

## AN INTERDISCIPLINARY EXPERIENCE-BASED LEARNING (ABEX) APPROACH: A CASE REPORT ENCOMPASSING MECHANICAL ENGINEERING AND PHYSICAL THERAPY UNDERGRADUATE COURSES

UMA ABORDAGEM INTERDISCIPLINAR DE APRENDIZAGEM BASEADA EM EXPERIÊNCIA (ABEX): UM RELATO DE CASO ABRANGENDO OS CURSOS DE GRADUAÇÃO EM ENGENHARIA MECÂNICA E FISIOTERAPIA

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### ABSTRACT

This manuscript presents a case report of an interdisciplinary teaching approach that encompassed the academia and the private sector aiming at social care. The main goal consisted of allying academics and professors from Mechanical Engineering and Physical Therapy undergraduate programs for the development of assistive medical devices manufactured from polyvinyl chloride (PVC) pipes, being these sponsored by a local company. Physical Therapy students approached the issue by tracking low-income patients from primary health care facilities, identifying their functional disabilities and providing health care assistance. Mechanical Engineering ones, on the other hand, focused on the design, structural analysis and manufacture of the devices. The methodology was framed within the so-called Experience-Based Learning (ABEx<sup>®</sup>), which is a novel pedagogical concept that takes place in all undergraduate courses at Community University of Chapecó Region – Unochapecó. The successful results achieved, by both academic and social point of views, may motivate other undergraduate courses to implement similar approach.

**Keywords:** Teaching; Active Learning; Assistive Medical Devices.

### RESUMO

Este manuscrito apresenta um relato de caso de uma abordagem de Ensino interdisciplinar que abrangeu a academia e o setor privado visando a assistência social. O objetivo principal consistiu em aliar acadêmicos e professores dos cursos de graduação em Engenharia Mecânica e Fisioterapia para o desenvolvimento de dispositivos médico-hospitalares fabricados a partir de tubos de policloreto de vinila (PVC), sendo estes patrocinados por uma empresa local. Os estudantes de Fisioterapia abordaram o problema rastreando pacientes de baixa renda em unidades básica de saúde, identificando seus problemas funcionais (motores) e fornecendo assistência. Os alunos de Engenharia Mecânica, por outro lado, concentraram-se no projeto, análise estrutural e fabricação dos dispositivos. A metodologia foi enquadrada dentro da chamada Aprendizagem Baseada na Experiência (ABEx<sup>®</sup>), a qual consiste de um novo conceito pedagógico inserido em todos os cursos de graduação da Universidade Comunitária da Região de Chapecó - Unochapecó. O sucesso dos resultados alcançados, tanto do ponto de vista acadêmico quanto social, visam motivar outros cursos de graduação a implementar uma abordagem semelhante.

**Palavras-chave:** Ensino; Aprendizagem ativa; Dispositivos médico-hospitalares.

## INTRODUCTION

Nowadays, there is a worldwide consensus that the higher education system has been facing challenging times with regard to the quality of learning. This issue arises from a network of complex factors that do not only concern the faculty itself, but they are also related to dynamic changes in technology, economics, politics, among other (Hartikainen et al., 2019). For instance, covid-19 pandemic has brought massive digital transformations (*e-learning*) in global higher education settings (García-Morales et al., 2021). Such external factors considerably shape students' lifestyle and needs, which in turn strongly impact their learning curve and technical skills, resulting in ill-prepared graduates for the labor market. Accordingly, it is a fact within the pedagogical field that an ongoing innovation and transformation in the teaching-learning process must follow the current changes of the world scenario (Castro, 2019; García-Morales et al., 2021).

In this regard, a wide range of teaching-learning methodologies have been proposed over the last years in order to keep up with the continuous educational changes and, therefore, mitigating associated learning issues. Among the several methodologies found in literature, those based on *active learning* – and variations thereof – have been claimed to be the best choices for the higher education (Freeman et al., 2014; Hartikainen et al., 2019; Konopka et al., 2015; Macedo et al., 2018; Pupin & Pieczkowski, 2021). Briefly, the rationale behind *active learning* relies to engage students in the center of the learning process, assigning to professors the role of instructors (Kane, 2004). In theory, such methodologies have the aim to develop an independent and critical thinking by the use of instruction-based activities, where learners are seen as *protagonists* (less passive) throughout the learning process. This is, in fact, different of what traditional learning is grounded, where students passively listening to a lecture and taking notes, for instance.

Within this context – and concerned with these challenging times in the higher education – Community University of Chapecó Region (Unochapecó, Brazil) has conducted in 2019 a deep restructuration in its educational system, from a traditional approach to a more active one. Among the several institutional steps given in this direction, the so-called Experience-Based Learning

(ABEx<sup>®</sup>) was one of the most important of them. Consisting of formal subjects introduced within all the undergraduate courses of Unochapecó, ABEx is not only a novel teaching-learning methodology, but also an elaborated pedagogical conception that impact the entire academic environment, encompassing teaching, research, extension and innovation. In brief, ABEx seeks to foster the entire academic background covering social, personal and professional scopes of the students by means of pedagogical approaches focused on concepts/principles (*knowledge*), skills (*know-to-do*) and attitudes (*know-to-be*), which in turn should be framed within methodologies that lead and encourage *student's protagonism*. This novel active learning conception was grounded and tailored within the seminal ideas of the greatest minds of the educational field (Bondía, 2002; Freire, 1996; Piaget, 1981; Vygotsky, 2008). It is referred to Santos & Cecchetti (2021) for further details on the theoretical and practical aspects of ABEx.

Within the aforementioned context, this manuscript presents a case report of an interdisciplinary teaching approach framed within the ABEx concept that encompassed the academia and the private sector aiming at social care. The main goal consisted of allying academics and professors from Mechanical Engineering and Physical Therapy undergraduate courses for the development of assistive medical devices manufactured from polyvinyl chloride (PVC) water pipes. In this article, focus on is given on the interdisciplinary nature of the subject.

## METHODOLOGY

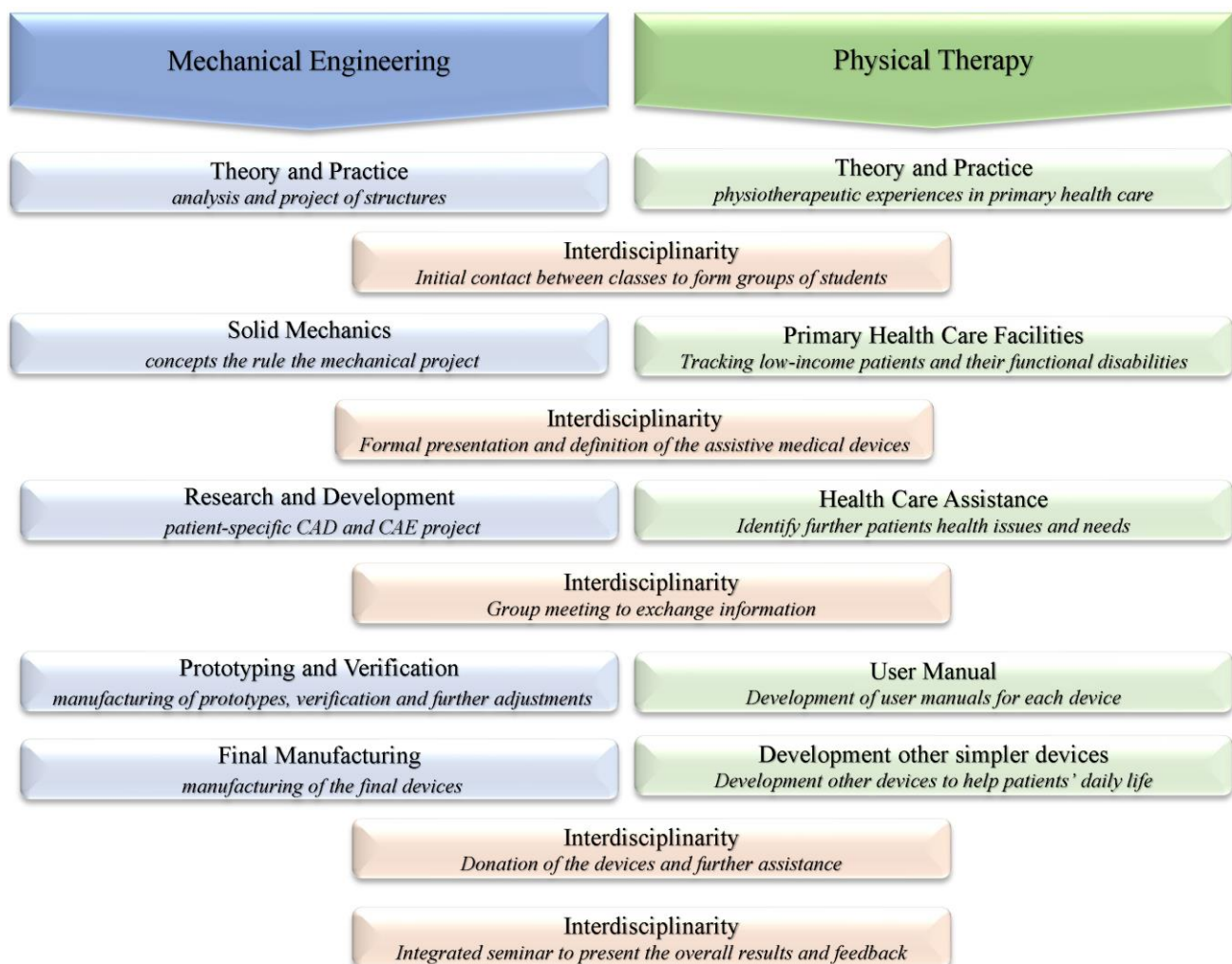
This section reports the events that took place at Community University of Chapecó Region in the 4<sup>th</sup> semester of Mechanical Engineering and Physical Therapy undergraduate courses in the year of 2022. The teaching-learning methodology described herein was framed within ABEx concepts, which the main educational aspects was previously presented (Santos & Cecchetti, 2021). Briefly, the main idea consisted of allying academics and professors from both of the mentioned courses aiming at the development of assistive medical devices, being these, afterward, donated to low-income patients of Chapecó community.

The main teaching events and contents

approached are summarized in the schematic chart shown in Figure 1. As one can see, the overall teaching strategy run in parallel, where each course focused on its main theoretical and practical aspects of that semester, *i.e.*, Mechanical Engineering approached subjects associated with the analysis and project of structures (Hibbeler, 2015, 2016) and Physical Therapy deals with physiotherapeutic

experiences in primary health care (Marques Abreu da Fonseca et al., 2016; WHO & UNICEF, 2018). The interdisciplinarity, on the other hand, was tailored by creating groups of students between the courses and keeping them in touch from the beginning of the subject. Brief descriptions of the main aspects of each point highlighted in Figure 1 are presented as follows.

**Figure 1.** Schematic chart summarizing the main teaching events and contents that took place throughout the subject.



The first interdisciplinary moment occurred within the very first classes, where the students of both courses were presented to each other and the main goal of the component was stated. Moreover, groups of students from both courses were formed, where each one of them

become responsible for a single patient.

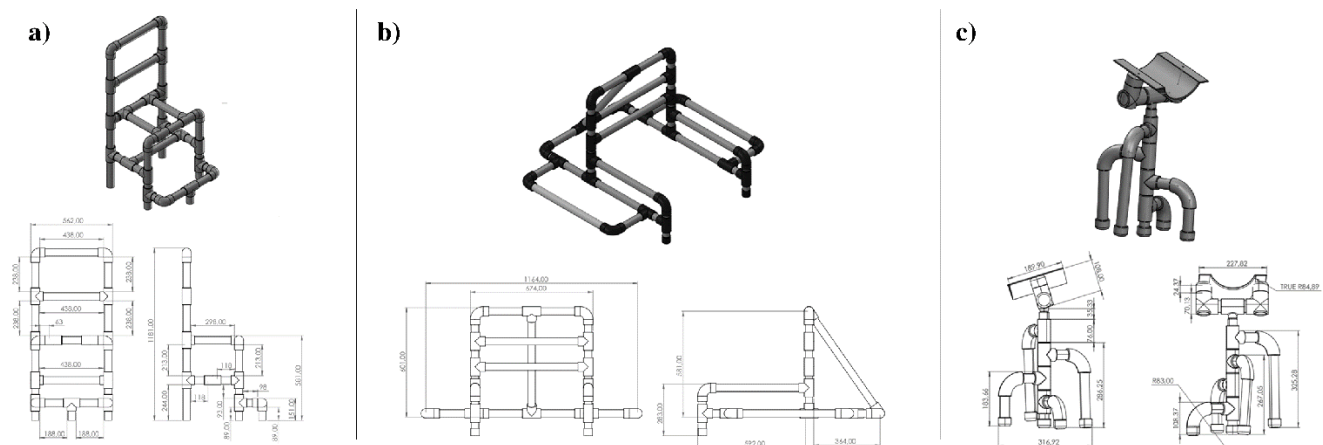
In the sequence, Physical Therapy students approached the issue by tracking low-income patients from primary health care facilities, performed the so-called *territorialization* (Ferreira et al., 2020) and

identifying the particular functional disabilities of the patients. Simultaneously, the Mechanical Engineering ones were concerned to study the main principles and concepts that rule the mechanical project. It is important to emphasize that in the 4th semester of Mechanical Engineering, the students were already in contact with structural project components, *e.g.*: Mechanics of Materials (Hibbeler, 2015).

After that, the groups of students were instructed

to elaborate a formal presentation of the data and knowledge acquired so far. This step was performed in a seminar-like fashion, where the students presented – based on their point of views – to what extent such information could help to achieve the main goal of the subject, *i.e.*, to define the particular assistive medical device based on patients’ disabilities. In the present work, three different devices were developed: bath chair, bed chair and leg stump support (see Figure 2 and 3, for instance).

**Figure 2.** Illustrative representation of the CAD sketches of the devices (dimensions in mm). a) Bath chair, b) Bed chair. c) Leg stump support.



In the sequence, the groups of students, leading by Physical Therapy ones, started to perform visits to patients’ home in order to raise their profiles and important information to the project, such as: the disability and related causes, anthropometric data, housing features, family details, further health assistance needed, etc. In parallel, Mechanical Engineering students started to work within the context of Research and Development (R&D), where Computed Aided Design (CAD) and Computer Aided Engineering (CAE) techniques were studied (Figure 2), such as technical drawing and finite element analysis (Chandrupatla & Belegundu, 2002; Zienkiewicz & Taylor, 2000). Moreover, laboratory classes were held to assess the material properties of the PVC pipes and thus select the proper pipes for each device. At this stage of the subject, the related groups of students of both courses kept in touch often to exchange information aiming at the design of the devices based on the specific needs of each patient (*patient-specific design*), *e.g.*: the dimensions of

the chairs with regard to the sizes of the bathrooms and beds, the strength needed to withstand patients’ weight, the geometry of the devices looking for patient’s comfort, among others.

Once the theoretical design was concluded, Mechanical Engineering students began to build prototypes of the devices in order to verifying if further adjustments were necessary to afterward manufacture the final version of them, which are shown in Figure 3. At this stage, the academics of Physical Therapy developed user manuals for the devices, containing good practices for use and storage. In addition, other simpler devices were developed based on the patients’ disabilities in order to help their daily life. For instance, a low-cost and reliable wheelchair transfer belt was made for one of the patients.

Finally, the groups of students performed the donation of the devices for the patients, instructing them (or those how take care of them) for the correct use and storage. Moreover, feedback from the patients and their

relatives were also obtained, regardless the nature of the critiques: opinions, compliments, suggestion for improvements and others. The closure of the subject consisted of an integrated seminar (open for the

community) where each group of students presented not only the overall developments and results, but also the learning outcomes achieved and the importance of them for their academic and professional life.

**Figure 3.** Final version of the patient-specific devices (bath chair, bed chair and leg stump support) manufactured from PVC pipes.



## DISCUSSION AND FINAL REMARKS

As one can realize in the previously described teaching methodology, the main pedagogical focus of this ABEx relied strongly on the interdisciplinarity between the courses (Ashby & Exter, 2019), which in turn led to an active learning process (Kane, 2004; Macedo et al., 2018). In other words, despite the technical contrasts between the courses, the solution of a mutual problem naturally enforced students to be at the center of the learning process, i.e., being protagonists. Likewise, professors took on the role of tutors/mentors throughout this process, guiding instruction-based activities and promoting the debate among students in order to develop an independent and critical thinking about the issues approached. Therefore, it is important to state herein that this close relationship between interdisciplinarity and active leaning was one of the most significant facts that was experienced throughout this project.

A relevant point that deserves further discussion concerns the teaching planning. As already mentioned, the present interdisciplinary approach encompassed not only two very distinct undergraduate courses, but also a local (private) company that provided support to the project by

sponsoring all the necessary materials for the manufacturing of the devices. Moreover, the primary health care facilities and related staffs, the patients and their families, were also directly involved. Accordingly, one can see that such a project embraces several personnel and agencies, differently from an ordinary subject where the professor and students go throughout the semester by themselves, i.e., in a classical teaching fashion. Based on this, it was verified that the development of the teaching planning in such a case could not be a trivial task. Therefore, in order to achieve success – both from an academic and social point of views – the teaching planning must be carefully designed by taking all the involved actors into account. In other words, all stages of teaching and people involved must be carefully coordinated into a well-planned agenda.

Regarding to the assessment process, formative and summative approaches were employed (Pereira et al., 2016). Particularly, the following methods were used throughout the subject: a) presentations and seminars; b) technical reports; c) peer-review; d) integrated final test based on Brazilian National Exam on Students' Performance (Enade) (Griboski, 2012). Moreover, feedback from tutors to students concerning activities and

assessments was constant. In addition, due to the dynamics of the subject, the use of messaging apps was essential for a quick exchange of information.

Finally, it is important to emphasize that, based on the authors' point of view, although the described teaching-learning methodology produced very good results overall, there is no a *gold standard* method within interdisciplinary learning approaches. Within the ABEx concept, the focus must be on the students' protagonism, therefore, any active learning method (or more than one) – or sometimes even classical teaching methods – could be applied, leaving it up to professors to decide which of

them better fits to the interdisciplinary problem to be solved and the related topics of that semester.

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