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Occupational Therapy and Assistive Technology: Experience in Using 3D Printing and Open Source Platforms

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ABSTRACT

Three-dimensional printing technology has evolved rapidly, being widely spread throughout the world and used in various fields such as design, engineering, medicine, and dentistry, among others. However, it is still little used in research and clinical practice in occupational therapy. A report is presented on the use of three-dimensional printing and open source platforms in clinical practice, based on experience in research and extension activity developed by the Laboratory for Research in Neuropediatrics, Technology and Inclusion (LINTI), which aims to provide an assistive product made in 3D printing to patients treated in the Supervised Internship in Occupational Therapy services that take place at the Specialized Rehabilitation Center (CER II). The actions are developed in four stages: 1- identification of the need; 2 - problem analysis and specification of the open source product; 3 – 3D printing production; 4- user assistive product validation tests. This project has highlighted the possibility of creating functional, accessible assistive products, with desired aesthetics, and above all, with modification alternatives and adjustments for the user. 3D printing technology and open source platforms can be applicable and innovative tools in the practice of occupational therapists working in assistive technology.

Keywords: Occupational Therapy; Printing Three-Dimensional; Self-Help Devices.

INTRODUCTION

Assistive Technology (AT) is an area that encompasses interdisciplinary knowledge related to products, strategies, methodologies, and services that seek to promote functionality, autonomy, social participation, and quality of life of people with disabilities, whether permanent or temporary, mobility-reduced, or other health conditions that impact functionality[1]. When it comes to promoting functionality and eliminating barriers, AT represents an indispensable element in allowing people with disabilities to live more independent, healthy, productive, and dignified lives[2,3].

Considering the perspective of inter-disciplinarity that permeates AT, professionals

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from different areas dialogue, enabling the sharing of ideas and the personalization of the assistive product according to the needs of each user[4]. One of the professionals involved with AT is the occupational therapist, who uses the understanding of the transactional relationship between the user's bodily functions and structures, their involvement in occupations considered important, and the context in which they are inserted, with this they can plan interventions that facilitate or increase participation and occupational performance[5] and, in many cases, AT is essential.

Thinking exclusively about offering assistive products, in recent years 3D printing technology has proven to be a promising alternative for manufacturing these products. The main advantage of 3D printing is the ease of producing individual, personalized, and low-cost resources[6]. This technology provides different possibilities, such as refining adaptations on an individual basis, avoiding the use of materials that may cause discomfort to the user, improving the aesthetics of the product, and lowering costs compared to other AT products available on the market[7]. Such factors allow the user to respond positively to emotional demands, increasing treatment adherence and, consequently, reducing the possibility of abandoning AT[8].

3D printing technology has gained space in the practice of occupational therapists (OT) who have services in the area of AT and, as a result, has fostered multidisciplinarity between OTs, designers, and engineers in the search for innovative alternatives in this area[4,9-11]. The clinical knowledge of the OT regarding the user's needs has proven to be an important ally for the designer concerning the development of assistive products in 3D printing[12].

From the point of view of OTs, the use of 3D printing for the development of orthoses can be more precise, with lower cost and better aesthetics, however, this technology is not part of the curriculum of most OT training courses[13]. In the field of OT, knowledge about 3D printing is still incipient, mainly because it demands high and specific levels of knowledge[14,15] such as those related to modeling software, and printing parameters, among others, which makes multidisciplinary even more relevant and essential in this area and highlights the need for initial and continued training for OT who intend to use 3D printing in the area of AT.

Because they do not know how 3D printing works, its potential in clinical practice, and its viability, many OTs end up not using this technology. However, there is the possibility of purchasing 3D printing assistive products that are available for free on Open Source websites such as Thingiverse (https://www.thingiverse.com), which help to mitigate the knowledge barrier caused by the proliferation of friendlier, less specialized software user interfaces16, and require little to no costomization17.

Open source is a concept that describes products or ideas in which "the intellectual contribution of the inventors is not proprietary in nature"[18]. The successful results and democratization of open source software inspired the creation of Open Source Hardware (OSH)[19], tangible, electrical, or mechanical products that anyone can use, allowing changes, distribution, and use[20]. Open Source Hardware distribution platforms are relevant as they have accessible materials and free model repositories, and allow more people to benefit from these services.

Such platforms can enable OT to materialize low-cost assistive products, in addition, they have two main purposes: to act as a community platform and to provide tools that allow satisfactory contributions, as well as the exchange of information and knowledge between users[21]. Open-source files have standardized devices that can be downloaded and printed according to parameters indicated for each piece, many of the files allow size adjustments[22], an extremely relevant feature, as it allows the product to be adjusted to the user to make it functional and custom.

At OT, studies on the use of 3D printing technology and files available on open-source websites for the implementation of assistive devices are still incipient. These technologies innovate how OTs have been developing assistive technologies for decades and can be implemented by OTs with knowledge in AT and 3D printing.[23]

It is in this direction that the proposition of this report is configured, which aims to contribute to reflections on the possibility of using Open Source platforms and 3D printing to make AT products available in Occupational Therapy services.

The Proposal

The experience of a research and extension project developed by the Laboratório de Investigação em Neuropediatria, Tecnologia e Inclusão (LINTI) is presented, whose actions seek to meet the need to make an assistive product made using 3D printing available to patients treated in Supervised Internship services in OT which take place at the Centro Especializado de Reabilitação (CER II) -Specialized Rehabilitation Center, linked to the São Paulo State University (UNESP), Marília campus. At CER II, patients with different health conditions are cared for, from childhood to the elderly, in the areas of Physiotherapy, Speech Therapy, and Occupational Therapy. Concerning OT, supervised internship practices are carried out in Neuropediatrics; Adult Neurology; Orthopedics; Social Programs – Child care, and Geriatrics. It is noted that this project began in May 2022 and includes collaborative actions with teachers/internship supervisors in OT, and with fourth-year OT students who carry out internships at CER II.

To constitute a collaborative proposal, the project is developed in four stages: identification of need, product specification, production, and validation. The four stages were established based on Löbach[24] (2001) and Baxter[25] (2003), which are described below.

Step 1- Identification of the need

Firstly, contact is maintained with supervisors and interns to identify whether they determine the need for an assistive product to perform daily tasks based on the analysis of the results of the occupational therapeutic assessments carried out with the patient and/or caregivers. In this way, patients who will benefit from AT are identified and selected, who are previously informed by the OT interns and, accordingly, the student members of this project use the Brazilian version of the Canadian Occupational Performance Measure – COPM[26] with the patient and/or caregiver to document the level of importance of the occupational activity that is intended to be improved through the use of AT, obtained through a scale of 1 to 10 (1=not very important; 10=very important), scoring also perceived performance (1=unable to perform it; 10=able to perform it extremely well) and satisfaction with performance (1=not at all satisfied; 10=extremely satisfied). At this point, the user's preferred color for implementing the assistive product is also investigated by demonstrating the colors of the filaments available for 3D printing of the product. This is one of the aspects that contributes to greater user adherence to the product and reduces the possibility of abandonment[27].

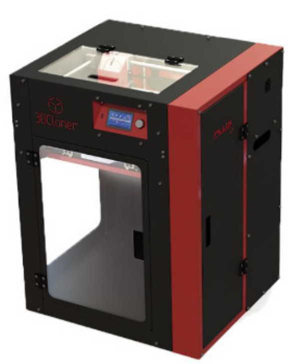
Because we seek to meet greater user demand, after scoring performance and satisfaction, the user is asked to select only one activity that they consider can benefit from the use of an assistive device, and that is most meaningful and relevant to them. him in his daily life, making it clear that he can purchase other assistive devices in the future, if necessary and if he so desires. Additionally, this criterion allows for greater coordination between teaching, research, and university extension activities, to favor the educational process of a greater number of undergraduate students and not just students linked to the project.

Step 2 - Problem Analysis and Open Source Product Specification

The second stage begins with a discussion among project members about the importance of the relationship that needs to exist between the demands of the subject and the task to be performed to define the specifications of the assistive product. Then, the search for it begins on the open-source platform Thingiverse (www.thingiverse.com), and at the Centro Tecnológico de Acessibilidade (CTA) of the Federal Institute of Rio Grande do Sul (www.cta.ifrs.edu.br). Several AT products available on the market are high-cost, produced on a large scale, and may not meet the user's exclusive demand28. Thus, the Open Source platform is an alternative that facilitates access and production of low-cost assistive products, with refined and personalized parts. To search for the desired product, keywords corresponding to it are used. However, it is important to highlight that it is not always possible to find what is available through the use of keywords, as the AT sought is often not included in the category in which it is intended29. To illustrate, during the search for an assistive device to replace the shoelace, it was acquired using the keyword "awesome", a term suggested in the "tags" section of other resources found previously. This setback highlights the problem raised by Buehler et al.29 (2015), who emphasizes that the majority of designers who make files available on Open Source platforms do not have knowledge of AT, and by making them available without adding keywords consistent with the product's assistive function for users to find the solutions they are looking for.

Step 3 – 3D printing production

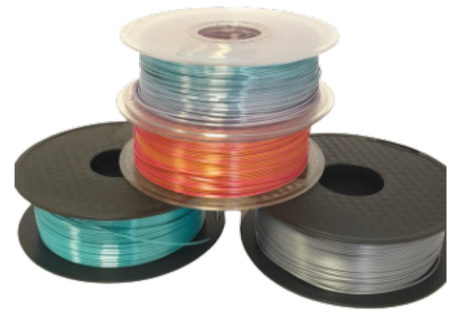
Once the product is selected, the file is downloaded in "STL" format and, using the Matter Control 1.7 slicing software, converted into "OBJ". LINTI uses a 3D printer (Figure 1) with Fused Deposition Modeling (FDM) technology, which generates a 3D object by adding layers of filaments. The materials most used in this type of process are Acrylonitrile Butadiene Styrene (ABS) and Polylactic Acid (PLA). ABS is a petroleum-derived filament whose main characteristic is its flexibility, allowing for more detailed work on parts and the creation of objects that do not break easily. PLA (Figure 2) is a non-toxic and biodegradable thermoplastic, originating from natural renewable sources (corn starch, sugar cane, beet, and potato), available on the market in a variety of colors and brands. This material is easy to use due to its physical and chemical characteristics[30], and because it has



Source: LINTI Files

Figure1: FDM type 3D printer

low contraction and allows greater control of the final dimensions of the object, it is recommended for printing large and technical parts, which will suffer friction.



Source: LINTI Files

Figure 2: PLA Filaments

Stage 4 – User assistive product validation tests

At this stage, the printed product is first analyzed by all project members to check the quality of the printing and, if necessary, the product is printed again. Subsequently, this is delivered to the OT intern to make it available to the beneficiary for usability tests, aiming to obtain their opinion regarding performance and satisfaction with the occupational activity to be carried out with the assistive product, as well as satisfaction regarding the characteristics of the product in terms of comfort, functionality, and aesthetics, and the service offered.

To this end, users are oriented and trained on how to use the device, and after fifteen consecutive days of use, project members reapply to the COPM, and apply the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST 2.0), validated for Brazil by Carvalho et. al.31(2014), which aims to evaluate user satisfaction with assistive technology in various aspects (dimensions, weight, ease of adjustment, stability, and safety, durability, ease of use, comfort and effectiveness), and with the service offered (delivery process, repairs, and technical assistance, quality of professional services and follow-up services) with scores ranging from 1 to 5 (1 – Dissatisfied to 5 – Completely Satisfied). The proposition is to investigate the adequacy of the assistive product to the user's demands so that, if dissatisfaction is found with the functionality

Table 1. Assistive solutions in 3D printing and beneficiaries

Assistive Product	Beneficiares
Thingiverse - Plastic bottle opener 	Child, male, three years old, was diagnosed with Obstetric Brachial Palsy. Demand: open a plastic bottle using both hands. 
CTA - Acionador de Bastão(stick trigger) 	Child, female, eight years old, diagnosed with Spastic Quadriplegic Cerebral Palsy. Demand: encourage active play. 
Thingiverse - Bag holder  Option 1 Option 2	Adult, female, 32 years old, diagnosed with Brachioradial Injury. Demand: transport bags and purses. 
Thingiverse - Cutlery Holder 	Child, female, 9 years old, diagnosed with Quadriplegic Cerebral Palsy. Demand: take the food to the mouth. 

Assistive Product	**Beneficiares**
Thingiverse - Klots: quick shoe ties 	Child, male, eight years old, was diagnosed with Diparetic Cerebral Palsy. Demand: tie your sneaker laces 

Source: Authors

Based on the above, it is believed that 3D printing technology and the use of open-source platforms represent an innovation in the practice of OT, as they enable not only the development of functional assistive technologies (ATs), but also those that address issues aesthetic and low-cost, which influence user satisfaction and contribute to the acceptance and usability of ATs. Although the literature regarding the use of 3D printing by OTs has evolved in recent years, it is still quite scarce, the presentation of this report adds information to this growing body of knowledge.

Conclusion

This report aimed to demonstrate the feasibility of 3D printing and open source platforms in occupational therapeutic practice and the procedures and protocols used for evaluation, prescription, selection of assistive products, and user monitoring. The actions were based on user-centered practice, prioritizing user participation throughout the process, allowing feedback and adjustment of the assistive product with quick and effective solutions. This report demonstrates the potential of 3D printing for the development of ATs, and points to the opportunity to innovate the practice of OT in AT.

Conflict of Interest

The authors Luciana Ramos Baleotti, Amanda Letícia Santos da Silvaand Roberta Martinelli Palacio of the manuscript entitled “Occupational Therapy and Assistive Technology: Experience in Using 3D Printing and Open Source Platforms” declare that there are no conflicts of interest of a personal, commercial, academic, political and/or financial nature, in the process of assessment and publication of the aforementioned article.

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Ethical Clearance

I certify that I participated in the conception of the work to make public my responsibility for its content, as well as that I presented pertinent information about the sources of resources received for the development of the research.

I declare that there are no connections or agreements between the authors and funding sources that characterize a real, potential, or apparent conflict of interest that may have affected the results of this work.

I certify that when the research involved experiments with human beings there was appreciation and approval by the Ethics Committee of the relevant institution and that the dissemination of images was authorized, assuming full responsibility for the same.

I certify that the text is original and that the work, in part or in full, or any other material authored by me with substantially similar content, has not been sent to another journal, in printed or electronic format.

I certify that, if requested, I will provide or cooperate fully in obtaining and providing data on which the text is based, for examination by the editors.

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