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ASSISTIVE LETTERS - WRITING AID TOOL FOR CHILDREN WITH DISABILITIES AND ACADEMIC DIFFICULTIES

Filippi Benevenuto Ongarelli*[1], Huemerson Maceti[1,2], Vinicius Benatti[1]

[1]*Colégio Puríssimo Coração de Maria, Rio Claro – SP.*

[2]*Fundação Hermínio Ometto – FHO.*

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***Corresponding Author: Filippi Benevenuto Ongarelli**

Colégio Puríssimo Coração de Maria, Rio Claro – SP.

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ABSTRACT

Currently, many people face challenges in everyday activities due to lack of fine motor coordination and learning difficulties, which compromises their autonomy and social inclusion. Tasks that require precision, such as writing, drawing, and handling objects, become complex, affecting academic performance and social interaction. The present project proposes an innovative solution to these difficulties through the creation of three assistive alphabets for educational purposes, using an inclusive, technological approach based on the Maker Culture. The objective of the project is to promote the development of fine motor coordination and the learning of writing in individuals with limitations, such as children with cerebral palsy, muscular dystrophies and other neurological disabilities. The project was divided into three phases: initially, a Tactile Alphabet was created to stimulate perception and muscle memory by touching the letters. In the second phase, a Channel Alphabet was developed, which allows children to trace the letters with the help of an adapted pen, promoting more interactive learning. In the third phase, the Assistive Cursive Alphabet uses a steel sphere guided by a magnetic pencil, facilitating motor control and the formation of cursive letters. The research that underlies the project highlights the importance of adaptive and interactive educational methodologies for the inclusion of students with motor difficulties. The lack of adequate pedagogical interventions can create barriers to learning and full participation in educational environments. Thus, the project aims to create an accessible and inclusive environment, where each student can progress at their own pace, developing the confidence necessary for social interaction. This project contributes to educational inclusion,

offering an accessible and low-cost tool, capable of being implemented in various school contexts.

KEYWORDS: Accessibility; Inclusion; Literacy.

I. INTRODUCTION

Currently, many people face significant challenges in their daily activities due to difficulties in fine motor coordination and learning, which impacts their autonomy and social inclusion. These limitations can manifest themselves in various situations, making it difficult to perform tasks that require precision, such as writing, drawing, and manipulating objects. This scenario not only compromises academic performance, but also generates barriers to social interaction and full participation in educational environments. Several factors contribute to this problem, the most relevant being the lack of adapted educational methodologies and the absence of appropriate technical support. Traditional teaching approaches often do not consider the specific needs of students who have learning difficulties, resulting in frustration and demotivation. In addition, the scarcity of resources and initiatives that integrate technology and pedagogy makes it even more difficult to develop the motor skills necessary for writing and other daily activities. A study by the Institute of Applied Economic Research (IPEA) highlights that the social and educational inclusion of students with motor and learning difficulties requires adequate investments and innovative approaches that consider the specificities of each student. By contrast, most support programs still focus on generic solutions, leaving aside the personalization of learning. This lack of attention to individual needs results in an educational environment that is often not inclusive. Since the implementation of initiatives aimed at inclusive education, it has been observed that interactive and adaptive methodologies can significantly improve the autonomy and confidence of students with motor and learning difficulties. Projects that utilize technology, such as laser-cut letter templates and adaptive writing tools, have shown promising results in promoting learning. However, these solutions are not yet widely adopted and remain restricted to a few contexts. Fine motor coordination is an essential skill for various daily activities, impacting academic, professional, and social performance. For many students, especially those who have conditions that affect motor control - such as cerebral palsy, muscular dystrophies, and other neurological disabilities - developing this skill represents a significant challenge. These limitations can compromise not only writing, but also the expression of ideas and feelings, generating frustration and negatively affecting self-esteem.

For these students, the difficulty in developing fine motor coordination makes the learning process more challenging, often resulting in social and academic exclusion. The lack of mastery of this skill transforms activities considered simple for most into complex and exhausting tasks, contributing to a growing lack of interest and, in some cases, even to school dropout.

KEYWORDS: Disabilities; Academic Difficulties; Technology; Maker; Science, 3D.

II. OBJECTIVE AND PROBLEM ISSUE

A. *Issue Problem*

The difficulties faced by students with fine motor coordination problems during the literacy process are a challenge that directly impacts the development of writing, an essential skill in the early years of elementary school. Fine motor coordination is crucial for precise control of the movements required to hold the pencil, form legible letters, and arrange strokes in space appropriately. When this skill is compromised, the learning of writing can be significantly impaired, affecting not only the quality of the texts produced, but also the child's self-esteem and engagement in the educational process. Children with motor difficulties may be slow in performing tasks that involve writing, as well as fatigue and frustration, which compromises learning and motivation. The lack of manual dexterity affects the ability to keep up with the pace of classroom activities, impairing the development of spelling and spelling. In addition, Ferreiro and Teberosky (1986) highlight that motor mastery is essential for the construction of the relationship between sound and spelling, a fundamental part of literacy. When a child cannot master the physical part of the act of writing, his focus is diverted from phonetic and semantic relationships, making it difficult to advance in the understanding of written language. Several authors emphasize that motor development and literacy are interconnected and that the stimulation of motor skills should be part of pedagogical planning. Early intervention strategies, such as the use of playful activities that promote motor coordination, are essential to minimize the impacts of these difficulties. Therefore, it is essential that educators and specialists understand the importance of supporting students with motor difficulties, offering pedagogical tools and strategies that favor the development of writing and the inclusion of these students in the learning process.

B. Objective

This project aims to promote the learning of writing and improve fine motor coordination in individuals who face school difficulties, through the use of innovative and adaptive solutions.

To this end, an assistive cursive alphabet was developed for educational purposes, with an inclusive approach that seeks to explore the benefits of assistive technology. This alphabet will allow all participants to practice the act of writing in a guided way, respecting their individual limitations. Additionally, the project aims to create a more inclusive and accessible educational environment, where each student can progress at their own pace, developing the confidence necessary to fully interact in society. The playful and interactive methodology is essential to make learning more engaging, promoting not only motor development, but also the autonomy and social participation of all involved.

It is important to note that this tool was designed with an optimized cost-benefit ratio, aiming at its accessibility. Its MDF construction reflects a commitment to sustainability, ensuring that the project meets the needs of users while simultaneously respecting the environment. The project is based on an educational model that simulates the daily routine of students, allowing the practice of writing to be naturally integrated into their daily lives. The assistive alphabet will be used in school activities, facilitating the practice of writing during classes and at home, where students will be able to continue their learning autonomously. Throughout the day, the material will be available for use in a variety of contexts, ensuring that the practice of the writing movement is constant and integrated into the participants' daily lives. In this way, the assistive alphabet not only becomes a learning tool, but also aligns with the students' daily activities, enhancing practice and contributing to effective motor development. With this approach, it is expected that teachers and students will experience a more efficient, inclusive and transformative literacy process, where physical barriers are minimized and the potential of each child is fully valued.

III. DESCRIPTION OF MATERIALS AND METHODS

A. Development

During the development and manufacture of the letters, a calligraphy notebook pattern was adopted, which divides the letters into three parts: Top, Center and Bottom. This approach aims to facilitate the learning of writing by allowing students to more clearly understand the structure of the letters and the correct position in the line of writing. The proposed division contributes to greater precision in the formation of characters, favoring the stabilization of writing and, consequently, the autonomy and confidence of the students. Right below, there is the image representing the division made.

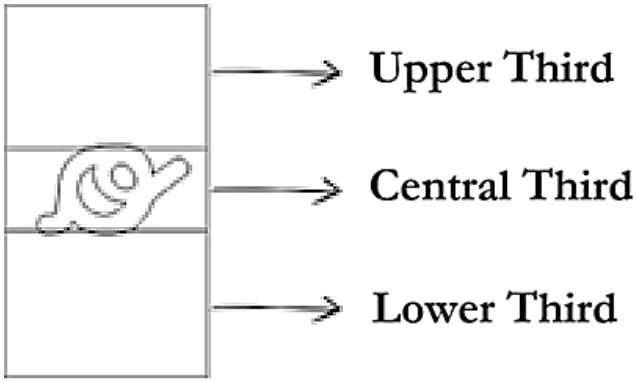

FIGURE 1 - DIVISION OF SECTORS FOR STANDARDIZATION OF LETTERS - SOURCE: THE AUTHOR

Additionally, the research included the analysis of different styles of letters and their respective applicability in the educational context, in order to identify which characteristics most favor effective learning. The application of this pattern in the development of letters enriches the educational experience and integrates concepts of ergonomics and accessibility, ensuring that the assistive alphabet works as an effective tool for all students. Ultimately, the implementation of this strategy in the school environment has the potential to positively impact students' academic performance and self-esteem, promoting more inclusive and meaningful learning.

B. Tactile Alphabet - Phase 1

The Alphabet in Shape Letter was designed with the aim of making it easier for children to see the letters by adopting a tactile approach that encourages learning to write. The structure of this alphabet is made up of precisely crafted molds, allowing users to explore the shapes of the letters through touch, promoting a deeper understanding of each character. The construction of the alphabet begins with the manufacture of MDF molds, which are laser cut to ensure precision in the contours and dimensions appropriate to the practice of writing. Each letter is marked in a way that allows children to run their fingers through its shapes, thus developing tactile perception and muscle memory. This direct contact with letters provides a learning experience that is both practical and engaging. The letters are presented in a clear and accessible way, making it easy to understand their characteristics and structures. This tactile approach not only assists children in recognizing letters but also encourages them to become more confident in their ability to write. To complement the alphabet proposal, the Helvetic font was used, which gives it a friendly and attractive visual aspect. In this way, the Tactile Alphabet is not limited to being a tool for learning to write, but also establishes itself

as a valuable resource for sensory development and social inclusion, providing an effective and enjoyable educational experience. Below, the image of the Tactile Alphabet, used in phase 1, is presented, which illustrates the developed proposal, accompanied by the image of a student with Down syndrome and a student with hydrocephalus using the Tactile Alphabet.

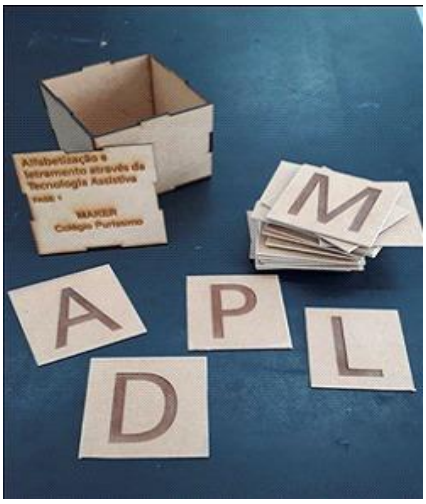

FIGURE 2 - TACTILE ALPHABET - PHASE 1 - SOURCE: THE AUTHOR

FIGURE 3 - 2ND YEAR ELEMENTARY SCHOOL STUDENT, WITH DOWN SYNDROME - SOURCE: THE AUTHOR

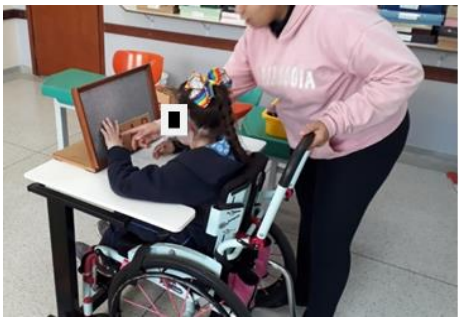

FIGURE 4 - STUDENT OF THE 2ND YEAR OF ELEMENTARY SCHOOL, CARRIER OF HYDROCEPHALUS - SOURCE: THE AUTHOR

C. Gutter Alphabet - Phase 2

In the continuity of the development of the Channel Alphabet, the present phase was designed with the aim of deepening the interaction of children with the letters, adopting an approach that stimulates the learning of writing in a significant way. As in the previous phase, the structure of this alphabet is composed of rigorously elaborated molds, incorporating a relevant innovation in the form of interaction. The construction of the alphabet begins with the manufacture of MDF molds, which are laser cut to ensure precision in the contours and dimensions appropriate to the practice of writing. At this stage, instead of marks that allow children to pass their fingers, the innovation consists of the implementation of a channel made with a laser. This approach allows users to use a pen, developed through 3D printing, accompanied by a support designed to position the finger properly. This new methodology offers a learning experience that is both practical and engaging, promoting a deeper understanding of each letter. The letters are presented in a clear and accessible way, making it easy to understand their characteristics and structures. This innovative approach not only assists children in recognizing letters but also encourages them to develop greater confidence in their writing skills. The interaction with the pen and the channel provides a direct contact that reinforces the learning process.

To complement the alphabet proposal, the same font as the previous alphabet, Helvetica, was used, which gives it a friendly and attractive visual aspect. Thus, the Channel Alphabet is not limited to being a tool for learning to write, but establishes itself as a valuable resource for sensory development and social inclusion, providing an educational experience that is both effective and enjoyable. Below, the image of the Alphabet Canaleta, used in phase 2, illustrates the proposal developed, accompanied by the image of a student with motor difficulties using the Alphabet Canaleta.

FIGURE 5 - CHANNELED ALPHABET - PHASE 2- SOURCE: THE AUTHOR

FIGURE 6 - 3RD YEAR STUDENT WITH MOTOR DIFFICULTIES - SOURCE: THE AUTHOR

D. Cursive Alphabet - Step 3

The assistive cursive alphabet was designed with the intention of facilitating the learning of writing for individuals with disabilities that affect fine motor coordination. The structure of this alphabet is made up of elaborate molds that incorporate a small metal ball inside, allowing users to practice the formation of the letters in a guided and interactive way. The construction of the alphabet begins with the creation of laser-cut MDF molds, ensuring precision in the contours and dimensions suitable for the practice of writing. Each letter has an internal space specifically designed to accommodate the steel ball, which acts as a "control point" during the activity. This little ball is designed to move smoothly along the strokes, offering a dynamic learning experience. At the heart of this system is the assistive pencil, which has a neodymium magnet at the tip. This magnet is essential as it exerts a magnetic force that pulls the metal ball as the user traces the letters. This magnetic interaction not only facilitates the movement of the ball, but also allows participants to focus on the gesture of writing, developing their fine motor skills in a playful and intuitive way. The assistive cursive alphabet design is designed to provide an adjustable challenge to different skill levels, allowing users to practice at their own pace. The combination of the metal ball and the assistive pencil transforms the practice of writing into an engaging activity, stimulating the confidence and autonomy of the participants. We used the MamaeQueNosFaz font because it is a cursive font, which complements the alphabet proposal and makes the material even more accessible and enjoyable. It is worth mentioning that the font was digitally modified using the CorelDraw program, allowing adjustments that specifically meet the needs of the project. Thus, the assistive cursive alphabet not only offers a tool for learning to write, but also establishes itself as a valuable resource for motor development and social inclusion. Below, the image of the Cursive Alphabet, used in phase 3, is presented, which exemplifies the proposal developed.

FIGURE 7 - CURSIVE ALPHABET - PHASE 3 - SOURCE: THE AUTHOR

E. Assistive Pencil

The assistive pencil was developed with the aim of facilitating the practice of writing for individuals with motor difficulties. Using a 3D printer, the pencil design was created in the Tinkercad software, which allows you to model objects intuitively and accurately.

During the development process, we conducted a lot of research on the structure of the pencils and their functions, which led us to the decision to create a triangular pencil. This format not only offers a firmer grip but also helps prevent slippage by providing greater control while writing.

The pencil structure has been ergonomically designed, ensuring that it fits comfortably in the user's hand, promoting easier and more natural handling. The use of 3D printing made it possible to customize the pencil, allowing adjustments to the dimensions and shape to meet the specific needs of each participant.

At the tip of the pencil, a neodymium magnet was incorporated, which plays a crucial role in the interaction with the small metal ball present in the molds of the assistive alphabet. This magnetic force allows the ball to move along the contours of the letters as the user traces, providing a playful and interactive learning experience.

In addition to its functionality, the assistive pencil is lightweight and durable, features that are essential to ensure a comfortable user experience over long periods. 3D production also contributes to the sustainability of the project, as it allows for the efficient use of materials and the possibility of local production.

In this way, the assistive pencil not only facilitates the development of fine motor skills, but also integrates seamlessly with the assistive cursive alphabet, creating a learning environment

that is both accessible and motivating. Below is the image of the Assistive Pencil, used in phase 3.

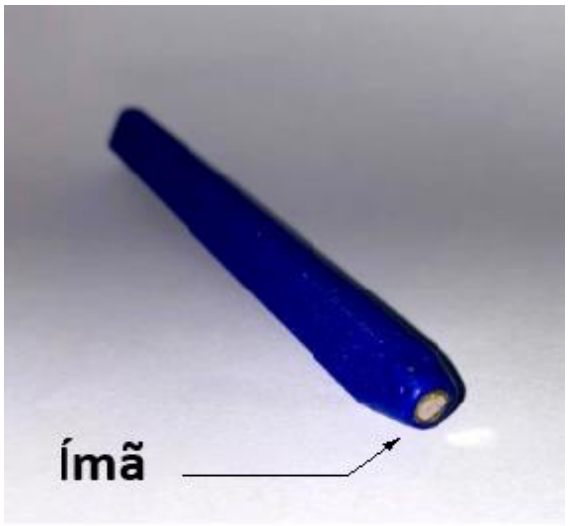

FIGURE 8 - ASSISTIVE PENCIL USED IN THE CURSIVE ALPHABET (PHASE 3), DEVELOPED THROUGH THE TINKERCAD PLATFORM - SOURCE: THE AUTHOR

F. Assistive Pencil Adapter

The construction of an assistive thimble, designed to facilitate learning the correct pencil grip, represents a significant innovation in teaching writing to children with motor difficulties. This device, developed through the TinkerCad (3D Modeling) platform, is designed to act as a support that guides users in the proper position of the fingers when holding the assistive pencil. The thimble has two guides, one for the index finger and the other for the thumb, ensuring that the child maintains the correct position while writing. This ergonomic structure not only promotes the proper practice of gripping, but also contributes to the development of fine motor coordination, which is essential for carrying out everyday activities. The thimble development process involved the use of 3D modeling, which made it possible to create a design optimized for comfort and learning effectiveness. 3D printing allowed the production of prototypes with high precision, ensuring that the dimensions and contours of the thimble were suitable for children's use. Additionally, the use of TinkerCad allowed for adjustments to the design, ensuring that the thimble was both functional and practical. 3D printing enabled the fast and efficient production of thimbles, facilitating the implementation of the project in educational environments. In short, the construction of the assistive thimble, with its guides for the index finger and thumb, represents an innovative approach in the teaching of writing, promoting not only the correct technique of holding the

pencil, but also the inclusion and autonomy of children in the literacy process. Below, the image of the Assistive Pencil Adapter, developed through the TinkerCad platform, is presented.

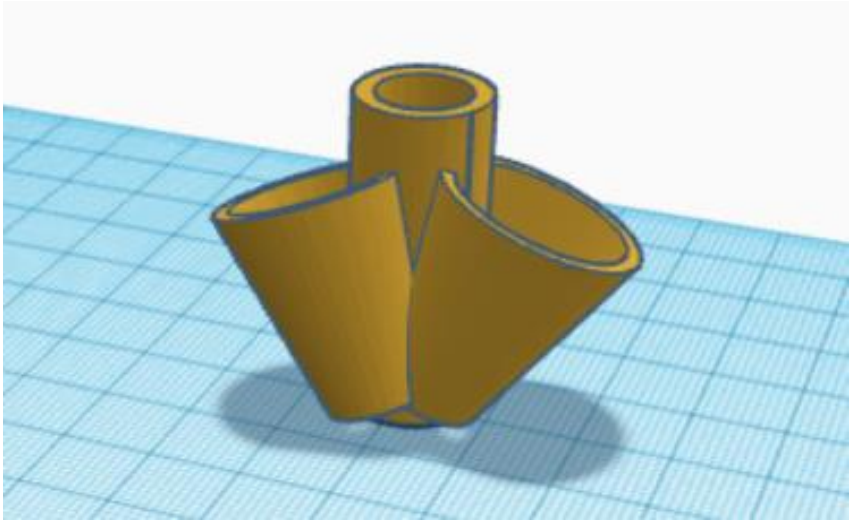

FIGURE 9 - ADAPTER FOR THE ASSISTIVE PENCIL, DEVELOPED THROUGH THE TINKERCAD PLATFORM - SOURCE: THE AUTHOR

G. Main Rail

The rail where the letters are positioned is an essential component of the project, designed to ensure accuracy and stability during writing practice. This rail allows the fitting of letters so that words can be formed. For its construction, five layers of laser-cut MDF were used, totaling half a 3 mm MDF sheet. This choice of material and manufacturing technique makes it possible to obtain a robust and durable structure, with perfectly defined contours that facilitate the interaction of users with the letter molds.

Each layer of MDF has been carefully cut to create a precise fit that ensures proper attachment of the letters. The use of laser cutting not only provides high precision in dimensions, but also ensures smooth and well-defined finishes, which are fundamental to the user experience. The layers were joined together to form a solid rail, capable of withstanding the pressure exerted during writing practice.

The overlapping of the layers contributes to the strength of the rail, making it able to withstand the wear and tear of continuous use. In addition, the multi-layered structure offers a lightness that facilitates manipulation, without compromising the stability necessary for the execution of writing movements. The design of the rail was also thought to allow the metal

ball to move smoothly along the contours of the letters, promoting an effective learning experience.

Thus, the MDF rail not only serves as the basis for the letter molds, but also plays a crucial role in the effectiveness of motor learning, ensuring that every interaction of the participants is comfortable and productive. This thoughtful approach to rail construction reflects the project's commitment to offering a tool that combines functionality, durability, and affordability. Below, the image of the Main Rail, developed through the CorelDraw Software, is presented.

FIGURE 10 - ASSISTIVE LETTERS RAIL, DEVELOPED WITH CORELDRAW SOFTWARE - SOURCE: THE AUTHOR

H. Project cost

Tables 1, 2 and 3 are presented below, which detail the development cost of each phase of the "Assistive Letters" project, as well as the total cost for the full realization of the project. The tables include a description of each component used, its context of application, quantity, and respective price.

TABLE 1 - DEVELOPMENT COST OF THE 1ST PHASE - SOURCE: THE AUTHOR

Object	**Quantity**	**Total Price**
MDF Cru 3mm Plate (60 cm x 40 cm)	1 pc.	US$ 0,77
		Total: **US$ 0,77**

TABLE 2 - DEVELOPMENT COST OF THE 2ND PHASE - SOURCE: THE AUTHOR

Object	Quantity	Total Price
MDF Cru 3mm Plate (185 cm x 275 cm)	1 pc.	R$ 65,00
Thimble Printing	1 pc.	R$1,15
Impression of the Assistive Pencil	1 pc.	R$ 1,94
Transparent Acetate Sheets size A3 30x42cmx0.20mm	5 pcs.	US$ 1,41
		Total: **US$ 7,1**

TABLE 3 - DEVELOPMENT COST OF THE 3RD PHASE .

Object	Quantity	Total Price
MDF Cru 3mm Plate (185 cm x 275 cm)	1 pc.	US$ 12,5
Magnetic Pen Printing	1 pc.	US$ 0,37
Neodymium Magnet 5mm x 2mm	1 pc.	US$ 0,36
Transparent Acetate Sheets size A3 30x42cmx0.20mm	5 pcs.	US$ 1,41
		Total: **US$ 14,70**

TOTAL COST: **US$ 30,00**

(SUM OF COSTS OF ALL PHASES)

- SOURCE: THE AUTHOR

IV. RESULTS

The final results of the "Assistive Letters" project show an effective and innovative approach, based on the maker culture, to overcome challenges faced by individuals with limitations in fine motor coordination and learning difficulties. The implementation of the three phases of the project, which prioritized creativity and cost-effectiveness, resulted in significant gains for the participating children, standing out in the following areas:

1. **Development of Fine Motor Coordination**: The use of the Tactile Alphabet enabled students to improve their tactile perception and muscle memory, facilitating the identification and writing of letters. This advancement was evidenced by improvements in students' fine motor skills and confidence when interacting with writing materials.

2. **Interactive Learning**: The introduction of the Channel Alphabet, which allows the tracing of letters with an adapted pen, provided a more dynamic learning experience. Students reported greater engagement in activities, reflecting an increase in interest in and participation in educational activities. The educators' observations indicated remarkable progress in the ability to trace letters and in the retention of learning.

3. **Facilitation of Motor Control**: The third phase, which used the Assistive Cursive Alphabet, proved to be an effective tool for the formation of cursive letters. The steel ball

guided by a magnetic pencil helped students better control their movements, resulting in more legible and confident writing.

4. **Educational Inclusion**: The project fostered an inclusive educational environment in which each student could advance at their own pace. The research indicated that, by providing adaptive and interactive tools, the project not only facilitated learning, but also fostered students' self-esteem and social confidence.

5. **Implementation in Various Contexts**: The results showed that assistive alphabets are accessible and low-cost, which enables their application in different school contexts. This versatility opens up new opportunities for educational inclusion, catering to a wider range of student needs.

In summary, the **Assistive Letters project** achieved its objectives by demonstrating that it is possible to create practical and innovative solutions for the inclusion of students with motor difficulties, proving that it is feasible to "do a lot with little" in terms of production costs. This approach not only proves to be sustainable, but also contributes to a fairer and more accessible educational environment. Below, the image of the final phase of Assistive Letters is presented.

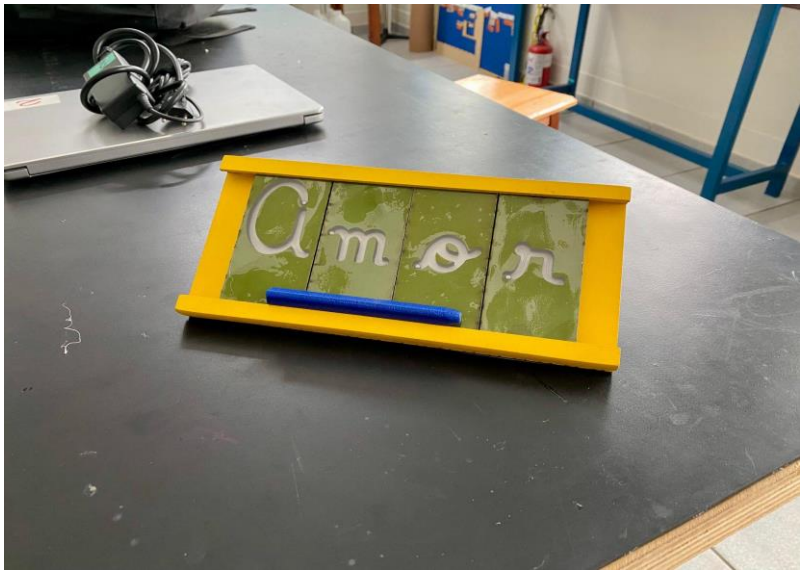

FIGURE 11 - RESULT OF THE FINAL PHASE OF ASSISTIVE LETTERS - SOURCE: THE AUTHOR

V. CONCLUSIONS

After tests and analyses, the efficiency of the "Assistive Letters" project was proven, showing that innovations and adaptations can lead to its continuous improvement. The challenges faced by students with learning difficulties, such as understanding concepts and retaining

information, as well as those with limitations in fine motor coordination, which impact essential skills such as writing, drawing, and manipulating objects, are partially mitigated by the introduction and dissemination of this educational method. Thus, the goal of creating a more accessible and effective learning environment has been achieved. "Assistive Letters" does not propose to revolutionize inclusive education in order to be replicated on a large scale, but rather to demonstrate that it is possible to promote greater accessibility, efficiency and development through the use of assistive technologies and elements of Industry 4.0. The use of design software for the creation of molds, as well as the 3D printing of the adaptive pencil, exemplifies how these technologies can be applied to meet the specific needs of users. With the integration of technological tools, inclusive education is expected to become increasingly accessible, positively impacting the development of motor skills in students with difficulties. However, such transformations will bring challenges that will require adaptations on the part of educators, family members and institutions. Therefore, it is essential that the search for innovative and effective solutions is maintained, not only to overcome obstacles, but also to promote a fairer and more inclusive educational environment for all. The search for effective and affordable alternatives for the development of fine motor coordination and learning skills is crucial. It is necessary to have a collective engagement that unites educators, family members and specialists in search of solutions that can effectively impact the lives of these individuals. In addition, it is essential to promote greater awareness of the importance of integrating assistive technologies into everyday school life, not only as learning tools, but as a means of ensuring full inclusion. Only through a joint effort and a real commitment from all parties involved will it be possible to transform the reality of these students and promote a fairer and more accessible environment, where everyone has the opportunity to develop and actively participate in society.

VI. ACKNOWLEDGEMENTS

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