ARTIGO

INTERPROFESSIONALITY AMONG DESIGN, ENGINEERING, AND HEALTH (IDEH): COLLABORATIVE SOLUTIONS IN TIMES OF PANDEMIC

INTERPROFISSIONALIDADE ENTRE DESIGN, ENGENHARIA E SAÚDE (IDES): SOLUÇÕES COLABORATIVAS EM TEMPOS DE PANDEMIA

INTERPROFESIONALIDAD ENTRE DISEÑO, INGENIERÍA Y SALUD (IDES): SOLUCIONES COLABORATIVAS EN TIEMPOS DE PANDEMIA

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RESUMO:

A gestão de equipe interprofissional ao longo do processo de desenvolvimento de projetos é dinâmica e complexa, ao depender do segmento na qual está sendo projetado, do contexto do projeto e envolve o trabalho de diferentes profissionais. Uma das dificuldades dos gestores está na mensuração do engajamento dos profissionais envolvidos no projeto, tendo como referência as ações realizadas a cada procedimento, por meio da relação dos indicadores: influência e participação. Diante disso, o objetivo deste estudo foi analisar o engajamento de uma Equipe Interprofissional de projeto no desenvolvimento de um produto médico-hospitalar no contexto da COVID-19, formada por profissionais do Design, Engenharia e Saúde. Para isso, foi realizado um estudo aplicado com objetivo descritivo com abordagem qualitativa, com procedimentos técnicos de pesquisa-ação, no qual foi organizado em três fases: a primeira envolveu o planejamento do projeto, a segunda o relato do desenvolvimento do projeto, ambas a partir do Guia de Orientação para o Desenvolvimento de Projetos, e a terceira com a mensuração e análise do engajamento dos profissionais no projeto, com base no Modelo Genérico do Registro de Pessoas Interessadas. Os resultados indicam que dos 21 procedimentos utilizados no projeto, em 17 (80.9%) houve o engajamento de todos os profissionais envolvidos, tomando como referência os valores atribuídos qualitativamente pelo gestor de design. Esta pesquisa apresentou questões importantes a serem consideradas ao planejar e gerenciar um projeto de produto com equipe interprofissional, as quais podem ser utilizadas como referência em outros projetos com contextos similares.

PALAVRAS-CHAVE: Interprofissionalidade; Gestão de Projetos; COVID-19; Produto Médico-hospitalar.

ABSTRACT:

Interprofessional team management throughout the project development process is dynamic and complex, as it depends on the segment being designed and the project context and involves the work of different professionals. One of the difficulties of managers is in measuring the engagement of the professionals involved in a project, having as a reference the actions carried out in each procedure through the relationship of the indicators of influence and participation. This study aimed to analyze the engagement of an interprofessional project team composed of design, engineering, and healthcare professionals in the development of a medical-hospital product in the context of COVID-19. To that end, an applied study was carried out with a descriptive objective, adopting a qualitative approach and technical procedures of action research, in which it was organized into three phases: the first involved the project planning, the second, the reporting of the project development — the former and latter according to the *Orientation Guide for the Development of Projects* — and the third with the measurement and analysis of the engagement of professionals in the project based on the *Generic Model of the Record of Interested Parties*. The results indicate that of the 21 procedures used, 17

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had the engagement of all professionals, using as reference the values assigned qualitatively by the design manager. This study presents important issues to be considered when planning and managing a project with an interprofessional team, which may be used for reference in other projects of similar contexts.

KEYWORDS: Interprofessionality; Project management; COVID-19; Medical-Hospital product

RESUMEN:

La gestión de equipos interprofesionales durante todo el proceso de desarrollo del proyecto es dinámica y compleja, dependiendo del segmento en el que se esté proyectando, del contexto del proyecto e implica el trabajo de diferentes profesionales. Una de las dificultades para los gestores es medir el compromiso de los profesionales que participan en el proyecto, tomando como referencia las actuaciones realizadas en cada procedimiento, a través de la relación de los indicadores: influencia y participación. El objetivo de este artículo fue analizar el compromiso de un Equipo de Proyecto Interprofesional en el desarrollo de un producto médico en lo contexto del COVID-19, compuesto por profesionales de Diseño, ingeniaría y Salud. Para ello, se desarrolló un estudio aplicado, con objetivo descriptivo, enfoque cualitativo, con procedimientos técnicos de pesquisa-acción. Siendo organizado en tres fases: en la primera fue realizada la planificación del proyecto, en la segunda, la elaboración de informes sobre el desarrollo del proyecto, ambas basadas en la Guía de Orientación para el Desarrollo de Proyectos, y en la tercera, la medición y el análisis de la participación, basado en el Modelo Genérico de Registro de las Personas Interesadas. Los resultados indican que, de los 21 procedimientos utilizados, en 17 hubo el compromiso de todos los profesionales, teniendo como referencia los valores atribuidos cualitativamente por lo gestor del proyecto. Esta investigación permitió evidenciar aspectos importantes, que deben ser considerados en el momento de planificar y gerenciar un proyecto con un equipo interprofesional, pudiendo servir de referencia para otros proyectos similares.

PALABRAS CLAVES: Interprofesionalidad; Gestión de proyectos; COVID-19; Producto médico-hospitalario.

INTRODUCTION

The development of healthcare projects requires the assembly of interprofessional teams for collaborative practice, given that the World Health Organization (WHO, 2010) recognized interprofessional collaboration in education (theory) and the project (practice) as an innovative strategy that plays an important role in mitigating global crises and in changing the culture of health professions, leading to more significant interaction among professionals from different fields.

In addition, it is understood that interprofessional education is an experience that "occurs when students of two or more professions learn from each other in order to improve collaboration and quality of care"; in turn, in collaborative practice, it "occurs when multiple people from different professional backgrounds work together with patients, families, caregivers, and communities to provide the highest quality of care" (WHO, 2010, Pg. 7).

During the COVID-19 pandemic, unexpected demands from society were identified, from the reorganization of transportation systems for products and people to contingency planning for the provisioning or reprocessing of devices that were used as protectors of health professionals and the virus expelled by patients (GARRIGOU et al., 2020).

Different authors believe that the COVID-19 pandemic highlighted the need and centrality of interprofessional practice to provide health care, making it indispensable both in the present and future global health crises (JONES, VIDAL, and TAYLOR, 2020; SY et al., 2020; GOLDMAN and XYRICHIS, 2020). Sy et al. (2020) also highlighted the sharing of ideas and practices among different professionals, which allows collaborative work in various areas. It is understood that this movement of cooperation needs to go beyond the formal duties of individuals, and that voluntary and citizenship behaviors are what represent the basis for ethical and social development (ALOUSTANI et al., 2020).

However, there are two main challenges in interprofessional practice. The first consists of appropriately managing the activities of the professionals involved in the practical aspects of the project, and the second involves measuring their engagement in the project development, be it qualitatively or quantitatively. For this, CAMARGO (2014) and the *project-management body of knowledge* (PMBOK, 2021) indicate that one of the possible ways to measure the engagement of the professionals involved is through the control and assessment of the *design manager*, who upholds the desired performance and actions of each professional throughout the project, which in turn provides the basis for measuring engagement based on the relationship between influence and participation in each specific procedure (Figure 01).

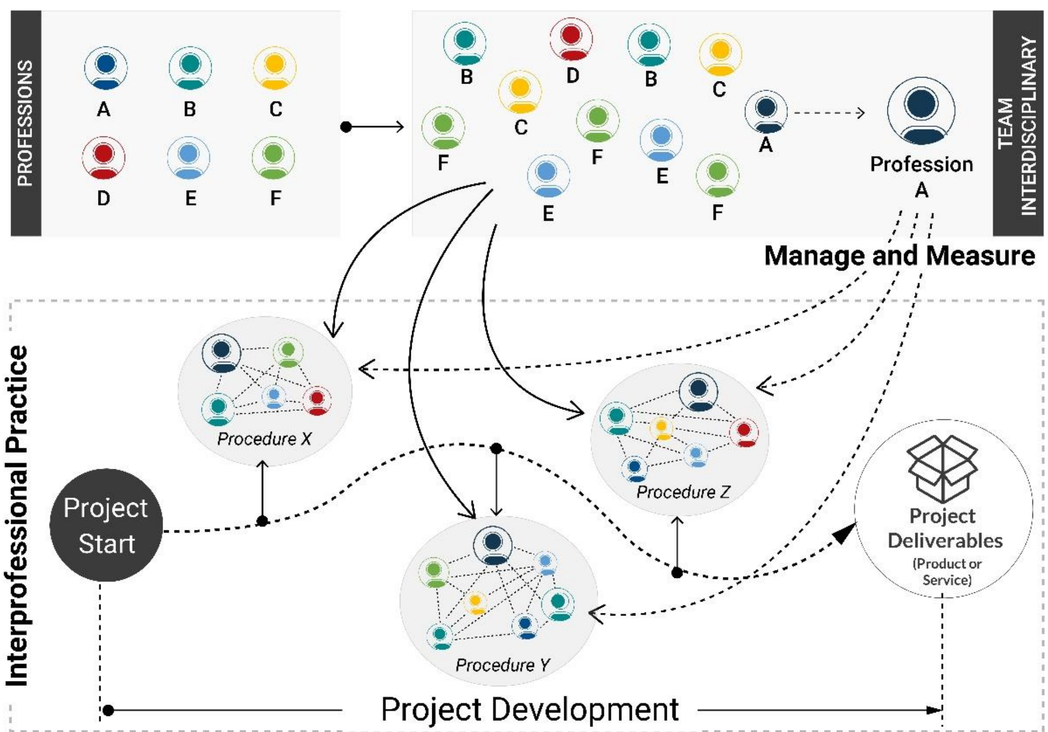

Figure 01. Interprofessional Pratice

Source: Created by the authors

From the point of view of the design project, Löbach (2001) specified that the design manager usually has two roles of responsibility, the first related to the general design policy, together with the board or strategic sectors of a company, and the second associated with the management of design projects, with them being responsible for the main decision-making of the project.

Mozota (2010) understood that *design management* (DM) is a tool that works as a mechanism to manage data, time, and resources and to ensure continuous learning as the project progresses as well as coherence with the goals and strategic objectives of the design project.

It is known that the management of the project development process is dynamic and complex, as it depends on the type of product (and/or service), the segment in which it is being designed, and the context in which the project is being developed. It involves the work of several different professionals, whether from the same field or not, through a set of activities that triggers a new product and/or the improvement of existing ones.

However, one of the difficulties of project managers is in measuring the engagement of the professionals involved in the development of each moment of the project, whether qualitatively or quantitatively.

It should be noted that the pandemic revealed numerous challenges such as fearful, skeptical, and overloaded professionals in the face of uncertainty of the best treatment and preventive models as well as substantial political interference (global and local), not to mention the universe of information on the sidelines of the realm of science.

In this sense, we started from the assumption that the engagement of professionals involved in project practice is proportionally balanced, even when, in specific project procedures, there is a greater or lesser influence and participation of one professional or another, according to their theoretical specialty.

In this context, this study aimed to analyze the engagement of an interprofessional project team composed of design, engineering, and health professionals in the development of a medical-hospital product in the context of COVID-19.

This research is justified by the need to understand the engagement of different professionals from distinct fields in the project practice of a product based on the indicators of influence and participation and how the assignment of values performed by the design manager takes place qualitatively. The specific project was selected because it involved professional individuals and teams from different fields linked to an involved public institution of considerable relevance in the Brazilian context, and because it contributes practically and theoretically to academic and professional activities.

METHODOLOGICAL PROCEDURES

This study is characterized as applied research with a descriptive objective, given that it intended to describe the analysis of the engagement of an interprofessional team in the project and product development process. Regarding the approach to the problem, it is characterized as qualitative since the measurement was carried out by the design manager and based on qualitative indicators. Regarding the technical procedures, this study is characterized as action research because it was conceived and carried out with close association and participation of the researchers and participants collaboratively in order to solve a collective problem (SILVA and MENEZES, 2005).

This study was organized and divided into three phases: (I) planning, (II) reporting of the project development, and (III) measurement and analysis of the engagement of professionals in the project.

To organize the product development, the three moments of *inspiration*, *ideation*, and *implementation* (3Is) of the Design Thinking approach (BROWN, 2009) were used, according to the *Guia de Orientação para o Desenvolvimento de Projetos* (GODP) (MERINO, 2016) and *Conjunto de Procedimentos para o Desenvolvimento de Projetos* (COSTA, 2023), divided into 21 project procedures, as shown in Figure 02.

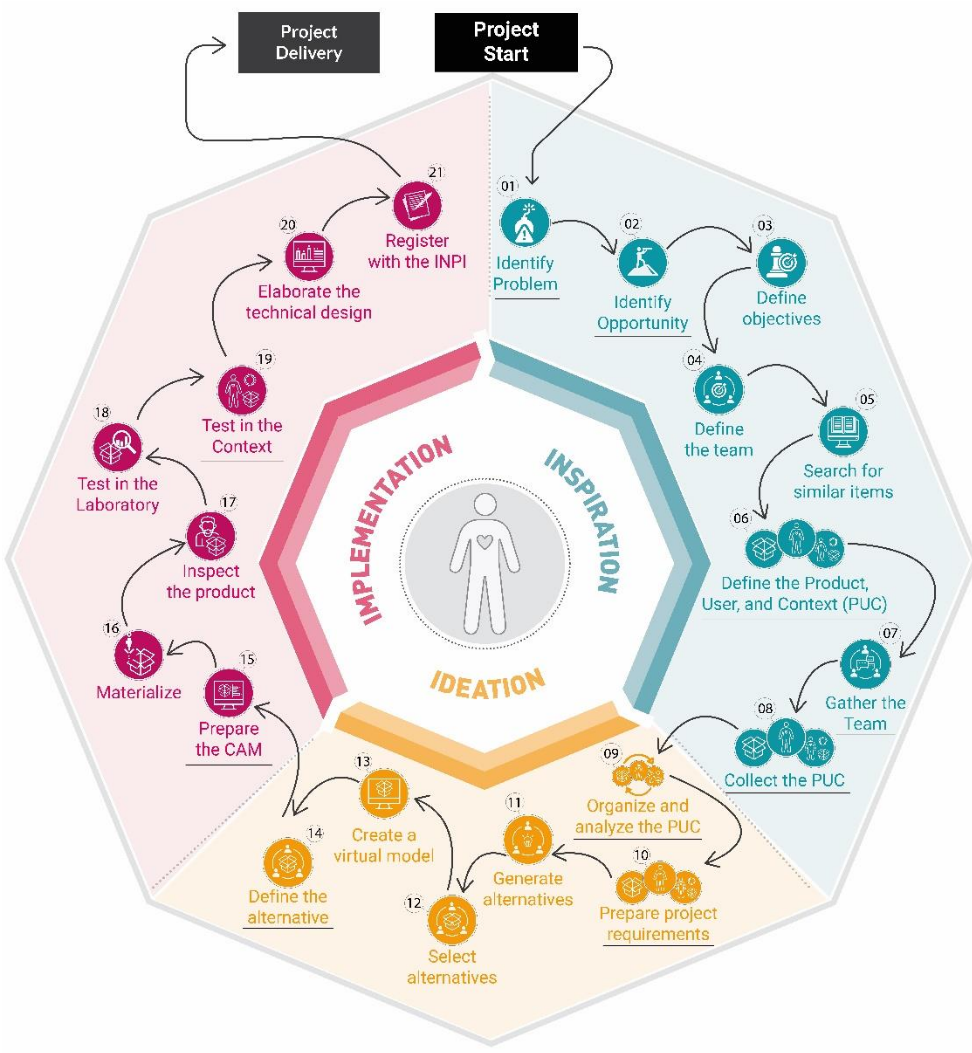

Figure 02. Procedure in the image

Source: Created by the authors

The 21 design procedures were organized and systematized in the three moments proposed by GODP, namely:

- **Inspiration**: (01) identify the problem; (02) identify opportunities; (03) define objectives; (04) define the team; (05) search for similar items; (06) define the product, user, and context (PUC); (07) gather the team; (08) collect PUC data;
- **Ideation**: (09) organize and analyze the PUC; (10) prepare project requirements; (11) generate alternatives; (12) select alternatives; (13) create a virtual model; (14) define the alternative;
- **Implementation**: (15) prepare the CAM file; (16) materialize; (17) inspect the product; (18) test it in the laboratory; (19) test it in the context; (20) elaborate the technical design; (21) register with the National Institute of Industrial Property – Brazil (INPI/BR).

The Generic Model of the Record of Interested Parties presented by Camargo (2014, p. 170) was used for the documentation (TABLE 01) of the general information on the project interprofessionality among the participants of design, engineering, and health (iDEH) professionals.

Table 01. Model of General Registration of the Participles

Source: Model adapted from Camargo (2014)

NAME	FIELD – SPECIALTY	POSITION – TRAINING	INFLUENCE ON THE PROJECT*	PROCEDURES**
Identification of the interested party.	General area of knowledge of the individual's main training and specialties.	Position in the formal hierarchy of the institution and main training; preferably enter the basic training and the highest degree.	How this interested party will influence the project specifically.	Level of participation in project procedures. This interested party shall actively participate in the project.

* Influence assessed on a three-level scale from one to three, with:
H = High (5) – Interested parties directly influence all aspects of the procedure, which will directly affect the final result of the project.
M = Medium (3) – Interested parties influence some aspects of the procedure, which will not have much of an effect on the final result of the project.
L = Low (1) – Interested parties indirectly influence the project without playing a role in the procedure.

** **21 Procedures used in the project development:** (01) identify the problem; (02) identify opportunities; (03) define objectives; (04) define the team; (05) search for similar items; (06) define the Product, User, and Context (PUC); (07) gather the team; (08) collect PUC data; (09) organize and analyze the PUC; (10) prepare project requirements; (11) generate alternatives; (12) select alternatives; (13) create a virtual model; (14) define the alternative; (15) prepare the CAM file; (16) materialize; (17) inspect the product; (18) test it in the laboratory; (19) test in the context; (20) prepare the technical design; (21) register with the INPI.

According to Camargo (2014, p. 170), "The information in the Record of Interested Parties may vary in the level of detail depending on the needs and complexity of a project." Based on this, it is important to highlight that the information in the previous table was aligned to meet the needs of the present study, removing the expectations column and replacing the nomenclature "department/company" with "area/specialty."

To measure *engagement*, the design manager used two indicators involving effective participation and temporality: *influence* and *participation*. In the end, the information was organized and synthesized in separate tables for each person involved, specifying their actions, as per Table 02.

Table 02. Identification of the Professional

Source: Camargo (2014)

IDENTIFICATION OF THE PROFESSIONAL				
PROCEDURE	**INFLUENCE**	**PARTICIPATION****	**ENGAGEMENT**	**ACTIONS**
Identification of the procedure reported in the previous table.	How this interested party will influence the project specifically.	Levels of participation in project procedures. This interested party shall actively participate in the project.	The mean of the ratio between the *influence* and the *participation*.	Describe what was performed.

** Participation in the considered project procedure (monitored based on the activities provided for in the schedule): H = High (5) – Active participation; M = Medium (3) – Medium participation; L = Low (1) – Low participation.

The assignment of the participation level of the professionals was qualitatively made by the design manager, as per Camargo (2014, p. 199):

> *In monitoring and control, the project manager collects and communicates information on the performance of all project areas. They are also responsible for comparing the actual performance with the planned performance, analyzing variances, evaluating trends to improve processes in the future, evaluating possible alternatives, and recommending corrective measures as needed* (CAMARGO, 2014, p. 199).

The reports on the meetings and those generated in the research project entitled "*P&D COVID-19 pesquisa e desenvolvimento integrando Design, Engenharia e Saúde*" and extension project entitled "*COVID 19 Ações do design, engenharia e saúde na produção de equipamentos, dispositivos e acessórios utilizando tecnologias de materialização e metrologia*", both made by the project team, under the coordination of the Design Manager. Later, a five-level scale was used (TABLE 03): high influence with high participation (H+), high influence with low participation (H-), medium influence with medium participation (M), low influence with high participation (L+), and low influence with low participation (L-).

Table 03. Management plan adapted

Source: Adapted from Camargo (2014)

ACRONYM	INDICATOR	DEFINITION
H+	High influence with high participation	This indicator reflects interested parties with a high level of influence and a high level of participation.
H-	High influence with low participation	This indicator reflects interested parties with high influence who did not actively participate, either due to a lack of time or because they did not carry out the activities assigned to them.
M	Medium influence with medium participation	This indicator typically reflects the professionals involved at managerial levels who will participate only at specific points in the project or professionals who are called upon to perform activities on specific project deliverables.
L+	Low influence with high participation	This indicator reflects interested parties with a low level of influence and a high level of participation. These interested parties, most often, are experts who will be used as important sources of information.
L-	Low influence with low participation	This indicator reflects interested parties with a low level of influence and whose participation in the project is very lacking.

A score of 0 was given in procedures in which the professional did not influence or participate. Finally, summary charts were generated with the level of engagement of the parties involved based on data recorded by the design manager in the software Microsoft Excel.

This research was approved by the Ethics Committee, CAAE 52661021.0.0000.0121 Plataforma Brasil (National and unified base of registries of research involving human beings for the entire CEP/Conep system), dated 05.09.2022 "*P&D COVID-19: Ações do design, engenharia e saúde na produção de equipamentos, dispositivos e acessórios utilizando tecnologias de materialização e metrologia*."

PROJECT PLANNING (PHASE I)

This research is based on the measurement of the performance of an interprofessional team in the development of a project for a medical-hospital device to assist health professionals in the procedure of intubation of patients, offering greater safety and agility and reducing the level of exposure of professionals to COVID-19: a low-cost laryngoscope with an attached microcamera, with the interprofessional participation of design, engineering, and health professionals (iDEH), as described above.

Regarding the interested parties, this research was delimited to a Health Team (HT) and a Project Team (PT). The HT had four professionals: one hospital manager and three health professionals specializing in anesthesiology from the surgical center University Hospital Polydoro Ernani de São Thiago. The PT had three professionals: one design manager, one project designer, and one biomedical engineer from the *Núcleo de Gestão de Design e*

Laboratório de Design e Usabilidade (NGD/LDU). All professionals were linked to *Universidade Federal de Santa Catarina* and divided according to their specialties.

As mentioned, the product in question was a laryngoscope with a microcamera, and the main characteristic of the project development was a human-centered approach. Using this approach in the project was necessary because, according to Adam et al. (2020), human-centered design can support complex health system interventions, navigating complex implementation issues that often hinder project development.

PROJECT REPORT (PHASE II)

FIRST MOMENT OF INSPIRATION

Regarding the development of the procedures for the first moment (inspiration), the project arose from the identification of the problem by the health professionals (Procedure 01), specifically anesthesiologists, given that, in the context of the COVID-19 pandemic, conventional laryngoscopy during intubation was a high-risk procedure for the professionals, exposing them to the virus by the generation of aerosols and droplets. Furthermore, there were limitations in access to safer medical-hospital devices due to scarcity in the market, lack of resources for acquisition, and difficulties in using certain existing alternative equipment.

Most patients present mild symptoms; however, 15% may develop acute respiratory distress syndrome. During anesthesia, all measures to maintain patient safety and prevent the spread of infection must be taken. Since manipulation of the airways of infected patients and those with suspected infection can generate aerosols, any unnecessary manipulation must be avoided. Tracheal intubation, preferably with a video laryngoscope, is the primary rapid sequence technique for airway control. Such care may last indefinitely (QUINTÃO et al., 2020; MAGALHÃES et al., 2022).

Subsequently, the hospital manager contacted the coordinator (Design Manager) to report said difficulties that were occurring in the Surgical Center (SC). Both identified the opportunity for the project (Procedure 02) and, soon after a project feasibility analysis, they defined the objectives to be achieved (Procedure 03).

Next, the team was assembled (Procedure 04), composed of professionals from different fields, such as engineering, design, and health. Next, the participation of all members was confirmed, and the iDEH Team was formed, as shown in Figure 03.

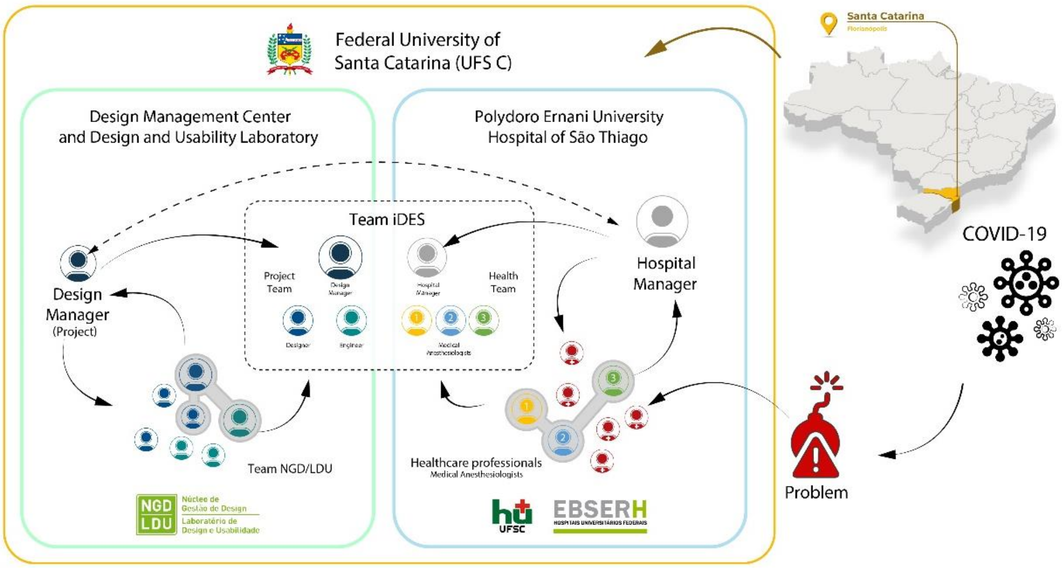

Figure 03. Formation of the iDEH team

Source: Created by the authors

To define the formation of the iDEH Team, the following were considered: training, technical specialties, experience, interpersonal communication skills, and availability for project follow-up meetings, among others. Subsequently, a search for similar items was carried out (Procedure 05), and the health professionals indicated manufacturers of models commonly used in hospitals and those that are difficult to procure due to price or import limitations. They also showed, and provided for the designers' analysis, two models of laryngoscopes they usually used and two other models that one of the professionals had.

The definition of the *product*, *user*, and *context* (PUC), (Procedure 06) had the participation of all involved, taking as primary references the experience of health professionals associated with the searches for similar items.

After these preliminary actions that allowed verifying the viability and relevance of the project, a meeting was held with the entire team (Procedure 07) in which the objective of the project was informed and the main points discussed. The procedures that the project would go through and the responsibility of each person were also informed. At this time, the various aspects of the project were discussed, including the subsequent actions, after which the explicit declaration of agreement to participate was made. A direct communication channel was also created among those involved (WhatsApp group), which relayed the definition of influence levels per procedure, as shown in Table 04.

	ID	FIELD – SPECIALTY	POSITION – TRAINING	ACTIONS IN THE PROJECT	INF.	PROCEDURE
PROJECT TEAM	Product Designer	Design – Product Design	Doctoral level CAPES scholarship holder – Graduate in Product Design; Master in Health Science and Technology; Doctoral Candidate in	Research, development, and organization of the collected product information; preparation of the CAD design; technical detailing;	High	(04) define the team; (05) search for similar items; (06) define the PUC; (07) gather the team; (08) collect PUC data; (09) organize the PUC data; (10) prepare the design requirements; (11) generate alternatives; (12) select alternatives; (13) create a virtual model; (06) define the alternative; (15) prepare the CAM file; (16) materialize; (17) inspect the product; (18) test

Table 04. Synthesis of the iDEH Team Meeting

Source: Created by the authors

			Design and Technology	documentation of the data.		in the laboratory; (19) test in the context; (20) prepare the technical design; (21) register with the INPI.
					Medium	-
					Low	(07) gather the team
	Biomedical Engineer	Engineering – Biomedical Engineer	Doctoral level CAPES scholarship holder – Graduate in Biomedical Engineering; Master in Design and Technology; Doctoral Candidate in Production Engineering (Product and Process)	Research and development of the product, with emphasis on the materialization and the technological aspects of the product.	High	(04) define the team; (05) search for similar items; (06) define the PUC; (07) gather the team; (08) collect PUC data; (09) organize the PUC data; (10) prepare the design requirements; (11) generate alternatives; (12) select alternatives; (13) create a virtual model; (06) define the alternative; (15) prepare the CAM file; (16) materialize; (17) inspect the product; (18) test in the laboratory; (19) test in the context; (20) create the technical design; (21) register with the INPI.
					Medium	(20) create the technical design
					Low	(07) gather the team; (11) generate alternatives; (13) create a virtual model.
HEALTH TEAM	Hospital manager	Health – Hospital Management	Graduate in Nursing and Hospital Management; Post-Graduate in Management of Nursing Services; Specialist in Hospital Management. Master of Nursing from the Graduate Program in Nursing; Doctor of Nursing from the Graduate Program in Nursing.	First contact of the health professionals with the designers; obtain access to the hospital for the designers	High	(01) identify the problem; (02) identify opportunities; (03) define project objectives; (04) define the team; (06) define the PUC; (07) gather the team; (15) prepare the CAM file; (17) inspect the product; (18) test in the laboratory; (19) test in the context; (21) register with the INPI
					Medium	-
					Low	(05) search for similar items; (08) collect PUC data;(09) organize the PUC data; (10) prepare the design requirements; (11) generate alternatives; (12) select alternatives (13) create a virtual model; (06) define the alternative; (16) materialize; (20) create the technical design.
	Physicians 1, 2 and 3	Anesthesiologist	1. Graduate in Medicine; Specialist in Anesthesiology Administrative Technician at UFSC.	Identification of the initial problem; co-participation in the project from the initial stage to the finishing.	High	(01) identify the problem; (02) identify opportunities; (03) define project objectives; (04) define the team; (05) search for similar items; (06) define the PUC; (07) gather the team; (08) collect PUC data; (09) organize the PUC data; (10) prepare the design

			2 and 3. Graduate in Medicine from the University of the Far South of Santa Catarina (UNESC).			requirements; (11) generate alternatives; (12) select alternatives; (13) create a virtual model; (06) define the alternative; (15) prepare the CAM file; (16) materialize; (17) inspect the product; (18) test in the laboratory; (19) test in the context; (20) prepare the technical design; (21) register with the INPI
					Medium	-
					Low	(07) gather the team

The next step was the PUC data collection (Procedure 08), which aimed to provide theoretical and practical knowledge of those involved. In this step, there was the active engagement of all, and it was possible to identify a scenario of information exchange, both in the communication channel and during in-person meetings, which were characterized by being objective and dynamic (agile).

Regarding the **product**, in addition to the survey already carried out in the procedure of searching for similar items, the members of the NGD/LDU carried out a series of searches in the Brazilian and international patent databases: INPI/BR, Espacenet, and the World Intellectual Property Organization (WIPO). They also searched journal databases and the internet to identify similar projects and information associated with the project. w

As for the **user**, two groups were defined: SC physicians and patients. For the **context**, the configuration of the environment relative to the rules and regulations of regulatory institutions and the difficulties inherent in the context of the pandemic were determined. It was also necessary for the designers to seek information about human anatomy, focusing on the operational characteristics of the airways, such as the larynx, the region of most significant interest. Regarding laryngoscopy itself, the health professionals indicated scientific articles, documents from medical institutes containing the step-by-step procedure, and videos available on virtual platforms; in addition, a recording was made by the professionals themselves simulating its use in the relevant context, providing a better understanding for the project team and in order to speed up the process.

THE SECOND MOMENT OF IDEATION

Regarding the development of the procedures for the second moment (ideation), the first procedure was to organize and analyze the PUC data: the data were organized into folders shared among the professionals (Procedure 09), and, after a period of analysis, discussion, and definition of the main information, visual panels were prepared, synthesizing the information.

With all this information organized and synthesized, it was possible to define the project requirements (Procedure 10), categorized into the three blocks of *product*, *user*, and *context*. With this, the procedure of the generation of alternatives (Procedure 11) was carried out, initially freehand by the project team, and later, after the selection of the alternatives that met the requirements (Procedure 12), they were developed virtually (Procedure 13) through mathematical modeling software of the computer-aided design (CAD) system.

For the definition of the alternative to be materialized by 3D printing (Procedure 14), all the contributions of the team were considered, e.g., issues associated with the 3D materialization by the project team, such as time, percentage of filling, and adjustments in the CAD model, among others. On the part of the health professionals, airway visibility, handle, weight, and blade, among others.

THE THIRD MOMENT OF IMPLEMENTATION

In the third moment (implementation), the procedure of preparing the virtual file (Procedure 15) was initially performed using computer-aided manufacturing (CAM) software to define the best positioning and direction for materialization (I), aiming at the best use of the material and surface finish, in addition to preserving the designed geometry. Next, the virtual file was transferred to materialization (Procedure 16), (II and III), as shown in Figure 04.

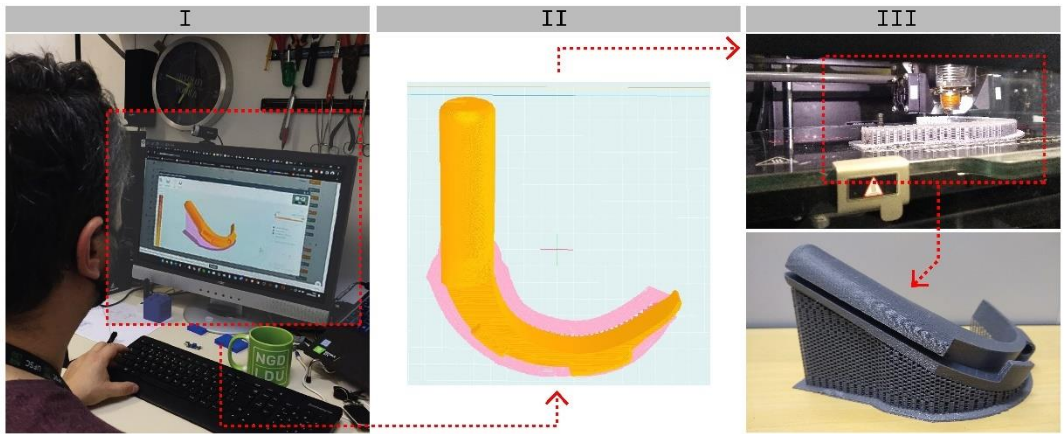

Figure 04. CAM Procedures and Materation

Source: Created by the authors

These two procedures were performed three times because in the first two it was verified that the parameters used in the CAM software needed adjustments, e.g., shell thickness (mm), bottom/top thick (mm), and infill (%). Subsequently, the product inspection was carried out (Procedure 17). Concomitantly, in addition to the verification (dimensional), the finishing was performed, which consisted basically of removing the support material created during the printing process using styluses and precision scalpels, performing surface finishing using sandpaper with 120, 220, 400, and 600 grit to achieve a fine finish, and, in the end, sanitizing it with isopropyl alcohol.

With the prototype materialized, laboratory testing was performed (Procedure 18) to verify if the measurements that were planned in the virtual model were reproduced (I), along with the assembly, synchronization, and operation of the micro camera and application (II), in addition to the positioning of the camera (III), as shown in Figure 05.

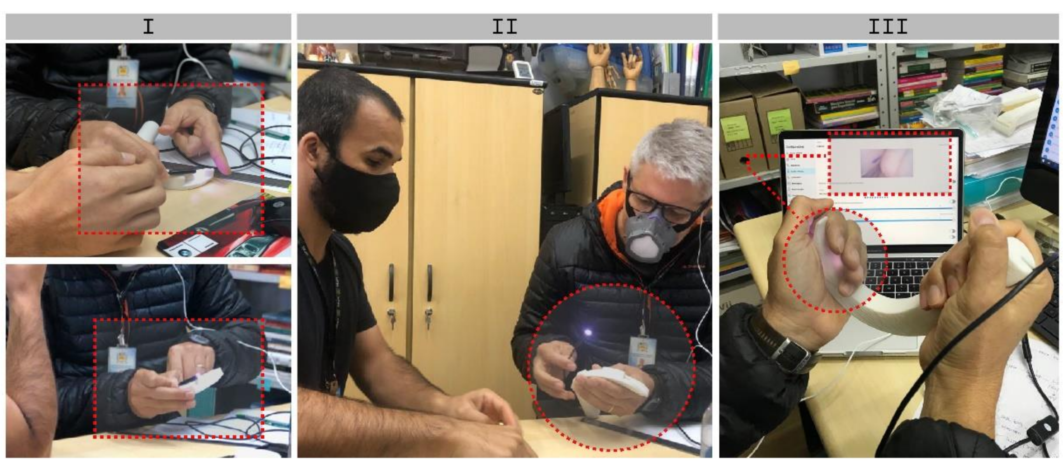

Figure 05. Prototype Testing

Source: Created by the authors

After this procedure, a meeting was held with the health professionals to present the laryngoscope so that testing could be performed in the context (Procedure 19). The tests were recorded through images, videos, and comments that were analyzed by all those involved in the project. Subsequently, the potentialities and opportunities for improvement were reported. Among the potentialities were the (1) diameter and height of the handle, (2) curvature of the blade, and (3) positioning of the wire along the device, which proved efficient, requiring no adjustments. The following were among the opportunities for improvement: (4) improve the quality of the surface finish; (5) absence of a guide/marking for the correct positioning of the camera; (6) decrease in the width of the blade since there were difficulties using it on patients with reduced airway access (Figure 06).

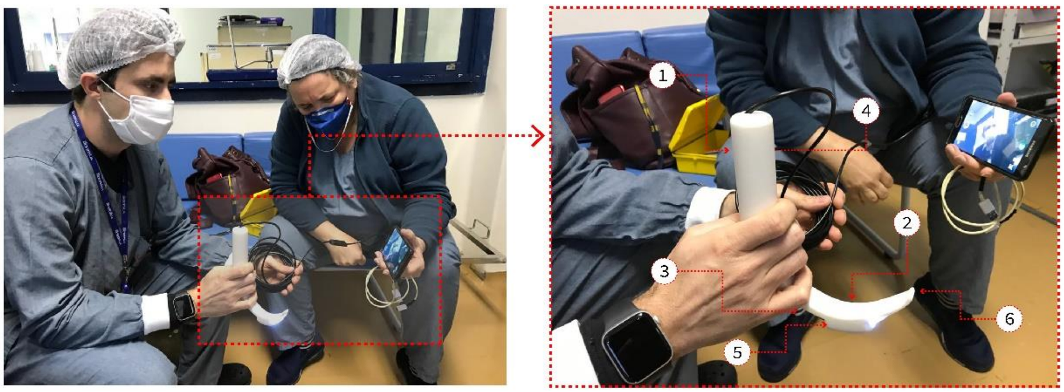

Figure 06. In-context testing by the Health Team

Source: Created by the authors

Based on this information, adjustments were made to the virtual file, returning to the virtual creation procedure (Procedure 13); soon after, a new file was prepared using the CAM software (Procedure 15) for later materialization (Procedure 16). The main adjustments were the following: definition of the positioning of the virtual object on the CAM software platform, with an inclination of 45° in relation to the base; the addition of an element at the end of the pass slot coupled to the camera; a decrease in the width of the end of the blade, leaving it with 15 mm; a decrease in the height of the barrier element of the inspection camera wire, leaving it with 7 mm; a change in color of the filament, which the professionals recommended not using white or black, but preferably colors that are contrasting.

After the new materialization, the procedures of inspection (Procedure 17) and laboratory testing (Procedure 18) were performed. Subsequently, three more units were delivered (Figure 07) with all the necessary accessories — laryngoscope (I), cable and LED micro camera (II), and adapter (III) — for a new round of in-context testing (Procedure 19) over the following two weeks.

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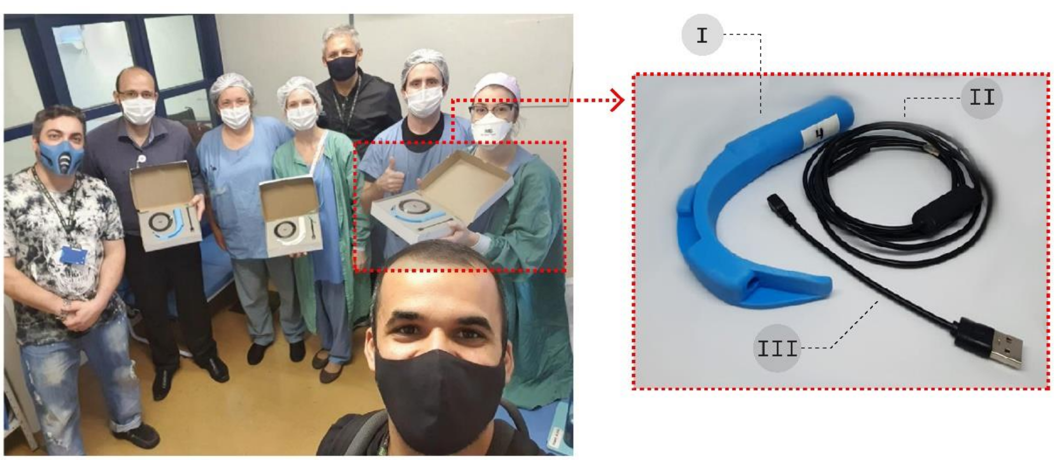

Subsequently, the technical design files were developed by the project team (Procedure 20). Lastly, the documentation to apply for the registration of intellectual property with the National Institute of Industrial Property was prepared (Procedure 21) with the assistance of the Secretariat of Innovation and filed: BR302021002209-5.

IDEH ENGAGEMENT ANALYSIS (PHASE III)

To organize the results, three synthesis tables were prepared, having as a reference the three moments of the GODP, recording the main actions performed each procedure and the values assigned by the design manager, as described in the methodological procedures.

ANALYSIS OF THE ENGAGEMENT AT THE MOMENT OF INSPIRATION

Table 05 shows descriptions of the actions and the measurement of the engagement of each professional involved in the procedures of the first moment of Inspiration of the Project.

Table 05. Actions of the Moment of Inspiration

Source: Prepared by the authors

			PROJECT TEAM		HEALTH TEAM	
			Designer	Biomedical Engineer	Hospital Manager	Physicians
MOMENT OF INSPIRATION	(01) Id. problem	Inf.	-	-	High	High
		Part.	-	-	High	High
		Eng.	0	0	H+	H+
		Action	Did not directly participate in this procedure.	Did not directly participate in this procedure.	Identified the problem of the difficulty of acquiring the product to meet the demands of physicians.	Identified the problem of the project from the actual problems.
	(02) Id. opportunities	Inf.	-	-	High	High
		Part.	-	-	High	High
		Eng.	0	0	H+	H+
		Action	Did not directly participate in this procedure.	Did not directly participate in this procedure.	Identified the opportunity to develop the project.	Identified the opportunity to develop the project.
	(03) Define objective	Inf.	-	-	High	High
		Part.	-	-	High	High
		Eng.	0	0	H+	H+
		Action	Did not directly participate in this procedure.	Did not directly participate in this procedure.	Participated in the definition of the project objective.	Participated in the definition of the project objective.
	(04) Define the team	Inf.	High	High	High	High
		Part.	Low	Low	High	Low
		Eng.	H-	H-	H+	H-
		Action	Influenced the decision of the design manager but was not responsible for deciding on the professionals who	Influenced the decision of the design manager but was not responsible for deciding on the professionals who	Defined the team together with the design manager.	Influenced the decision of the design manager but was not responsible for deciding on the professionals who

		would compose the team. Participation was restricted to accepting to collaborate on the project.	would compose the team. Participation was restricted to accepting to collaborate on the project.		would compose the team. Participation was restricted to accepting to collaborate on the project.
(05) Search for similar items	**Inf.**	High	High	Low	High
	Part.	High	High	High	High
	Eng.	H+	H+	L+	H+
	Action	Searched industrial/intellectual property websites and specialized websites for registered products. Subsequently, documented the results of all similar items found.	Searched industrial/intellectual property websites and specialized websites for registered products.	Showed the devices usually available for purchase.	Searched specialized websites for similar items, indicated the products already used, and pointed out the positive and negative points.
(06) Define the PUC	**Inf.**	High	High	High	High
	Part.	High	High	High	High
	Eng.	H+	H+	H+	H+
	Action	Documented and assisted in the definition of the PUC and their main attributes.	Assisted in the definition of the PUC and their main attributes.	Assisted in the definition of the PUC and their main attributes.	Assisted in the definition of the PUC and their main attributes.
(07) Gather the team	**Inf.**	Low	Low	High	Low
	Part.	High	High	High	High
	Eng.	L+	L+	H+	L+
	Action	Participated in the meeting convened by the design manager, raised questions, and assisted in decision-making.	Participated in the meeting convened by the design manager, raised questions, and assisted in decision-making.	Participated in the meeting convened by the design manager, raised questions, and assisted in decision-making.	Participated in the meeting convened by the design manager, raised questions, and assisted in decision-making.
(08) Collect PUC data	**Inf.**	High	High	Low	High
	Part.	High	High	High	High
	Eng.	H+	H+	L+	H+
	Action	Searched in scientific journals, books, documents from government institutes, and specialized websites about the PUC. Was responsible for the organization and synthesis of data to provide all with a better understanding.	Searched in scientific journals, books, documents from government institutes, and specialized websites about the PUC.	Searched the documents of government institutes and specialized websites for the limitations of using the product in the context of the pandemic.	Searched the documents of government institutes and specialized websites for the limitations of using the product in the context of the pandemic.

Regarding the levels of participation in each step of this first moment, the first step of identifying the problem was performed by the health professionals. In turn, the identification of the opportunity and definition of the objectives had the participation of the design manager.

In the definition of the team, the design manager and the hospital manager had more significant participation and influence, as they were required to make decisions about whom to invite to participate in the project and what technical specialties would be needed. The others involved participated by agreeing to the terms set forth and confirming their interest.

As previously mentioned, seven professionals participated in the project: two designers, the first with an emphasis on management and the second on product development; one engineer with specialization in projects for hospitals; four health professionals from the University Hospital Polydoro Ernani de São Thiago, with one nurse specialized in hospital management and responsible for relating the designers with the other health professionals, and three anesthesiologists who were responsible for identifying the problem and participating in the project.

ANALYSIS OF THE ENGAGEMENT AT THE MOMENT OF IDEATION

Table 06 shows the description of the actions and the measurement of the engagement of each professional involved in the procedures of the second moment (ideation of the project).

Table 06. Actions of the Moment of Ideation

Source: Prepared by the authors

			PROJECT TEAM		HEALTH TEAM	
			DESIGNER	ENGINEER	HOSPITAL MANAGER	PHYSICIANS
MOMENT OF IDEATION	(09) Organize the PUC	Inf.	High	High	Low	High
		Part.	High	High	Low	Low
		Eng.	H+	H+	L-	H-
		Action	Documented the information collected by all, synthesized it in a table format for viewing by all, and pointed out the limitations of the available technological resources.	Documented the information collected by all, synthesized it in a table format for viewing by all, and pointed out the limitations of the available technological resources.	Did not directly participate in this procedure.	Assisted in the organization and documentation of the data.
	(10) Prepare requirem ents	Inf.	High	High	Low	High
		Part.	High	High	Low	High
		Eng.	H+	H+	L-	H+
		Action	Prepared the project requirements from the PUC data	Prepared the project requirements from the PUC data	Did not directly participate in this procedure	Indicated the main requirements that the project should meet
	(11) Generate alternati ves	Inf.	High	Low	Low	High
		Part.	High	High	Low	Low
		Eng.	H+	L+	L-	H-
		Action	Prepared the designs and discussed and organized the ideas with the design team.	Assisted in preparing the designs and discussed the ideas with the design team.	Did not directly participate in this procedure.	Influenced the generation of alternatives, even without active participation.
	(12)	Inf.	High	High	Low	High
		Part.	High	High	Low	High
		Eng.	H+	H+	L-	H+

	Select alternatives	**Action**	Actively participated and assisted in the selection of alternatives for creating the virtual model.	Actively participated and assisted in the selection of alternatives for creating the virtual model.	Did not directly participate in this procedure.	Actively participated and assisted in the selection of alternatives for creating the virtual model.
	(13) Create a virtual model	**Inf.**	High	Low	Low	Low
		Part.	High	High	Low	Low
		Eng.	H+	L+	L-	L-
		Action	Created the virtual models in the CAD software.	Assisted the designer in the creation of virtual models in the CAD software.	Did not directly participate in this procedure.	Influenced the creation of the virtual models in CAD software, even without active participation.
	(14) Define the alternative	**Inf.**	High	High	Low	High
		Part.	High	High	Low	High
		Eng.	H+	H+	L-	H+
		Action	Actively participated and assisted in the definition of the alternative for materialization.	Actively participated and assisted in the definition of the alternative for materialization.	Did not directly participate in this procedure.	Actively participated and assisted in the definition of the alternative for materialization.

In the data organization, the Health Professionals had lower participation; however, their observations, considerations, and reading indications, among others, were fundamental.

The procedures for defining the project requirements and the final alternative had the participation of all those involved, which was considered important and satisfactory. The project team had technical experience with the equipment and the creative ability to solve the problem. The health team had the knowledge and in-depth experience of their real needs and the use limitations of the project, allowing a complementarity of information, analyses, and consequently more accurate and reliable results.

In the generation of alternatives, there was a more significant participation of the project team, with a series of designs being elaborated and the options that best met the requirements being selected and modeled virtually and three-dimensionally using CAD software. The participation of the HT in these procedures was fundamental, given the considerations and analyses. As an example of this collaboration with the health professionals, after conducting tests in the actual context, they recommended increasing the height of the device by three centimeters.

ANALYSIS OF THE ENGAGEMENT AT THE MOMENT OF IMPLEMENTATION

The description of the actions and the measurement of the engagement of professionals involved in the procedures of the third moment of the project implementation are presented in Table 07.

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			PROJECT TEAM		**HEALTH TEAM**	
			DESIGNER	**ENGINEER**	**HOSPITAL MANAGER**	**PHYSICIANS**
MO	**(15)**	**Inf.**	High	High	Low	Low
		Part.	Low	High	High	Low
		Eng.	H-	H+	L+	L-

Prepare the CAM	**Action**	Sent the STL file to the engineer to prepare the file in the CAM software.	Prepared the file in the CAM software.	Informed what could be used in that context, using safety standards as a reference.	Informed that PLA polymer filament could be used.
(16) Materialize	**Inf.**	High	High	Low	Low
	Part.	High	High	High	Low
	Eng.	H+	H+	L+	L-
	Action	Performed the finishing of the materialized product.	Followed the materialization, removed the part from the printer.	Informed and indicated the level of finish that would be required to test the product.	Informed and indicated the level of finish that would be required to test the product.
(17) Inspect the product	**Inf.**	High	High	High	High
	Part.	High	High	High	High
	Eng.	H+	H+	H+	H+
	Action	Inspected whether the materialized product matched the file created in the CAD software.	Tested the operating system of the inspection camera and searched for and set the application for image projection.	Inspected the product.	Inspected the surface quality of the product.
(18) Test laboratory	**Inf.**	High	High	High	High
	Part.	High	High	High	High
	Eng.	H+	H+	H+	H+
	Action	Tested the functions and use of the product, the fit of the camera and the cord, and the shape and size of the handle.	Tested the functions and use of the product, the fit of the camera and the cord, and the shape and size of the handle.	Tested the functions and use of the product, the fit of the camera and the cord, and the shape and size of the handle.	Tested the functions and use of the product, the fit of the camera and the cord, and the shape and size of the handle.
(19) Test context	**Inf.**	Low	High	High	High
	Part.	Low	Low	High	High
	Eng.	L-	H-	H+	H+
	Action	Waited for the results of tests carried out by health professionals.	Waited for the results of tests carried out by health professionals.	Articulated the release of the tests.	Tested the product in the context of use.
(20) Prepare the technical	**Inf.**	High	Low	Low	-
	Part.	High	Low	Low	-
	Eng.	H+	L-	L-	0
	Action	Prepared the technical designs for documentation.	Indicated what information was needed to prepare the procedure.	Did not act in this procedure.	Did not act in this procedure.
(21) Register INPI	**Inf.**	High	High	Low	Low
	Part.	High	Low	Low	High
	Eng.	H+	H-	L-	L+
	Action	Organized the data, wrote the report, and contacted the UFSC innovation secretariat.	Submitted the data for record and provided information about the manufacturing process.	Submitted the data for record and provided information about the usage process.	Submitted the data for record and provided information about the usage process.

Regarding participation, it was observed that, in the third moment, there were seven procedures in which the project team was responsible for CAM preparation, materialization, product inspection, laboratory testing, preparation of technical details, and registration with the INPI, having the health team as collaborators.

In turn, in the testing procedure for the actual context, the health professionals were responsible for carrying out and recording images and videos of the activities, and the designers were in charge of organizing the information and analyzing the records.

The participation of health professionals in the third moment was of paramount importance, as several parameters in the CAM software were selected, having their considerations as reference, for example: the thickness of walls for 3D printing; positioning of the object on the 3D printing platform, which influenced the surface finish and the amount of material added for support; the type of internal structure, which influenced durability; the choice for Polylactic Acid Super Tough (PLA-ST) polymer filament, as it has better performance and accuracy in printing, and higher temperature resistance, among others.

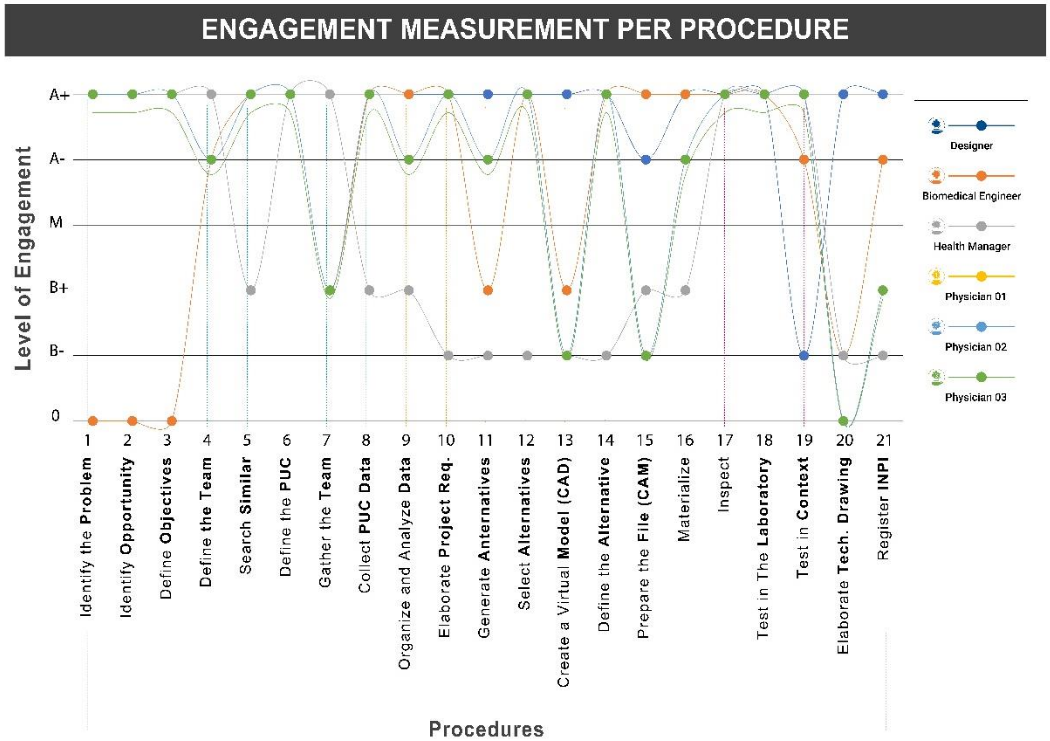
The materialization of the prototypes allowed the reduction of uncertainties and provided more assertive and objective decision-making regarding the developed product. This was corroborated by Vianna (2011, p. 124), who stated that the materialization of prototypes "reduces project uncertainties, as they are an agile way to abandon alternatives that are not well received and, therefore, help in identifying a more assertive final solution". Likewise, it was conducive in this sense to demonstrate concretely to the HT physical prototypes in full scale created from ideas that, until then, had been presented abstractly and represented in two- and/or three-dimensional drawings on paper.

FINAL CONSIDERATIONS

Figure 08 provides a summary of the measurement of engagement of the professionals involved in the project practice, taking as reference the values assigned qualitatively by the design manager through the indicators of *influence* and *participation* in the project procedure. It was possible to observe that, in the first two procedures, there was no influence or participation of the PT, given that identifying the problem and the opportunity stemmed from the HT. On the other hand, in the procedures of *inspecting* and *testing in the laboratory*, it was observed that an A+ was assigned since everyone showed a high level of influence and active participation. In turn, in the procedures of *in-context testing* and *preparation of the technical design*, there was alternation in the engagement of those involved. Thus, it was possible to observe that there was a trend of equivalence in the engagement curve, even when, in specific project procedures, there was a greater or lesser influence and participation of one professional or another.

Figure 08. Summary of the Engagement Mensurement per Procedure

Source: Prepared by the authors



Another point to be observed was the composition of the team by health professionals with complementary knowledge, which was the case of the anesthesiologists and the hospital manager, given that the collaborations held different points of view and complemented each other, in agreement with Matziou et al. (2014), who described that collaboration among health professionals is necessary for any healthcare environment since no single profession can meet all patient needs.

Throughout the development of the project, it was observed the participatory and active collaboration of the physicians in decision-making procedures, such as in the selection of alternatives (12), definition of the alternative (14), and inspection of the prototype (17). The health manager, due to the high demand for work and unforeseen events that occurred in the hospital, had to, at times, reduce participation, but continued to be responsible for the coordination among those involved.

Due to the physicians' highly demanding work load and the need to expedite delivery, during the procedure of generating alternatives that aimed to produce as many solutions as possible to solve the problem (11) through techniques and resources designed to foster creativity, the physicians participated remotely. However, through the use of group messaging applications, it was possible to approximate and involve the physicians in the procedure by sending photos and videos on which they could express their opinions. Similarly, the same occurred in the test procedure for the (19) context, where the designers had access to images of the product in use through the messaging app group. This was because only the medical team was authorized to access the intensive care unit due to the restrictions in place for the pandemic.

In view of this, it is possible to affirm that the practice of collaborative design (Codesign) was practiced, as understood by Manzini (2017, Pg. 62) when referring to the "broad and multifaceted dialogue between individuals and groups that initiate design activity in which different actors interact in different ways (collaboration and conflict) and at different times (in real-time or *offline*)". This was observable as the physicians collaborated by sending the necessary information capable of advancing or hindering the development of the product, in varying degrees, from the limitation of the form to the appropriate use, in different ways and at different times. It is believed that this practice tends to spread and strengthen the design process in different sectors of society, as it tends to impact people's lives, helping them to solve real and emergency issues.

With regard to communication between those involved, no problems were observed that hindered the progress of the project and/or the relationship between those involved. It is believed that this was possible thanks to the proper management of managers and the engagement of professionals in the project, and also because the interaction of those involved was constant, objective, and performed in different ways, as indicated in the list of ten basic principles for multidisciplinary team formation, by Back *et al.* (2008, P.66) that one should "stimulate formal and informal communication".

It is important to highlight that there occurred identical terms but with different meanings, such as "procedure", which for ES meant the performance of the complementary diagnostic examination of laryngoscopy, and for PE it meant one portion of the design process. This particularity in the vocabulary intrinsic to each area was already expected, as described by Schulmann (1994, p.43) "Each profession has its own vocabulary, originating from its culture and specific to its needs". Thus, the work and needs of the designer manager in the development of projects were prominent.

It was found that the prior definition of the actions in the project of each professional involved according to their field, specialty, interests, and availability, which was performed in the *gathering the team* procedure, associated with the successful management of the project practice by the design manager, were the main factors behind the successful organization and systematization of the project procedures.

Regarding the in-person meetings, it is important to note that all the rules and guidelines that the pandemic period required were followed. This shows that, despite the difficulties and limitations imposed by the context, the collaboration and participation of the professionals directly involved in the project and those indirectly involved were crucial for its viability.

Regarding the duration of the project, from (01) identification of the problem to (21) registration at INPI/BR took 11 months to complete. The first month was necessary to perform the first moment (inspiration). It is believed that the participation of health professionals was essential in terms of agility, especially for the procedure of data collection PUC (08). The second month was used to carry out the second moment (ideation), while the procedures of generating alternatives (11) and creation of the virtual model (13) were the ones that most required invested time to complete. To define alternatives (14), two meetings were required, each of approximately 45 minutes in duration with the participation of all the physicians, designers, and engineers.

For the third moment (implementation), the last nine months were used, but it is important to highlight that the preparation of the CAM file (15) to testing within the context (19) took three months to complete. Thus, the delivery of the prototypes ready for testing by the medical team within the context was delivered in five months. The remaining six months were allocated to submitting the registration application (21) at INPI/BR, which involved completing the forms, the survey of the state of the art, analysis of previous prototypes, to the actual submitting of the application.

From the viewpoint of the development of the project in the context of the pandemic, the following measures adopted to decrease the problems were crucial for the conclusion and satisfactory results:

- Structuring an interprofessional team from the three fields for the development of the project (design, engineering, and health);
- Having professionals experienced in people and project management, responsible for managing each team (designers and health professionals);
- Having health professionals involved in the project with access to the context and consequently able to test the product;
- Defining an accessible communication channel for all project participants;
- Assigning responsibilities and setting deadlines with control and monitoring.

CONCLUSION

With the measurement of the engagement of the professionals involved in the project practice, it was possible to observe that contributions were made by each professional that resulted in the **balance of participation**, even when, in specific procedures, there was a greater or lesser influence and participation of one professional or another, according to their theoretical specialty, thus confirming the **research assumption**.

The **development of an interprofessional project** is challenging and, in the case presented, it was made evident that the **collaborative** project practice with different professions (engineering, design, and health) with a common goal was fundamental to meet the needs of users. In this sense, it is believed that developing products with interprofessional teams with an emphasis on health requires research and in-depth theoretical and practical knowledge, mainly because these are directly related to the preservation of a person's life. Therefore, designing collaboratively with the active participation of health professionals who understand the context and the difficulties faced daily is crucial to meet their needs and those of their patients.

This article presented important issues to be considered when planning and managing a product project with an interprofessional team, specifically with design, engineering, and health professionals, and it may be used as a reference in other projects of similar contexts. Therefore, it is believed that this case is a satisfactory example and that it can motivate the academic community to invest in and form interprofessional teams.

It is important to consider the continuity of this practice of collaborating design managers with managers from different fields (in this case, the hospital field) for forming interprofessional teams with the human-centered design approach. The gains achieved from the integration of each professional were noticeable; for example, when the designers and engineers had difficulties understanding the details of the procedures of the work of the health professionals, they explained, demonstrated, and indicated reading material. Similarly, when the health professionals had any doubts about the project processes, procedures, or functional, formal, and material characteristics of the product, the designers and engineers presented, demonstrated, and explained, and there was, in fact, an exchange of knowledge and experience.

The iDEH team was important in this pandemic period, especially because the teams faced unusual challenges, putting the principles of collaborative work to the test. In addition, this research was not only essential to sustain scientific and academic activities but was also able to contribute to the personal and professional development of those involved, as well as to higher education and project practice, health care, and collaboration among these areas.

In the context of the project practice, it is believed that health product projects, regardless of their complexity, may have a satisfactory result enhanced when developed by iDEH teams, in line with the position of the WHO (2010, pg. 11) that interprofessional education and collaborative practice may play a significant role in reducing many of the challenges faced by healthcare systems worldwide.

However, there are challenges to be faced, as could be observed in this research, due to the intrinsic differences in each field and also the characteristics of each person involved. This challenge becomes even more significant in the context of undergraduate and graduate design programs, making it necessary to reflect on how to teach this practice in professional training settings so that the challenges of real projects become better understood and more easily solved. In this sense, it is recommended for future research to survey the status of the scenario of interprofessional practices in the training of designers.

In addition, it is also recommended to develop a metric model to quantitatively and/or qualitatively assess the engagement of professionals involved in a project more precisely in the case of health product development projects, given that the complexity and dynamicity of the context and products and the variation of users and professionals involved make it even more challenging.

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