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**MATH LEARNING
ASSISTANCE FOR
PEOPLE WITH
BLINDNESS OR
LOW VISION
USING ARTIFICIAL
INTELLIGENCE
THROUGH A FREE
SOFTWARE MOBILE
APPLICATION**

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Abstract. This study will investigate the information available on visual impairment in order to understand the mathematics learning process in students with blindness or low vision who attend schools. It will analyze the means they use, their difficulties, as well as the current developments in ICT and the different ways of possible developments that can serve as a guide for these students and their teachers, becoming a means of teaching/learning. After the analysis, we will conclude with the programming of a prototype of a mobile application that, using voice and the sensors of the touch screen of a cell phone, will allow people with blindness or low vision to make geometric figures with their fingertips. Currently, the integration of an artificial intelligence model is being developed so that the student can choose the geometric figure to draw and, within the virtual environment, obtain answers to questions related to mathematics, simulating the presence of a tutor to accompany him in his learning. In addition, there are plans to add new functions such as assisted mathematical calculations.

Keywords: disability, accessible technologies, inclusion, artificial intelligence, learning, teaching

INTRODUCTION

In order to be a fairer society, it is necessary to include everyone, from people in street situations, offering them not only a place to live, resources and the necessary means to meet their needs, but also ways to get out of that situation, as well as people in the context of confinement, creating tools to break the vicious circle that perpetuates in time, in most of these people, their situation and that has been analyzed in other publications, from the sick in the research of new treatments and medicines to cure diseases, people with various disabilities, among others. In our country there is currently much talk of inclusion from the language in the so-called inclusive language, but our reality is

that 8 out of 10 people with disabilities do not get a job according to the National Agency on Disability (ANDIs)[1] which can contribute, among many others, to increase their social exclusion and poverty in the “recognition of the existence of a vicious circle disability-poverty that is documented in many countries” (Bellina Yrigoyen, J., 2013)[2].

PROBLEM STATEMENT

Description of the problem

At present, there are 3.620 high school students with visual impairment (La Nación, 2023)[3] out of 5.1 million people, i.e. 12.9% of the total Argentine population with some disability [2], so it is necessary to take measures from multiple areas and especially from education to reverse this situation of exclusion, and specifically in the present case study, by means of the research carried out, that the difficulties in the study of mathematics of students with blindness or decreased vision is not a cause of stigmatization or another cause of desertion that has increased in general (CIPPEC, s.f.)[4] in recent years due to the consequences the COVID-19 pandemic, although the official publication (Dirección Nacional de Evaluación, Información y Estadística Educativa, 2022)[5] of the National Ministry of Education published in 2022 only analyzes the evolution of enrollment in the special education modality up to 2019, which is prior to the beginning of the COVID-19 pandemic, so indicators and information published from other sources such as various Non-Governmental Organizations (NGOs), books, scientific and academic publications, in specialized journals, newspapers and conferences citing such sources are also included in the research. Although in this introduction disability is approached not only from the topic under investigation, it is important to take into account the framework where the

problems in learning that have been detected and investigated are developed (Gajardo Alveal, S., & Rojas Zavala, O. M., 2017)[6] to be able to analyze then the specific topic since this influences it reciprocally being disability multidimensional, dynamic, complex and object of discrepancy, definition according to the World Report on Disability.

Problem formulation

Worldwide, at least 2.2 billion people suffer from visual impairment (World Health Organization [WHO], 2020) [7] and in Argentina it is estimated that around 900,000 people have some degree of visual impairment (National Institute of Statistics and Census [INDEC], 2018) [8]. In the approach to education in blind or visually impaired people is “to provide them with education which is equivalent to developing as much as possible their individual potential to make them useful to , their family and the society in which they live, without forgetting that the common thread of any program should be the development of communication and the acquisition of language” (Consejería de Educación, Dirección General de Participación e Innovación Educativa, 2008)[9] in our case focused on formal symbolic language, mathematical notation and within its branches, geometry, which deals with the study of the properties of figures in the plane or space, which are the two areas where these people have the greatest difficulties [6]. Argentina has a debt in terms of the correct implementation of inclusive education programs for students with disabilities (Cinquegrani, M. A., 2022)[10] and it is also a debt of the educational system of most of the countries of the American continent (Fernández, C., 2018)[11] which includes in what is investigated corresponding to the Secondary Education or Secondary Education that in our country is Public of State Management and Private Management (National Education Law No. 26,206, 2006)[12].

JUSTIFICATION

It has been shown that the implementation of Information and Communication Technologies (ICTs) in classrooms helps in the teaching-learning processes, being an important source of teaching resources for students with disabilities, allowing the consolidation of inclusion by enabling schools with various teaching strategies, bringing into play different ways of learning, proposing new educational scenarios, allowing in turn to develop skills to function in the social context, among many others [8].

ICTs are a starting point and will often mean the difference between exclusion and inclusion. From this perspective, if we do not use inclusive technologies in the classroom, it is likely that we are contributing to such exclusion. ICTs “(...) enrich the teaching process and facilitate the learning of different curricular contents (Parette and Vanbiervliet, 1992); have an impact intellectual development through the development of higher order thinking and the learning of problem-solving skills (Brasford, Goldman and Vye, 1991); facilitate the learning of strategies (Ryba and Chapman, 1983); develop sequence association (Ugarte, 1990) and memory (Black and Wood, 2003; Ugarte, 1990); make the most of conserved faculties and intelligence (Imbernon, 1991); increase self-esteem, autonomy, independence and self-determination (Davies, Stock and Wehmeyer, 2001; Imbernon, 1991); and enhance labor and social integration (Pérez, Ruiz, and Troncoso, 1997). (Soto Pérez, F. J., 2013) [13].

THEORETICAL FRAMEWORK

Research background

We found several types of learning strategies through which students-teachers teach-learn, it is important to make a review of them that will be taken later in the various methodologies and learning strategies mentioned in students with visual impairment, with or without the

use of ICTs. The following will describe how the use of ICTs in education by blind students helps them in their learning in mathematics, through the use of different programs (software) and physical devices that use these programs (hardware) mostly a personal computer or a smartphone, but there have also been found developments that use for example a talking calculator (Rueda Díaz, B. A., 2020) [14].

The qualitative and quantitative results of studies such as stimulation of spatio-temporal structures in blind children indicate that when using software based on editors with specialized sound interfaces, together with a careful methodology of case application in blind children, with cognitive tasks and tests of representation of spaces and times initially navigated in virtual audio worlds, the learner can develop spatio-temporal mental structures, diversify and deepen the experiences of their use and transfer them to everyday tasks. The above leads to feedback the methodology to be created for the prototype established in the present work with particularities of case and sound environment for the immersion of the student in the abstract concepts of mathematics (Rueda Díaz, B. A., 2020) [14].

We find as background “Braille and mathematics” by José Enrique Fernández del Campo which has provided a “Scientific-matematical notation” which I have found relevant for us so that we were able to adapt this notation into a prototype [14], this scientific-matematical notation helps blind children learn mathematics using Microsoft Excel spreadsheet, a Lambda mathematical text editor, and a talking calculator.

The use of adapted physical materials has also been shown to improve learning.

Several studies that have explored the development of reasoning processes and concept acquisition in blind students are conclusive in stating that there are no significant differences (particularly qualitative ones) in the development of formal thinking skills between blind and sighted students. Both

groups use similar strategies to solve problems based on abstract concepts (MEN, 2006). According to the previous document, it was necessary to adapt some materials such as a perforated Cartesian plane, a graduated protractor, and a graduated protractor for the study of probability, since the institution did not have the materials required for the teaching-learning of mathematics. (Gutiérrez Molano, E. A., & Guataquira Quevedo, O., 2017)[15].

Cardozo argued that “the use of ICT with blind and low vision students will facilitate access to information and written production” (Cardozo, 2014), (as cited in [15]) so the practical applications of Artificial Intelligence (AI), as a tool ICT, in the Education of people with disabilities are multiple, and we can use it in the design of advanced study programs that include personalized tutorials according to the student's profile (NGO Educo..., 2023)[16] which is created internally by the AI, according to its interaction with the system, because AI is not a static process, but develops with its use, which makes it more complex by increasing its content and internal connections, coupled with the ability of its algorithms to process large amounts of information and make decisions, providing the student through it, learning content and personalized evaluations [16] finally allowing him to adapt the content of the educational material to his specific characteristics, to determine the knowledge and skills that form the system, as well as to increase the efficiency of the professional activity of a teacher (Sadykova, A.R., & Levchenko, I.V., 2020)[17]. Where its uses in the educational process is one of the most important tasks in modern education (Artificial Intelligence in Education, 2020) [18], keeping in mind education as the basis of human development (Singh, K. ,2016)[19] (Contreras, F., & Alejo, M., 2019)[20].

HYPOTHESIS

To learn about the mathematics learning process of visually impaired people in schools in order to research and develop ICT tools with artificial intelligence, such as, for example, an open source and free mobile application to assist them in their learning.

METHODOLOGY

The methodology of this research work is descriptive and projective, with a qualitative approach. It is descriptive because it is a fundamental requirement prior to the collection and analysis of data to know how the learning process is in students with visual impairment or decreased vision, and then, in a second stage, currently under development, the methodology will be projective, seeking to solve the problem that has been evidenced.

For the development of this research the qualitative approach was carried out where several sources were analyzed which are cited in the References section, this has been done to analyze the background on the subject that allows us to obtain a conclusion on the impact of ICTs, including for example the integration of Artificial Intelligence (AI) in the prototype, as a guide according to the interaction of the student with visual impairment or decreased vision by means of an application, for example, which is only one of the multiple tools used in education, in the learning processes of students as social subjects that modify their environment, transform it and, reciprocally are transformed by it, always bearing in mind education as a means of transformation, generator of the process of social change (Iovavich, M. L., 2003)[21].

We used the Paper.js framework used in the programming of vector graphics scripts, choosing the object-oriented programming language Javascript because it is an interpreted programming language that can run in most browsers without the need for installa-

tion and because it is easy to adapt it to mobile devices using, for example, the Apache Cordova framework, which is also free software.



Figure 1. Main page of the prototype accessible from the URL: <http://santimonia.org/accessibility>

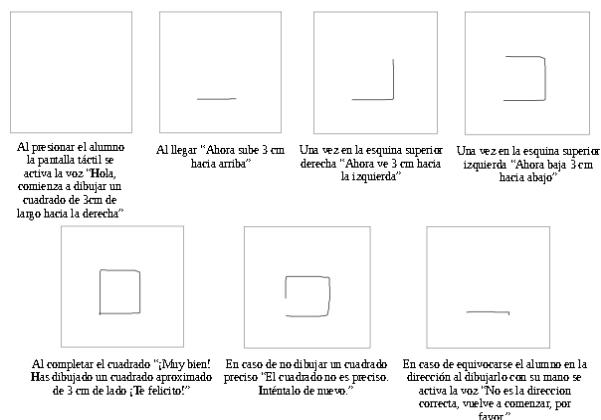


Figure 2. Very simple implementation of the prototype that guides the student by voice in the realization of a geometric figure. Accessible from the URL <http://santimonia.org/accesibilidad/index19.html>.

The project is about to be uploaded to GitHub that includes the implementation that his voice (SpeechRecognition) the student can choose the geometric figure to draw, and within the virtual environment, can get answers on questions related to mathematics, simulating the presence of a tutor, to be connected through the API of Mistral AI. This company has been chosen because it is free

software and is focused on energy efficiency, reducing the polluting environmental impact generated by the processing of large amounts of data (Big Data), since pollution is one of the causes of disability-poverty that triggers the exclusion of people. The implementation in the prototype is with Web Speech API that is compatible with most current browsers. In an example using voice, the student asks the program: "What is a square and why does it have four sides?", that question is sent through the API forming the *input* that the artificial intelligence model processes and responds using the speech synthesizer (SpeechSynthesis), the answers are only as an example.

```
describe('Mistral AI', () => {
  let client;
  beforeEach(() => {
    client = new MistralClient();
  });

  describe('chat()', () => {
    it('Debe devolver el objeto de la respuesta del chat', async() => {
      const mockResponse = mockChatResponsePayload();
      client._fetch = mockFetch(200, mockResponse);

      const response = await client.chat({
        model: 'mistral-large-latest',
        messages: [
          {
            role: 'student',
            content: '¿Qué es un cuadrado y porque tiene cuatro lados?',
          },
        ],
      });
      expect(response).toEqual(mockResponse);
    });
  });
});
```

Figure 3. JS Client library for the Mistral AI platform. Retrieved: <https://github.com/mistralai/client-js>

(IA): "A square is a geo-metric figure with four equal sides and four right angles (of 90 degrees each). It has four sides because it is a specific type of quadrilateral, which is a figure with four sides.". Student: "What are ninety degrees in an angle and why does the square have four angles?" (AI): "Ninety degrees is the measure of a right angle, which is an angle that forms an "L". The square has four right angles because it is a requirement for its sides to be equal and parallel, forming a balanced figure.". Student: "It's hard for me to draw the four sides and have them equal, how can I make them equal?

(AI): "Sure! Imagine this: 1. Draw a straight line to the side of the . 2.From the end of that line, draw a straight line up. 3.From the end of that line, draw another straight line to the side back to where you started. Finally, close the square by drawing a straight line down, back to the beginning. Now you have a square!".

CONCLUSION

It is essential in the XXI Century where we, because of the reciprocity demonstrated between ICTs and the improvement in learning that in any educational process, not only related to students with various disabilities, they are always present. The economically poorest countries are the most vulnerable, since they cannot access special equipment or implement classes remotely without taking into account whether students with various disabilities as happens in Ghana, a country on the African continent and also in countries that are called developed, such as the United States, where some problems were evidenced where the COVID Pandemic19 highlighted these problems in learning that already existed a long time ago, for this and other reasons in countries considered economically poor, the information on the number of students with disabilities who have dropped out of school is omitted (Simeone, O., 2018)[22], as also happens in our country, so it is not only an economic issue, but a political one.

As a conclusion to this introduction to the research on how children and young people with visual impairment learn mathematics without the use of computers, their difficulties especially in the areas of geometry and calculus with algebraic expressions, and the great advances that have been achieved by various investigations that have been cited in such learning by incorporating the use of ICTs in the classroom, can be taken as a basis for other future developments, and the great advances that have been achieved by various investigations that have been cited in such learning

by incorporating the use of ICTs in the classroom, can be taken as a basis for other future developments, among the same incorporating the AI that is currently very promising not only in the field of education, or to continue research on this topic since there is much biography available for analysis. The project link on Github is as follows: <https://github.com/sergiooscarfauez/guidedlearning>.

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REFERENCES

1. Agencia Nacional de Discapacidad, “8 de cada 10 personas con discapacidad no tienen trabajo en Argentina,” *Página12*, 2022. URL <https://www.pagina12.com.ar/464426-8-de-cada-10-personas-con-discapacidad-no-tienen-trabajo-en-argentin>.
2. J. Bellina Yrigoyen, “Discapacidad, mercado de trabajo y pobreza en Argentina,” *Dialnet*, 2013. URL <https://dialnet.unirioja.es/descarga/articulo/4234635.pdf>.
3. *La Nación*, “Discapacidad visual. Entregarán dispositivos que pasan texto a voz a estudiantes secundarios,” 2023. URL <https://www.lanacion.com.ar/sociedad/discapacidad-visual-entregaran-dispositivos-que-pasan-texto-a-voz-a-estudiantes-secundarios-nid11022023/>.
4. Centro de Implementación de Políticas Públicas para la Equidad y el Crecimiento (CIPPEC), “El impacto de la pandemia en la educación secundaria en Argentina y América Latina,” 2023. URL <https://www.cippec.org/proyecto/el-impacto-de-la-pandemia-en-la-educacion-secundaria/>.
5. Dirección Nacional de Evaluación, Información y Estadística Educativa, *Informe Nacional de Indicadores Educativos: situación y evolución del derecho a la educación en Argentina*, 1a ed., Ciudad Autónoma de Buenos Aires: Ministerio de Educación de la Nación, 2022. ISBN: 978-950-00-1583-7. URL https://www.argentina.gob.ar/sites/default/files/informe_nacional_indicadores_educativos_2021_2_1.pdf.
6. S. Gajardo Alveal y O. M. Rojas Zavala, “Aprendizaje de matemática en estudiantes en situación de discapacidad visual que acceden a la educación secundaria. Un estudio de caso,” Universidad de Concepción, 2017. URL <http://repositorio.udc.cl/bitstream/11594/2510/4/AlvealRojas.pdf>.
7. Organización Mundial de la Salud, *Informe mundial sobre la visión*, Ginebra: OMS, 2020. URL <https://apps.who.int/iris/bitstream/handle/10665/331423/9789240000346-spa.pdf>.
8. M. Gallegos Navas, *La inclusión de las TIC en la educación de personas con discapacidad. Relatos de experiencias*, Quito: Universidad Politécnica Salesiana, 2018. ISBN: 978-9978-10-331-9. URL <https://dspace.ups.edu.ec/bitstream/123456789/17078/1/La%20inclusio%CC%81n%20de%20las%20TIC%20en%20la%20educacion%20de%20personas%20con%20discapacidad.pdf>.
9. Consejería de Educación, Dirección General de Participación e Innovación Educativa, Junta de Andalucía, *Manual de atención al alumnado con necesidades específicas de apoyo educativo derivadas de discapacidad visual y sordoceguera*, ISBN: 978-84-691-8128-7, 2008. URL https://sid-inico.usal.es/idocs/F8/FDO23841/apoyo_educativo_visual_sordoceguera.pdf.

10. M. A. Cinquegrani, *Entre la resistencia, el amor y la esperanza. Familias, discapacidad y educación*, Buenos Aires: Editorial Biblos, 2022. ISBN: 978-987814-024-7.

11. C. Fernández, “La situación del derecho a la educación inclusiva en América Latina,” en *Ciclo de Webinarios sobre Educación Inclusiva*, Organización de los Estados Americanos (OEA)-Red Regional por la Educación Inclusiva de Latinoamérica (RREI), 2018.

12. *Ley de Educación Nacional 26.206*, República Argentina, 2006.

13. F. J. Soto Pérez, “Promoviendo el uso de tecnologías inclusivas en contextos educativos diversos,” *Enter 2.0. Revista Digital*, vol. 1, pp. 14-22, 2013. URL <https://www.ciberespiral.org/enterados/wp-content/uploads/2013/09/Soto-TICInclusivas.pdf>.

14. B. A. Rueda Díaz, “Implementación de un dispositivo de enlace entre docentes y estudiantes con discapacidad visual en el área de matemáticas,” *EDÉDVAM*, Universidad Pedagógica Nacional, Universidad Militar Nueva Granada, 2020.

15. E. A. Gutiérrez Molano y O. Guataquira Quevedo, “Estrategias de aprendizaje de matemáticas en estudiantes con ceguera o baja visión,” Universidad Nacional Abierta y a Distancia (UNAD), Escuela Ciencias de la Educación (ECEDU), 2017. URL <https://repository.unad.edu.co/handle/10596/12082>.

16. ONG Educo, “Aplicaciones de inteligencia artificial (IA) en la educación,” 2023. URL <https://www.educo.org/blog/aplicaciones-de-ia-en-la-educacion>.

17. A. R. Sadykova y I. V. Levchenko, “La inteligencia artificial como componente del contenido innovador de la educación general: análisis de la experiencia mundial y perspectivas nacionales,” *Revista de la Universidad Rusa de la Amistad de los Pueblos*, 2020.

18. “Inteligencia Artificial en la Educación,” *Boletín pedagógico de Sebastopol*, 2020.

19. K. Singh, “La educación es un bien público y una obligación moral,” *Semana de Acción Mundial para la Educación*, UNESCO, 2016. URL <https://www.unesco.org/es/articles/semana-de-accion-mundial-para-la-educacion-la-educacion-es-un-bien-publico-y-una-obligacion-moral>.

20. F. Contreras y M. Alejo, “Educación: base del desarrollo humano,” *Revista Digital Postgrado*, vol. 8, no. 2, e177, 2019. URL <http://portal.amelica.org/ameli/jatsRepo/101/101676008/html/index.htm>.

21. M. L. Iovanovich, “El pensamiento de Paulo Freire: sus contribuciones para la educación,” CLACSO, Consejo Latinoamericano de Ciencias Sociales, 2003. URL <https://biblioteca.clacso.edu.ar/clacso/formacionvirtual/20100720092748/19iovanovich.pdf>.

22. O. Simeone, “A very brief introduction to Machine Learning with applications to Communication Systems,” *Institute of Electrical and Electronics Engineers (IEEE)*, 2018. URL <https://ieeexplore.ieee.org/document/8542764>.