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EXPERIENCE REPORT

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3D printing in the physician-patient relationship, experience report on the integration between education, innovation and care

Impressão 3D na relação médico-paciente, relato de experiência da integração entre ensino, inovação e assistência

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ABSTRACT

Introduction: In the literature, several articles demonstrate patient satisfaction and better understanding of the information transmitted by the medical team, with the aid of three-dimensional pieces. Education and health are inseparable and interdependent practices, they have always been articulated, and considered crucial elements in the action process of health professionals. Thus, teachers and students of the medicine course at Universidade Federal de Pernambuco created a university extension project that aimed at the use of anatomical models printed in 3D, for the education of patients in the orthopedics and traumatology outpatient clinic.

Experience Report: Over the six months of the project, 77 patients were assisted and the project employed the work of 3 teachers and 18 undergraduate students, totaling 98 people involved in the project. The actions were divided into 2 blocks: the first consisted of training the students and, in the second, the students visited the outpatient clinic, accompanied by a specialist physician in charge and used pieces printed by the students themselves, to guide the patients regarding their respective condition and provided guidance on therapy using these printed pieces.

Discussion: the possibility of using this tool as an aid in medical communication opens up a vast horizon of application of 3D printing in health education. This, in turn, favors the improvement of health promotion in less developed regions, since this interaction between the health team and the community allows the promotion, protection and recovery of health, based on a horizontal dialogue, valuing and respecting the users of the health system, aiming to make them an agent and protagonist of the health and disease process.

Conclusion: It can be concluded, therefore, that extension projects such as this one have enormous potential to generate impacts on medicine, the academic community and the assisted population, especially the less educated ones.

Keywords: Health Communication; Physician-Patient Relationship; Health Education; Three-Dimensional Printing; Community-Institutional Relationship.

RESUMO

Introdução: *Na literatura, diversos artigos apresentam a satisfação dos pacientes e a melhor clareza de entendimento acerca das informações transmitidas pela equipe médica, com o auxílio de peças tridimensionais. A educação e a saúde são práticas inseparáveis e interdependentes, sempre estiveram articuladas, consideradas elementos fundamentais no processo de atuação dos profissionais da saúde. Assim, professores e alunos do curso de Medicina da Universidade Federal de Pernambuco criaram uma extensão universitária, que objetivava o uso de modelos anatômicos, impressos em 3D, para educação dos pacientes do ambulatório de ortopedia e traumatologia.*

Relato de experiência: *Ao longo dos seis meses de projeto, foram assistidos 77 pacientes, e o projeto contou com o trabalho de três professores e 18 alunos da graduação, totalizando 98 pessoas envolvidas no projeto. As ações foram divididas em dois blocos. O primeiro consistiu na capacitação dos alunos. No segundo, os discentes realizavam visitas ao ambulatório, acompanhados por um médico especialista responsável, usavam peças impressas pelos próprios alunos, para orientar os pacientes quanto à sua respectiva condição, e davam orientações sobre a terapêutica valendo-se dessas peças impressas.*

Discussão: *A possibilidade de utilização dessa ferramenta como auxílio na comunicação médica abre um vasto horizonte de aplicação da impressão 3D na educação popular em saúde. Isso, por sua vez, propicia o aperfeiçoamento da promoção da saúde de regiões menos desenvolvidas, uma vez que essa interação entre equipe de saúde e comunidade permite a promoção, a proteção e a recuperação da saúde, a partir de um diálogo horizontal, valorizando e respeitando o usuário do sistema de saúde, de maneira a torná-lo agente e protagonista do processo saúde e doença.*

Conclusão: *Projetos de extensão desse tipo têm um enorme potencial para gerar impactos na medicina, na comunidade acadêmica e na população assistida, sobretudo a menos instruída.*

Palavras-chave: *Comunicação em Saúde; Relações Médico-Paciente; Educação em Saúde; Impressão Tridimensional; Relações Comunidade-Instituição.*

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INTRODUCTION

Currently, 3D printing is made up of a vast ecosystem of different technologies, whose foundation is based on rapid prototyping or additive manufacturing, supported by computer-aided design[1]. Its operation consists in the deposition of successive layers of molten material, which, when solidified, lead to the creation of a real three-dimensional object[2].

Although the first patents and prototypes in this technological area date back to the 1970s, it was in 2010, after the expiration of many patents, that there was a major advance in the large-scale implementation of three-dimensional printing. This allowed the development of cheaper desktop printers, further democratizing the technology to the general public[3].

3D printing has been applied in medicine since the early 2000s, when the technology was used to manufacture dental implants and personalized prosthetics[4]. In Orthopedics, there are records of its use since 1997, with the purpose of aiding teaching and surgical planning[5]. In 2003, the use of this technology was reported in the literature, with the purpose of planning surgeries and reducing the time of exposure to radiation in 117 surgical cases[6].

Since its popularization, 3D printing has been studied for another application of this tool: the potential to aid communication between medical staff and patients. In the literature, several articles have shown greater patient satisfaction and better clarity of understanding regarding the information transmitted by the medical team, thanks to the greater visual potential of these three-dimensional pieces[7-9].

Education and health are inseparable and interdependent social practices. They have always been articulated, being considered crucial elements in the process of health professionals' action [10]. The context of difficulty in understanding and carrying out the received instructions, as well as the doctor's inaccessible language, leads to a deficit in Functional Health Literacy, defined by the World Health Organization (WHO) as the ability to obtain, process and understand information aiming at making appropriate decisions regarding self-care[11]. Studies from the international literature highlight the benefits of education for the population's health conditions and longevity and, on the other hand, the respective harm of its absence[12]. Among the causes that weaken the health of patients with low education is the difficulty in establishing the doctor-patient bond[13].

Regarding this aspect, research on doctor-patient communication has generated considerable evidence that effective communication results in better rates of patient satisfaction, adherence to treatment and cure of the disease[14,15]. On the other hand, both searches for different health services and health expenditures showed a decrease due to the improvement in the health professional's relationship with their patient[15].

Considering the enormous relevance of communication and popular health education in the patient's therapeutic process and the difficulties imposed by the lack of education, it is possible to infer that health education practices in Brazil would be of great value, especially in the northeast region of the country. This is due to the fact that school dropout in Brazil is a phenomenon that remains high throughout the country. In 2020, the Brazilian Institute of Geography and Statistics (IBGE, *Instituto Brasileiro de Geografia e Estatística*) found that 51.2% of people aged 25 or over have not yet completed high school. This rate is even more accentuated in the Northeast region, where three in every five adults (60.1%) did not complete high school. It is also observed that the illiteracy rate in Brazil is 6.6%, that is, 11 million people; of these, 6.2 million (56.2%) live in the Northeast region[16].

Bearing that in mind, teachers and students from the Medicine course at Universidade Federal de Pernambuco created an extension project that aimed to use musculoskeletal anatomical models, printed in 3D, to assist the medical team in explaining pathophysiology and treating diseases frequently observed in patients assisted at the Orthopedics and Traumatology outpatient clinic of Hospital das Clínicas of Universidade Federal de Pernambuco (HC-UFPE).

EXPERIENCE REPORT

Over the six months of the project, 77 patients were assisted and the project involved the work of three teachers and 18 undergraduate students, totaling 98 people involved in the project. The activities were divided into 2 blocks: in the first, the students underwent training, seeking to familiarize them with software for obtaining three-dimensional images, editing these images and printing, discussing the applicability and future perspectives of these technologies in medical practice. Moreover, the students were instructed on the most prevalent diseases in the service outpatient clinic, aiming to enable them to answer questions and explain pathophysiological and treatment aspects to the patient under the guidance and supervision of a specialist physician. In the second block, students did weekly rotation visits to the orthopedics and traumatology outpatient clinic, accompanied by a specialist doctor in charge. During consultations, they used three-dimensional models, printed by the students themselves, to guide and discuss, together with the patients, their respective conditions and approach therapeutic proposals, guided by the specialist physician.

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Student Training and Model Printing

Although one of the teachers was relatively familiar with software for acquiring, editing and modeling three-dimensional images, it was necessary to find those that best fit the project conditions. The qualities and limitations were then compared, based on the tutor's previous experience, of three popular software for creating and editing models (MeshMixer®, Blender® and OnShape®) and three software programs for obtaining three-dimensional images from medical exams (Invesalius®, 3D slicer® and Horos®), which are depicted in Table 1.

Considering how easy they were to use and the possibility of being used with any operating system, the Invesallius® and MeshMixer® software programs were chosen to train and educate the students.

The students then underwent training, where they were able to learn about imaging exams, how they are stored in the Digital Imaging and Communications in Medicine (DICOM) format and the possibility of importing files in this format into programs for obtaining three-dimensional images.

They learned about exporting these images to the main 3D image formats (.obj and .stl,) which, in turn, can be imported into three-dimensional image modeling and editing software. Using MeshMixer®, they were then taught how to handle these images and the main editing features (cutting, merging, rounding tools, etc.)

After learning about obtaining a three-dimensional image and modeling, the students were then trained in the integration between software and hardware, where slicing programs (slicing the piece into several layers for printing) configure the printer on how it should print the piece; thus, the Ultimaker Cura® software was chosen for training and carrying out the activities.

After that, for the practical activities in the Orthopedics and Traumatology outpatient clinic, the students participated in the last stage of the training, where the main degenerative pathologies of the joints were explained, as well as the importance of the doctor-patient relationship and the importance of clear and objective communication. This reinforces the purpose of the project, which is to make the disease they face clearer to the patient, including them into the disease process and also the therapy, aiming to comfort them in the process of choosing and adhering to treatment, as well as how to help them, in a humane way, to overcome this difficult moment.

After these activities, the first models were printed, as shown in Figure 1, using three-dimensional image databases as a source available on the internet, although the students were already able to extract these images from three-dimensional imaging exams; however it was decided to use these databases, for ethical issues, preventing the exposure and possible moral or material harm to any patient.

Educational activities in the outpatient clinic

The students were divided into weekly rotations, always carrying three-dimensional printed pieces. Under the guidance of a specialist physician, they discussed the present

Table 1. Comparison of Medical Image Conversion and Editing Software.

Type of Software	Software	Qualities	Limitations
DICOM to STL Converter			
	Invesalius®	Free, intuitive and available for Mac® and Windows®	Limited features and functions compared to other software
	3D slicer®	Free, many extensions that greatly expand the range of use of the software, available for Mac® and Windows®	Too many functions, which makes it less intuitive
	Horos®	Free, familiar with medical image viewing programs	Available only for Mac®
3D image modeling and editing			
	MeshMixer®	Free, intuitive and available for Mac® and Windows®	Limited features, less intuitive measurement tool
	Blender®	Free, Animation recording features included and available for Mac® and Windows®	Too many functions, which makes it less intuitive
	OnShape®	Free, available to use directly from the browser, no download required	Very technical, little intuitive designs

Source: The authors.

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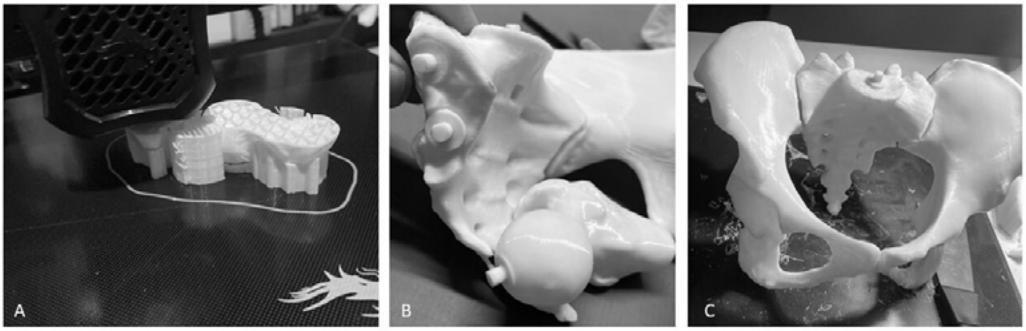
Figure 1. Anatomical models printed by the project students. A) Printing process for 2 Femurs. B) Dismantled pelvic girdle, showing teaching aid fittings. C) Printed and assembled pelvic girdle model.



Source: The authors.

case, where 3D materials often helped students and doctors in understanding deformities, malformations and pathologies that had been seen, until then, only through medical examinations of two-dimensional images, such as Computed Tomography scans and Magnetic Resonance Imaging, which only show views of anatomical sections of the individual, or even X-ray examinations, which show the radiographed structures superimposed on a single plane.

After this discussion of cases between students and medical teachers, both used the created pieces to instruct patients about their respective affecting condition, demonstrating to them how the disease developed, the prognosis depicted in the literature, showing the treatment modalities and clearing possible patient doubts, always using accessible language, simplifications of concepts and compatible analogies, aiming to engage the patient and make them an agent and protagonist in the health-disease process.

The impact perceived and reported by the doctors who already provided care activities in the service outpatient clinic, after implementing these activities, was that the patients no longer just knew the name of the condition that affected them and started to understand, through more simplified language and concepts, the entire disease process that affected them, the prospects for the evolution of the condition and the treatment options, always advised by a specialist physician, based on the professional's own technical knowledge and experiences, but with due respect for the patient's autonomy .

For the students, the experience had a strong impact on their learning and understanding of the main orthopedic pathologies encountered throughout the extension project. Since, normally, throughout the undergraduate course, such diseases are only presented through two-dimensional imaging exams, such as X-Rays, Computed Tomography and Magnetic Resonance Imaging, limiting the three-dimensional understanding of the condition.

Moreover, students also reported a deeper reflection on the doctor-patient relationship, going beyond technical and biomedical aspects. This effective communication skill, aiming to engage the patient and make them protagonists in their own therapeutic process, is very little addressed throughout medical training; however, this extension project allowed students to study and apply such knowledge during outpatient clinic activities.

DISCUSSION

With the increase in democratization and the numerous applications of 3D printing, it is expected that this technology will be increasingly present in healthcare services, especially in orthopedics. Therefore, it is extremely pertinent that future health professionals know the main aspects involving 3D printing.

Additionally, the possibility of using this tool as an aid in medical communication, as already reported in the literature, opens up a vast horizon of application for 3D printing in popular health education. This, in turn, allows the improvement of health promotion in less developed regions, such as the Northeast region of Brazil, as it surpasses the hitherto used two-dimensional exams, such as computed tomography and magnetic resonance imaging, in dealing with didactic possibilities.

This interaction between the health team and the community allows the promotion, protection and recovery of health, based on a horizontal dialogue, valuing and respecting the health system users, aiming to make them agents and protagonists of the health-illness process.

Bearing these characteristics in mind, the extension project was designed and allowed the interaction between 77 patients from the Orthopedics and Traumatology Outpatient Clinic at Hospital das Clínicas of UFPE, 18 students and 3 teachers.

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Limitations

The present study presents only one experience report with a qualitative evaluation of doctors and medical students at Universidade Federal de Pernambuco, regarding activities carried out within the institution's own University Hospital. Further investigations are needed, approaching other places and quantifying the results of these actions in the medium and long term in these communities to ratify the impact that 3D Printing can have as an instrument to aid communication between medical staff and patients.

CONCLUSION

It can be concluded, therefore, that extension projects, such as this one, have enormous potential to generate impacts on medicine, the academic community and the assisted populations, especially the less educated ones. It is thus necessary that more studies be carried out to quantify the potential impact generated by this technology on the aforementioned groups.

AUTHORS' CONTRIBUTIONS

Each author contributed individually and significantly to the development of this article.

Alessandro Uono Sanchez: Conception of the extension project, experience report, participation in the developed activities. Afonso Miguel de Souza Silva: critical review of the intellectual content and participation in the developed activities. Rodrigo Mendes Heilmann: writing of the manuscript and participating in the developed activities; Milton Ignacio Carvalho Tube: conception of the extension project and critical review of the intellectual content; Múcio Brandão Vaz de Almeida: Critical review of the intellectual content and participation in the developed activities; Epitácio Leite Rolim Filho: conception of the extension project, activity guidance and writing of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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