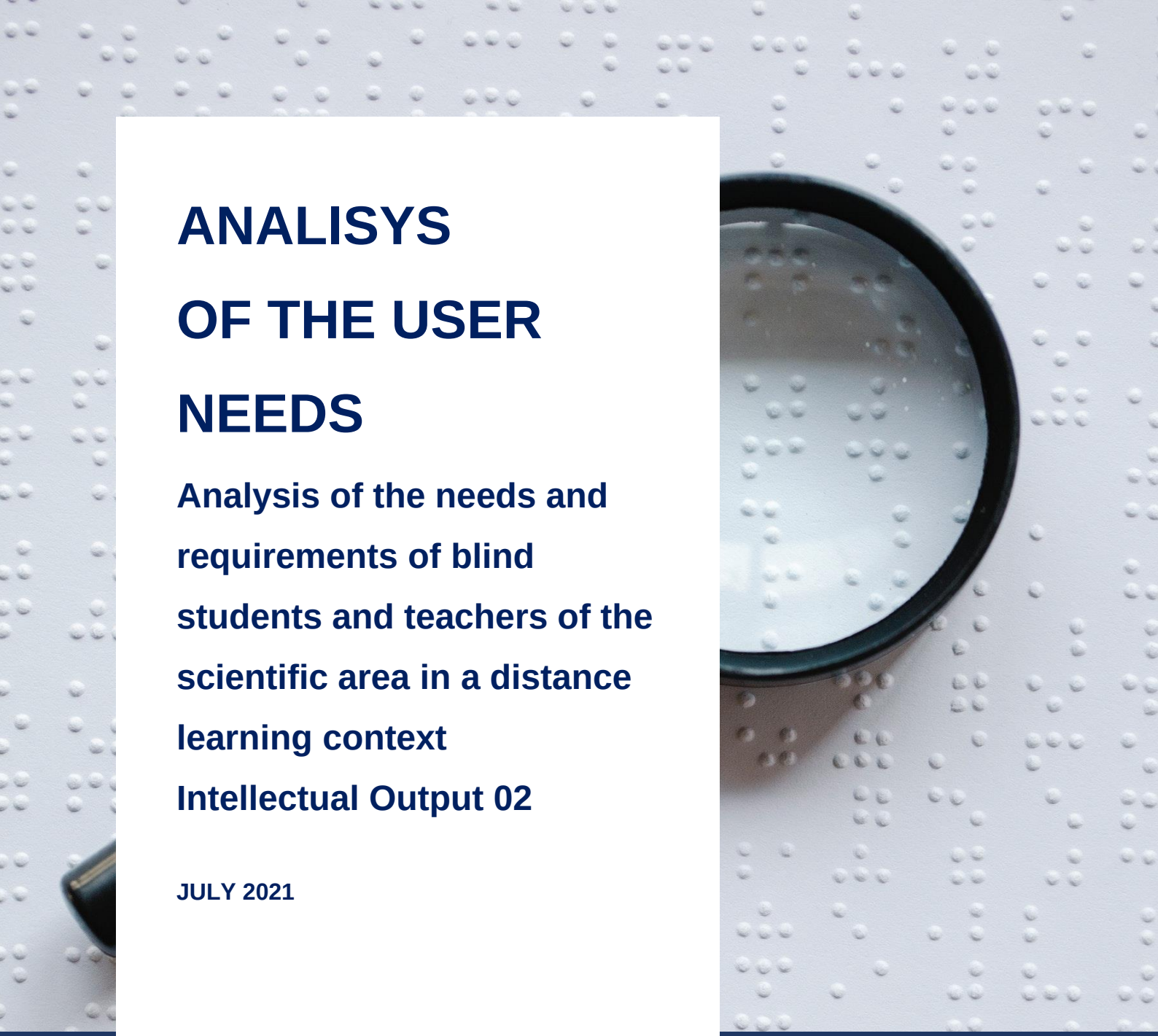

ANALISYS OF THE USER NEEDS

Analysis of the needs and requirements of blind students and teachers of the scientific area in a distance learning context

Intellectual Output 02

JULY 2021

PROGETTO DDMATH
Digital learning in mathematics for blind students
ERASMUS+ Program

Co-funded by the Erasmus+ Programme of the European Union

DD MATH

ERASMUS+ Program

DDMATH PROJECT

Digital learning in mathematics for blind students

INTELLECTUAL OUTPUT 2

ANALYSIS OF THE USER NEEDS

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July 2021

Project within the ERASMUS+ program – School Education Gateway – Action KA2 - Strategic partnerships for digital education KA226 – Convention n. 2020-1-IT02-KA226-SCH-09557

Project number: ERASMUS+ program – School Education Gateway – Action KA2 - Strategic partnerships for digital education KA226 – Convention n. 2020-1-IT02-KA226-SCH-09557
Project title: DDMATH- Digital learning in mathematics for blind students
IO type: Publication
IO number 1
Contractual date of the Delivery: July 2021
Actual date of the Delivery: July 2021
Title of IO: Analysis of the needs and requirements of blind students and teachers of the scientific area in a distance learning context
Nature of the Deliverable: Public
Authors: All partners of the DDMATH Consortium
Abstract: The present analysis aims at identifying and assessing the needs of support teachers, mathematics teachers, students, parents who have to follow their children at home in distance learning, user associations, libraries, study assistants, in order to understand the real needs along the training course (from 13 to 19 years old) for scientific subjects (mathematics, physics, chemistry) in a context of integrated digital teaching.
Keyword List: Blind, mathematic, Braille, 8dots, education, computing, LaTeX
The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Sommario

1 Introduction

The analysis of user needs is part of the first phase of the DDMATH Project. The aim is to identify and evaluate the needs of support teachers, mathematics teachers, students, parents who have to follow their children at home in distance learning, user associations, libraries, study assistants in order to understand the real needs along the training course (from 13 to 19 years old) for scientific subjects (mathematics, physics, chemistry) in a context of integrated digital teaching.

The DDMATH project is inserted in a European context of research, rich in ideas and proposals. The analysis of users' needs can't be a formal and routine action.

The project team, made up by people with very deep experience in the field of Maths for the blind and in the application of computer technology, started obviously from some hypothesis (those were the basic motivations to present the project itself)

- for a blind person it's more difficult to learn Mathematics than for the others, but it's not absolutely impossible.

- there are enormous expectations about the advantages that technology can offer to blind students' autonomy.

- the integration of an efficient system of mathematical notation and of a management program, really qualified to the blind's needs. Another aim of this work was to find significant experiences, even local and individual, that could give ideas to the project.

The tool chosen is the questionnaire / interview with many closed questions but also the opportunity of inserting any observations and information in order to collect news about the experiences.

The activity was carried out in the 4 countries representing the project (Italy, Germany, France, Poland), through questionnaires and interviews.

This report therefore consists of a collective and concise description of the answers to the interviews carried out (mainly through online forms or telephone

interviews) which illustrates the characteristics of the educational needs of users, with a reading that is as close as possible to the reality of the health emergency in progress, the assumption of ideal reference frameworks, in order to identify the directions of intervention and the clear objectives to be privileged for the subsequent phases of the DDMATH project.

The survey questionnaire on user needs was proposed for compilation anonymously, therefore without asking for personal data, email address or other information that could identify the interviewee. However, at the end of the questionnaire an invitation was inserted asking to follow the future developments of the project by accessing the project web page, or on a voluntary basis to contact the local partner of the project in order to be able to offer their willingness to collaborate with the project in particular for the experimentation phase of the resources present on the website.

This way, that is thanks to these contacts, IO2 offered the opportunity to identify a small group of expert users (teachers, students and parents, school managers) who will be involved in the external evaluation activity.

In fact, thanks to the promotion for the questionnaire on user needs, additional actors have been added to the project as associated partners and collaborators, which I list here:

1) The Polin laboratory of the University of Turin, a laboratory with the aim of carrying out research activities for scientific studies for blind students. (Prof. Anna Capietto and the staff of the Polin laboratory)

2) The CNR of Genoa and the investigation department on educational technologies for inclusion (Dr. Lucian Ferlino and Dr. Rebecca Tarello)

3) Sertec, a Portuguese company expert in the field of scientific aids for blind users (Sertec by Prof. Aquilino Rodrigues)

4) A PhD student, prof. Gianpaolo Rossi of the Uninettuno University, who set up his research activity on the themes of the DDMATH project. We would like to underline that prof. Rossi is also a full professor of mathematics at a professional institute in Padua.

The survey activity was carried out on the basis of questionnaires prepared for profiles of user categories (blind students in the ordinary school or in the special school and their parents, teachers, assistants, school managers, representatives of education and education policy special) also asking for support from user associations and school networks in the 4 countries represented in the project.

Therefore, each partner collaborated in the drafting of the questionnaire, in the translation of the questionnaire in their own language, in the dissemination of the link of the questionnaire web page at national level, following a common line of work under the coordination of the EKMS partner.

This report is structured as follows:

✔ a short presentation on the practices and differences related to the forms of school inclusion in each country is first presented;

✔ a presentation of the questionnaire;

✔ reading, interpretation and table and graphical presentation of data;

✔ the conclusions with an overview that will present the issues, the gaps, the needs, the solutions undertaken and the degree of appreciation of the methodologies used, the degree of appreciation of the users with respect to the existing transcriptions of mathematics texts in Braille by the printing companies and of national and local Braille libraries and recommendations to guide the next steps of the project.

In the appendix there is a further very short survey carried out with visually impaired students with motor disabilities, dyscalculics and their families, always remaining tied to the issues of mathematics and the use of IT tools. The DDMTAH project intends to create as an additional activity a prototype of mathematical editor that can exploit the potential of linear mathematics writing in favor of other disabilities. The survey was carried out with a few open questions with the sole purpose of intercepting the interest of some family members and teachers to promote a future pilot phase of testing and experimentation of the program that the project will carry out and

to identify further needs and solutions that can guide the choices of the DDMATH project.

2 Models of school inclusion

We analyzed the documents of the European Agency for Special Needs and Inclusive Education and compared them with the experiences of individual partners, in order to compose a concise presentation of the school systems and the inclusion in the four countries covered by this survey (Italy, Germany, Poland, France), and also to understand to whom it is more appropriate to address our questionnaire on user needs.

In Europe, the organization of education systems is left to the individual states. A 2014 UN budget reports that pupils with Special Educational Needs, including those with disabilities, were 4.1% of the total student population. In Europe, 60% of the education of SEN children in that year took place in common classes and 40% in special schools.

Schematically we can indicate that the various European education systems for students with disabilities can be classified into 3 categories:

✔ Totally inclusive system (also called unidirectional), which provides for the closure of schools and special institutes and for the attendance of disabled children in the common school.

✔ Mixed system (also called multidirectional approach), with various distinctions, i.e. where:

- it is possible for families (at the suggestion of specialists) to choose enrollment and attendance in the common school for all or in the special school;
- there are special sections or special classes in the common school
- there is a separate special education, but occasionally (especially in extracurricular activities) connected with the activities of the common school.
- It is possible to attend the common school, but for certain, more specialized activities, it is necessary to resort to the experience of the special institute.

✔ Separate or segregated system (still called bidirectional), where students with disabilities only attend special schools or special institutions. Bidirectional also means that normal kids go to regular school.

The three categories are not to be considered in a rigid way. For example, in Italy, where there has been a highly inclusive school with the closure of special classes since 1977, the Magarotto institute is operating, a State Institute of Specialized Education for the Deaf, but there is also the Paolo Colosimo State Institute of Higher Education for the blind, which also welcomes sighted students. In Italy special schools are estimated to be attended by 2,000 pupils, mostly with severe disabilities.

In addition to Italy, the countries that adopt the inclusive approach are Spain (with some conditions), Greece, Portugal, Sweden, Iceland, Norway and Cyprus.

In Italy, mathematics teachers of the common school with experience in teaching blind children, but also support teachers constitute the well-known reference. In fact, support for disabled children in common schools is the task of teachers called "support teachers", that is, specialized teachers who are effective part of the class council in ordinary schools. Therefore they act as teachers of the whole class, because of the presence of a disabled student in it ,and are co-responsible with the class teachers for the teaching activity of all students. This aspect of the support teacher being a full class teacher is a unique feature in the European landscape. The disabled pupils carry out their training activity in the classroom and can only rarely, and only if provided for in the inclusion project (called the Individual Educational Plan), carry out some activities outside the classroom, but only if strictly necessary.

Separate special education is prevalent in Belgium, with eight types of schools relating to as many types of handicaps, in Germany, with ten types of schools and in the Netherlands, with fifteen types.

Dwelling on Germany, the situation is not the same for the various Länder; in fact, as indicated in the website of the European Agency for Special Needs and Inclusive Education[1]:

“Germany is a Federal Republic of 16 Länder. Development in the different Länder of Germany is diverse. Each Land has its own responsibility, including individual legislation according to the guidelines of the Basic Law system. One core element of this status is so-called cultural sovereignty (Kulturhoheit), i.e. the predominant responsibility of the Länder for education, science and culture. This means, in principle, that each Land bears responsibility for its educational and cultural policy.”

However, Germany is the one that, more than any other European country, maintains a strong school of segregation. There are some exceptions and some rare experimental cases of inclusive classes as, for example, in some Berlin institutes.

However, the German partner IN2 believes that the sensitivity of parents has been changing for some years and that the pressure of parents in favour of integration is increasing.

In Germany, we even find special classes for pupils with SLD. The training that the institutes in Germany provide for blind children is very specialized and the very teachers of special schools come from a specialized training course for that specific disability.

The role of support teaches in Germany is played by the specialist teachers of special schools or social services.

Their task is broad because it does not only provide for specialist intervention in institutes, but also carries out preventive actions, common educational actions in ordinary schools, and the supervision of cooperation between special and ordinary schools. This means that the specialized teachers of the special schools offer their service for minor situations in support of the common schools in the form of supervisors.

These experts are usually part of the school staff.

[1] https://www.european-agency.org/country-information/germany/legislation-and-policy

These teachers are the ones to whom our questionnaires must be addressed because they work directly with the students, inside or outside the class and according to their needs.

The countries that belong to the second category that was defined as mixed or with multidirectional approach include the following: Denmark, France, Ireland, Luxembourg, Austria, Finland, England, Lithuania, Liechtenstein, Czech Republic, Estonia, Lithuania, Poland, Slovenia.

In **France** an important law was passed in 2005 on the equal rights of people with disabilities in school, university and work, which allowed children with disabilities to enter normal classes. It is up to the family, in agreement with social services, the child neuropsychiatrist and teachers, to be able to ask that their children attend a special class together with other students, all of them with disabilities (in small classes of about 8 students). These differential classes are often located in the same common school, in the same environment, but with different teachers and programs. This location favours common activities with the normal classes.

Support in France is delegated to the specialized teachers of the various services that help integrated pupils for a shorter or longer period and is also aimed as specialist support for class teachers. These are the teachers who were contacted for our investigation.

In **Poland**, too, parents can choose whether to enroll their children in a common school or in a special school. The EKMS partner reports from direct experience that on average 3 out of 4 still choose the special school. Teachers in special schools receive help, supervision and training from experts from the National Center for Psychological and Pedagogical Support or from the regional Teaching Methodology Centers.

In ordinary schools, support for students, teachers and also for parents is guaranteed by independent psycho-pedagogical and psychological support experts.

3 Statistical methodology

3.1 The sample

In order to reach the aim of this research it was important to get about 25 -30 complete questionnaires from each country (Italy, Poland, France, Germany)

In these four countries the population of blind children aged 10 to 19 who have no further disabilities in addition to blindness, can be assumed to be no more than 2000 units (the data was identified by extending known local situations to the total number of population of the four countries).

The questionnaires have not been given with any probable sample: we have chosen the sample by direct knowledge or according to the availability of the interviewed person. So we have not applied the principle of casualness.

Why did we choose this kind of sample?

For three reasons:

- because the population in the blind condition or with small visual abilities is really limited in final footing.
- because it's difficult to reach all the units destined to give the sample, if it's a casual one.
- because it's not simple to write a precise list; the reason is that there aren't any detailed official data about blind population.

It should be a hard, long and precise job to make these lists. According to the small population, the technique of analysis has been (for the 55%) the interview, made by a specialized staff.

So, even if regarding only 25-30 questionnaires, we have obtained high levels of answers.

In the different European countries the staff has found these advantages in the direct interview:

- interviewed people could better understand the questionnaire;
- we could exactly identify the person who answered;

- we had more probability to contact and to convince the person to co-operate.

At the end, in order to collect the data, the system has prepared some actions useful to understand the mistake not included in the sample.

Using this system, all the data collected can get valid.

We have found some preventive actions in order to reduce the probability of mistakes; for instance we usually send an email to the interested people to give notice about the questionnaire, and to give our phone number if they need to clarify their doubts.

- we check the staff's action during the job
- we value the collected data in order to quantify the level of probable mistakes when they are not sampled.

We tried with a casual sample from normal students and teachers; there were no blind among them.

3.2 Validation.

The meaning of this word is a process during which we value whether the information is useful if compared with the aims it was produced for. So we want to compare the objectives we had planned at the beginning of the analysis with the real results we have reached:

- to promote quality actions in the interviews
- to find some quality indicators

We have chosen a sample of 30 students and 15 teachers to compare the data. The test called "Chi square " (there are two variables) has offered values with different meanings. That means that we have reached the aim of the questionnaire: to get information about the way the blind can use Maths and computer technology.

4 Description of the questionnaires

4.1 Preparatory phase

Four different questionnaires were developed in the first draft by the EKMS partner. Subsequently, the consortium produced a series of comments and amendments. In this phase it should be noted that the questionnaires have undergone a revision and a strong reduction of the questions to make it less heavy in the compilation phase. Subsequently, a test phase was carried out by asking five students, five parents and five teachers to try it out in order to have their opinion on the consistency of the topics of the online module, the ease of understanding the questions, the congruence of the length and time of compilation. In this phase the questionnaires have been further reduced and simplified.

At the end we prepared four models of questionnaire: one for students, one for their parents, one for teachers, study assistants or school managers, one for user associations, transcription centers and libraries .

They have a very similar structure so we can compare homogeneous questions.

The questionnaires were published on the website, giving a lot of prominence to their visibility on it, as they can be accessed both from the menu and from the main page of the website.

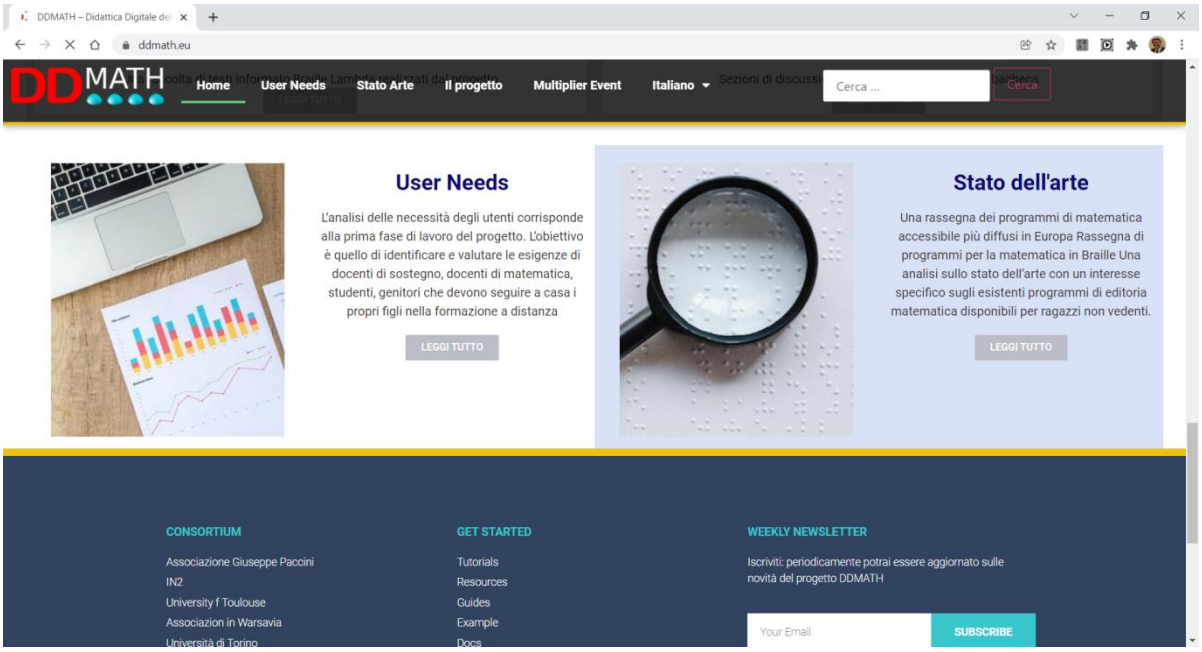


Figure 1: Website page of the project and link to questionnaires about user needs

By accessing the questionnaires page, 3 boxes are presented:

1) Questionnaire for Students and their parents

2) Questionnaire for school staff and special institutions

3) Questionnaire for Associations, transcription centers, libraries

Each box has a button that makes it possible to open each of the three questionnaires in 5 different languages: English, Italian, French, German and Polish.

The image shows the page of the website selected in the Italian language. It should be remembered that the website too is available in 5 different languages: English, Italian, French, German and Polish.

Figure 2: Website access page to the questionnaires about user need

The questionnaires were created using Google forms and then encapsulated on the project webpage www.ddmath.eu.

Each partner has started a dissemination phase for the collection of the questionnaire data, which can be summarized as follows:

- Use of discussion groups (mailing lists) of users and teachers; among these we cite as an example the invitation message in the mailing list of Italian CTS.
- A message was disseminated to all the members of the network European Pole of Knowledge, and to the partners of the network projects.
- Direct telephone contacts were made with school managers and special institutions
- Direct contacts were made with user associations, libraries and transcription centers.
- An e-mail was sent to the main Braille associations and libraries in the 4 countries.

In all the messages, teachers and study assistants were asked to inform the parents of their blind students too, and through them to involve their children in contributing to the answers to the questionnaire.

4.2 Students' questionnaire.

The form is divided into two parts, one for students and one for their parents. It was considered useful to prepare a single questionnaire for both students and parents, in order to guarantee the assistance of parents in filling out the questionnaire for their children, mostly minors.

The student questionnaire was designed to collect information on the difficulties and tools that children use to do mathematics mainly with the computer, having as a reference the blind children of the 4 countries involved in the project.

Figure 3: Website page of the questionnaire for students and parents in 5 languages (current page in Italian)

❖ DDMATH Project

The first section presents a brief information on the project DDMTAH and its objectives, to involve the reader more in the aims of the questionnaire for analyzing the needs of the students and their parents.

Figure 4: first section of the questionnaire in Italian

❖ Background

The second section, titled “Background”, contains some basic information about the interviewed, which will be useful to better situate their next answers:

- ✓ age and school attended,
- ✓ information about the disability and knowledge of the Braille System
- ✓ information about the kind of school attended (special or integrated)

❖ 3. You and maths

In this section we aim at understanding the respondent's attitude to mathematics, most of all from a personal point of view (i. e. interest for the subject, motivation, self-esteem, refusals and frustrations –if any – and so on.)

❖ 4. Difficulties in maths

This section is dedicated to the experiences and difficulties linked to calculation. Although the ability to perform arithmetical operations is officially considered as a marginal aspect of the knowledge of mathematics, people start experiencing difficulties (which are sometimes lasting and pervasive) with figures right in this very field.

Among the questions, respondents are asked if they use special aids such as:

- ✔ a talking calculator,
- ✔ if the school texts specifically for the study of mathematics are produced by the school in paper Braille
- ✔ or in the form of audio-books, meaning the recordings of the lessons (with all the major limitations that this format presents for a graphic text such as mathematics)
- ✔ digital textbooks, which can be read through the speech synthesizer
- ✔ Drawings, graphics and tables in relief
- ✔ Solids or other embossed patterns
- ✔ Traditional tools such as dactyl rhythm cubarithm or, in their place, the computer or a portable Braille tablet.

A subsequent question delves into the practical difficulties of:

- ✔ reading and writing math signs such as, for example, markers (as parentheses, punctuation marks, commas)
- ✔ Management of tasks with the tools they usually use for the execution of operations: sums, multiplications, divisions, square roots, calculations with simple fractions

- ✔ The study of plane geometry
- ✔ The study of solid geometry
- ✔ Use of logical notation and use of set theory (for example: an empty set, an infinite set, a set that contains or is part of another, the use of the terms "not and or" and so on)
- ✔ Algebra (for example: calculations with algebraic fractions, solving linear or quadratic equations, sets, etc.)
- ✔ The study of analytical geometry
- ✔ Use of data graphs (understanding relationships starting from their two components)
- ✔ Use of graphs and histograms (e.g. analysis of statistical data)
- ✔ Use of logarithms in equations
- ✔ The study of analysis (limits, derived functions, integrals)

Always remaining linked to the practical aspects, we continue by asking about the main difficulties that students may encounter with the tools they use in the activities of reading, comprehension, control and execution of work. The purpose of the question is to learn about the students' achieved ability, not so much in terms of disciplinary content, but in terms of approach to the mathematical text. Here are the areas of interest:

✔ Presentation of the mathematical text (e.g. you can read parentheses, fractions and powers)

✔ Understanding maths text (e.g. how parentheses – open/ close, complex fractions and powers work)

✔ Checking (checking and re-reading parts of expressions)

✔ Difficulty in memorizing in execution phase (too many things to remember at the same time)

✔ Manipulating the text to solve an expression.

❖ Experience in the use of the computer

This section aims at deepening the students' experience solely in the field of new information technologies.

At the beginning there are general questions about the possession of a personal computer, whether it is equipped for adequate school use and with which aids, whether it is used at school and at home, and, in particular, for which uses it is employed, such as writing texts, reading books and audio books, surfing the Internet, communicating with social networks, using dictionaries, listening to music and playing games.

These are common activities that are carried out by several students, but for the blind a good computer management involves their skill, knowledge of the screen reader, any well-written scripts and the accessibility of the programs they have installed. Concerning the general use, the question regards the level of satisfaction about their abilities and programs and, in case of low satisfaction, they are asked to give their opinion about the reason/s.

Then there is a passage from the more general themes to the ones concerning the mathematics software and which they are, in few words about the level of satisfaction, thus being able to have a reference between the ability in the use of common software and of the specific ones designed for mathematics. Connected with the software, it is also important to get information about the knowledge of the digital codes of representation of the mathematical text and among these, about the 8-dot or 6-dot format, and LaTeX.

Obviously the following question concerns the main difficulties that students may encounter both with the mathematics program and with the Braille representation code. If the difficulties were not large, the study, the exercises and tasks would be expected to be carried out through an exchange of digital documents. Closely linked to this factor, the questionnaire ends the section by asking students if this baggage of computer knowledge and management of electronic documents have ever been used in distance learning, and if the teacher has taken advantage of this opportunity for a productive exchange of materials between school and home .

4.3 Parents' questionnaire

The questionnaire for parents is inserted in the same form as the one of the students, because it is probable that the completion by the latter is carried out with the help and presence of their parents and also in order to have a common thread (possible only by having a single module, since questionnaires are anonymous) between the student's and their parents' answers, so to check for any discrepancies in the reading phase or, as one would rather expect, for a series of connections.

The questionnaire for parents has been shortened several times so as not to make it extremely boring, as parents have already spent a lot of time helping their children in the first part of the questionnaire.

The first question asks to declare if a distance learning experience has been made by their children. If not, they are asked to skip to the end of the questionnaire for sending.

In the affirmative case, i.e. that the child has had a distance learning experience, the first question is of a general nature, about the possible difficulties met in accessing the texts (obviously electronic) from the moment in which training in DL was started.

The next step aims at learning whether new or different computer aids or computer programs for mathematics and science have been used.

Training at home for disabled children - and especially for younger ones – is known to require an increase in parents' availability; if this hypothesis is true, parents are asked if it was necessary to pay more attention and spend longer time for everything that concerned the activation of the connection, the internet, the management of the videoconferencing program, the management of files. So the question (even if it appears a bit rhetorical) focuses not so much on general aspects, but especially on what concerns mathematics, in case parents and users – should any problems have occurred – could give suggestions to the ones in charge of developing solutions for DLE.

4.4 Questionnaire for teachers and other school staff

The questionnaire for teachers and other educational staff (study assistants, managers) has a similar structure to the one for students, so that it is possible to compare the data.

This questionnaire too, in order to be more approachable by teachers, has been deliberately set up for an anonymous compilation, without asking for personal data.

The questionnaires were distributed mainly through teachers' discussion networks and above all thanks to the partner network European Pole of Knowledge which, as already mentioned, is very collaborative among teachers. Thanks to its contribution, it was also possible to reach some school managers. The questionnaire is divided into 5 sections:

Figure 5: Website page of the questionnaire in 5 languages (page in Italian)

❖ 1- Background details

General information about teachers, especially referring to their experience with blind students and mathematical Braille.

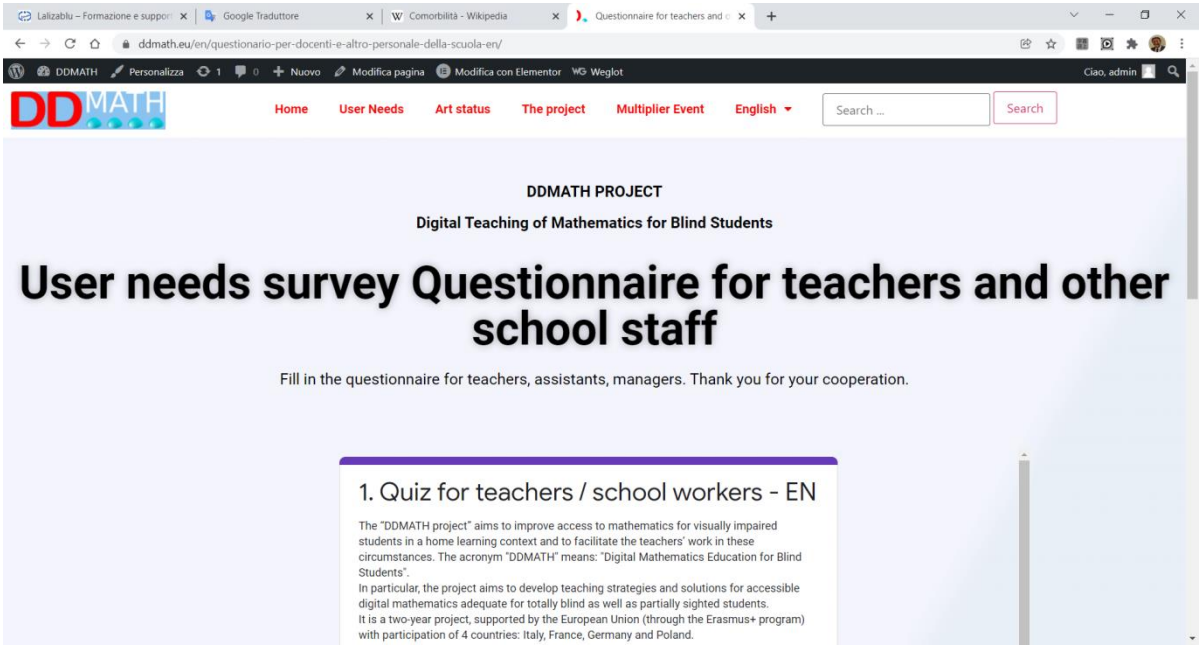


Figure 6: Questionnaire form

❖ Difficulties in maths (and other scientific subjects) noticed in visually impaired students

The first question of the second section was deliberately inserted both as a control question (related to the knowledge of the systems of writing and reading mathematical Braille) and as a cue for interpreting the other answers of the questionnaire. It can help understand if the tools for writing and managing mathematical symbols adopted in the school with their students are up to their task. The question takes into account the level of the student's class and asks to indicate, in the teacher's opinion, whether the greatest effort that the student has to face is related to concepts, general principles, rules and theorems or if the teacher still has to intervene to solve other difficulties that

students encounter in doing mathematics, that is, in solving expressions, equations and problems on the side of the text and the IT tools.

The problem of writing, reading, of the practical management of the text of mathematics and of work strategy accompanies the student from the end of primary to the first years of upper secondary school, but if it were to continue beyond, it would become a serious problem that risks a delay in a general sense. The student should have solved the problems of doing mathematics using work strategy tools (be it Lambda, 6-dot Braille, or other solutions that he could create by himself using text programs on the PC) and becoming as autonomous as possible even before accessing secondary school. As we will see in the following pages, most of the answers were for the item "b": the student has difficulty in solving expressions, equations and problems; this means that the student is very intelligent and easily understands concepts, but there are still practical difficulties to be solved.

The following question concerns some of the possible difficulties encountered by students in the field of writing and reading. Obviously, the teacher will have the level of his own students as a reference: if they are middle school children, he can leave the items about complex topics blank.

The next question concerns the operative procedure in the management of exercises and expressions, working memory, manipulation and processing speed.

The last question in the section is open and comes after a series of questions about possible difficulties in writing and operational issues that students may have encountered. Basing on the answers given, the teacher has the opportunity to rethink about the work done and to reflect on the students' commitment and required workload in comparison with other sighted students. The question aims at understanding if the good technological and compensatory solutions, together with the aids adopted, have really carried out the positive action of making mathematics just as "easy" as for other more theoretical subjects, such as the humanities, which use Braille books or files or audio books.

❖ 4. The use of Personal Computers in Distance Learning

The fourth section intends to deal with computer aids and the way they have been used in the experience of distance learning with blind students. A particular attention will be placed in comparing the teacher's reflection written in the final part of section three and distance teaching issues, which will probably further complicate the teacher's difficulties in working with blind students. All this could become even more problematic if the teacher has indicated in section one that he has superficial knowledge of aids and didactics of mathematics for blind students.

Questions here aim at learning whether students use the Personal Computer both at home and at school and if they employ it also for other activities. In this case students would prove to be well experienced as users and therefore, in possession of appropriate tools, they should not have difficulties even in scientific subjects.

In fact the following questions are precisely aimed at knowing which tools students use and what improvements they would introduce, given their experience in DL.

❖ 5. Collaboration between teacher and students in the period of distance education

The fifth section was inserted to understand what kind of collaboration there was between the school and the family, how the teacher felt working in DL with a blind student, if the DL was a period of positive work.

Obviously, this section will be related to the parents' questionnaire in order to understand if the needs of parents were also felt by teachers and vice versa.

❖ 6. Beyond mathematics: let's talk about chemistry, physics and sciences ... in general

This section aims at understanding the teacher's impression with regard to DL and learning about the aids employed for other scientific subjects in addition to mathematics, in order to know if any solution has been positive for the student.

4.5 Survey questionnaire for user associations and Braille libraries

Figure 7: Webpage of the questionnaire available in 5 languages (page in Italian)

As indicated in the introduction of the form of the fourth questionnaire, we consider the role of user associations and Braille libraries to be fundamental in times of emergency, school closures and forced quarantine, because these bodies, having always been close to their members, know how to give immediate responses to possible new needs that should gradually emerge. Obviously, the survey and the questionnaire will be oriented only to issues related to scientific studies (mathematics, physics, science, technology, chemistry).

These centers were asked to provide their experience in the period of school closures, to offer some suggestions about the main problems they encountered and requiring their intervention, for example the need for additional Braille transcriptions, support for teachers and training activities, new forms of collaboration with the school, proposals to research centers for the development of new technological solutions, support and assistance for videoconferencing lessons, teacher and / or student training.

Also in this case the questionnaire is anonymous, even if it concerns associations and institutes which are known to be small in number on the territory.

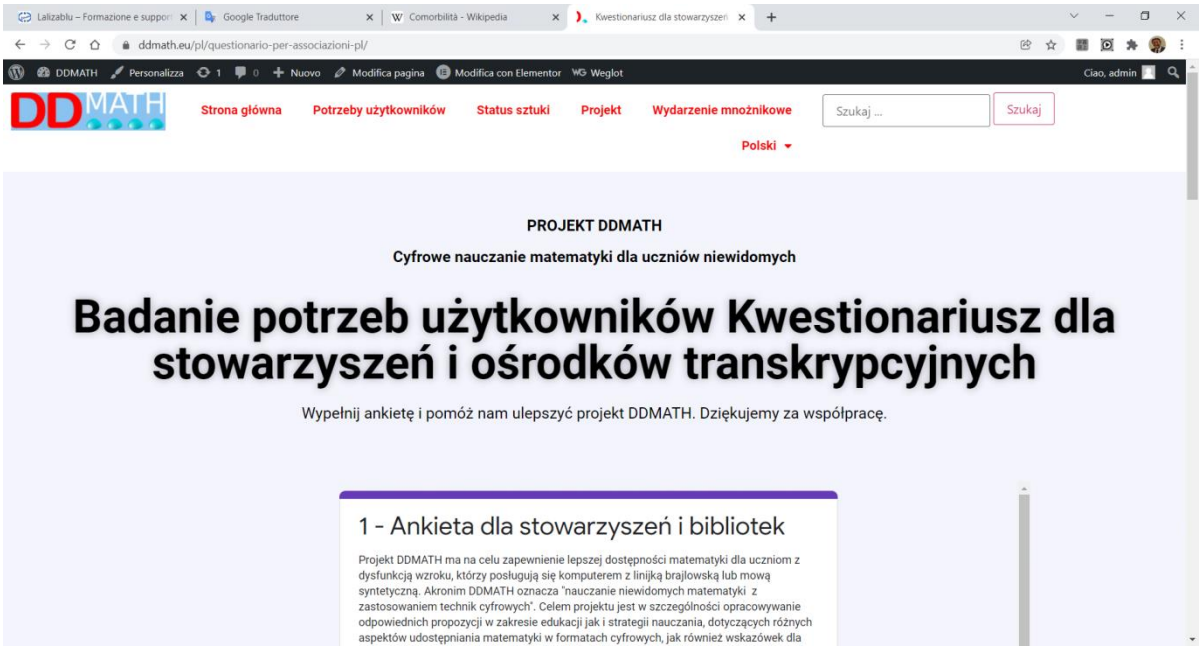


Figure 8: Form of the questionnaire in Polish

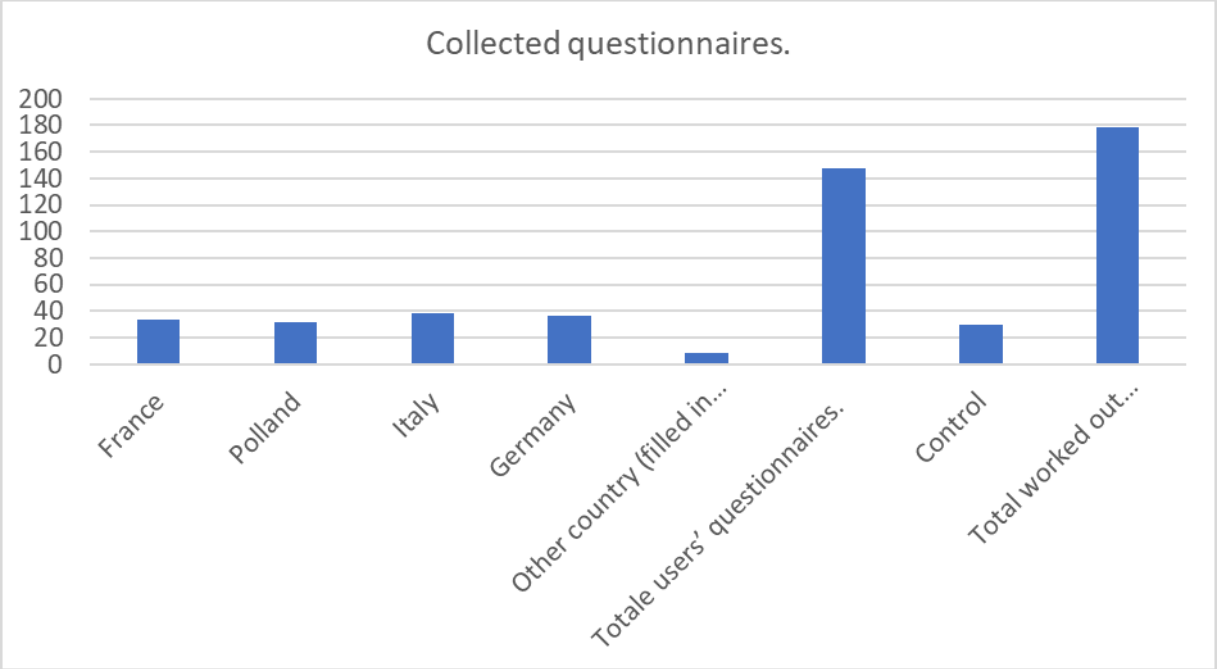
5 Students' questionnaire. Analysis of results.

5.1 Collection and analysis of results.

Each partner collected and summed up the replies received in a statistic.

They wrote their own comments and sent the final report to EKMS, who are responsible for the whole IO and for the relevant final report. The final report was once again distributed among the partners for them to disseminate it locally.

Country	Collected questionnaires.
France	34
Polland	32
Italy	38
Germany	36
Other country (filled in English)	8
Total users' questionnaires.	**148**
Control	30
Total worked out questionnaires.	**178**



5.2 1 - Background details

2.01 Where do you live? (city / what is your nearest major city?)

This data informs about the efforts that have been made to distribute the questionnaire. The result reports that only 45% of respondents reside in the area of residence of the project partners (Verona, Munich, Toulouse and Warsaw), and the rest from geographic areas distributed throughout the territory. Some users are from Portugal, Lisbon (thanks to the distribution of the associated partner), the Czech Republic and Spain.

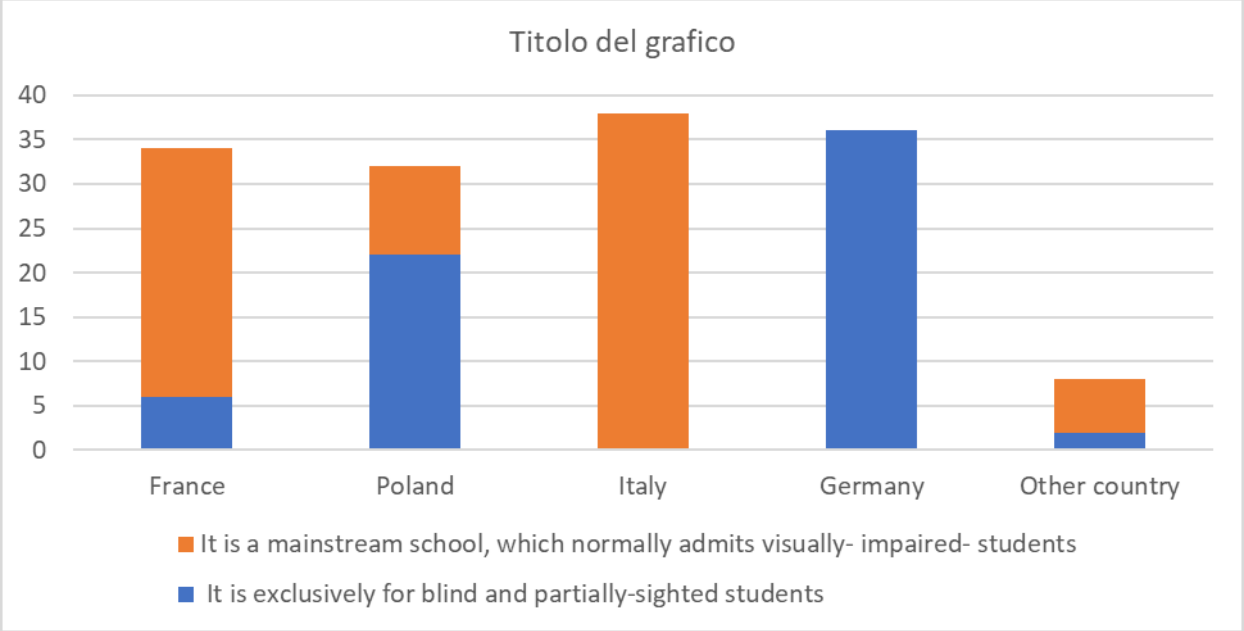
2.02 How old are you?

	AGE RANGE
France	14-18
Polland	10-18
Germany	15-18
Italy	10-19
Other	15-18
Control	15-19

MODA	15 years old
RANGE	10-19 years old
DATA INTERPRETATION	Age includes Middle and High School.

2.03 Is your school exclusively or mainly for visually impaired students?

	It is exclusively for blind and partially-sighted students		It is a mainstream school, which normally admits visually- impaired- students		total
France	6	18%	28	82%	34
Poland	22	69%	10	31%	32
Italy	0	0%	38	100%	38
Germany	36	100%	0	0%	36
Other country (filled in English)	2	25%	6	75%	8
Total	66	45%	82	55%	148



DATA INTERPRETATION	The data reflects the national school system, highlighting those countries that abolished special institutions, such as Italy, and others that prefer specialized

	courses, or where a certain flexibility is envisaged.

2.04 What is your visual disability?

The collected data are treated in a global way, the sample is basically made up of blind students.

I am totally blind or with some residual vision	82%
I am partially sighted	18%

MODA	Blind
DATA INTERPRETATION	In all countries there is a prevailing number of blind people. The sample, not casual but pursued, gives proper information about the possibility of using Braille and computer aids for mathematics.

2.05 Do you have any other special need besides your visual impairment? (e.g. hearing or motor impairment etc)

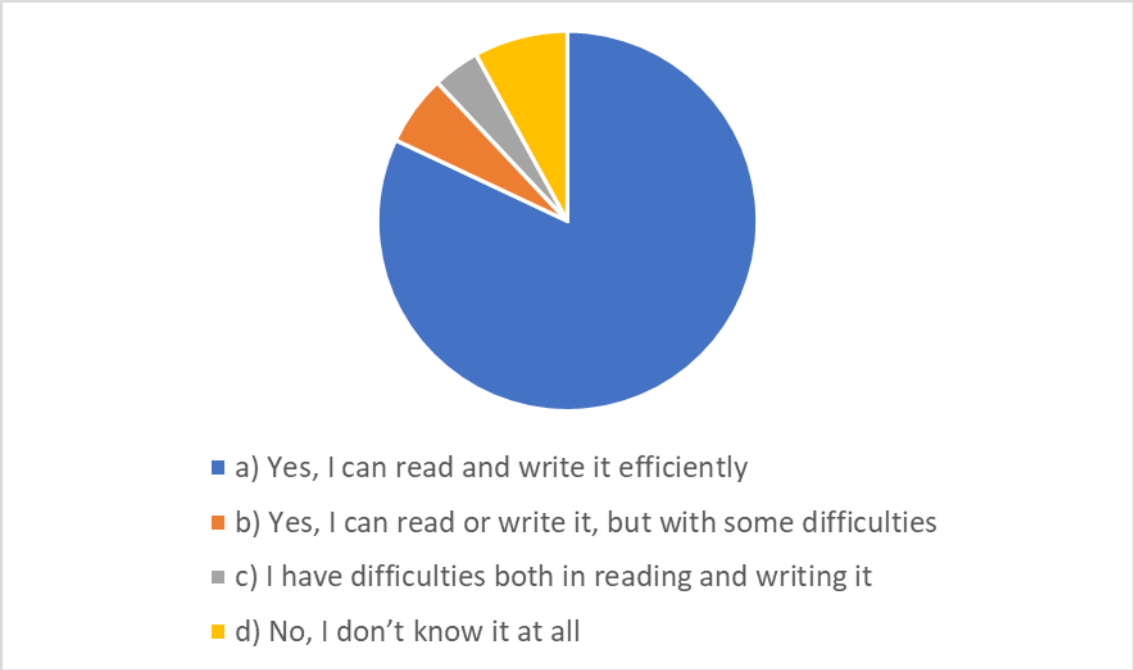
No	93%
Yes	7%

MODA	NO
DATA INTERPRETATION	For most samples the visual disability is the only

	one they have.

2.06 Do you know Braille ?

a) Yes, I can read and write it efficiently	82%
b) Yes, I can read or write it, but with some difficulties	6%
c) I have difficulties both in reading and writing it	4%
d) No, I don't know it at all	8%



MODA	Yes, I can write and read with no problems
DATA INTERPRETATION and EVENTUAL CORRELATION	Correlation with items 2.4 e 2.5 where some visually impaired people, who may have become blind as adults, do not know Braille well or have very little knowledge of it. Other students also have little knowledge of Braille because they have an associated motor disability, where the use of vocal synthesis is evidently preferred.

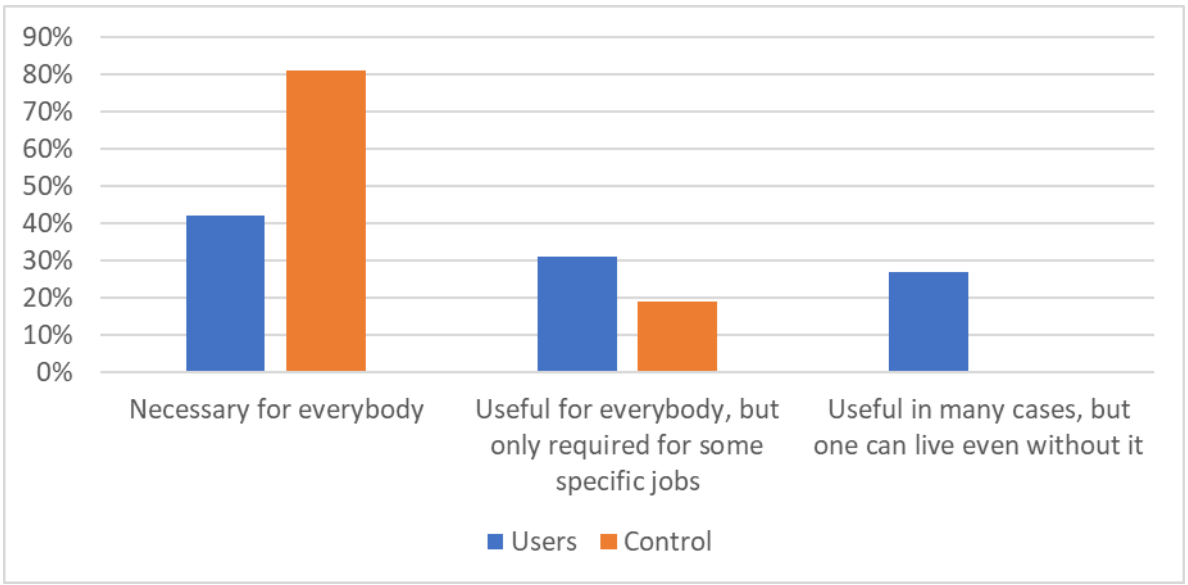
Considerations

The statistic features of the sample are analyzed in chapter 2 (Statistic Methodology). It looks coherent with the aims of DDMATH Project, especially for the age and the kind of ability (almost exclusively visual, absolute or almost absolute), the usage and the knowledge of the Braille code. The sample is homogeneous enough, comparing the different countries and inside them.

5.3 You and mathematics

3.01 How do you view the role of mathematics nowadays?

	Necessary for everybody	Useful for everybody, but only required for some specific jobs	Useful in many cases, but one can live even without it
Users	42%	31%	27%
Control	81%	19%	0%

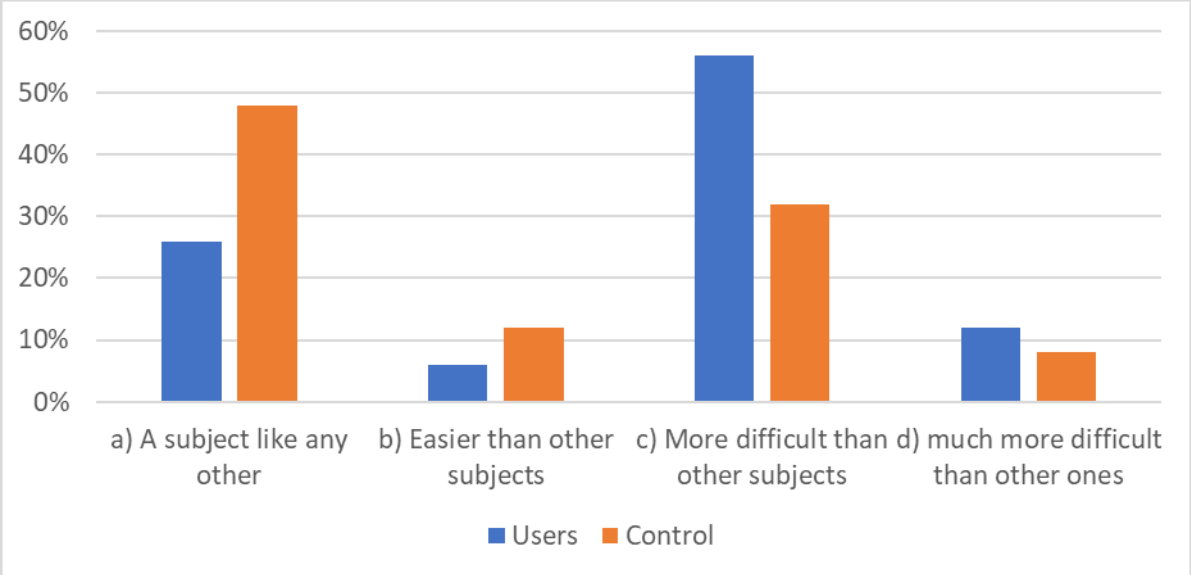


DATA INTERPRETATION	Less than half of the respondents think that the study of mathematics is necessary for everyone. This figure contrasts with the control one, where, on the contrary, more than 80% believes it is an important subject in the scholastic path. The data introduces and reveals, for many of them, the presence of great study difficulties in this subject, to the point that more than half feel it is necessary for specific jobs that they will probably not be able to carry out, or even useful, but only to a limited extent and in any case not fundamental to their life. In other words, the difficulties encountered push young people to ask themselves how they can apply the teachings of mathematics (for them so inaccessible) as a useful and real resource in other fields. Correct and accessible mathematics teaching seems to be lacking in them, and it is essential for building **mathematical competence** in students, i.e. the ability to develop and apply mathematical thinking to solve a series of problems in everyday situations; this is especially true for the ones who, like blind children, are forced to face perhaps a greater number of complex problematic situations in their lives than others. DATE INTERPRETATION Less than half of the respondents think that the study of mathematics is necessary for everyone. This figure contrasts with the control one, where, on the contrary, more than 80% believes it is an important subject in the scholastic path. The data introduces and reveals, for many of them, the presence of great study difficulties in this subject, to the

	point that more than half feel it is necessary for specific jobs that they will probably not be able to carry out, or even useful, but only to a limited extent and in any case not fundamental to their life. In other words, the difficulties encountered push young people to ask themselves how they can apply the teachings of mathematics (for them so inaccessible) as a useful and real resource in other f Therefore, more than half of the children in the sample hardly understand that mathematical competence is not aimed at those who want to carry out a specific job in the future, but it is a resource for their life. To achieve it, you need a solid mastery of arithmetic-mathematical skills, you need to learn the processes and knowledge of doing mathematics, and in this way you can build the ability to use mathematical models of thinking (logical and spatial thinking) and presentation (formulas, models, diagrams, graphs, representations), as indicated by the European competences.

3.02 With regard to your mathematical difficulties, do you think mathematics is:

	a) A subject like any other	b) Easier than other subjects	c) More difficult than other subjects	d) Much more difficult than other ones
Users	26%	6%	56%	12%
Control	48%	12%	32%	8%

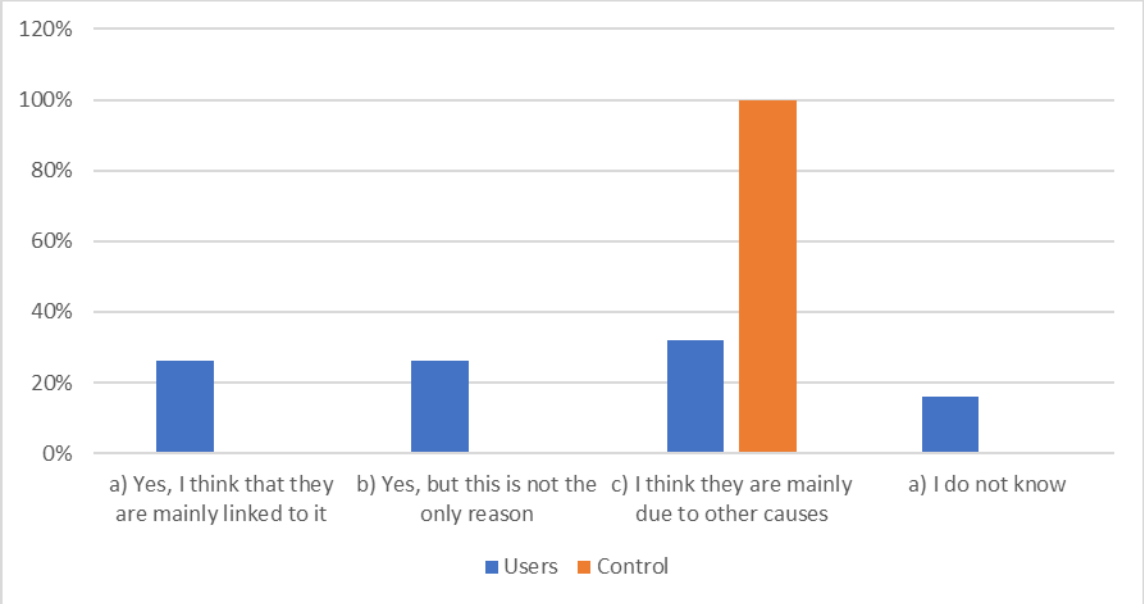


MODA	More difficult than other subjects
DATA INTERPRETATION	Two out of three consider maths to be more complex to tackle than the other subjects. The answer also sees a small group of 6% who finds it less difficult. To be noticed that there is also a small sample of visually impaired people who, with enlargement tools, can actually overcome the difficulties of writing and reading the mathematical graphic text. The figure clearly differentiates from the control sample, almost half of which considers mathematics as a subject completely like the others, even if more than one in three declares to have difficulties in it. This figure also reflects the 2018OECD-Pisa survey, which presents a fairly homogeneous average among the European countries, stating that one in 4 does not reach the basic level of competence in mathematics. Yet, we would like to remind of the fact that the control sample is random and did not take into account the school level, that is if

	relating to middle or high school and, in the latter case, if in the scientific, professional or humanistic field.

3.03 Do you think your difficulties in studying mathematics are linked to your visual disability?

	a) Yes, I think that they are mainly linked to it	b) Yes, but this is not the only reason	c) I think they are mainly due to other causes	a) I do not know
Users	26%	26%	32%	16%
Control			100%	



MODA	I think they are mainly due to other causes
DATA INTERPRETATION	52% attribute their difficulty to visual impairment, even though 26% of these believe that it is not the only reason. However, one in 3 feels that the causes are

	of a different nature. From the information collected later, we can interpret this data as a reference to the inadequate tools used, the lack of textbooks and/or to the inadequate training of their teachers.

3.04 Do you believe that home learning as adopted last year has disadvantaged your learning compared to regular school attendance? If so, please describe in what way.

85% answered, without leaving the question blank. The replies are on average 3-4 lines.

Being an open-ended question, we prepared a summary of the most significant answers on similar areas, which are the following:

1) **Connection difficulties:** Just over 30% mentioned problems related to the internet, connection difficulties, slowness of the network ("the network did not manage me and my sister's activities together") The overall impression was that "the internet was about to stop working "
2) **Meeting with friends:** 35% of the respondents, homogeneously across countries, expressly mentioned the fact that DL had a negative impact because " DL did not allow me to meet my friends"
3) **Study as a private student:** Only one student declared that he is studying on his own to take his exams privately and therefore was not affected by the change in teaching, in presence or distance**.**
4) **Communication difficulties**: Over 60% report communication difficulties that are highlighted through these brief reports:
    a. Geometry issue:
        - Because it is difficult to describe in words, for example, some geometry drawings (most of them emphasize that their teacher is a common sighted teacher).

- Still on geometry, others point out that a lesson in class would make understanding much easier thanks to gestures, tools and other methods which would "tangibly" let them visualize certain figures and elements of mathematical graphics.
- Someone even goes further: "In my opinion, with distance lessons, everything could be learnt except geometry"
- Decline in profit: DL compromised profit; 10% expressly mention that such difficulties led to a decrease in maths grades because it is difficult to understand, because "it is more difficult to learn", it is more difficult to concentrate. Internet is not enough to make subjects easy and enjoyable.
- Corrections of written assignments with dactyl-Braille: no teacher ever corrected their Braille text, written with the dactyl-Braille machine, and for 30% (not so small a figure) mathematics can only be done with dactyl-Braille.

5) Issue related to pupils'fatigue:

a. **Issue related to the limited duration of the lesson:** DL implies limits in the duration each lesson, in order not to overstrain students at the computer. At least 10% of the answers mention this issue, which increases difficulties. Here is an example of an answer: "The teacher did not have the opportunity and sufficient time to explain the new topics he introduced and to correct the mistakes I made in my homework.

b. **Issue related to possible distractions:** lessons in DL inevitably involve various kinds of distractions, which are difficult to contain. A mobile phone may happen to be used, a family member might be present and represents a source of diversion; one user (probably a visually impaired boy) mentions that during 2020 DL time never passed so he played solitaire.

c. **Excessive strain**: eye strain for visually impaired kids.

d. **Positive sides:** A small percentage - that can be classified around 10% - also mentions some positive elements in distance learning, which we summarize in the following points:

e. With distance learning you save time (sometimes up to an hour) because you do not have to travel

f. It is possible to work without interruptions or downtime

g. You can take advantage of the availability of the teacher and get individual lessons, even at different times from school hours .

Considerations

The section highlights that when a subject entails a certain difficulty - even for a significant group - it is downgraded to being “not very useful”, thus justifying the lack of interest and probably even the low academic performance. The desire to learn is still felt, but if this involves too much effort, a certain resignation emerges.

The comparison with the control sample clearly showed that disability creeps in as a limiting factor for learning this discipline and also for the interest in it.

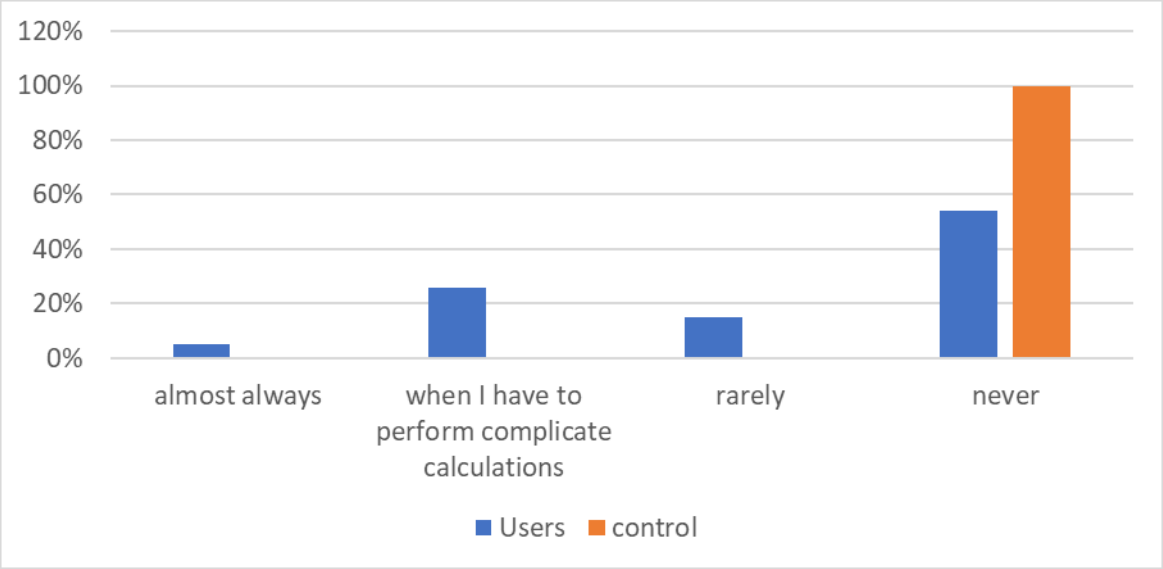
The already existing difficulties are then increased, in particular for geometry, when the pupils are forced to distance learning.

5.4 Mathematical difficulties

Section 4 aims at learning the main difficulties that students have in mathematics.

4.01 Do you usually use a speaking calculator or a Braille one to perform calculations?

	almost always	when I have to perform complicate calculations	rarely	never
Users	5%	26%	15%	54%
control	0	0	0	100%

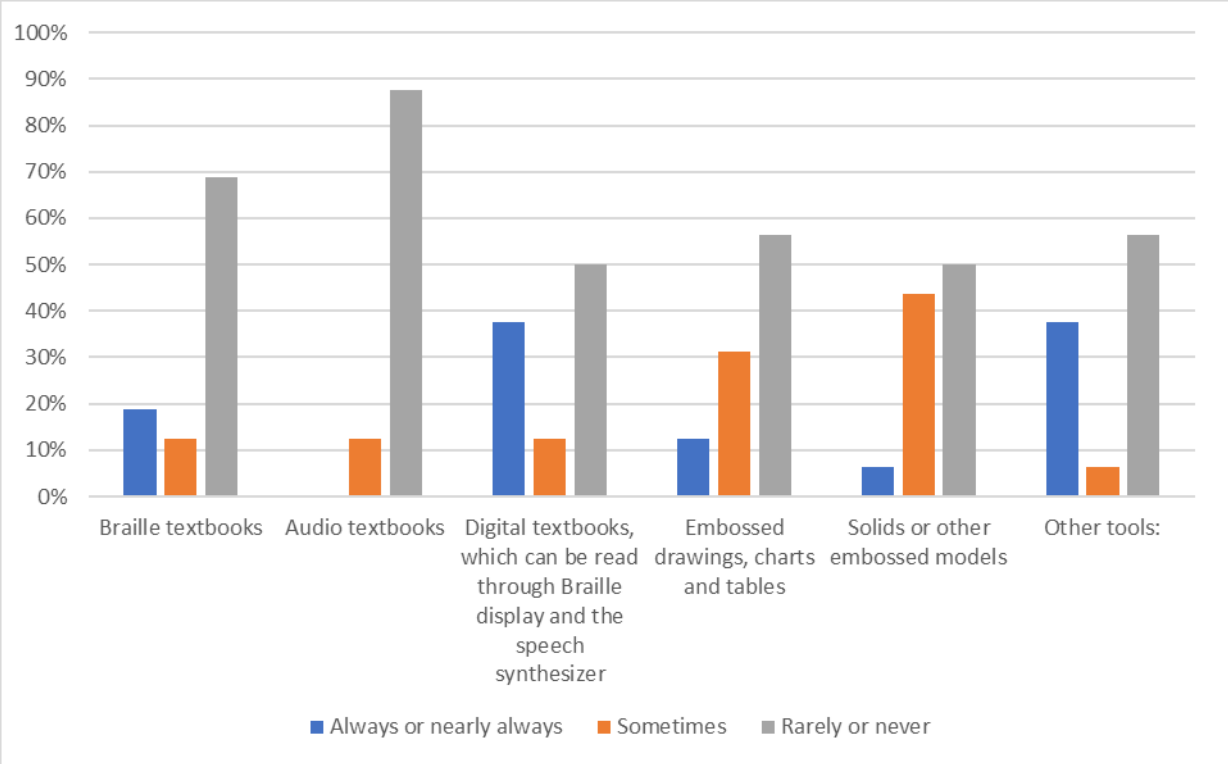


MODA	Never
DATA INTERPRETATION	Talking calculators are no longer very popular and 69% never or rarely use them. This figure in Italy rises to 90%, as students use the calculator present in Lambda, and do not need additional tools. Even the smartphone, which

	has a calculator with a voiceover, seems to be preferred to other solutions, which were once widespread. This question is about speaking calculators or Braille ones, so all the answers of the control group (all negative) are not useful for a comparison.

4.02 What resources do you usually use to read and study mathematics?

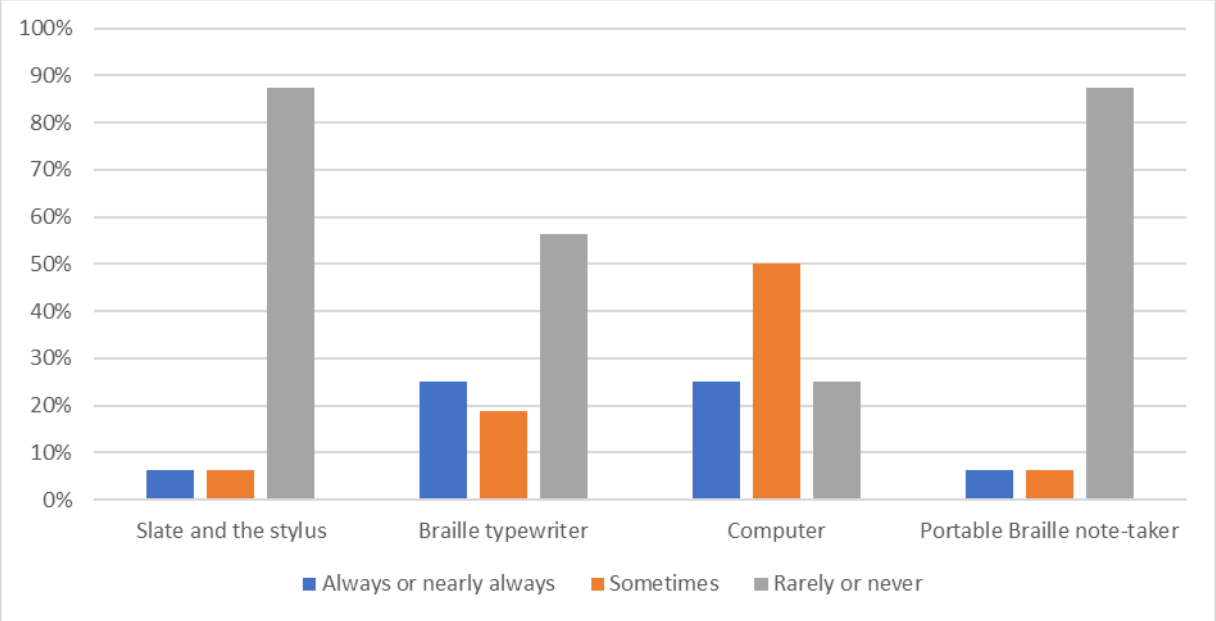
	Always or nearly always	Sometimes	Rarely or never
Braille textbooks	19%	13%	69%
Audio textbooks	0%	13%	88%
Digital textbooks, which can be read through Braille display and the speech synthesizer	38%	13%	50%
Embossed drawings, charts and tables	13%	31%	56%
Solids or other embossed models	6%	44%	50%
Other tools:	38%	6%	56%
Control (Other tools) 100%			



MODA	Considering the use: Digital Textbooks
DATA INTERPRETATION	Digital text books prevail in all countries, and the distribution of 6-dot maths books printed in embossed Braille is low (under 20%). Digital texts in Lambda or LaTeX are becoming the reference for users.

4.03 What resources do you usually use to write mathematical texts, solve problems and equations?

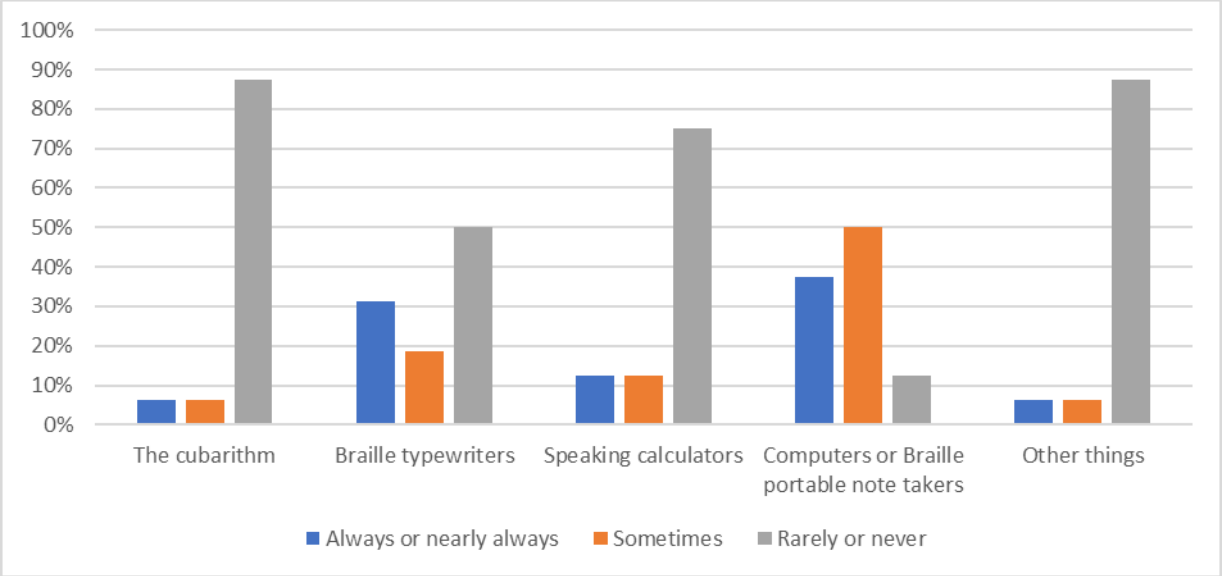
	Always or nearly always	Sometimes	Rarely or never
Slate and the stylus	6%	6%	88%
Braille typewriter	25%	19%	56%
Computer	25%	50%	25%
Portable Braille note-taker	6%	6%	88%
Control (computer) 100%			



MODA	Computers
DATA INTERPRETATION	About 70% of the students usually use computers to write mathematical texts.

4.04 Which tools do you usually use to do mathematical calculations which cannot be done mentally

	Always or nearly always	Sometimes	Rarely or never
The cubarithm	6%	6%	88%
Braille typewriters	31%	19%	50%
Speaking calculators	13%	13%	75%
Computers with Braille display or Braille portable note takers	38%	50%	13%
Other things	6%	6%	88%
Control (Other things) 100%			



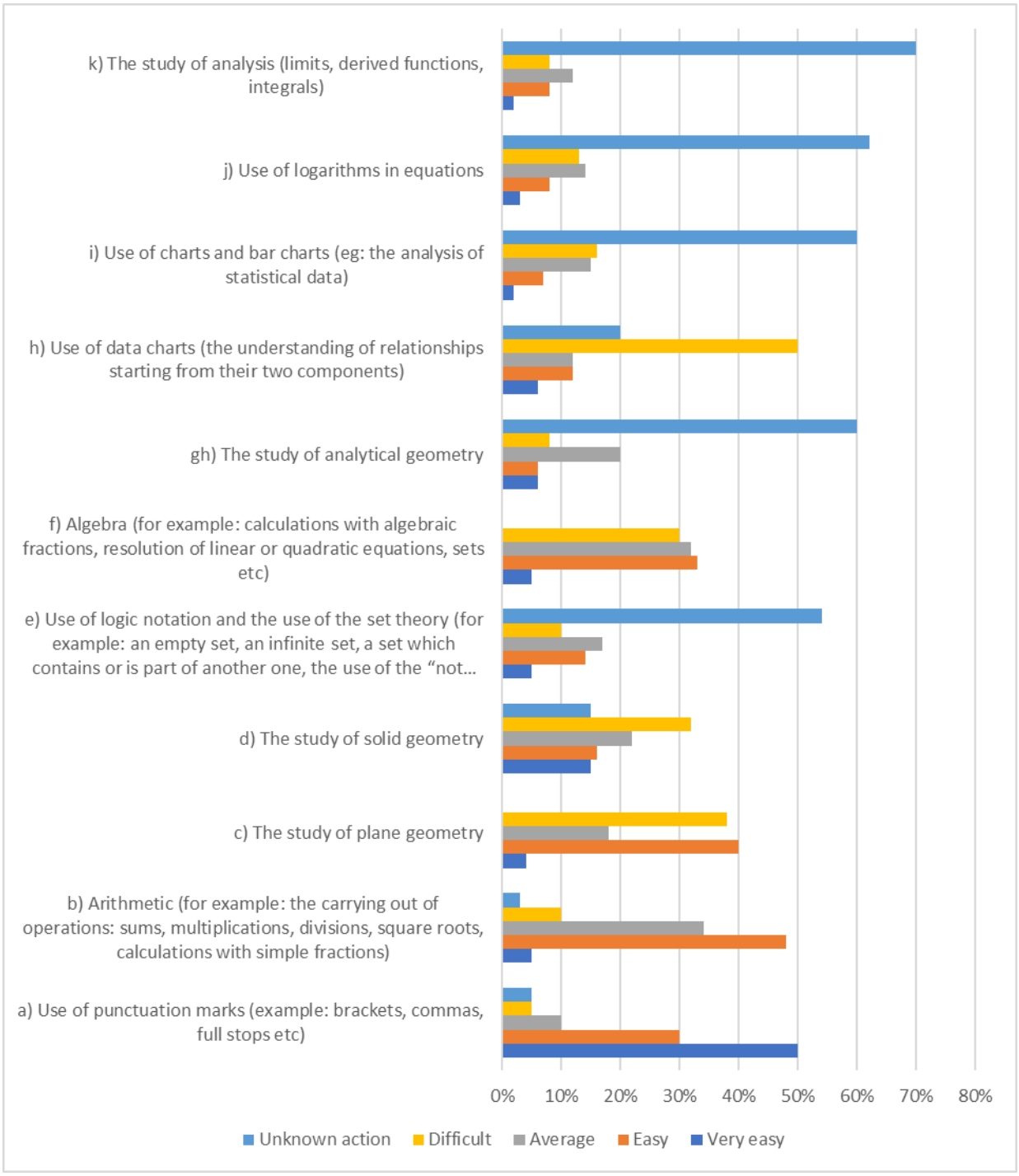
MODA	Computers with Braille display or Braille portable note takers
DATA INTERPRETATION	Computers with Braille display or Braille portable note takers are the most used calculation tool. Cubarithm is used in primary schools and the users of the sample are mainly middle and high school ones, while the use of the

	Braille typewriter is very high (derived from Polish students' data)

4.05 Please indicate how difficult you find each of the following activities :

	Very easy	Easy	Average	Difficult	Unknown action
a) Use of punctuation marks (example: brackets, commas, full stops etc)	50%	30%	10%	5%	5%
b) Arithmetic (for example: the carrying out of operations: sums, multiplications, divisions, square roots, calculations with simple fractions)	5%	48%	34%	10%	3%
c) The study of plane geometry	4%	40%	18%	38%	0%
d) The study of solid geometry	15%	16%	22%	32%	15%
e) Use of logic notation and the use of the set theory (for example: an empty set, an infinite set, a set which contains or is part of another one, the use of the "not and or" terms and so on)	5%	14%	17%	10%	54%
f) Algebra (for example: calculations with algebraic fractions, resolution of linear or quadratic equations, sets etc)	5%	33%	32%	30%	0%
g) The study of analytical	6%	6%	20%	8%	60%

geometry					
h) Use of data charts (the understanding of relationships starting from their two components)	6%	12%	12%	50%	20%
i) Use of charts and bar charts (e.g.: the analysis of statistical data)	2%	7%	15%	16%	60%
j) Use of logarithms in equations	3%	8%	14%	13%	62%
k) The study of analysis (limits, derived functions, integrals)	2%	8%	12%	8%	70%


k) The study of analysis (limits, derived functions, integrals)
j) Use of logarithms in equations
i) Use of charts and bar charts (eg: the analysis of statistical data)
h) Use of data charts (the understanding of relationships starting from their two components)
gh) The study of analytical geometry
f) Algebra (for example: calculations with algebraic fractions, resolution of linear or quadratic equations, sets etc)
e) Use of logic notation and the use of the set theory (for example: an empty set, an infinite set, a set which contains or is part of another one, the use of the "not...
d) The study of solid geometry
c) The study of plane geometry
b) Arithmetic (for example: the carrying out of operations: sums, multiplications, divisions, square roots, calculations with simple fractions)
a) Use of punctuation marks (example: brackets, commas, full stops etc)
0%
10%
20%
30%
40%
50%
60%
70%
80%
Unknown action
Difficult
Average
Easy
Very easy

CONROL GROUP	Very easy	Easy	Average	Difficult	Unknown action
a) Use of punctuation marks (example: brackets, commas, full stops etc)	100%				
b) Arithmetic (for example: the carrying out of operations: sums, multiplications, divisions, square roots, calculations with simple fractions)	100%				
c) The study of plane geometry	90%	10%			
d) The study of solid geometry	90%	10%			
e) Use of logic notation and the use of the set theory (for example: an empty set, an infinite set, a set which contains or is part of another one, the use of the “not and or” terms and so on)	58%	12%	30%		
f) Algebra (for example: calculations with algebraic fractions, resolution of linear or quadratic equations, sets etc)	55%	20%	25%		
gh) The study of analytical geometry	22%	25%	10%	23%	20%
h) Use of data charts (the understanding of relationships starting from their two components)	30%	35%	25%		10%

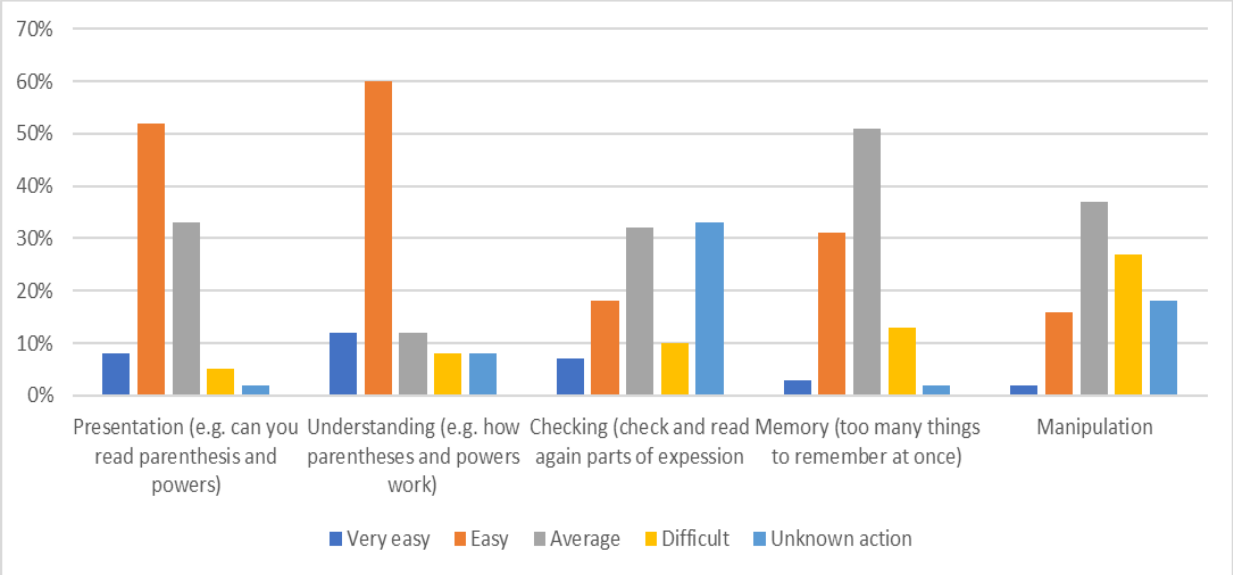
i) Use of charts and bar charts (e.g.: the analysis of statistical data)	25%	40%	35%		
j) Use of logarithms in equations		25%	14%	35%	26%
k) The study of analysis (limits, derived functions, integrals)	10	15%	14%	35%	26%

DATA INTERPRETATION	Analyzing the total data and comparing them with the control group, we can notice that answers move towards “difficult“. As we forethought, the major differences are in the items with high graphic-visual components (for example plane and solid geometry, graphic reading)

4.06 What problems do your usually face in solving algebraic expression?

	Very easy	Easy	Average	Difficult	Unknown action
Presentation (e.g. can you read parenthesis and powers)	8%	52%	33%	5%	2%
Understanding (e.g. how parentheses and powers work)	12%	60%	12%	8%	8%
Checking (check and read again parts of expession	7%	18%	32%	10%	33%
Memory (too many things to remember at once)	3%	31%	51%	13%	2%
Manipulation	2%	16%	37%	27%	18%

CONTROL	Very easy	Easy	Average	Difficult	Unknown action
Presentation (e.g. can you read parenthesis and powers)	100%				
Understanding (e.g. how parentheses and powers work)	100%				
Checking (check and read again parts of expession	10%	90%			
Memory (too many things to remember at once)	10%	40%	50%		
Manipulation	60%	10%	30%		



DATA INTERPRETATION	Even in this case the sample with visual disability shows much more difficulties than the control group, especially in comprehension and in memory.

3.02 With regard to your mathematical difficulties, do you think mathematics is:

	a) A subject like any others	b) Easier than other subjects	c) More difficult than other subjects	d) Much more difficult than others
Users	26%	6%	56%	12%
Control	48%	12%	32%	8%

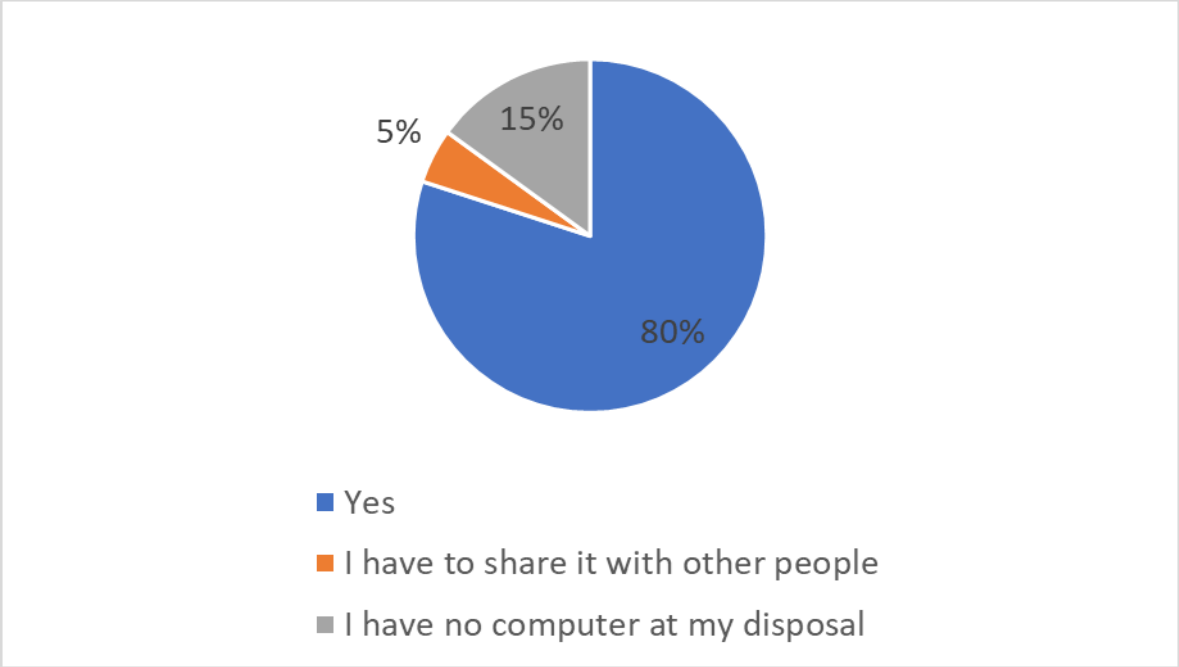
Considerations

The answers in this section show that the visually impaired sample finds significant difficulties in mathematics. The data are in line with the answers in 3.02, where 56% thought maths was more difficult than other subjects. The data deviate from the control ones, and all the difficulties of reading and especially of managing mathematics and executing expressions emerge clearly as the complexity and level of study grow.

5.5 Experiences in the use of the computer

5.01 Have you got a computer for your exclusive use?

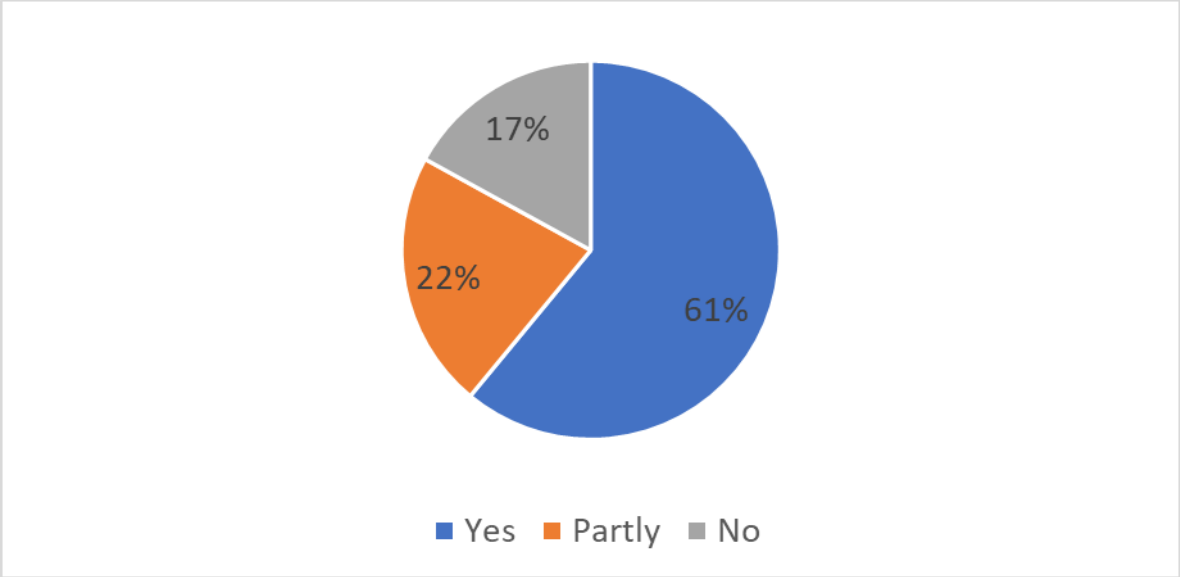
Yes	80%
I have to share it with other people	5%
I have no computer at my disposal	15%
Control (YES)	100%



MODA	YES they have a computer for exclusive use
DATA INTERPRETATION	The great majority (80 %) of the students in our sample have the opportunity to habitually use a computer tool suitable for their specific needs to perform their school work.

5.02 **Has it been adjusted to your specific needs so that you can perform your school activities?**:

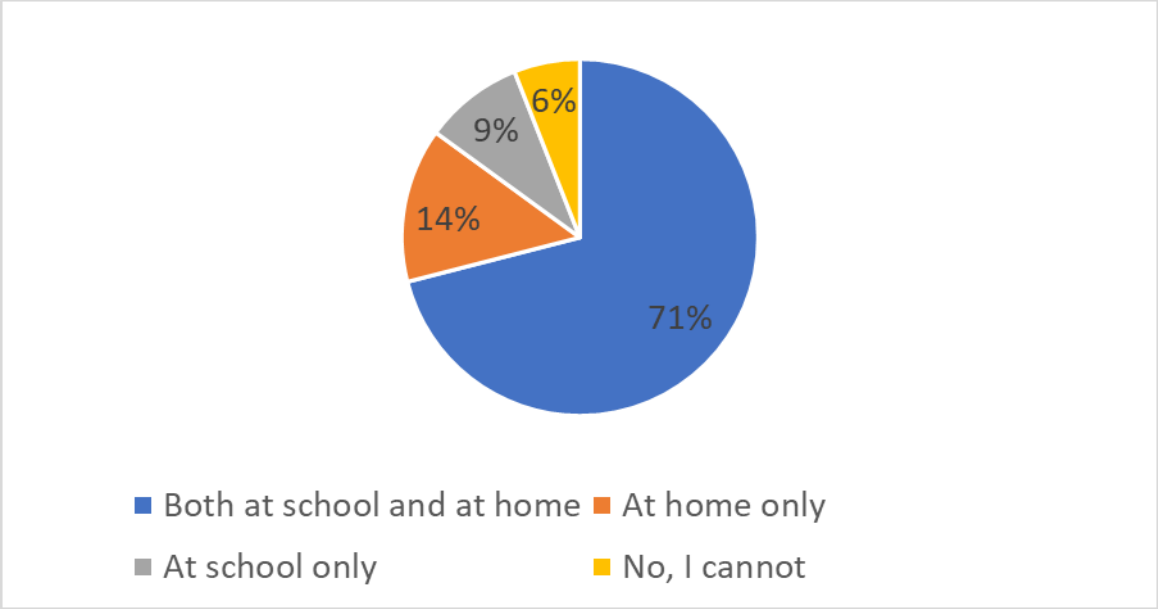
Yes	61%
Partly	22%
No	17%



MODA	Yes, it has been adjusted for specific needs
DATA INTERPRETATION	A computer equipped to be used requires a screen reader with speech synthesis and, to a lesser extent due to the costs, of Braille line as confirmed by the answers in 5.04

5.03 Where and when do you use your computer?

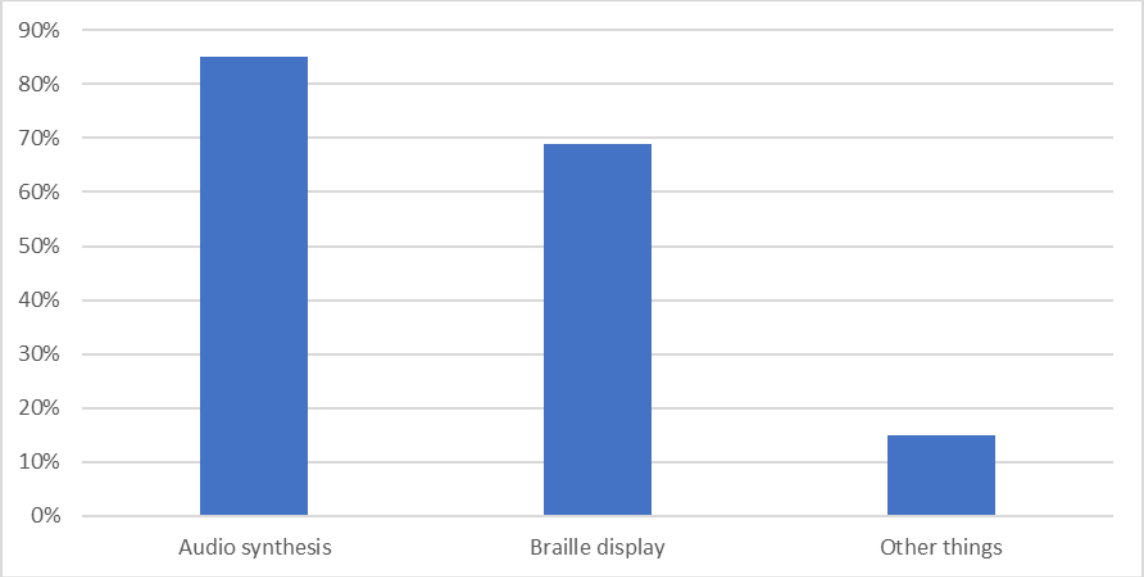
Both at school and at home	71%
At home only	14%
At school only	9%
No, I cannot	6%
Control (at home)	100%



MODA	Both at school and at home
DATA INTERPRETATION	The figure aligns with question 5.01 and 71% of the students have their own personal computer at home and a second (or the same one transported daily) at school, with the addition of those who use it mainly at home

5.04 Which access peripheral devices do you have?

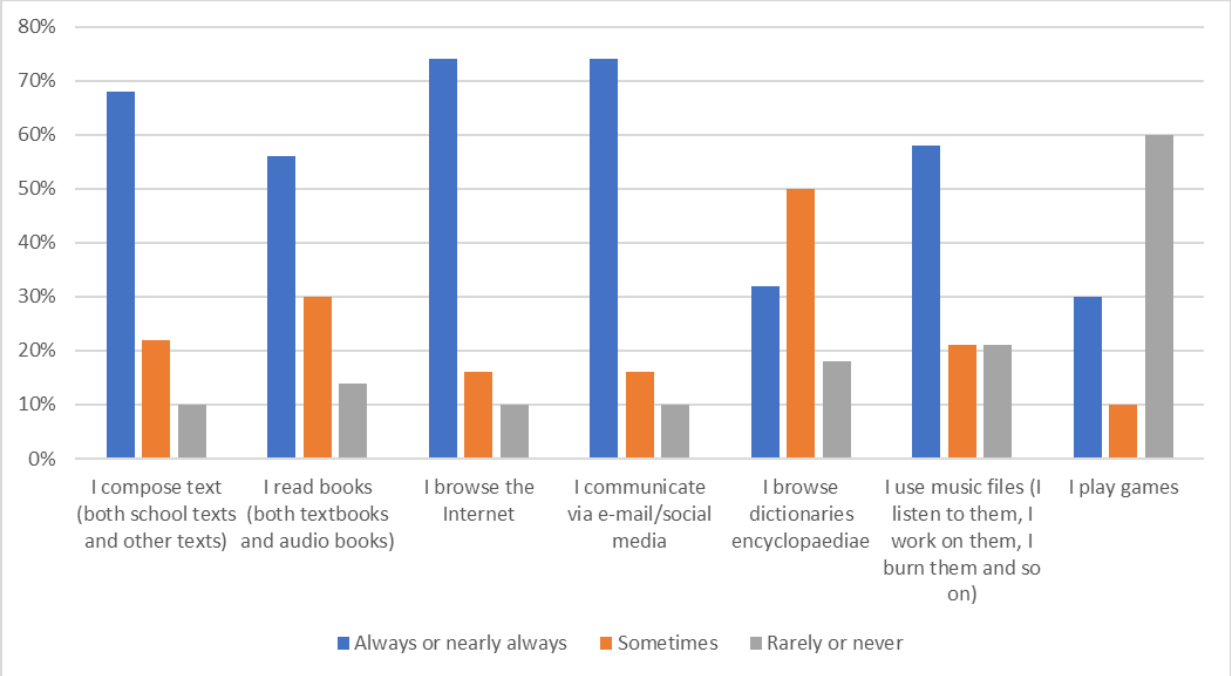
Audio synthesis	85%
Braille display	69%
Other things	15%



MODA	Audio synthesis
DATA INTERPRETATION	The computer equipped with a screen reader is widespread among the great majority of all users. The screen reader is also used to drive the expensive Braille line, which is not very common in Poland compared to other countries.

5.05 Which activities do you usually carry out with the computer?

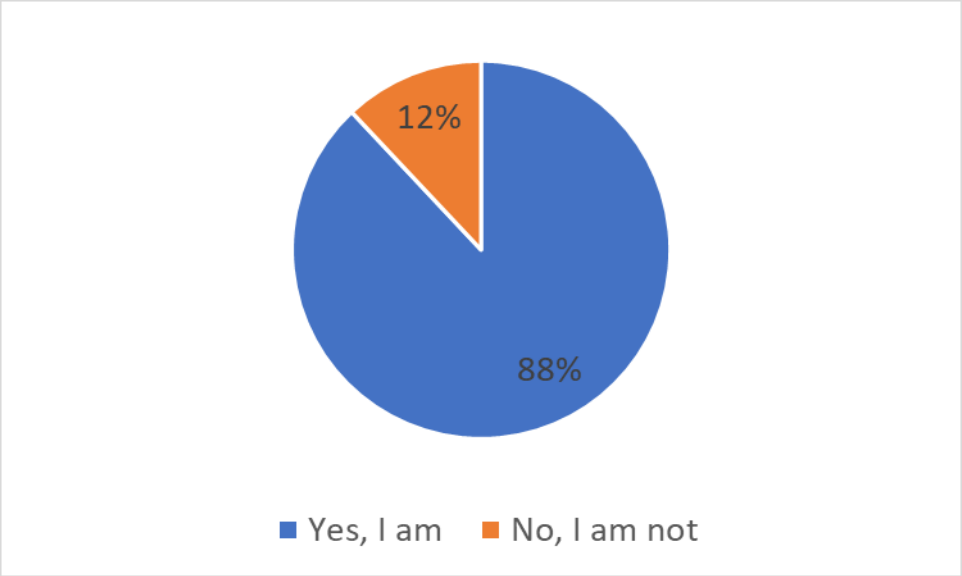
	Always or nearly always		Always or nearly always		Rerely or never	
I compose text (both school texts and other texts)	68%	Control 100%	22%	Control	10%	Control
I read books (both textbooks and audio books)	56%	40	30%	60	14%	
I browse the Internet	74%	80	16%	20	10%	
I communicate via e-mail/social media	74%	60	16%	20	10%	20
I browse dictionaries encyclopaediae	32%	50	50%	40	18%	
I use music files (I listen to them, I work on them, I burn them and so on)	58%	60	21%	20	21%	20
I play games	30%	80	10%	20	60%	



DATA INTERPRETATION	There is some correlation between blind students and the control group, except probably for the consultation of Wikipedia or other encyclopedias, or for the use of social media and communication, where perhaps the smartphone is more common than the computer. The same happens in case of some games which are not easily accessible from the computer, while they are from the smartphone.

5.06 Are you satisfied with your workstation? (also considering the use of home learning)

	sample	control
Yes, I am	88%	100%
No, I am not	12%	



If not, please describe why?

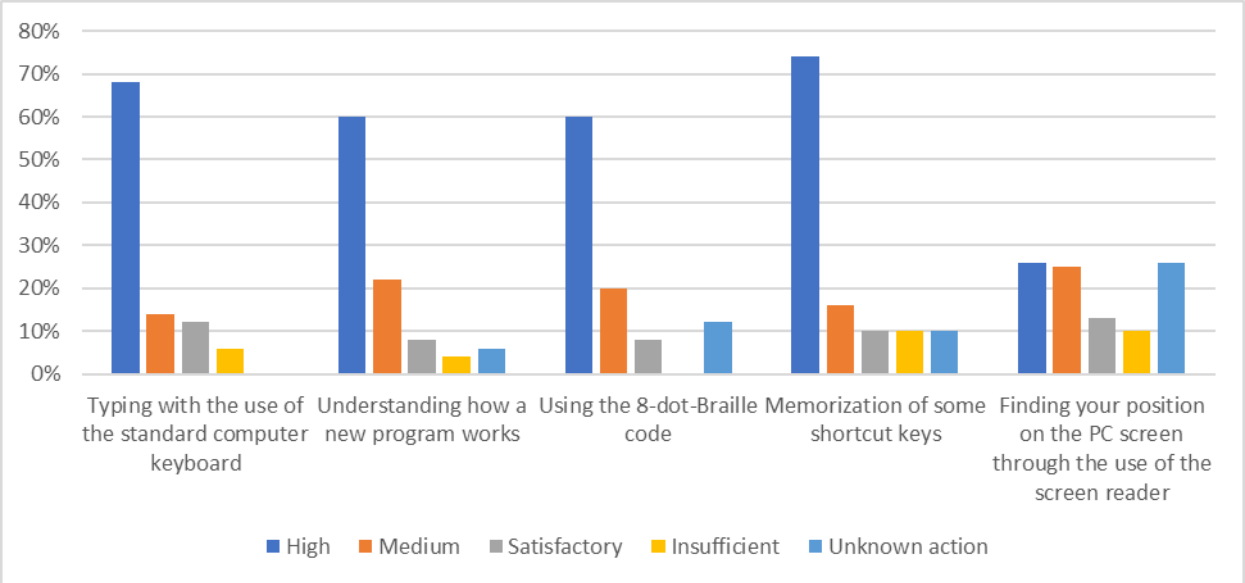
The few answers collected report about not possessing a computer, or about using the school one, which is old, slow and represents a source of frustration.

MODA	YES I AM
DATA INTERPRETATION	The majority of the people interviewed say they are satisfied with the work station they have. But the speed of the system and maybe the use of obsolete computers is a source of frustration for some.

5.07 Please describe your level of efficiency on the following computer activities

	High	Medium	Satisfactory	Insufficient	Unknown action
Typing with the use of the standard computer keyboard	68%	14%	12%	6%	0%
Understanding how a new program works	60%	22%	8%	4%	6%
Using the 8-dot-Braille code	60%	20%	8%	0%	12%
Memorization of some shortcut keys	74%	16%	10%	10%	10%
Finding your position on the PC screen through the use of the screen reader	26%	25%	13%	10%	26%

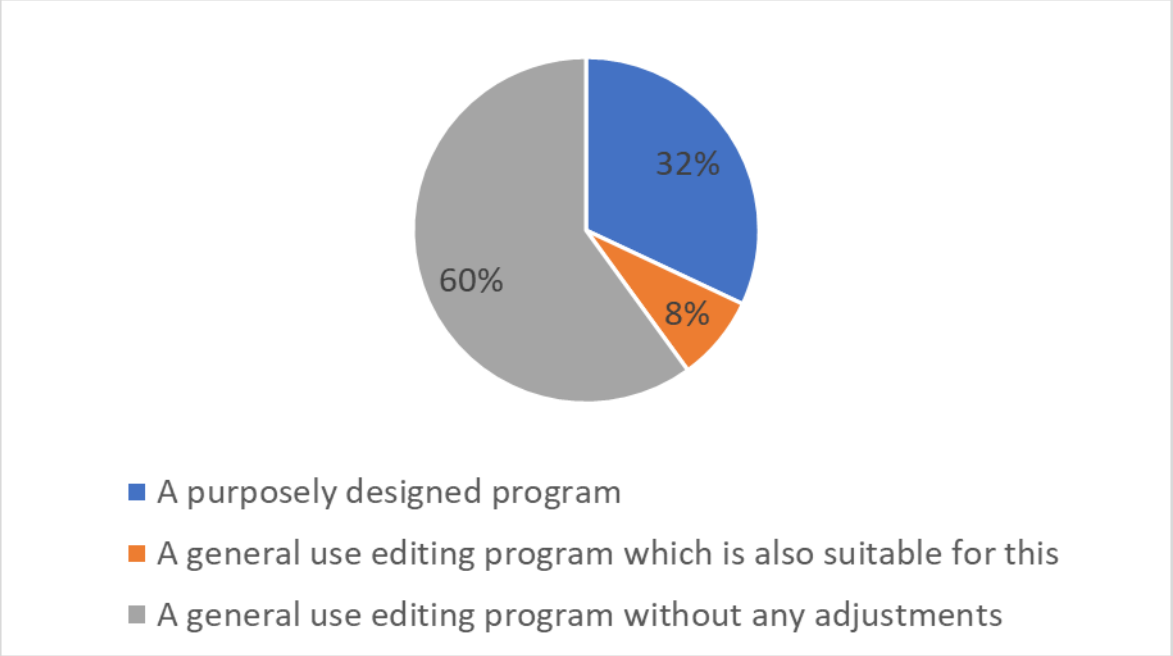
CONTROL	High	Medium	Satisfactory	Insufficient	Unknown action
Typing with the use of the standard computer keyboard	100%				
Understanding how a new program works	70%	20%	10%		
Using the 8-dot-Braille code					100%
Memorization of some shortcut keys			10%	00%	30%
Finding your position on the PC screen through the use of the screen reader					100%



DATA INTERPRETATION	The most difficult activities are: learning how to use a new program and dealing with unexpected situations due to personal or system errors. Considering the answers of the interviewed students from different countries, they appear very homogeneous. Everyone thinks that using a normal PC keyboard is easy Although almost everyone uses a computer, more than half of the sample are familiar with 8-point math Braille code. The control data highlights the lack of ease and therefore the habit of using quick commands (better the mouse), while the quick keys are more congenial to blind students.

5.08A - What program do you use to do mathematics on your computer?

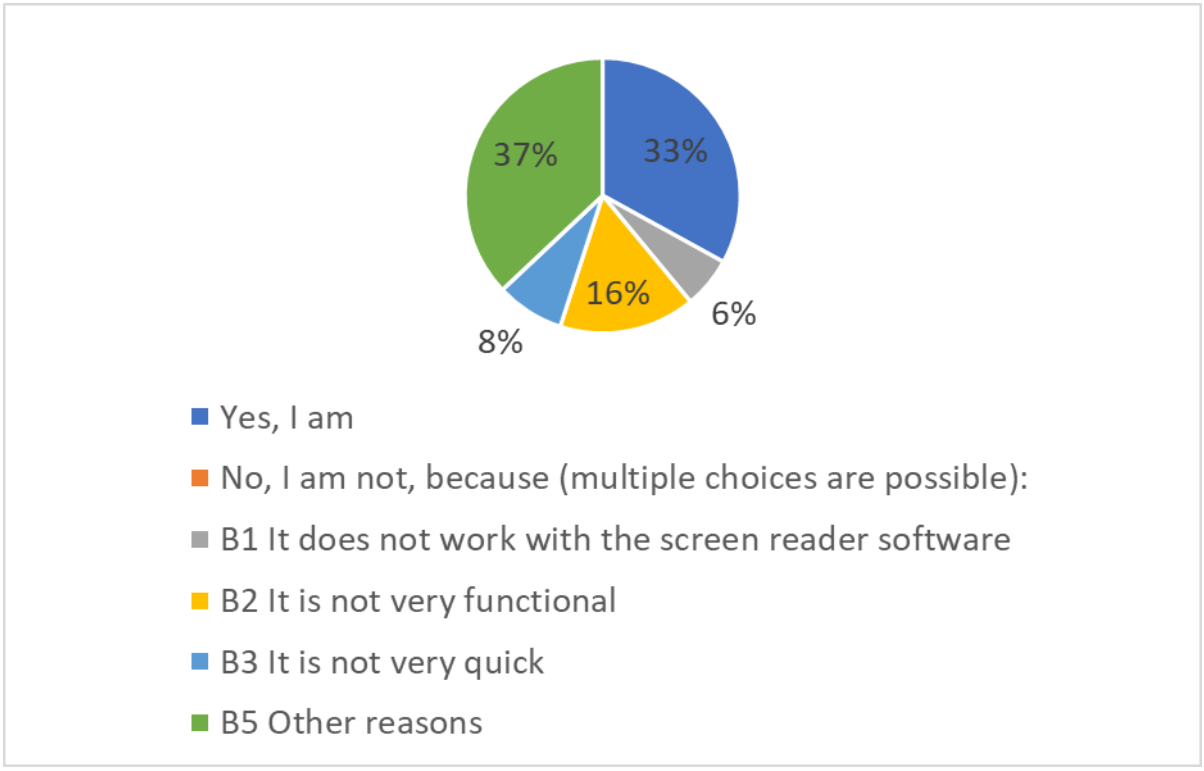
A purposely designed program	32%
A general use editing program which is also suitable for this	8%
A general use editing program without any adjustments	60%
CONTOL: A general use editing program without any adjustments	100%



MODA	A general use editing program without any adjustments
DATA INTERPRETATION	The question does not take into account students who do not use a computer. in Italy all the ones who use a PC employ Lambda; in other countries, 60% use standard programs or generic editors, such as text editors.

5.09A Are you satisfied with the program you are currently using to carry out mathematical activities on your computer? (also considering use for home learning)

Yes, I am	33%
No, I am not, because (multiple choices are possible):	(67%)
B1 It does not work with the screen reader software	6%
B2 It is not very functional	16%
B3 It is not very quick	8%
B5 Other reasons	37%
CONTOL Yes, I am	80%
CONTOL No, I am not, because B5 Other reasons	20%



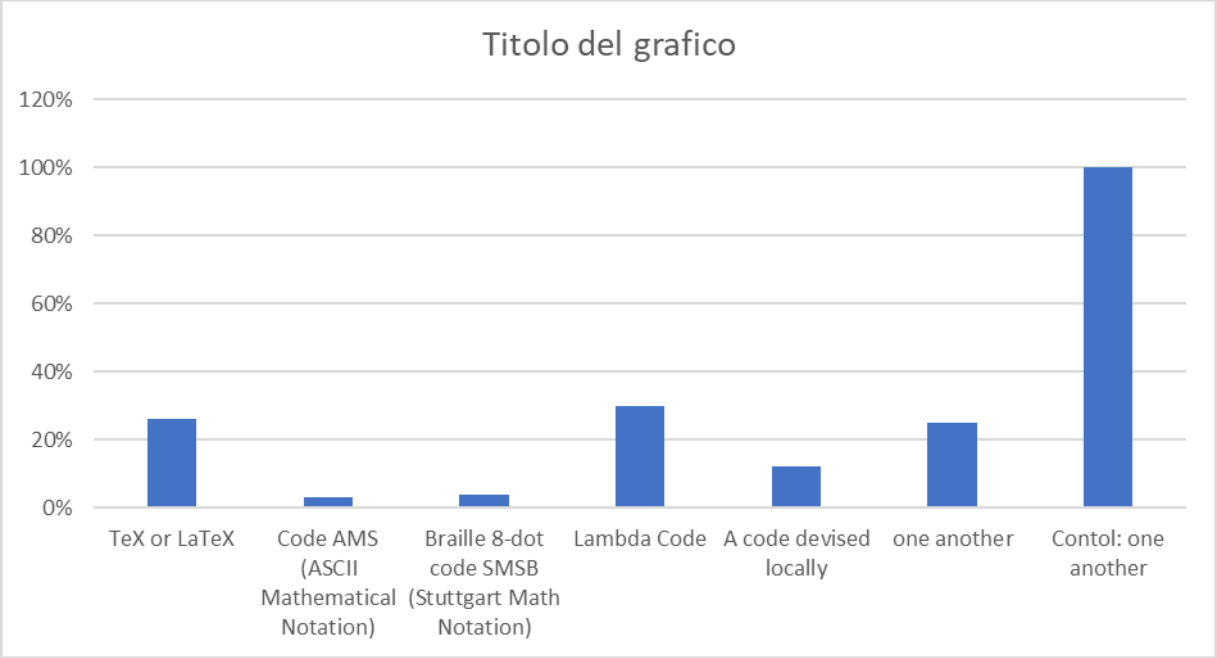
MODA	NO, B5 - other reasons
DATA INTERPRETATION	The users are not satisfied with the tools they have to do Mathematics, especially because they are not very functional. The data are opposite in the control group.

5.09B In case of different reasons, please describe them.

Reading the answers of 5.07 (Please describe your level of efficiency on the following computer activities), which are very high in terms of the answer score for the efficiency and capacity of use of the computer, one would expect a positive value in this case too, while 67% say they are dissatisfied with using their computer for maths. So the problem lies not so much in the potential of the users, but presumably in the low level of accessibility or functionality of the programs used for the specific task of writing mathematics. It is important to notice that those who do not have programs or do not use the computer to do mathematics have selected this item and the sub-item "other reasons", namely reporting as other reasons the fact that they declare that *"there are no specific programs for doing mathematics".*

5.10 **Which computer mathematical notation system do you usually use to correctly represent all the mathematical objects? (for example a code associated to the specific program in use, or a general use textual code like "TeX" code or the "LaTeX" one, or a specific code for the Braille computer or for the speech synthesizer like the "AMS" code the 8-dot-SMSB-Braille code, Lambda code, simplified "LaTeX" code, a code, which was invented by me/my teachers)**

TeX or LaTeX	26%
Code AMS (ASCII Mathematical Notation)	3%
Braille 8-dot code SMSB (Stuttgart Math Notation)	4%
Lambda Code	30%
A code devised locally	12%
On or another	25%
Contol: one or another	100%



MODA	Lambda Code
DATA INTERPRETATION	Lambda and LaTeX are the most used codes Notice that specific codes, such as AMS and SMSB, are not widely used. Under “one another” there are also several codes invented by students or their teachers. The comparison with the control group is not significant.

5.11 What are the greatest difficulties you experienced while doing mathematics on your computer? (also considering use for home learning)

Being an open question, the answers were grouped by categories:

✔ Lack of transcripts of maths school textbooks (but also of science, chemistry, physics and geometry)

✔ Need for more help from teachers, who have little knowledge of computer systems for scientific studies;

✔ Complexity of the mathematical system in LaTeX, which makes it difficult to use it for solving expressions.

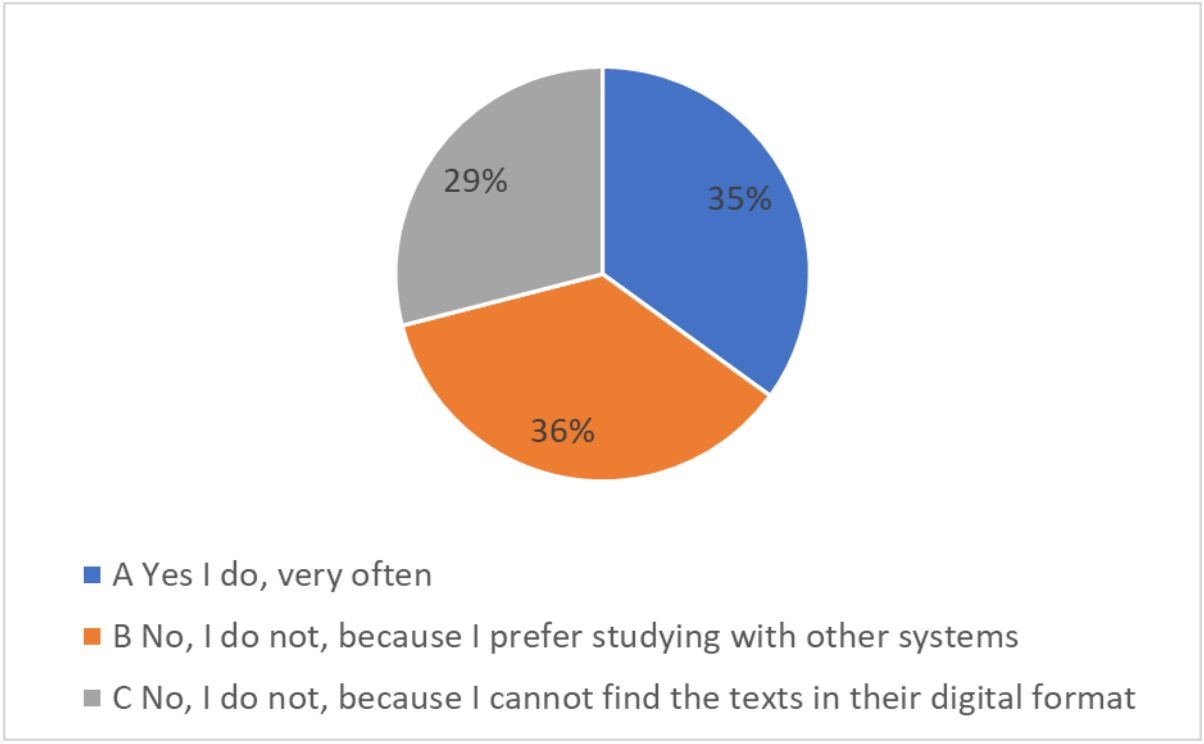
✔ In distance learning, system accessibility problems, problems with the microphone which are difficult to solve.

✔ I do not use a computer for maths, I don't know how to use a computer to learn maths;

✔ Code invented by me and my teacher to write signs or figures.

5.12 Do you normally use the computer to read/study mathematical texts in their digital format?

A Yes I do, very often	35%
B No, I do not, because I prefer studying with other systems	36%
C No, I do not, because I cannot find the texts in their digital format	29%



MODA	B No, I do not, because I prefer studying with other systems
DATA INTERPRETATION	In Italy, all users who filled in the questionnaire use Lambda and therefore answered “yes I do”. The data for the other countries confirms the answer 5.13 and what emerged in general terms, namely that dedicated programs and digital mathematics books are missing. A minority uses LaTeX and therefore an electronic text, while others prefer other systems invented by themselves or text in Braille on paper and the use of typing.

5.13 Do you have any comments on the exchange of maths study resources and homework with your teacher during remote learning?

A distinction about the different countries must be made. In Italy, students report having used Lambda so the communication and exchange of tasks for maths took place using Lambda files. The exercises are produced by the support teacher or by the teacher of mathematics; others (luckier ones) used the same exercises as their peers, which were present in the textbook that was transcribed in Lambda. The tasks carried out were exchanged via email with the teacher. The teacher in his turn can view the assignment in traditional graphic mode.

In Italy the systems used, such as Google classroom, are reported not to be very accessible and the email is mentioned several times as a means of exchange. In the other countries, almost everyone reports that there have been no important exchanges of material for maths; therefore, most of them answered “I don't know”, “it didn't happen to me”. In general there was oral communication using videoconferencing, or the telephone, but only for an exchange of instruction messages.

5.6 Considerations

The great majority of the sample has the possibility to use a computer to carry out school activities and, from the answers collected, it appears clear that they really use it with satisfaction.

Writing is the main activity carried out on the computer by the sample who answered the questionnaire. Other frequent activities are reading books, surfing the Internet and writing e-mails.

The kids claim that they do most of their study activities using a computer. Analyzing the data of each nation, we can see that Poland, compared to other countries, presents a particular situation because, not possessing a widespread Braille line, they have to rely more on speech synthesis and therefore have greater difficulties in managing PC programs.

In all countries the Braille book is very important for reading and studying. Audio books played an important role, especially in the period of distance learning. In examining the difficulties, the contrast between the high knowledge of the 8-dot Braille system but not of 8-dot mathematics, is surprising. The only exception is represented by Italy.

6 Parents' questionnaire. Analysis of results

In this section parents will be asked for little information about the commitment that has proved necessary to support their children in distance learning, especially for mathematics. The number of answers and the breakdown by country is identical to the number of the students, having incorporated both questionnaires into a single module, so that the support of parents can be obtained in the phase of accessing the young students' module.

6.01 This section is about the way your child uses home learning. Has your child done home learning due to recent restrictions? If your answer is no, you can skip the entire section.

The totality answered "yes". Therefore, between 2020 and 2021, all students in the four surveyed countries had a period of restriction and lock down .

6.02 Compared to face-to-face teaching, did you find your child's interest in reading increased during the home teaching period? If so, can you briefly indicate the kind of reading preferred by them?

The question tries to enter into the issue of study of scientific subjects, by first trying to understand if, in general, the interest in reading and studying has been maintained or has decreased. From the data collection, an average of 30% reported that they noticed a greater use of audio books or texts in Braille for the humanities (History, literature, anthology) and also for scientific subjects as sciences; 20% said they did not notice any difference, while the remainder is very critical as they state that there were no study materials for reading, but only audio recordings by the teachers.

6.03 For mathematics and scientific studies in general did you have to equip yourself with new programs or new IT solutions? If so, can you briefly tell us which ones?

The answers were different. In Italy, the school provided the families with the Lambda program, in case it was present only on the school computers.

In the other countries there is no news, except generic references to consumables, memory media or spare parts of parts that had been broken (keyboard, new microphone).

Therefore, the emergency has not led families to look for innovative or new IT support products or programs for their children.

6.04 What were the most important difficulties you experienced in supporting your child's home learning, in particular in maths ?

The answers can be divided into four large groups:

✔ Support for the use of the videoconferencing program, poor network access

✔ Issues related to geometry, to the construction of relief graphics and solids

✔ Communication with the school and exchange of materials with teachers.

✔ Study assistance activities, with explanation of mathematical operations.

6.05 What advice could you give to those developing training solutions for blind students, in order to improve home education?

Also in this case the answers can be collected in four large groups:

✓ Direct advice to teachers: give less homework, listen more to your students during lessons in DL, allow more time for tests, eliminate geometry during this lock down phase; individualized lessons are needed even if in remote.

✓ Issues about materials: missing Braille books, overly complicated and long audio lessons.

- ✓ Issues to make school work more lively and interesting. Students suffered from boredom and depression.
- ✓ Issues related to the complexity of computer programs.

6.1 Considerations

The questionnaire for parents was organized in the form of open questions and was deliberately simplified, in order not to bore the parents and therefore reduce the number of users available to fill it in.

The difficulties that parents have encountered in the closing phase of schools emerge, exactly like the need expressed by their children to be helped to use communication systems that are not very accessible. Parents would probably have liked their children to have greater autonomy in carrying out their study activities. In some disciplines this autonomy seems to have been achieved, but not so in the scientific subjects. It seems clear that the lock down was a penalizing period for their children's education issues, since it slowed down their studies and required an extra commitment from parents.

7 Teachers' questionnaire. Analysis of results

7.1 The data

The questionnaires for teachers and operators in the school world collected were 72, divided as follows:

Italy	22
Poland	16
Germany	18
France	16
Total useres' questionnaires.	72
Control	15
Total worked out questionnaires.	87

The data were processed in a single form of presentation, without distinction between the various European countries, as this would have little significance and would make it more difficult to read the data

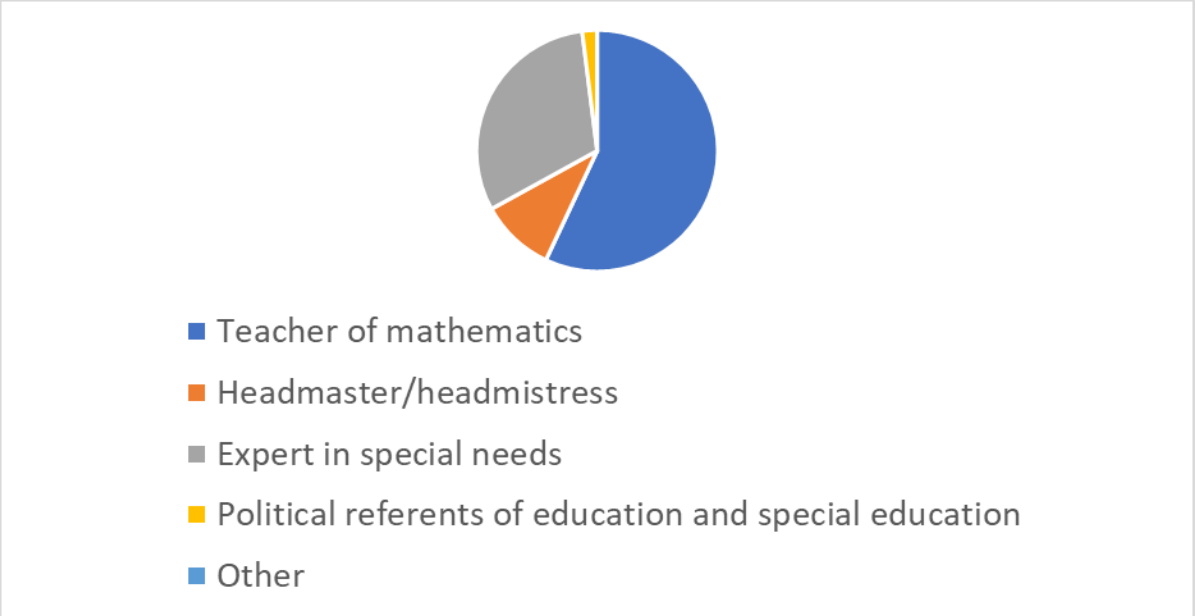
The control samples were 15.

Each partner collected and summarized the responses received in a statistical table. They wrote their comments and sent the final report to the EKMS partner, who is responsible for the entire IO and for the related final report. The final report was then redistributed among the partners for local dissemination.

7.2 General information.

2.01 You are:

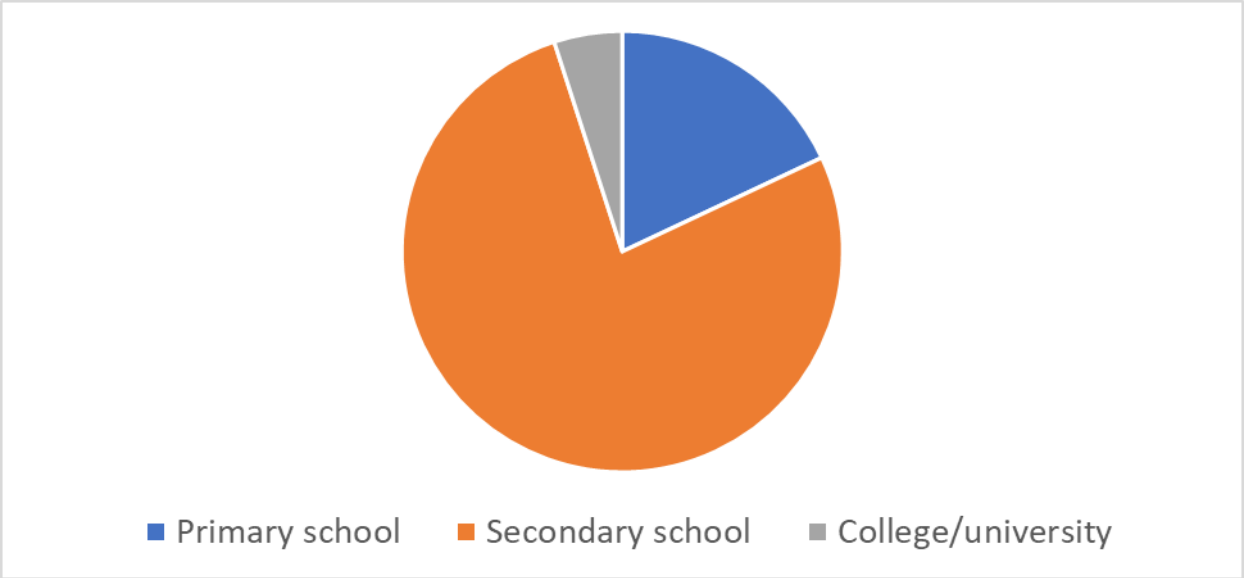
Teacher of mathematics	57%
Headmaster/headmistress	10%
Expert in special needs	31%
Political referents of education and special education	2%
Other	0%
Control (Teacher)	100%



MODA	Teachers
DATA INTERPRETATION	Most of the people interviewed, both for the sample and the control group, are teachers of Maths. The sample has teaching experience with blind students, but the control group doesn't

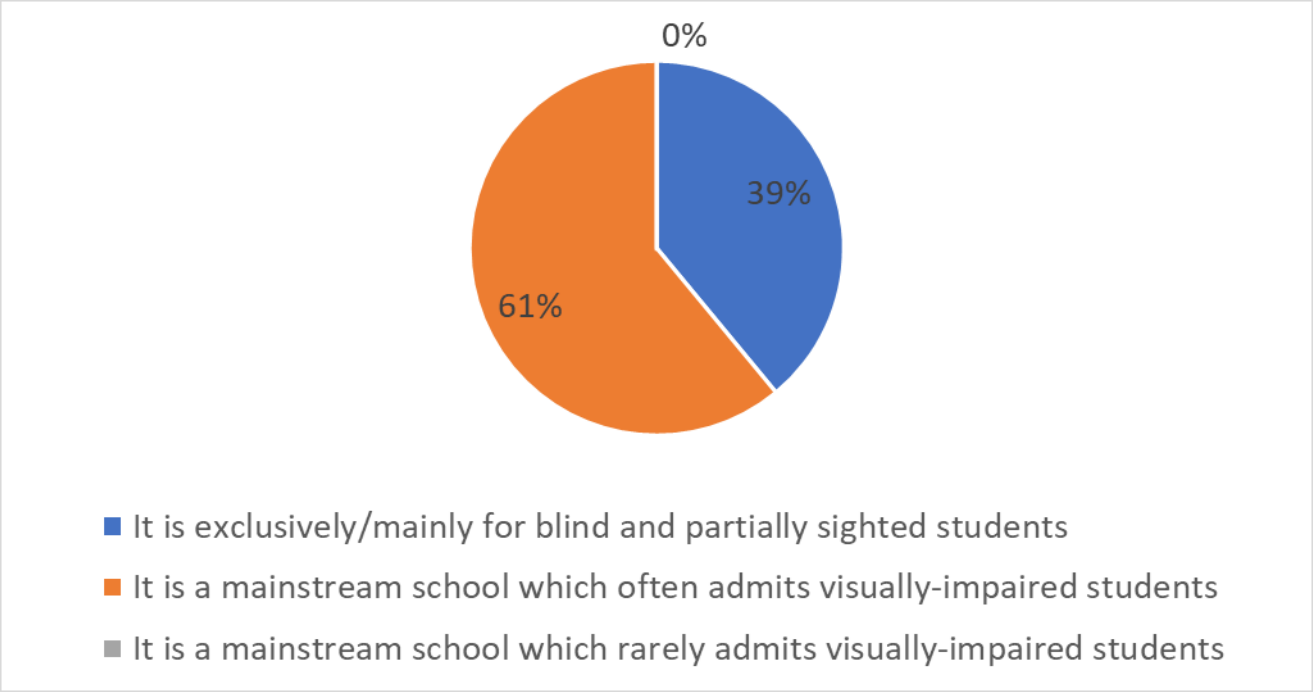
2.02 In which school are you working?

Primary school	18%
Secondary school	77%
College/university	5%
Control (Secondary school)	100%



2.03 Is your school exclusively or mainly for visually impaired students or is it a mainstream school?

	It is exclusively/mainly for blind and partially sighted students	It is a mainstream school which often admits visually-impaired students	It is a mainstream school which rarely admits visually-impaired students
Teachers	39%	61%	0%
Control		80	20

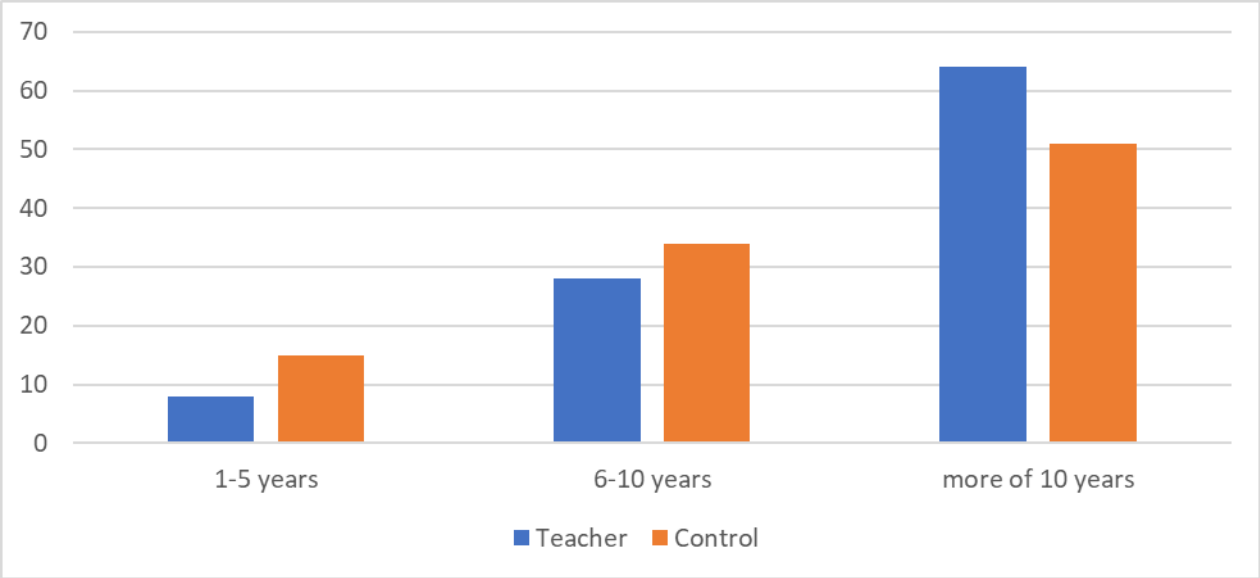


MODA	It is a mainstream school which often admits visually-impaired students
DATA INTERPRETATION	The figure highlights the presence of 39% of teachers working in special institutes or special classes, who are mainly German and Polish. The data, however, raises doubts and makes it clear that several teachers consider even the schools with special sections as part of

	common schools (therefore included in answer number 2)

2.04 How long have you been working as a teacher?

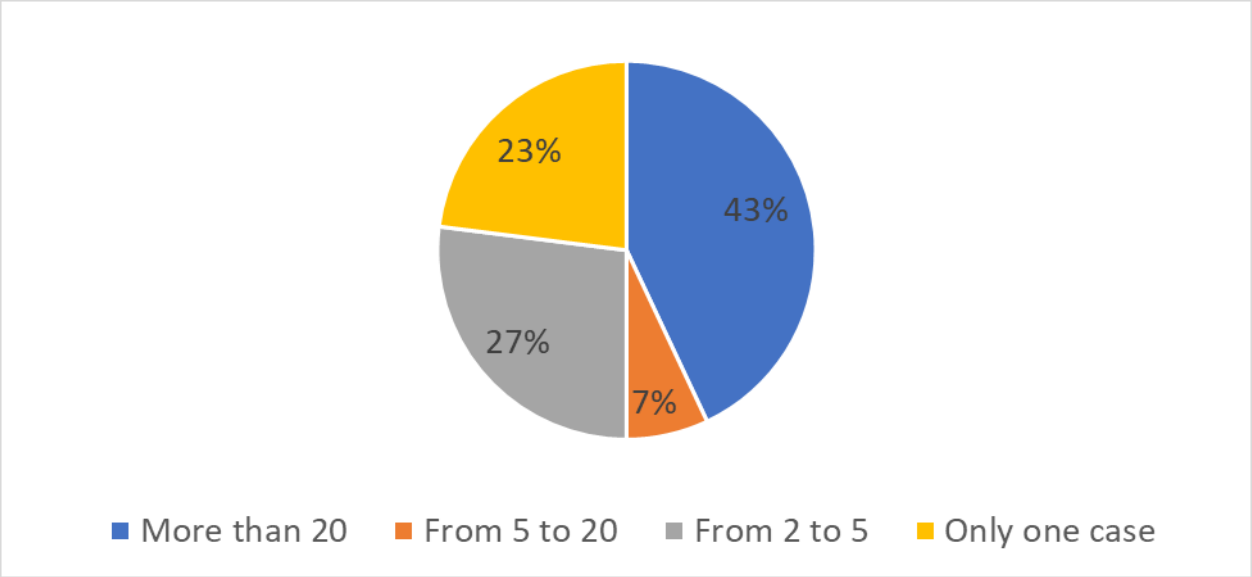
	Teacher	Control
1-5 years	8	15
6-10 years	28	34
more of 10 years	64	51



MODA	More than 10 years
DATA INTERPRETATION	Teachers prevalently have a good didactic experience, and this is important for the total results of the research.

2.05 In total, how many visually impaired students have you taught maths or supported in any other form in your career?

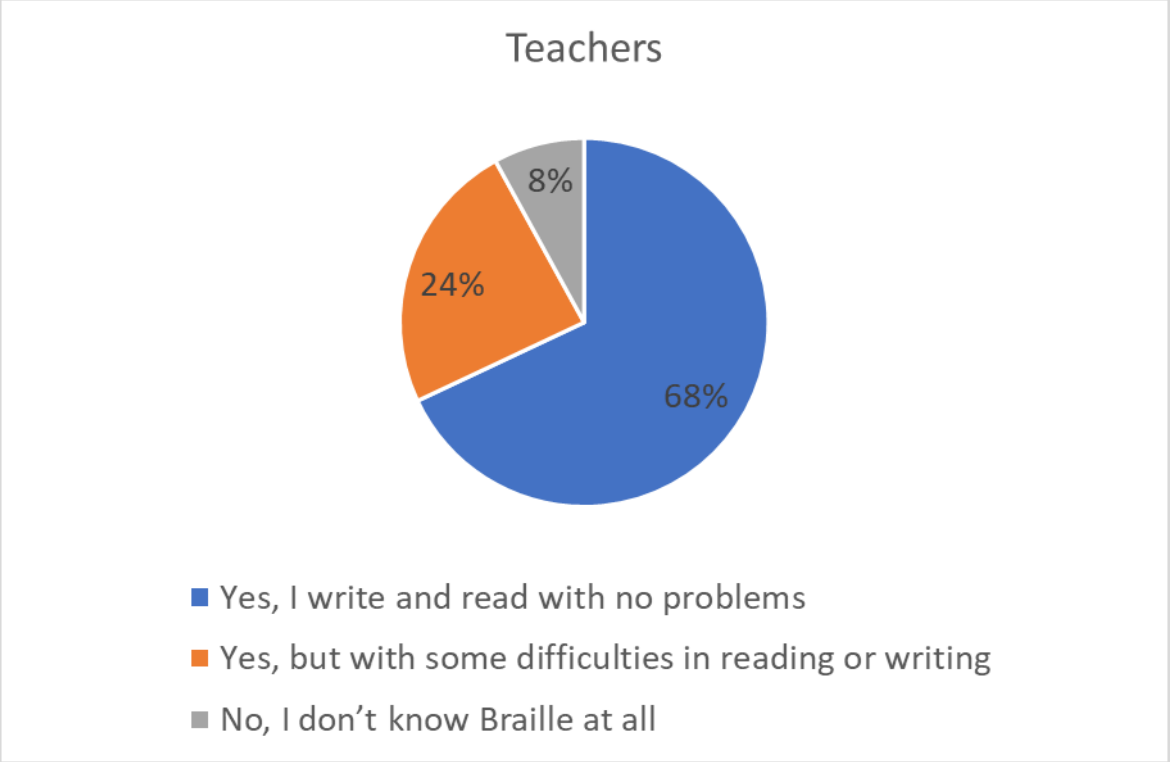
	More than 20	From 5 to 20	From 2 to 5	Only one case
Teachers	43%	7%	27%	23%
Control	0	0	0	0



MODA	More than 20
DATA INTERPRETATION	Data depend naturally on the kind of school (common, special, mixed) where the interviewed teacher works. About 50% have a great didactic experience with blind or visually disabled students. Ii is not the same for the others, so they can't have enough elements to answer some questions; they must refer to limited experiences, often referred to only one blind pupil.

2.06 Do you know Braille?

	Yes, I write and read with no problems	Yes, but with some difficulties in reading or writing	No, I don't know Braille at all
Teachers	68%	24%	8%
Control	0	0	0

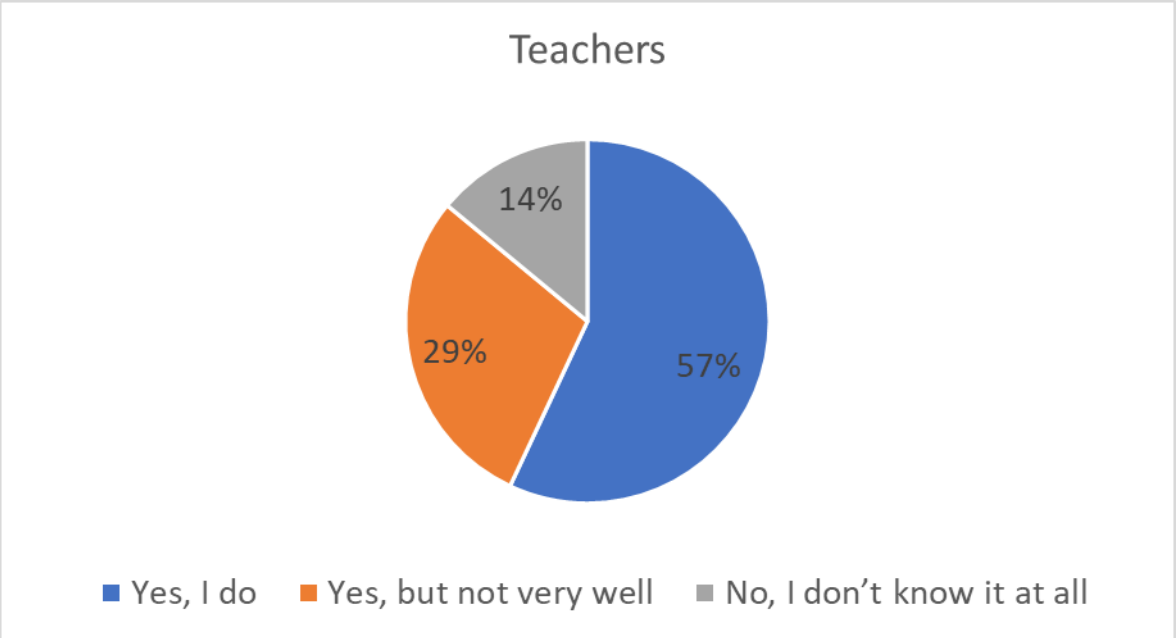


MODA	Yes, I write and read with no problems
DATA INTERPRETATION	The correlation is very high; it means that teachers who had significant teaching experience with blind or visually impaired students (and several years of work in special schools) have reached a good knowledge of the Braille system. As we could imagine, teachers of Maths in normal schools (as the teachers in the control group) do

	not know the Braille system. In Italy it is common that the mathematics teacher is not an expert in Braille as he is assisted by the support teacher.

2.07 Do you know Braille mathematics?

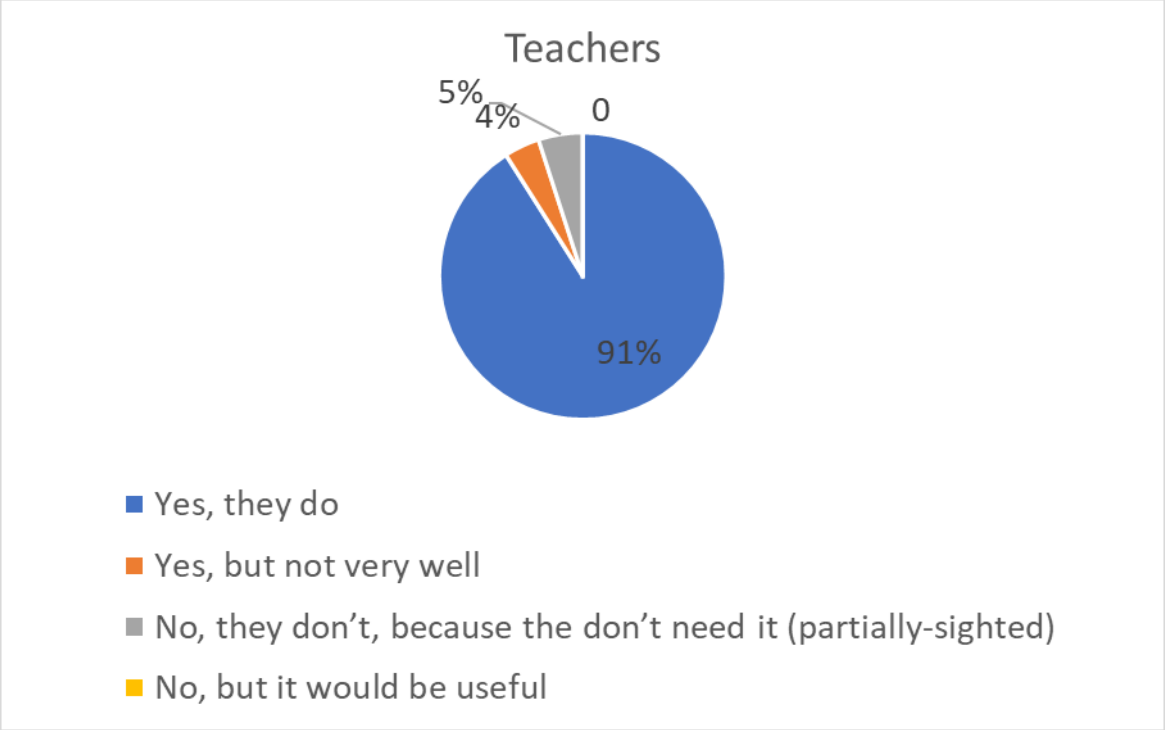
	Yes, I do	Yes, but not very well	No, I don't know it at all
Teachers	57%	29%	14%
Control	0	0	0



MODA	Yes, I write and read with no problems
DATA INTERPRETATION	The previous point is confirmed.

2.08 Do your visually impaired students know Braille?

	Yes, they do	Yes, but not very well	No, they don't, because the don't need it (partially-sighted)	No, but it would be useful
Teachers	91%	4%	5%	0
Control	0	0	0	0



MODA	Yes, they do
DATA INTERPRETATION	Students, even at the expense of some inexperienced teachers, know Braille very well. A small percentage probably relies more on speech synthesis.

2.09 What mathematical notation do your students use?

The replies basically mentioned national codes and only partially some electronic formats:

In France everyone uses the new 2007 edition of the "Notation mathématique Braille"

In Italy, the younger ones use the mathematical Braille edition of Regina Margherita Library in Monza and all the others the Lambda Code. A support teacher, probably of elementary school, states that she only teaches Lambda, because it will become the system used in subsequent middle and high schools, so she no longer uses the national 6-dot Braille .

In Germany, the Marburg code is used, but 8 replied that they use also LaTeX together with the Marburg code, or a series of signs created by the students themselves in order to use the computer.

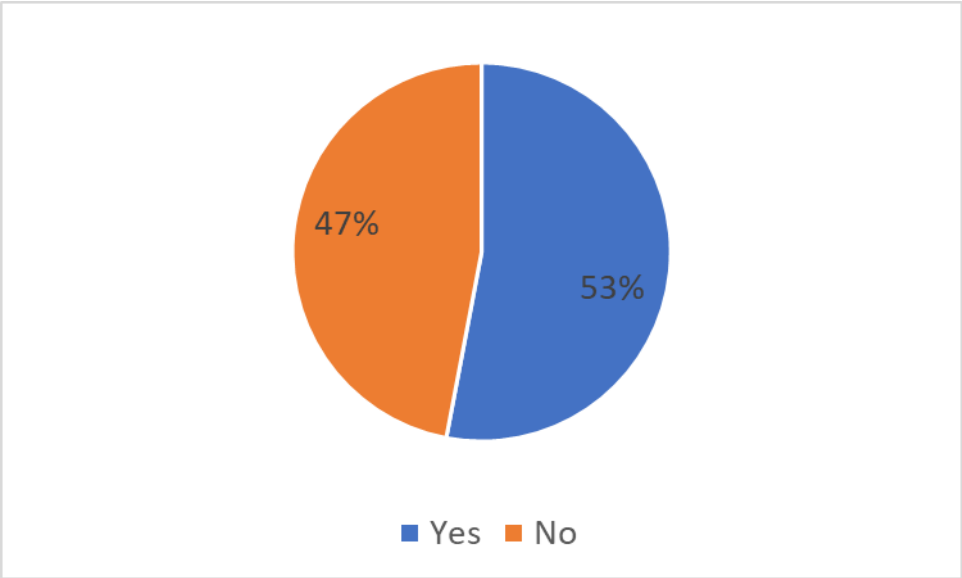
In Poland, the code Notation for mathematics-physics-chemistry Braille 2nd edition, edited by Jan Świerczek is widespread. Only one Polish teacher mentioned a student who can use LaTeX.

This figure reflects the indications given by the students themselves.

In fact, the figure shows that only few use LaTeX and mainly in Germany. LaTeX thus proves once again complex to use and not very functional for high school students, while it is known to be widely used by blind students at university level.

2.10 Do you find it satisfactory?

Yes	53%
No	47%



MODA	Yes
DATA INTERPRETATION	The teachers' interpretation of the mathematical codes used by their students states that the solutions adopted are appreciated by 53%. The ones who disagree are presumably the same who devised their own personal way of writing mathematics for their students, in order to have them use a personal computer, or those who still have not found adequate programs to do mathematics in a satisfying way.

2.11 If not satisfactory, what are the deficiencies?

Those who gave their answer complain about the fact that:

✔ Braille does not allow the management of column calculations, of drawings, of geometry and physics.

✔ There is a shortage of textbook transcripts for high school.

✔ There is difficulty in handling expressions when writing in Braille.

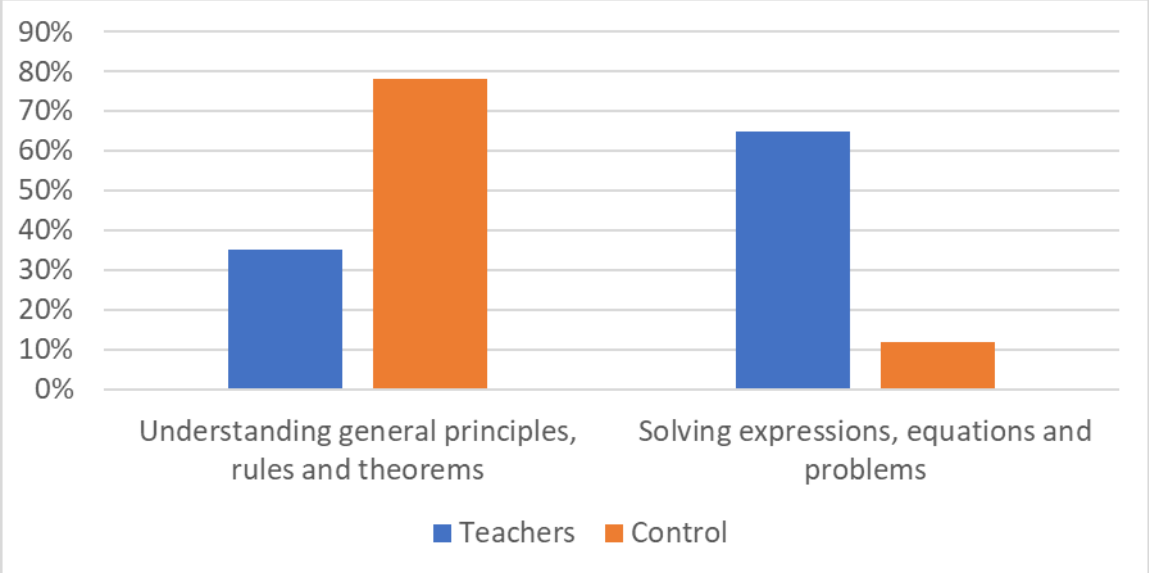
✔ There are difficulties with LaTeX, which is too complex to write and memorize and which uses programmers' terminology.

✔ Mathematical Braille is too complex when working with children with learning difficulties in addition to blindness.

7.3 Difficulties in mathematics (and other exact sciences) experienced by students with visual impairment

3.01 Based on your experience, please evaluate which of these two aspects of maths proves to be more difficult for visually-impaired students:

	Understanding general principles, rules and theorems	Solving expressions, equations and problems
Teachers	35%	65%
Control	64%	36%

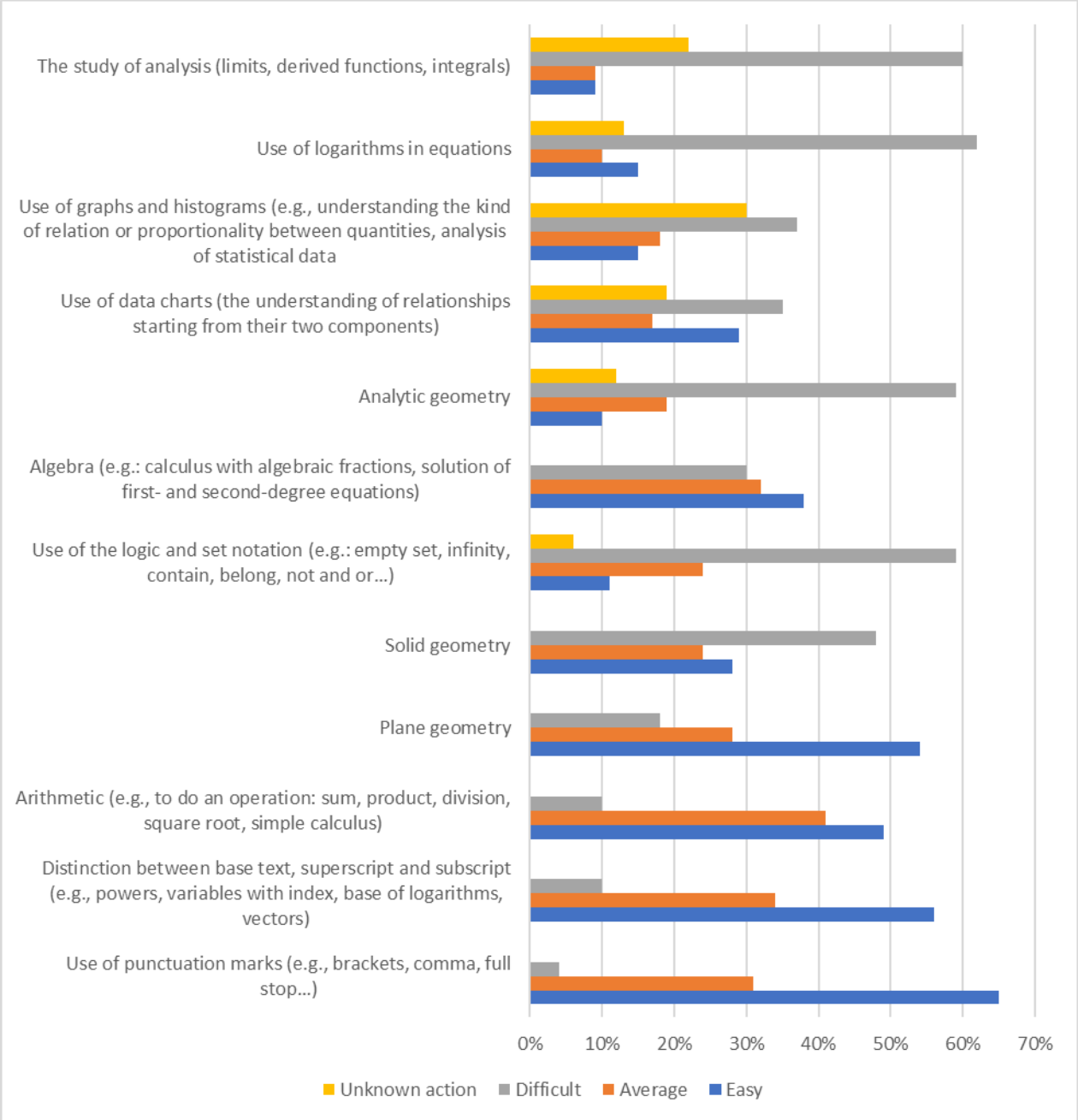


MODA	Solving expressions, equations and problems
DATA INTERPRETATION	The control sample highlights that, compared to the practical work of solving equations, the most challenging aspect for them is the transmission of concepts and principles. This commitment will later allow to obtain good results in carrying out tasks and in

	problems, and this is not considered as an element of difficulty. For the teachers of blind children, on the other hand, this aspect adds up and is therefore not sufficient on its own, but has an impact on the question of writing the text in Braille. If understood, a principle must also be put into practice and verified. On the part of teachers, there seems to be less effort in passing concepts than in teaching Braille writing and "doing" mathematics, that is, solving equations and problems in Braille. As a matter of fact, this difficulty in managing mathematical symbology was also expressed by the students in their questionnaire.

3.02 Rate the degree of difficulty for students with visual disabilities in the following areas (choose only the areas applicable to the education level your students are at):

	Easy	Average	Difficult	Unknown
Use of punctuation marks (e.g., brackets, comma, full stop…)	65%	31%	4%	0%
Distinction between base text, superscript and subscript (e.g., powers, variables with index, base of logarithms, vectors)	56%	34%	10%	0%
Arithmetic (e.g., to do an operation: sum, product, division, square root, simple calculus)	49%	41%	10%	0%
Plane geometry	54%	28%	18%	0%
Solid geometry	28%	24%	48%	0%
Use of the logic and set notation (e.g.: empty set, infinity, contain, belong, not and or…)	11%	24%	59%	6%
Algebra (e.g.: calculus with algebraic fractions, solution of first- and second-degree equations)	38%	32%	30%	0%
Analytic geometry	10%	19%	59%	12%
Use of data charts (the understanding of relationships starting from their two components)	29%	17%	35%	19%
Use of graphs and histograms (e.g., understanding the kind of relation or proportionality between quantities, analysis of statistical data	15%	18%	37%	30%
Use of logarithms in equations	15%	10%	62%	13%
The study of analysis (limits, derived functions, integrals)	9%	9%	60%	22%

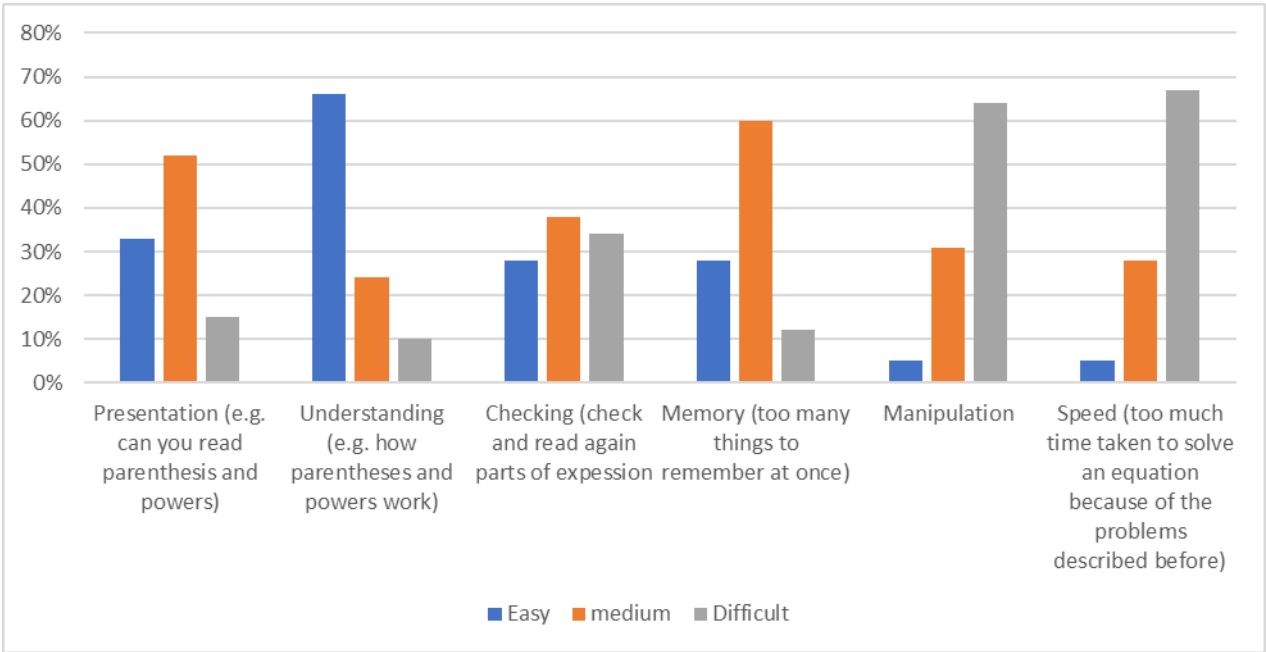


DATA INTERPRETATION	Analyzing the complex data (not just “moda“) we can notice in the answers something moving towards “difficult“. As we prevented, the greatest differences are in the subject with high graphic-visual components (for example the plane and solid geometry and graphs

	reading). It's interesting anyway to compare these items with students' ones, just to understand how students consider the same item less difficult. These fields of inquiry are the same as the ones for students, yet with some simplifications. The "very easy" item has been removed. Compared to students who have often answered "I don't know", simply because their curriculum still has not addressed these issues, the teachers have rarely answered the same way. When they did, the answer was given perhaps because the topics were outside their teaching field or because they taught in classes with younger pupils, where the topics were less complex. In fact, the item "I don't know" appears on questions related to analytical geometry, statistical logarithms, etc. The control group has rarely met students with visual disabilities, so they have just admitted of having no knowledge of the problem.

3.03 When they solve algebraic equations, students with visual disabilities have problems with:

	Easy	medium	Difficult
Presentation (e.g. can you read parenthesis and powers)	33%	52%	15%
Understanding (e.g. how parentheses and powers work)	66%	24%	10%
Checking (check and read again parts of expression	28%	38%	34%
Memory (too many things to remember at once)	28%	60%	12%
Manipulation	5%	31%	64%
Speed (too much time taken to solve an equation because of the problems described before)	5%	28%	67%



DATA INTERPRETATION	It is possible to notice here a substantial agreement between the answers of the teachers and the interviewed students. It stresses that difficulties in manipulating and solving algebraic equations are medium-high. Also in this case the control group did not answer because of the little knowledge about visually disabled kids.

3.04 Do you think that a visually-impaired student would require more time and/or practice to obtain satisfactory results?

The Braille writing and reading system is unanimously reported to determine by its nature a strong operational slowness. We refer to the equations that must not be too long, because they do not allow blind students to have a complete mental representation (a student needs a lot of time, but it is not always possible, so it is better to simplify; yet not always everything can be simplified).

The use of multiple parentheses creates some difficulties because students do not understand exactly when they should be closed. By having more time, difficulties could be overcome.

The difficulties to achieve good results may be attributed to the fact that there are no transcriptions of mathematics books in Braille allowing systematic study and exercises.

Furthermore, another difficulty is related to moving between the new writing line and the reading of the previous equation, which leads to the loss of a lot of time.

Teaching must be careful to grasp the individual difficulties with different and targeted exercises, so that the problem can be understood and consolidated.

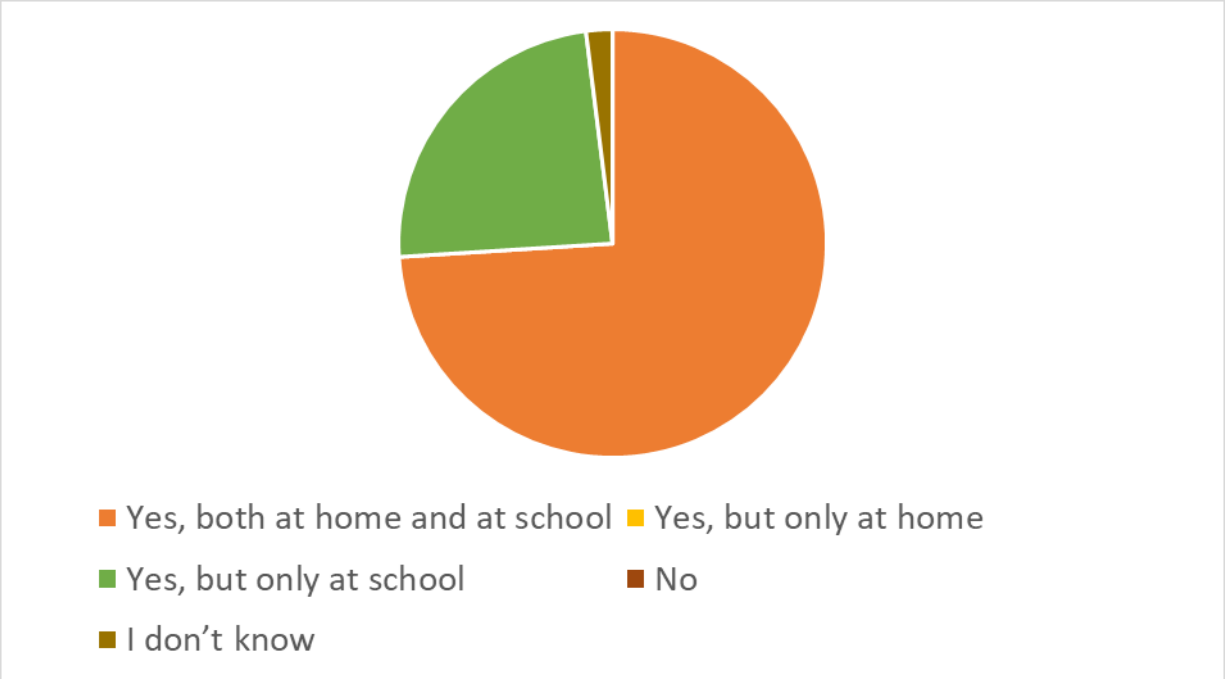
Finally, a big problem for students is the Braille notation itself and the efficient use of a typewriter.

Control	There are no suggestions or remarks.

7.4 The use of computer in the time of home learning

4.01 Do your visually-impaired students use a computer?

Yes, both at home and at school	74
Yes, but only at home	
Yes, but only at school	24
No	
I don’t know	2

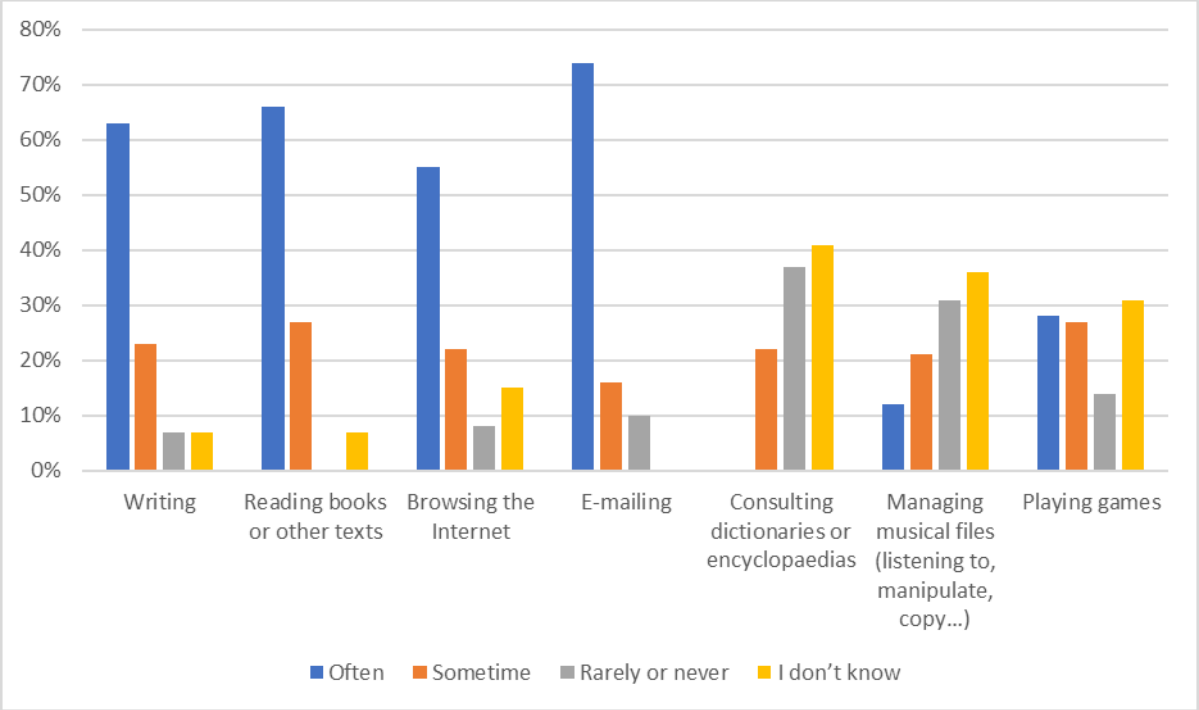


MODA	YES, BOTH AT SCHOOL AND AT HOME
DATA INTERPRETATION	The great majority of students in our sample have the opportunity to habitually use a computer tool, suitable for their needs, to perform school work. Most of them can use such an equipment both at school and at home. The teachers’ answers to the item are in accord with the students’ ones.

Control	The computer is used only for workshop activities, not for daily study.

4.02 What are the activities that they normally do with the computer?

	Often	Sometime	Rarely or never	I don't know
Writing	63%	23%	7%	7%
Reading books or other texts	66%	27%	0%	7%
Browsing the Internet	55%	22%	8%	15%
E-mailing	74%	16%	10%	0%
Consulting dictionaries or encyclopaedias	0%	22%	37%	41%
Managing musical files (listening to, manipulate, copy…)	12%	21%	31%	36%
Playing games	28%	27%	14%	31%
Control				100%

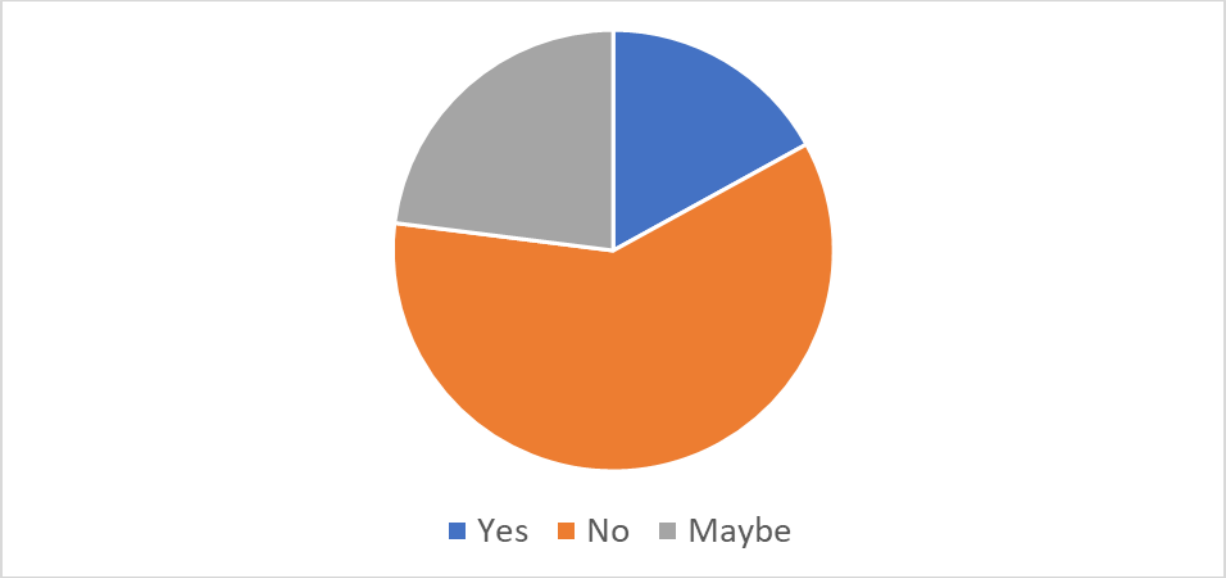


DATA INTERPRETATION	The questionnaire of the teachers is different from the one of the students, because instead of asking if they thought it was easy for their students to use the computer for certain activities, the question aimed at learning about the frequency in the use of it (Often, Sometime, Rarely or never), with the addition of the item "I don't know". Since the figure is very close to the students' one, this demonstrates that the teachers know their pupils' activities and habits, even if the readings are slightly higher, for example, as concerns the gaming activity. In fact some teachers probably believe that the computer is mostly used by all young people for playing, while unfortunately the games accessible to blind users are rare and limited. The question about music records many "I don't know", probably because of the presence of the word "manipulate",

	implying that it was not just a matter of listening to music, but also of copying, cutting and recording it.

4.03 Do you consider your students' computer equipment adequate for distance learning?

Yes	17%
No	60%
Maybe	23%



MODA	No
DATA INTERPRETATION	Although the use of computers is considered fundamental, vital for a blind student, its use in distance learning clearly sees the opposition of teachers. Briefly interpreting the answers given to the next question, it is clear that they strongly prefer face-to-face teaching as remote

	communication systems with blind users are not very functional. The teachers also have visually impaired students, which could justify 17% of positive responses.

4.04.1 If you do not, why? What is missing?

In summarizing the answers given, it is clear that teachers consider the computer a useful tool for communication, writing and reading, but not so much for mathematics and other graphic elements, such as geometry; this being the case, everything becomes more complicated in distance learning. .

In many replies students are reported of not having expensive Braille printers or Braille lines at home, all of which are available in centers and institutes. Similarly, computers used at home (sometimes not even available) do not have specialized software as the ones present at the institute for the blind or at school.

So evidently home computers are partly different systems from those present at school; we should also add that, in some cases, home computers are just used for games or for homework, where only a text editor is needed; instead, the equipped ones, for studying and working, are present only at school. Moreover some use tablets with Braille keyboards and therefore have difficulties in using videoconferencing programs. There are very different equipment among students.

Some make reference to the fact that some blind students use smartphones (more accessible than computers to use video conferencing software) for distance learning, and these tools are not suited to the students' needs for doing maths.

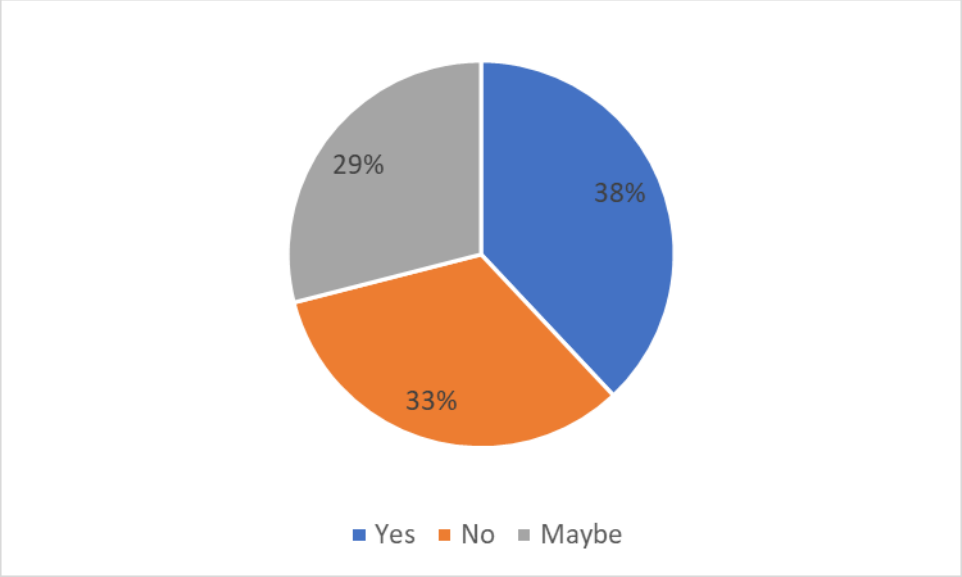
The reference to the low quality of the network, or to the unavailability of an internet network and the lack of accessibility of videoconferencing programs often occurs again, as indicated in the answers of the students.

Indeed, the students from the poorest families, not disposing of computers and network, are said to have worked on the telephone.

Finally, access is reported to be often limited, due to the need to share the device with family members or other siblings who were also in DL; in this case the Internet connection was sometimes poor.

4.05 Do you consider your students' computer knowledge adequate?

	Yes	No	Maybe
Teachers	38%	33%	29%
Contol	48%	20%	32%



MODA	Maybe
DATA INTERPRETATION	The added readings of No and Maybe (64%) makes it clear that teachers perceive their

	students' difficulties more carefully than students themselves do. The control value, on the other hand, goes in the opposite direction, assigning young people better skills in using computers, and adequate for the work required of them.

4.05.1 If you do not, why? What else should they be able to do?

The responses were very informative. We start from generic answers, such as " they need to practice more", to issues related to the poor accessibility of software (for example "LaTex for Mathematics is very limited").

We would like to mention:

- screen readers and speech output, beside the fact that students should learn more about the way they work
- they do not know how to work independently, lack of problem solving skills
- poor accessibility of websites, they do not know how to search on the Internet or to use mail
- more hours with the support teacher would be needed, longer time for lessons.
- acquisition of writing on the computer is sometimes so slow that it limits the independent use of the PC, for example, for writing e-mails for communication, which is only possible starting from the fifth grade or even later.
- learn about accessibility options
- one teacher reports "I think they are self-taught skills, or acquired thanks to the family at home; school has not made a decisive contribution."
- better teacher training
- Improve the choice of web-based sources to search for correct knowledge.

We would like to quote a very articulated text by a Polish teacher, who wrote:

"*Distance learning was an opportunity to demonstrate how difficult it is for students to use a computer and software. However, precisely to adapt to the demands and needs of distance learning, this fact has contributed to significantly increase their skills, but despite this, I believe that the knowledge in this field is still insufficient (obviously referring only to blind students) . Currently, a big problem is the constant change of software due to permanent updates. The whole Office 365 application causes a lot of problems, because the screening software doesn't keep up with the changes, often the keyboard shortcuts don't work anymore beside being too many and the students have trouble in remembering them. The same actions and commands should be standardized across applications. Furthermore, software is not intuitive, it is sometimes difficult to guess where the author has inserted a certain feature, which must be selected in order to continue to use the application effectively. In general, the majority of blind students are unable to manage the computer by themselves and need external support even occasionally, but necessary because otherwise they would not know how to go on with the work assigned to them".*

In schematic form, the following issues can be reported for improvement:

a - Writing using the standard PC keyboard

b - Understanding the functioning of a new program

c – Using 8-dot Braille

d - Memorizing series of shortcut keys

e - Finding your position on the pc video through the use of the screen reader software

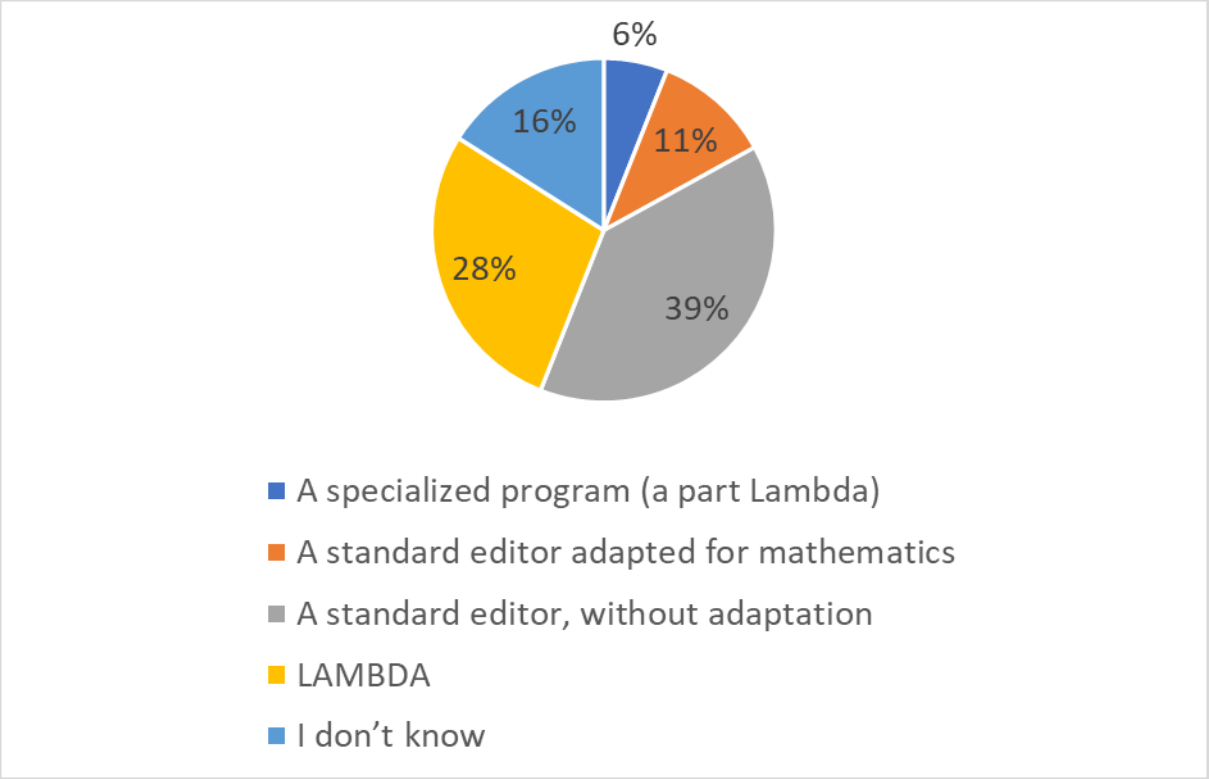
f - Finding a document on a Hard Disc you have not used for a long time

g – Handling unexpected occurrences- particular errors

Even the sample group expressed its opinion by reporting a 20% of limited digital skills, low critical spirit and poor knowledge of how to exploit the technological opportunities in a positive way (and not in a succubus way). Greater knowledge is required for a good use of Word or Open Word computer applications, spreadsheets, databases, information storage and management as well as an awareness of the opportunities and potential risks of the Internet and of communication via social media.

4.06 Which program do your students use to write maths on computer?

	A specialized program (a part Lambda)	A standard editor adapted for mathematics	A standard editor, without adaptation	LAMBDA	I don't know
Techers	6%	11%	39%	28%	16%
Contol			100%		



MODA	A standard editor, without adaptation
DATA INTERPRETATION	There are many programs, some specific, some more general. The "moda" data are conditioned by the choices of the German and Polish groups, which are now crucial, as many of the people interviewed claim that they simply use a word processor (for example MSWord). The Italian group replied to use only Lambda. The figure, summing 55% of standard editors and "I don't know", coincides with the answers given by the students, among whom 60% use traditional programs, while 30% of them use the Lambda program.

4.06.1 Which program?

The employed programs are the following:

Word, Excel, LaTeX Editor, Lambda, Duxbury, Netbraille for transcriptions from MathML (French only)

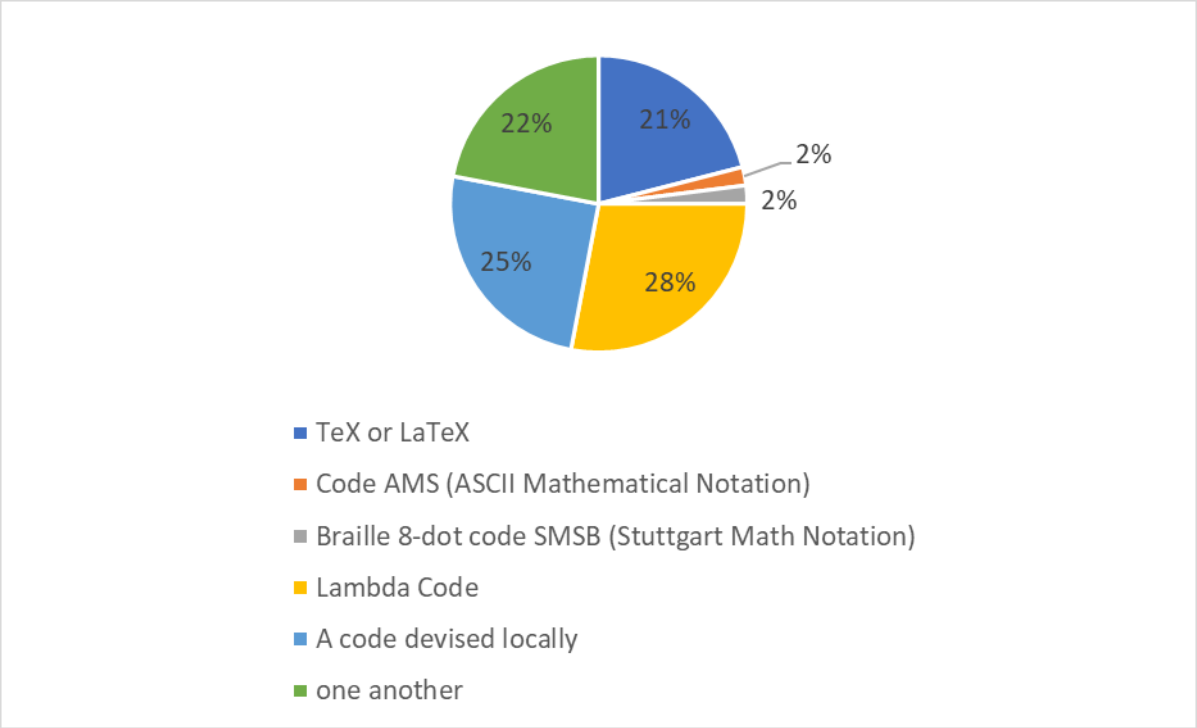
Slightly more than 50% of teachers expressly report that there are no specific programs for mathematics in Braille, others add that there are no programs for the management of geometric designs, or the study of functions.

One answer is emblematic: in maths, students write on a Braille typewriter : there is no other option.

The sample group cited Microsoft Mathematics, Wolfram | Alpha, Math-o-mir, RedCrab, Daum Equation, Equation Wizard, Photomath, Cymath, Mathway.

4.07 When students write maths on PC, how do they represent mathematical symbols?

TeX or LaTeX	21%
Code AMS (ASCII Mathematical Notation)	2%
Braille 8-dot code SMSB (Stuttgart Math Notation)	2%
Lambda Code	28%
A code devised locally	25%
One or another	22%
Contol: one or another	100%



MODA	One or another
DATA INTERPRETATION	The figure highlights the systematic use of the Lambda program in Italy, while in Germany AMS, SMSB and LaTeX, in Poland LaTeX and other national solutions, including the 6-dot one, solely related to the Braille typewriter, in France mainly other solutions and the national Braille.

4.07.1 If you wrote "one or another", which one?

Many write maths texts only on a Braille typewriter; others, who have invented their own mathematical symbology in words, use a kind of imaginary code.

4.08 Do you think Braille supported by modern technology (Braille displays, embossers) facilitates studying mathematics and other exact sciences for visually-impaired students?

The answers were very contradictory, from the belief that new technologies are fundamental for the study of mathematics, in particular for distance learning, to very negative answers. Here are some references:

✔ Yes for sure, now you have to use your PC and you can't go back to the days of the Braille typewriter

✔ Sure, you need a computer to write LaTeX

✔ No, the computer is used only to facilitate printing on embossed paper and is used by teachers who do not know Braille, and use programs for converting from MathML to Braille

✔ It should be like this! However, students are often not equipped with Braille displays, and without this device it is impossible to talk about education with the use of digital recording and with the reading of maths contents.

✔ Primary school students do not follow this approach.

4.09 In your opinion, what are the advantages offered by the use of a PC (particularly in situations of distance learning) compared to the traditional system of maths writing?

Like in the previous answer, we go from one extreme to the other. The most favorable responses cite advantages in the use of computers and are recorded in Italy, moderately in France and Germany, while those who do not see advantages are Polish teachers.

Here is a summary of the answers given, starting from the ones that show indicators of utility and advantage to the negative ones.

Useful:

✔ Through a PC and good programs, I can dictate the tasks at the same speed for everyone, I can exchange documents via Gsuite

✔ Blind students, as well as the others, can show their work which is displayed in graphic mode

✔ Flexibility, time saving, use of voice output

✔ The electronic format of mathematics facilitates uploading to platforms, checking and exchanging with students

✔ Fast communication. It is possible to make presentations via videoconference.

✔ Motivation, better handling, easier structure

✔ Fast availability; independent position

✔ Beside being an inclusive tool, using computers and the Lambda program means implementing integration

✔ Accessible work -> collaboration with Meet-SuS, since the same writing system is used

✔ Speech output -> faster understanding of texts, preparation for professional life, as PC is essential for blind students

✔ Quick sending and distribution of tasks in both directions, as well as the option of voice control or space-saving use of Braille.

✔ For visually impaired children, writing in black on paper is often easier and clearer and in distance learning they are asked to photograph their work and upload it to the platform.

✔ An advantage of PCs is constant spelling (for example, write in the correct position in case of crowding problems). The downside is that most programs cannot be tailored to the needs of students.

Not very useful:

✔ we do not use a computer for mathematical notation

✔ During distance learning, the computer was used for verbal communication with students (like the telephone). In primary school, blind students do not have great Braille maths skills and it was very difficult for them to learn and develop certain skills without the presence of a teacher

✔ Braille maths notation is difficult and requires direct supervision and support from an experienced teacher. All the students were very nervous and distracted, because the reverberation of the machines on which they were writing was so loud that it drowned out the teacher's voice, so they often had their microphone muted

✔ Parents do not know Braille and cannot replace the teacher. Computer learning will never replace traditional methods of working with blind students

✔ You cannot teach from a distance only thanks to communicators

✔ Student / teacher interaction is disturbed. Without digital recording, the teacher cannot control the students' work and creatively support them during the lesson, correct the notation according to Braille notation, cannot check and evaluate homework.

✔ Recording digital files would allow for effective remote work, comparable to work in class. Digital recording would make it easier for students to correct errors found in problem solving, which is currently impossible when working on a Braille machine. But there are no digital codes or formats to do this. So students invent their own modality, which is for his own use and consumption.

✔ Digital recording would facilitate the work on worksheets, where the student can enter the answer in a specific blank, without rewriting the activities in the notebook.

✔ Working on the computer is too difficult, but it is only necessary during distance learning, that is why it takes a lot of effort and students' progress is slow.

The Control Group expressed unanimous indications on the usefulness of personal computers even for the youngest children. If used well, the computer is fun, even if it requires to create long intervals for rest in between lessons.

7.5 Collaboration between teachers and students in the period of home learning

5.01 Please feel free to comment on the collaboration between teachers and visually impaired students and/or between visually impaired and sighted students.

The answers were multifaceted: in general collaboration appears to depend on the students' skills, there are undoubted difficulties, as waste of time, the need to explain the same issues several times, tiredness on both sides. Videoconferencing is not enough for blind children, contact via telephone has often been used (as more practical). DL is generally complex and not practicable, many pointed out that close contact is required because the difficulties are of a different nature: understanding, availability of the children, attention (it is easy to get distracted), need for cooperation. The greatest problem seemed to be the one of managing the entire class in DL with the presence of a blind student. He/she eventually risked being (or feeling) neglected.

In integrated schools, during DL there is a complete lack of exchange between sighted and blind students. Some teachers tried to broaden the use of LaTeX for everyone, so that it could become a useful work tool for all students. The result was interesting, even if the blind kids struggled to learn LaTeX and the sighted ones found the solution too complex, but interesting.

Families are reported not to have always been helpful; generally, collaboration lacked.

As a whole, the responses showing minimal satisfaction highlighted that this distance mode is a source of great frustration for students.

Also the control group pointed out some difficulties, such as the slowness in starting the lesson, the need to repeat several times, the tiredness of students, the necessity of greater commitment for the management of the portal and the platform.

5.02 How do you evaluate the results achieved in the distance learning period carried out with your blind or visually impaired students?

To confirm the answers of the previous question, the results of the period of school closure and of distance learning show worse results in terms of profit (and some also report worsening of grades) than in face-to-face teaching. Only the few very gifted students did not have any inflection, indeed they acquired greater autonomy and independence in the use of computers.

Better results were for the so-called "repetitive" or refresher activities, while difficulties emerged for completely new topics. Therefore, there was a period of compensation and review in the following months, after the return to school in attendance, leading to simplifying the program and postponing some topics to the following year.

Visually impaired students had fewer difficulties than totally blind ones and therefore a better profit. Indeed, visually impaired students, already accustomed to the use of video magnifiers and computers with magnifying programs, found themselves more comfortable than in face-to-face teaching.

Primary school children are the ones who had the most difficulties.

In integrated schools, however, it was possible to work hand in hand with the whole class, but this required the help of parents and additional activities, also via telephone.

5.03 You find it difficult or not satisfactory, what solutions could you suggest to improve the situation?

The teachers unanimously report that, in order to improve performance, distance education must work directly to make students more autonomous and faster, in managing time, study methods, materials and technologies. The most common words found in the answers are independence, autonomy, self-sufficiency, competence, development of abstraction, speed.

This requires a great deal of work that must be done at school, with the teachers face to face.

A second factor that causes difficulties is represented by the linear Braille writing of mathematics, which is too complex and always requires steps to simplify tasks and more time to study and work. A complexity that doubles in situations of DL. However, there is no other solution; this way of writing must be improved, and it must be taught with patience, by simplifying it when necessary.

Among the improvements there is also a request for greater collaboration with the families.

5.04 Feel free to add your comment.

Among the free comments there is a reference to active methods which are complicated to build in DAD: active discovery, teamwork, brainstorming, role playing etc.

Numerous references are to the low production of textbooks (which are said to be often delayed), which become essential in distance learning.

Primary school children need numerous typhlological tools for approaching numbers, calculating fractions, but these are only available at school and not in sufficient number to be distributed to everyone at home.

Other comments report that more extensive training would be needed for teachers in the use of platforms for DL, as well as in programs and aids for blind children.

7.6 Beyond mathematics: let's talk about chemistry, physics, science in general

6.01 Much of the information you have given above applies not only to mathematics, but also to physics and science subjects in general. With regard to these other subjects, we would like to know if you use different computer programs than the ones described above for your students; if so, which ones? are you satisfied with these tools? Or, as an alternative, which improvements or elements would you like them to provide?

In general, the teachers say that there are very few computer aids for other sciences, such as chemistry, and that they do not use computers, only voice explanation.

Sometimes they use instructional videos and the kids follow the verbal explanation.

One of the few possible existing aids, adaptable to blind students, is the Desmos or geogebra program.

In general, relief charts or periodic tables in relief are used.

This question produced few answers and many “I don't know”.

Considerations.

The interview with the teachers confirmed what had already emerged in the questionnaire of the students and their parents. The school is careful and prepared for face-to-face teaching, so it faced serious difficulty in the health emergency that forced school closures and special classes to move to remote teaching. Difficulties arose in particular for scientific subjects, as mathematics and geometry, since there are not so widespread alternative computer solutions or real support for 6-dot Braille.

The question of the lack of textbooks in mathematics Braille (but not only for all scientific fields) and the delay in their delivery often reappears in the answers of students, parents and teachers on several occasions. This reveals a structural

deficiency and the difficulty of transcription centers in the specific sector of scientific texts to meet the needs of students and teachers.

Finally, teachers need to work to make their students increasingly autonomous, faster and more skilled in their study work.

8. Survey questionnaire for user associations and Braille libraries

A specific questionnaire is addressed to associations, libraries, transcription centers, cooperatives that help blind children and their families in providing materials, transcriptions or study assistance. The questionnaire introduces the DDMTH project and then continues as follows:

User associations and Braille libraries have always been close to their associates, and we are convinced that especially in this period of health emergency your support for school-age children (10-19 years of age) has been very important.

With special attention to scientific studies (mathematics, physics, science, technology, chemistry) we ask you to answer the following questions so as to provide the DDMATH Project with some hints on the main problems you have encountered which required your intervention, for instance, need for additional Braille transcriptions, support for teaching programs or new technological solutions, support for videoconferencing programs, training for teachers, students or others.

In general, in European countries there are several associations for the blind at national or federated level, and several local offices. Libraries and transcription centers are limited in various countries and usually serve nationwide. By e-mail we invited national and local associations, libraries and transcription centers to participate in our research on user needs.

The invitation was sent by email to exactly 61 centers, including library associations and transcription centers, in the 4 countries participating in the project (including centers in Austria and Switzerland, in German and French). The responses and interest in the project were positive and in fact 22 questionnaires were collected as follows:

France	5
Poland	5
Germany	6
Italy	6

1. Yours is….?

The questionnaire identified the type of center/association.

Italy:	
User association (small <20 users)	4
Medium / large user association	
Library / transcription center	2
Germany:	
User association (small <20 users)	5
Medium / large user association	
Library / transcription center	1
Poland:	
User association (small <20 users)	3
Medium / large user association	1
Library / transcription center	1
France:	
User association (small <20 users)	2
Medium / large user association	2
Library / transcription center	1

2. In this emergency period, have you carried out interventions in favour of teachers and/or students experiencing home learning? If so, please give us a brief description of the intervention carried out.

The answers were very similar for all countries. The pandemic (and the consequent lock down) also forced associations to close or greatly reduce their activity. Therefore, and only in part, some libraries provided remote services for users, but none carried out additional distance training activities to teachers, just some limited advising on tools and IT aids to users.

3. **As an association or transcription centre or library, what problems and difficulties have you observed in schools delivering home learning activities?**

   The answers highlight the following difficulties:

   ✔ Lack of funds to have adequate IT tools for everyone.

   ✔ Distance learning solutions and communication platforms that are not very accessible if used independently, for example to catch up on homework.

   ✔ Luckily, the shipping service of books and Braille materials by traditional mail has not been suspended, and it was an excellent solution to meet user requests, as much as it was possible in that period.

4. **Have you implemented any training courses? If so, please tell us what topics were included and which were the most frequently requested ones by teachers or students**

   All of the responses reported that no specific training courses for students or teachers were activated by associations, transcription centers or user libraries during the school closing period. The associations themselves were closed or strongly reduced their commitment, and what was provided was only possible thanks to smart working.

5. **Have you noticed an increase in requests for Braille transcriptions of books? If so, in which subject areas?**

Almost all answers highlight that in France, Germany and Poland the transcription of scientific texts in Braille is considered complex and difficult. Therefore, considered that transcriptions were already few and limited in normal times, in the periods of lock down there has been no innovation or possibility to prepare new material and new transcriptions in Braille.

The opposite and in countertrend is what emerged in Italian transcription centers, which have received an increase in specific requests for scientific books on mathematics, chemistry, geometry, physics, and at least doubled the requests for transcriptions of entire chapters of textbooks in LAMBDA format. Since the transcription work is very expensive, schools preferred to reduce the number of pages by selecting a few chapters and inserting mainly the pages of the exercises in the transcription list.

A further element and a difficulty that emerges at a general level is the fact that there are numerous school texts on the publishing market, and teachers are free to choose the book they consider most suitable for their class, and that best suits their own style of teaching. This implies that demanding transcription work would be required for the numerous different books in existence, and this is not possible for a simple economic question due to the high costs of the transcription work. Therefore, for example, a single book is usually proposed and blind students even from different schools must adopt it, which is very common in Poland. The book is generally different from the one adopted by the teacher for the rest of the class. This frustrates children and adolescents because they cannot employ the same material as the whole class.

Sometimes, the adaptation and printing of Braille textbooks is delayed, due to the limited availability of experts who can transcribe such books. Schools do not always order textbooks for blind students on time; they have to seek funding themselves, and it all leads to even greater delay.

Ultimately, in all countries textbooks especially for foreign languages and science subjects are reported to lack, which is a general problem that has become more urgent with distance learning.

6. **Have you analyzed the market of the new technological proposals to make distance learning for visually impaired students accessible? If so, please comment.**

Unanimously, blind kids are reported to have regularly employed programs such as Meet, TeamViewer, Zoom, which are easier to use and more accessible, especially from a smartphone. For some of them, especially the younger ones, the presence of a sighted adult was required to provide the codes and activate the microphone. In any case, the existing tools were able to ensure communication between schools and students in distance learning.

Most answers emphasized that today, with the closure of schools, we must still refer to what exists and has been created for traditional teaching. In the future it would be important to dedicate specific research to these issues.

7. **What IT innovation, in your opinion, seems to be the most frequently required to improve the home learning environment?**

As far as transcription centers and associations are aware, most requests are for E-books in EPUB format, where the mathematical formulas are marked as MathML. Corresponding software / apps can reproduce these maths elements using speech synthesis.

Some libraries have experimented with automatic systems for converting maths books into spoken text, because they could be useful for accessing materials produced by teachers.

Considerations.

The number of filled-in questionnaires appears to be relevant when compared to the number of centers present at national level.

From the answers, it is clear that their main concern was aimed at supporting students for activities and subjects which are considered vocational for blind children, such as music, languages and the more humanistic subjects.

Numerous answers are short ones, of the type "no", "it was not done", "it was not observed", so it is clear that also these centers found themselves in an emergency, with relative closures or transfer to smart working. The center which responded with some emphasis that fortunately the postal services have not stopped working, once again makes us understand how much we rely on paper and Braille printing, while neglecting electronic texts, which can be distributed electronically, especially for areas such as mathematics. .

9. Conclusion

Sciences which study objects, entities or facts, both physical and social or cognitive ones, need information about the phenomena examined. This knowledge is obtained by a measuring process, which is considered one of the main elements to get knowledge. When you can express the features of an object through a number or a linguistic attribute, this element brings all the information about the property itself.

Unfortunately, not all ” measurements “ can be equally and perfectly measured. When you deal with “measurements “, such as difficulties in equations, or with typical features of social and cognitive sciences, the concept of measure gets a relevant importance because of the problems it can cause.

There are not precise procedures to measure look, taste, smell, the quantity of a service , the satisfaction of a customer. In our case, many variables were connected to open questions, even if we hardly managed to get them sufficiently homogeneous and classifiable.

The measurement of non-tangible attributes caused many operative problems. The first was to determine an adequate and objective concept, which could be expressed by empirical operations. The second problem was about the correspondence between a concept and the procedure of measurement. Finally, the third was about the construction of a scale of measurement which could require one or more interactions with the evaluating persons.

For these reasons, measurements which involve non-tangible attributes are more difficult to carry out and they often require the use of scales of a lower level, if compared with the ones we typically use. We usually base on properties which are mainly the equivalence and the arrangement (nominal and ordinal scales). It is difficult for a person to express an evaluation with more evolved properties, such as intermission properties, but in some items we managed to obtain it.

This can explain the apparent contradiction of the students’ answers to some questions. Differently from teachers and from the control group, students did not always understand all the questions correctly.

After collecting information, the problem was analyzing and elaborating them without modifying their meaning. We usually take information back to numerical data, which can be easily treated despite the way they have been collected. During the operation of “translation”, it is fundamental to know the empirical properties both of the collected data and of the scales used. In the applications we sometimes notice, a “ promotion “ of these properties, with the introduction of additional hypothesis, for example in the distribution of the answers and in the interpretation of data made by the evaluators.

What is absolutely necessary to test , in order to avoid emptying the initial information of their meaning, is the reliability of the assumed hypothesis.

We have used simple techniques of descriptive statistics in order to maintain the informative quality of the data: moda, average, correlation, statistic graphics, etc.

The validity of the research has been expressed through independent criteria, out of the aim that the questionnaire wants to measure. This happened with the two control groups , made of students and teachers who did not have visual disabilities. They were important groups in the overall system of the research, in order to allow controls on the data with regard to their coherence and reliability.

The research has been achieved with a precise sample but the control group, composed of students without sighting problems, has crossed many of these answers: for example, the greatest difficulties expressed by the visually impaired group, in formulas ,expressions, geometry, compared with ones of the control group.

The research can be interpreted as a “ focus group “ where the collection of the needs has not taken place using the technique of the group interview but making individual interviews, mainly led by an interviewer and based on an observation grid.

The needs emerged during the statistical research, where we have mainly observed visually impaired people, are the following:

✔ greater skills in the use IT tools should be acquired , with greater attention to accessibility

✔ training systems should devote more time to teaching IT solutions and technologies, to offer better basic skills, for example for the use of distance learning tools, and to participate in collaborative networks between students

✔ greater digital skills are also required in the sense of getting a useful and conscious use of the computer and the programs, in order to improve the study and access to information (database archives, etc.), but also for games, for free time and to use social networks.

✔ technologies are present in everyone's life, but this also clashes with the fact that aids are not always available, because they are expensive or obsolete

✔ students, but also their families, highlight the need for new skills and professionalism in the digital field; these should be acquired at school, yet there are numerous shortcomings such as, for example, the lack of digital books, and the fact that the mechanical typewriter is still used to do mathematics even in high school.

✔ need for new specialized tools for writing and managing mathematics.

✔ need for sufficient time to study and deepen contents; extra time as compared to normal daily activities.

In all this, the Coronavirus effect on digital skills is evident, effect which has found many students, teachers and transcription centers unprepared.

The development of digital skills appears to be not an easy undertaking, there should be an incentive for it; the lock down appeared to trigger this stimulus so that students took a step forward by enriching their wealth of digital skills. Life moved online with remote schooling and everyone had to put in an extra effort. Students became more familiar with computers, with writing and videoconferencing programs; teachers developed audio lessons, test forms and even used mobile phones in the most critical cases. But this development did not take place for scientific subjects and for mathematics.

For mathematics, in some cases, MathML and LateX were used in order to be able to communicate remotely, while in Italy (in contrast) the use of Lambda and the transcriptions of books in Lambda was encouraged.

In general, as concerns the study of mathematics in Braille the represented realities of four states show diversified approaches:

✔ for France, Germany and Poland:

- a general application of 6-dot Braille exists, which is managed through traditional text writing tools (word pad, MSWord etc.) or in some cases even through a mechanical typewriter
- LaTeX and speech synthesis are used, but only for the most capable students and for high school.

✔ For France, 6-dot mathematical Braille is produced for the purpose of printing on embossed paper using conversion programs from MathML to Braille

✔ In Germany the 8-dot SMSB code is also used, but by a small minority (6%).

✔ The Lambda 8-dot system is widely used in Italy and the production of transcriptions of mathematics textbooks has grown during the Lock down period.

In all countries, however, there is a strong need for transcriptions of textbooks, and in the age of digital and distance learning, transcriptions that can be used via personal computer and not only on embossed Braille paper are particularly needed.

The questionnaire dedicated to associations, libraries and transcription centers highlights the fact that the transition from face-to-face to remote teaching led to a further emergency and increased the difficulties already existing with regard to teaching, with the availability of materials and transcriptions of scientific texts. In the health emergency phase, with the closure of schools, the centers found themselves unprepared to be a reference, to be proactive, to train teachers, in particular common schools ones.

Closures were generalized for everyone, including associations. The development and research of technological and innovative solutions for aids to blind children are known to be progressing more slowly than in other technological fields, for the fundamental reason that this is a niche market and not very attractive for investments. Therefore, the educational proposals based on the technological solutions on the market today are the same started about 20/15 years back (Braille lines, Braille printers, etc.) and all oriented towards traditional face-to-face teaching. From the difficulties reported, a very urgent necessity emerges, that is to start a process of innovation of teaching models detached from traditional approaches, which can suggest new proposals for technological research, in order to guarantee the need for flexibility that emergency situations such as the recent one (which still has not been overcome) may request.

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11. Appendix A - Students' and Parent's Questionnaire

1. The "DDMATH" questionnaire (age 10-19 years) - EN

Short introduction to "DDMATH Project"

The acronym "DDMATH" means: "Digital Mathematics Education for Blind Students". The "DDMATH project" aims to improve access to mathematics for visually impaired students in a home learning context. In particular, the project aims to develop teaching strategies and solutions for accessible digital mathematics, such as producing mathematical texts in a digital Braille format.

It is a two-year project, supported by the European Union (through the Erasmus + program) with participation of 4 countries: Italy, France, Germany and Poland.

In the first phase of the project we will do our best to understand the needs of the project recipients, i.e. visually impaired students, and especially to recognise the issues that have emerged during the period of home learning.

We would like to question you on your approach to mathematics, including the computer use applied to mathematics, as well as any previous experience of it, and whether you have had to acquire new skills for home learning.

This questionnaire is strictly anonymous, however, if you send us your e-mail address, we will keep you updated on the development of the project.

We thank you very much in anticipation for your cooperation in the project, which will hopefully prove useful to you and also to your classmates.

2. Background details

This section contains some basic information about the interviewee, which will be useful to better situate his/her next answers.

1. 2.01 Where do you live? (in the city/what is your nearest city, state)

2. 2.02 How old are you?

3. 2.03 Is your school exclusively or mainly for visually impaired students?

Contrassegna solo un ovale.

- a) It is exclusively for blind and partially-sighted students
- c) It is a mainstream school, which often admits visually- impaired- students
- d) It is a mainstream school, which rarely admits visually- impaired- students

4. 2.04 What is your visual disability?

Contrassegna solo un ovale.

- a) I am totally blind or with some residual vision
- b) I am partially sighted

5. 2.05 Do you have any other special needs besides your visual impairment? (e.g. hearing or motor impairment etc)

Contrassegna solo un ovale.

- a) yes
- b) no

6. 2.06 Do you know Braille ?

Contrassegna solo un ovale.

- a) Yes, I can read and write it efficiently
- b) Yes, I can read or write it, but with some difficulties
- c) I have difficulties both in reading and writing it
- d) No, I don't know it at all

3. You and mathematics

In this section we would like to ask you about your approach to mathematics (i.e. your interest in the subject, motivation, self-esteem, possible frustration etc.) – if any

7. 3.01 WHow do you view the role of mathematics nowadays?

Contrassegna solo un ovale.

- a) Necessary for everybody
- b) Useful for everybody, but only required for some specific jobs
- c) Useful in many cases, but one can live even without it

8. 3.02 With regard to your mathematical difficulties, do you think mathematics is:

Contrassegna solo un ovale.

- a) A subject like any other
- b) Easier than other subjects
- c) More difficult than other subjects
- d) much more difficult than other ones

9. 3.03 Do you think your difficulties in studying mathematics are linked to your visual disability?

Contrassegna solo un ovale.

- a) Yes, I think that they are mainly linked to it
- b) Yes, but this is not the only reason
- c) I think they are mainly due to other causes
- a) I do not know

10. 3.04 Do you believe that the home learning adopted in this last year has disadvantaged your learning compared to regular school attendance. If yes please describe in what way.

4. Mathematical difficulties

It is common for people to experience difficulties in arithmetics.

11. 4.01 Do you usually use a speaking calculator or a Braille one to perform calculations?

Contrassegna solo un ovale.

- Almost always
- When I have to perform complicate calculations
- Rarely
- Never

12. 4.02 What resources do you usually use to read and study mathematics?

Contrassegna solo un ovale per riga.

	Always or nearly always	Sometimes	Rarely or never
Braille textbooks			
Audio textbooks			
Digital textbooks, which cn be read through the speech synthesizer			
Embossed drawings, charts and tables			
Solids or other embossed models			
Other tools:			

13. 4.03 What reasources do you usually use to write mathematical texts, solve problems and equations?

Contrassegna solo un ovale per riga.

	Always or nearly always	Often	Rarely or never
Slate and the stylus			
Braille typewriter			
Computer			
Portable Braille note-taker			

14. 4.04 Which tools do you usually use when to do mathematical calculations which canot be done mentally

Contrassegna solo un ovale per riga.

	Always or nearly always	Often	Rarely or never
The cubarithm	◯	◯	◯
Braille typewriters	◯	◯	◯
Speaking calculators	◯	◯	◯
Computers or Braille portable note takers	◯	◯	◯
Other things:.....	◯	◯	◯

15. 4.05 Please indicate how difficult you find each of the following activities :

Contrassegna solo un ovale per riga.

	Very easy	Easy	Average	Difficult	Unknown action
a) Use of punctuation marks (example: brackets, commas, full stops etc)					
c) Arithmetic (for example: the carrying out of operations: sums, multiplications, divisions, square roots, calculations with simple fractions)					
d) The study of plane geometry					
e) The study of solid geometry					
f) Use of logic notation and the use of the set theory (for example: an empty set, an infinite set, a set which contains or is part of another one, the use of the "not and or" terms and so on)					
g) Algebra (for example: calculations with algebraic fractions, resolution of linear or quadratic equations, sets etc)					
h) The study of analytical geometry					
i) Use of data charts (the understanding of relationships starting from their two components)					
j) Use of charts and bar charts (eg: the analysis of statistical data)					
k) Use of logarithms in equations					
l) The study of analysis (limits, derived functions, integrals)					

16. 4.06 What problems do your usually face in solving algebraic expression?

Contrassegna solo un ovale per riga.

	Very Easy	Easy	Average	Difficult	Very difficult
Presentation (e.g. can you read parenthesis and powers)	◯	◯	◯	◯	◯
Understanding (e.g. how parentheses and powers work)	◯	◯	◯	◯	◯
Checking (check and read again parts of expession	◯	◯	◯	◯	◯
Memory (too many things to remember at once)	◯	◯	◯	◯	◯
Manipulation	◯	◯	◯	◯	◯

5. Experiences in the use of the computer

17. 5.01 Have you got a computer for your exclusive use?

Contrassegna solo un ovale.

- ◯ I have to share it with other people
- ◯ I have no computer at my disposal

18. 5.02 Has it been adjusted to your specific needs so that you can perform your school activities:

Contrassegna solo un ovale.

- ◯ a) Yes
- ◯ b) Partly
- ◯ c) No

19. 5.03 Can you use your computer

Contrassegna solo un ovale.

- a) Both at school and at home
- b) At home only
- c) At school only
- d) No, I cannot

20. 5.04 Which access peripheral devices do you have?

Contrassegna solo un ovale.

- a) Audio synthesis
- b) Braille display
- c) Other things

21. 5.05 Which activities do you usually carry out with the computer?

Contrassegna solo un ovale per riga.

	Always or nearly always	Sometimes	Rarely or neve
I compose text (both school texts and other texts)			
I read books (both textbooks and audio books)			
I browse the Internet			
I communicate via e-mail/social media			
I browse dictionaries/encyclopaediae			
I use music files (I listen to them, I work on them, I burn them and so on)			
I play games			

22. 5.06 Are you satisfied with your workstation? (also considering the use of home learning)

Contrassegna solo un ovale.

- ◯ Yes, I am
- ◯ No, I am not

23. If not, please describe why?

24. 5.07 Please describe your level of efficiency on the following computer activities

Contrassegna solo un ovale per riga.

	High	Medium	Satisfactory	Insufficient	Unknown action
Typing with the use of the standard computer keyboard	◯	◯	◯	◯	◯
Understanding how a new program works	◯	◯	◯	◯	◯
Using the 8-dot-Braille code	◯	◯	◯	◯	◯
Memorization of some shortcut keys	◯	◯	◯	◯	◯
Finding your position on the PC screen through the use of the screen reader	◯	◯	◯	◯	◯

25. 5.08A - What program do you use to do mathematics on your computer?

Contrassegna solo un ovale.

- A purposely designed program
- A general use editing program which is also suitable for this
- A general use editing program without any adjustments

26. 5.082 B Which one?

_____

27. 5.09A Are you satisfied with the program you are currently using to carry out mathematical activities on your computer? (also considering a use of home learning)

Contrassegna solo un ovale.

- Yes, I am
- No, I am not, because (multiple choices are possible):
- B1 It does not work with the screen reader software
- B2 It is not very functional
- B3 It is not very quick
- B5 Other reasons

28. 5.09B If other reasons, please descibe?

_____

_____

_____

_____

_____

29. 5.10 Which computer mathematical notation system do you usually use to correctly represent all the mathematical objects? (for example a code associated to the specific program in use, or a general use textual code like "TeX" code or the "LaTeX" one, or a specific code for the Braille computer or for the speech synthesizer like the "AMS" code the 8-dot-SMSB-Braille code, Lambda code, simplified "LaTeX" code, a code, which was invented by me/my teachers)

30. 5.11 What are the biggest difficulties you experienced while doing mathematics on your computer? (also considering use of home learning

31. 5.12 Do you usually use the computer to read/study mathematical texts in their digital format?

Contrassegna solo un ovale.

- A Yes I do, very often
- B No, I do not, because I prefer studying with other systems
- C No, I do not, because I cannot find the texts in their digital format

32. 5.13 Have you any comnments on the exchange of maths study resources and homework with your teacher during remote learning

6. Section for parents

In this section parents will ask for little information on their commitment that has proved necessary to support their children in distance learning, especially for mathematics.

33. 6.01 This section is about the way your child uses home learning. Has your child done home learning due to recent restrictions. If your answer is no, you can skip this entire section.

Contrassegna solo un ovale.

- Yes
- No

34. 6.02 Compared to face-to-face teaching, did you find your child's interest in reading increased during home teaching period ? If so, can you briefly indicate the kind of reading preferred by them.

35. 6.03 For mathematics and scientific studies in general did you have to equip yourself with new programs or new IT solutions? If yes, can you briefly tell us what and which ones?

36. 6.04 What were the most important difficulties you experienced in supporting your child's home learning, in particular in maths ?

37. 6.05 What advice could you offer to those developing training solutions for blind students to improve home education?

7. Collaboration

The portal full of educational proposals of the DDMATH project on the website www.ddmath.eu will be implemented by 2021. www.ddmath.eu
If you as parent are interested in evaluating and testing the contents of the portal with your child, please contact the project directly at the following e-mail address: giuspaccini@gmail.com indicating: surname, first name, type of school, city, country, e-mail address.

Thanks for your help!

12. Appendix B - Teachers' Questionnaire

1. Quiz for teachers / school workers - EN

The “DDMATH project” aims to improve access to mathematics for visually impaired students in a home learning context and to facilitate the teachers’ work in these circumstances. The acronym "DDMATH" means: "Digital Mathematics Education for Blind Students".
In particular, the project aims to develop teaching strategies and solutions for accessible digital mathematics adequate for totally blind as well as partially sighted students.
It is a two-year project, supported by the European Union (through the Erasmus+ program) with participation of 4 countries: Italy, France, Germany and Poland.
In this initial stage we are mainly interested in understanding the needs of the users, i.e., visually impaired students, but also their teachers, especially considering the issues that have emerged for them during the period of home learning.
Thanks a lot for your collaboration.
The DDMATH Team

2. General information

1. 2.01 You are:

Contrassegna solo un ovale.

- ◯ Teacher of mathematics
- ◯ Headmaster/headmistress
- ◯ Expert in special needs
- ◯ Political referents of education and special education
- ◯ Other

2. 2.02 Do you work in?

Contrassegna solo un ovale.

- ◯ Primary school
- ◯ Secondary school
- ◯ College/university

3. 2.03 Ils your school exclusively or mainly for visually impaired students or is it a mainstream school?

Contrassegna solo un ovale.

- ◯ It is exclusively/mainly for blind and partially sighted students
- ◯ It is a mainstream school which often admits visually-impaired students
- ◯ It is a mainstream school which rarely admits visually-impaired students

4. 2.04 How long has it been your job?

Contrassegna solo un ovale.

- ◯ 1-5 years
- ◯ 6-10 years
- ◯ more of 10 years

5. 2.05 In total, how many visually impaired students have you taught maths or supported in any other form in your career?

Contrassegna solo un ovale.

- ◯ More than 20
- ◯ From 5 to 20
- ◯ From 2 to 5
- ◯ Only one case

6. 2.06 Do you know Braille?

Contrassegna solo un ovale.

- ◯ Yes, I write and read with no problems
- ◯ Yes, but with some difficulties in reading or writing
- ◯ No, I don't know Braille at all

7. 2.07 Do you know Braille mathematics?

Contrassegna solo un ovale.

- ◯ Yes, I do
- ◯ Yes, but not very well
- ◯ No, I don't know it at all

8. 2.08 Do your visually impaired students know Braille?

Contrassegna solo un ovale.

- ◯ Yes, they do
- ◯ Yes, but not very well
- ◯ No, they don't, because the don't need it (partially-sighted)
- ◯ No, but it would be useful

9. 2.09 What mathematical notation do your students use?

_____

_____

_____

_____

_____

10. 2.10 Do you find it satisfactory?

Contrassegna solo un ovale.

- ◯ Yes
- ◯ No

11. 2.11 If not, in 2.10 ... what are the deficiencies?

3. Difficulties in mathematics (and other exact science) experienced by students with visual impairment

12. 3.01 Based on your experience, please evaluate which of these two aspects of maths proves to be more difficult for visually-impaired students:

Contrassegna solo un ovale.

- Understanding general principles, rules and theorems
- Solving expressions, equations and problems

13. 3.02 Rate the degree of difficulty for students with visual disabilities in the following areas (choose only the areas applicable to the education level your students are at):

Contrassegna solo un ovale per riga.

	easy	medium	difficult	unknown
Use of punctuation marks (e.g., brackets, comma, full stop…)	◯	◯	◯	◯
Distinction between base text, superscript and subscript (e.g., powers, variables with index, base of logarithms, vectors)	◯	◯	◯	◯
Arithmetic (e.g., to do an operation: sum, product, division, square root, simple calculus)	◯	◯	◯	◯
Plane geometry	◯	◯	◯	◯
Solid geometry	◯	◯	◯	◯
Use of the logic and set notation (e.g.: empty set, infinity, contain, belong, not and or…)	◯	◯	◯	◯
Algebra (e.g.: calculus with algebraic fractions, solution of first- and second-degree equations)	◯	◯	◯	◯
Analytic geometry	◯	◯	◯	◯
Use of data charts (the understanding of relationships starting from their two components)	◯	◯	◯	◯
Use of graphs and histograms (e.g., understanding the kind of relation or proportionality between quantities, analysis of statistical data	◯	◯	◯	◯
Use of logarithms in equations	◯	◯	◯	◯
The study of analysis (limits, derived functions, integrals)	◯	◯	◯	◯

14. 3.03 When they solve algebraic equations, students with visual disabilities have problems with:

Contrassegna solo un ovale per riga.

	easy	medium	difficult
Presentation (reading brackets and powers and understanding how numbers and variables are in relations between each other)	◯	◯	◯
Comprehension (undestanding how brackets and powers act and what they do with numbers and variables)	◯	◯	◯
Checking (check and read again parts of equations in every moment)	◯	◯	◯
Memory (difficulty in remembering several things at a time)	◯	◯	◯
Manipulation (difficulty in solving an equation when you must isolate a variable)	◯	◯	◯
Speed (too much time taken to solve an equation because of the problems described before)	◯	◯	◯

15. 3.04 Do you think that a visually-impaired student would require more time and/or practice to obtain satisfactory results?

4. The use of computer in the time of home learning

16. 4.01 Do your visually-impaired students use a computer?

Contrassegna solo un ovale.

- ◯ Yes, both at home and at school
- ◯ Yes, but only at home
- ◯ Yes, but only at school
- ◯ No
- ◯ I don't know

17. 4.02 What are the activities that they normally do with the computer?

Contrassegna solo un ovale per riga.

	Often	Sometime	Rarely or never	I don't know
Writing	◯	◯	◯	◯
Reading books or other texts	◯	◯	◯	◯
Browsing the Internet	◯	◯	◯	◯
E-mailing	◯	◯	◯	◯
Consulting dictionaries or encyclopaedias	◯	◯	◯	◯
Managing musical files (listening to, manipulate, copy…)	◯	◯	◯	◯
Playing games	◯	◯	◯	◯

18. 4.03 Do you consider your students' computer equipment adequate for distance learning?

Contrassegna solo un ovale.

- Yes
- No
- Maybe

19. 4.04.1 If not, why not? What is missing?

20. 4.05 Do you consider your students' computer knowledge adequate?

Contrassegna solo un ovale.

- Yes
- No
- Maybe

21. 4.05.1 If not, why not? What else should they be able to do?

22. 4.06 Which program do your students use to write maths on computer?

Contrassegna solo un ovale.

- ◯ A specialized program
- ◯ A standard editor adapted for mathematics
- ◯ A standard editor, without adaptation
- ◯ LAMBDA
- ◯ I don't know

23. 4.06.1 Which program?

_____

24. 4.07 When students write maths on PC how do they represent mathematical symbols?

Contrassegna solo un ovale.

- ◯ TeX or LaTeX
- ◯ Code AMS (ASCII Mathematical Notation)
- ◯ Braille 8-dot code SMSB (Stuttgart Math Notation)
- ◯ Lambda Code
- ◯ A code devised locally
- ◯ one another

25. 4.07.1 If you wrote "one another", Which?

_____

26. 4.08 Do you think Braille supported by modern technology (Braille displays, embossers) facilitates studying mathematics and other exact sciences by visually-impaired students?

27. 4.09 What do you think are the advantages offered by the use of the PC (in particular in the situation of distance learning) as compared with to the traditional system of maths writing?

5. Collaboration between the teacher and students in the time of home learning

28. 5.01 Please feel free to comment on the collaboration between the teacher and visually impaired students and/or between visually impaired and sighted students.

29. 5.02 How do you evaluate the results achieved in the distance learning period carried out with your blind or visually impaired students?

30. 5.03 You find it difficult or not satisfactory, what solutions could you suggest to improve the situation?

31. 5.04 Feel free to add your comment.

6. Beyond mathematics: let's talk about chemistry, physics, science in general

32. 5.01 Much of the information you have given above has value for mathematics, but also for physics and science subjects in general. We ask you for these other subjects if you use computer programs other than those described above for your students and in doing so tell us which ones, and if you are satisfied with these products or alternatively which improvements or elements you would like them to be different or improved.

7. Thank you very much for your contributiong

The portal full of educational proposals of the DDMATH project on the website www.ddmath.eu will be implemented by 2021. We ask you if you are interested in evaluating and testing the contents of the portal with your students, and in this case contact the project directly at following email address: giuspaccini@gmail.com indicating: Surname and name, type of school, City Country, Email.

Thank you very much for your contributiong!

13. Appendix C - Association's Questionnaire

1 - Survey questionnaire for user associations and braille libraries - EN

The "DDMATH project" aims to improve access to mathematics for visually impaired students who use the computer with Braille display or speech synthesizer. The acronym "DDMATH" means: "Digital Mathematics Education for Blind Students".
In particular, the DDMTAH project intends to develop teaching proposals and work strategies on various topics of accessible digital mathematics, as well as guidelines for teachers useful for the production of mathematics texts in digital Braille formats.
It is a two-year project, supported by the European Union (through the Erasmus + program), with participation of researchers from 4 countries: Italy, France, Germany and Poland.
In this very first stage of the project we are really interested in understanding the needs of the users i.e. blind students from the countries involved in the project. This is why we kindly ask you to answer the questions in this questionnaire.
User associations and Braille libraries have always been close to their associates, and we are convinced that especially in this period of health emergency your support for school-age children (10-19 years of age) has been very important.
With special attention to scientific studies (mathematics, physics, science, technology, chemistry) we ask you to answer the following questions so as to provide the DDMATH Project with some hints on the main problems you have encountered which required your intervention, for instance, need for additional Braille transcriptions, support for teaching programs or new technological solutions, support for videoconferencing programs, training for teachers, students or others.

1. 1.1 Yours is.

Contrassegna solo un ovale.

- ◯ User association (small <20 users)
- ◯ Medium / large user association
- ◯ Library / transcription center

2. You have carried out interventions in this emergency period in favour of teachers and/or students experiencing home learning, and if so, give us a brief description of the intervention carried out

3. 1.3 As an association or transcription centre or library, what problems and difficulties have you observed in schools delivering home learning activities?

4. 1.4 Have you attended any training courses? If so, please tell us what topics were included and which were the most frequently requested ones by teachers or students

5. 1.5 Have you noticed an increase in requests for Braille transcriptions of books, if so, in which subject areas?

6. 1.6 Have you analysed the market of new technological proposals for accessible distance learning for visually impaired students? If so, please comment.

7. 1.7 What IT innovation, in your opinion, seems to be the most frequently required to improve the home learning environment?

14. Peer Review di Federico Benini, Presidente della Winpoll Srls,

Ho esaminato la relazione sulla ricerca sui bisogni realizzati dal Team del progetto DDMATH.

L'indagine, svolta con metodologia Cawi, si basa sulla compilazione di un questionario somministrato a studenti non vedenti, di un questionario per i loro genitori, per docenti di matematica che hanno una certa esperienza con studenti non vedenti ed infine per le associazioni e centri di trascrizione in braille.

Come è stato correttamente esplicitato all'interno della ricerca stessa, il questionario trova un campione non casuale che delinea con precisione un profilo dello studente della fascia di età dai 10 ai 19 anni, ossia della scuola fine della primaria, secondaria di I e di II grado.

Il processo statistico e i suggerimenti si basano sulle principali linee guida e strutture della statistica descrittiva: calcoli, media, correlazioni probabili e alcuni grafici statistici per rendere più efficienti valori e dati.

Il metodo di validazione attraverso gruppi di controllo è abbastanza buono, sia per gli studenti che per gli insegnanti (in primo luogo un gruppo di studenti vedenti della stessa età degli intervistati, in secondo caso qualsiasi gruppo di insegnanti di matematica senza esperienza di studenti disabili).

Le pagine elaborate sono abbastanza ampie e i suggerimenti sono opportunamente localizzati.

A livello globale, il numero di questionari raccolti non è così elevato ma è sicuramente sufficiente per questa tipologia di indagine. Infatti, occorre tenere in considerazione la tipologia del campione: i ragazzi ciechi sono in numero molto esiguo, rispetto alla popolazione scolastica generale, e la loro presenza non è certo centralizzata entro singoli istituti a livello provinciale, (e quindi facilmente rintracciabile per una azione di invito e sensibilizzazione), ma è distribuita in scuole sparse su tutto il territorio.

Inoltre, il campione è abbastanza rappresentativo per tutti i territori degli stati membri nonché per le diverse fasce di età.

Per quanto riguarda il numero delle risposte, un elemento molto importante è stata la complessità dei questionari stessi che ha richiesto, a mio avviso, un'attenta analisi e valutazione delle risposte. I questionari, infatti, sono molto ampi e affrontano in modo significativo una serie di problemi anche importanti, come l'atteggiamento dell'utente nei confronti della materia nei confronti della matematica e delle sue difficoltà, le sue competenze con il computer per presentare, infine, una richiesta dettagliata di informazioni su eventuali esperienza e migliorie richieste nell'uso del PC in ambito matematico.

L'utilizzo di più domande aperte non ha consentito una piena standardizzazione delle risposte ma questo, come si può desumere dal rapporto, ha mirato a raccogliere tutte le informazioni possibili su un'eventuale esperienza intrapresa soprattutto in un contesto di didattica a distanza.

Trovo questo approccio importante e corretto anche per integrare il lavoro svolto dal consorzio stesso sullo stato dell'arte, che ho già esaminato;

Dall'analisi delle risposte, a mio avviso, emergono indicazioni importanti in questo campo soprattutto colpisce la differenza spesso evidenziata nel report di approccio tra Germania, Francia Polonia a confronto con l'Italia in cui è diffuso e utilizzato il sistema Lambda. Lambda in Italia, infatti, sembra essere lo standard di fatto, unitario e condiviso tra studenti e docenti e centri di trascrizione, potendo probabilmente portare ad una stretta condivisione di esperienze e di materiali tra i vari attori.

Quanto ai risultati, chiaramente emerge che la matematica è per molti studenti ciechi una disciplina non facile da affrontare, che condiziona il loro percorso scolastico e formativo.

Una proposta formativa come quella del progetto DDMATH appare quindi non solo utile ma in grado di fornire un contributo determinante e significativo alla soluzione del problema.

Infine, un'analisi sul campionamento dell'indagine, svolta su 179 questionari. Con un intervallo di confidenza della gaussiana al 99%, possiamo stimare il

margine di errore delle risposte intorno al 5%. Il dato trova conferma anche tra le risposte date dagli intervistati rispetto al Paese di origine, dove non si riscontrano sostanziali differenze sulle domande poste. Inoltre, il campione (che è già di per sé molto specifico) è estremamente omogeneo per età e riduce al minimo le differenze del campione stesso, che possono generare delle distorsioni dal punto di vista statistico ed aumentare quindi il margine di errore.

14.1 Curriculum vitae di Federico Benini

Dott. Federico Benini, laurea magistrale in Economia press l'Università degli studi di Verona, scrive una tesi di statistica sulle metodologie dei sondaggi di opinione.

Federico Benini ha collaborato in modo continuativo con Huffington Post dal 2016 al 2017.

Nel 2014 fonda Winpoll, un istituto demoscopico che opera in tutto il territorio nazionale e ne è amministratore.

Wirpol SRLS è una azienda specializzata in analisi statistiche, indagini quantitative di mercato. sondaggi, analisi del consenso di politici, istituzioni, aziende, amministratori locali ed aspiranti tali attraverso indagini quantitative realizzate sul territorio interessato.

Conduce indagini di mercato per istituzioni ed aziende al fine di fornire una chiara analisi, propedeutica ad azioni di marketing strategico e operativo.

Wirpol ha maturato una ampia esperienza nel saper impostare la valutazione della dimensione del campione che sia la migliore e ideale per l'indagine, in modo da individuare fin dal principio il margine d'errore della rilevazione, basandoci sulle caratteristiche degli obiettivi del sondaggio e della natura dei campioni.

Wirpol collabora con Il Sole 24 Ore, Proforma, Centro Italiano studi Elettorali, Elif Lab, Demetria opinioni e molti altri.