Design Science and Innovation

Luciana Pereira
Petter Krus
Magnus Klofsten *Editors*

Proceedings of IDEAS 2022

Interdisciplinary Conference on Innovation, Design, Entrepreneurship, and Sustainable Systems

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Design Science and Innovation

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Luciana Pereira · Petter Krus · Magnus Klofsten
Editors

Proceedings of IDEAS 2022

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Preface

Innovators have arisen throughout the previous decades from problem-oriented research based on knowledge integration at the junction of several fields. As a result, interdisciplinary collaboration has been crucial in addressing complex societal challenges. However, there are few places within and outside of academia where researchers are encouraged to push the boundaries of their discipline, leveraging their disciplinary mindset into contributions to broad domains, particularly in Science, Technology, Engineering, Entrepreneurship, and Management (STEEM) and across Social Sciences and Humanities. Throughout history, technical progress has resulted in the most important components of development—economic, social, and environmental—driving fundamental changes in the way we live.

The Interdisciplinary Conference on Innovation, Design, Entrepreneurship, And Sustainable Systems—ideas—strives to generate new questions and challenge existing policies and practices to foster more innovative and sustainable systems.

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How can the good of the people be the foundation to design a sustainable community?

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Artificial Intelligence at the Front End of Innovation: Systematic Literature Mapping

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Abstract. The Front End of Innovation (FEI) is considered a critical point in the innovation process, as the choices made in the FEI will determine which innovation options should be considered for new product development and commercialization. Studies indicate that Artificial Intelligence (AI) can be used in the FEI and, although the literature suggests that AI may not be ready to fully take on highly creative tasks within the innovation process, it appears much promising as a support for managers and can play a key role in the innovation process. This research seeks to present these potentialities by systematically collecting and analyzing available studies in the literature with the aim to (I) gain a comprehensive understanding of the interconnections between Artificial Intelligence and Front End of Innovation, (II) provide an overview of the current state of the research in this field, and (III) identify important gaps in existing approaches as well as promising research trends. To achieve these goals, a systematic mapping was performed covering articles published in journals from three relevant databases. Initially, 494 primary studies were selected and subjected to a screening and review process, which resulted in the election of 53 articles whose models and solutions for using AI in FEI were classified and summarized. The results of the research point to the increasing use of AI in FEI. The Identification of Opportunities stands out for having the highest concentration of articles with use of AI, followed by areas of Analysis of Opportunities and Generation and Enrichment of Ideas.

Keywords: Front End of Innovation · Artificial Intelligence · Systematic Literature Mapping

1 Introduction

Innovation and technological advances, especially Artificial Intelligence (AI), are at the heart of economic change and their application has been explored in various disciplines in both academic and professional environments [7, 36]. According to Kakatkar, Bilgram, and Füller [22], it is a fact that AI will affect some businesses more than others, depending on the degree of creativity to which the economic activity is subjected. The higher the degree of creativity involved, the greater the difficulty of adding value through AI, which represents a dilemma and a challenge for those who are in charge of innovation processes in companies. The research in which authors point out that it is possible to use AI in the

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Front End of Innovation (FEI) generated the following research questions: How is AI being used in the phases of the FEI process? And what are the interconnections between AI and the FEI?

To answer these questions, the Systematic Literature Mapping method was used as the basis for developing the research with the triple goal of (I) obtaining a comprehensive understanding of the interconnections between AI and FEI; (II) gaining an overview of the current state of research; and (III) identifying important gaps in existing approaches. To achieve these goals, studies published in journals from three databases were collected and analyzed. As a result, 53 primary studies were selected that present models and solutions on how to use AI in FEI, and the challenges and opportunities generated.

2 Methodology

Systematic mapping is a secondary evidence-based study that uses a systematic and well-defined procedure and is used to synthesize existing work from the literature. Systematic mappings are able to provide a comprehensive overview of the state of the art on the research topic [25] and can also identify relevant gaps in the literature and collect evidence for further research, avoiding double efforts [38]. Thus, systematic mappings allow high-level analysis of all available studies in a given field and answer research questions [24].

Systematic mapping basically comprises three steps: planning, conducting, and analyzing. The planning stage produces the protocol that defines the research questions to be answered, the research strategy to be adopted, the selection criteria adopted, and the methods for extracting and synthesizing data. In the conducting stage, the primary studies are identified, selected, and evaluated according to the defined protocol. Finally, the analysis stage aggregates information extracted from the relevant primary studies considering the research questions and projects the results.

2.1 Research Questions

This step aims to find primary studies to understand the interconnections between AI and FEI and to get an overview of the current state of research and identify important gaps. The following research questions described in Table 1 were proposed:

Table 1. Research Items.

Research Questions	Goal
RQ1. What is Artificial Intelligence?	To achieve a comprehensive understanding of how the literature defines AI

(*continued*)

Table 1. (*continued*)

Research Questions	Goal
RQ2. How is AI being used in the phases of the Front End of Innovation (FEI)?	To understand the extent to which AI is already integrated into the FEI, what models and methods have been used, and in what sectors
RQ3. What are the interconnections between AI and the Front End of Innovation (FEI)?	To understand how well AI can integrate the FEI

Source: Prepared by the authors (2022).

2.2 Strategic Search

To retrieve the primary studies, it was used an automated search process conducted in three electronic databases (IEEEXplore, ScienceDirect, and Scopus), which are among the most popular and able to guarantee a high coverage of potentially relevant studies [6]. Other important criteria were considered, such as: (I) comprehensiveness of the electronic database, (II) content updating, (III) availability of the full text of the main study, (IV) ease of search construction through fields and commands available in the database, (V) quality of the results, and (VI) versatility in exporting the results [8].

To answer the research questions, the following keywords were considered and adapted according to the specificities of each database:

TITLE-ABS-KEY (“fuzzy front end” OR front end of innovation” AND "machine learning"OR "big data"OR "artificial intelligence"OR "ai"OR "Advanced Analytics"OR "sentiment analysis"OR "predictive analytics"OR "anomaly detection"AND "innovation"AND "front end"OR "project"OR "product innovation"OR "service innovation"OR "ideas bank") AND PUBYEAR > 2016 AND DOCTYPE (ar)

2.3 Selection Criteria

The selection criteria were used to evaluate each primary study retrieved according to the defined research questions. The primary goal was to include studies potentially relevant to answering the research questions and exclude those that do not contribute to answering them. In this systematic mapping, a primary study is considered relevant if it does not meet any of the mentioned exclusion criteria.

3 Selection Process

To systematize the search, it was used Parsif.al (www.parsif.al), an online tool designed to assist researchers in conducting systematic literature reviews, according to Kitchenham and Charters [24], which includes all steps of the mapping process and systematic literature reviews. It also allows researchers to work together in a shared workspace, designing the protocol, conducting the search, and recording each step of the process. The primary studies were selected and evaluated according to the established protocol, resulting in a set of possibly relevant studies. The generic search string was slightly modified to make it compatible with the specifics of each database. The search was limited to the title, abstract, and keyword fields only, from publications between the 2016 and 2021. The selection of the studies was divided into three main phases. The preliminary selection comprised reading the title, abstract, and keywords of the studies retrieved from the electronic databases. The second selection included reading the introduction and conclusion, and the final selection comprised reading the remaining articles in full. In order to eliminate any biases or misinterpretations in the selection of the articles, the three researchers performed the selection activities individually.

After removal of the duplicate studies, 524 studies were evaluated in terms of title, abstract, and keywords by the selection criteria, resulting in a set of 494 potentially relevant studies. Further filtering by reading the introduction and conclusion resulted in 177 studies to be analyzed by reading their contents in full for a final analysis. As a result, 53 primary studies were selected as relevant for this systematic mapping, according to Table 2.

Table 2. Research Items.

Database	1^{st} Selection minus duplicates	2nd Selection	Final Selection
IEEEXplore	124–2 = 122	14	8
ScienceDirect.com	55–26 = 29	18	9
Scopus	345–2 = 343	145	36
Total	494	177	53

Source: Prepared by the authors (2022).

4 Results

The selected articles were classified by area of the FEI, according to the classification by Koen et al. [26] and summarized according to Table 3. It is observed that the highest concentration of articles using AI is on Analysis of Opportunities, Generation and Enrichment of Ideas, and Identification of Opportunities.

From 2019 it can be observed an increase in the number of publications of articles related to the theme of AI in EIF, and also that the areas of the FEI corresponding to Analysis of Opportunities, Generation and Enrichment of Ideas, and Identification of Opportunities concentrate a greater number of publications than those more related to primary characteristics and customer benefits, selection of ideas, and definition of the concept.

As a result of the analysis of the keywords in the articles, Big Data, Analytics, Artificial Intelligence, Digital, Product and Innovation are the most referenced.

Table 4 presents the classification of the articles by areas of the FEI with the description adapted from Rochadel et al. [39].

Table 3. Total Articles by Area of the FEI

Area of the FEI	Total Articles
Analysis of opportunities	13
Definition of the concept	5
Generation and enrichment of ideas	13
Identification of opportunities	16
Selection of ideas	6
Grand Total	53

Source: Prepared by the authors (2022).

Table 4. Classification of the articles by areas of the FEI

Area of the FEI	Definition	Authors
Generation and Enrichment of Ideas	It is related to the improvement and/or development of new products, but also related to the feedback to the products on the market. This is an important phase because here the ideas are appropriated, which consists of the vision of the imagined solution to the problem	[11, 14, 17, 19, 22, 29, 30, 35, 41, 42, 46, 55]

(*continued*)

Table 4. (*continued*)

Area of the FEI	Definition	Authors
Selection of Ideas	It is linked to the selection of development projects, continuous improvement or prospection of new products and/or markets. Here the link with the partner and/or customer has the objective of exploring or seeking knowledge for the selection of ideas	[9, 16, 31, 33, 49, 58]
Definition of the Concept	It presents the visual and written description with the primary features and benefits to customers	[1, 3, 4, 37, 57]
Identification of opportunities	It aims to identify a business, service or product opportunity (a gap), with a view to the future, in order to obtain a competitive advantage to respond to threats and solve problems and/or situations. Some works relate the challenge of finding problems to generating opportunities, others to finding partners to understand the needs	[2, 15, 18, 23, 28, 32, 40, 43–45, 47, 50, 52, 60–62]
Analysis of opportunities	It seeks the partnership for the continuity analysis of an identified opportunity	[5, 10, 12, 13, 21, 27, 34, 48, 51, 53, 54, 56, 59]

Source: prepared by the authors (2022).

5 Final Considerations

With the accomplishment of this systematic literature mapping, it was possible to reach the initially proposed objectives and obtain the answers that motivated this research.

Regarding Artificial Intelligence (RQ1), despite being a field that began in the 1950s, it is still under development and advances as the technologies on which it depends advance, i.e., not everything that can be accomplished with its use has been seen yet. Among the algorithms, it was found a higher frequency in the use of machine learning, genetic algorithms, neural networks, and data mining, often used together with sentiment analysis methods, to propose new product development (NPD) or for the improvement of existing products.

Through the analysis of the selected articles it was observed that some stages of the Front End of Innovation (RQ2) are further ahead, i.e., they already incorporate this technology for better decision making; however, there is a long way to go. In the areas of the FEI that involve data and information analysis, the use of AI is more present than in those areas that require creativity and intellectual abilities such as Selection of Ideas and Definition of the Concept. In the analyzed articles, it was verified the growing use of big data together with data analytics for the Identification and Analysis of Opportunities of new products and/or services, or even in incremental innovation.

Artificial Intelligence has been the subject of studies like never before, since, together with new technologies, they become engines for the transformation of the way we live, which has already been happening, in a subtle and gradual way (RQ3). In the research it could be observed the growth in publications on the theme, which indicates a greater incentive from governments for the development of research, which can be easily observed by the origin of the authors of the articles; and the planning of investment in AI in the processes of the FEI processes by executives for the coming years, i.e., the increase in research in the area is justified by the growing interest and need of organizations to update and make use of available technologies in favor of their businesses, which also includes governments.

6 Future Works

The use of Artificial Intelligence in the Front End of Innovation is recent, and much of its application is linked to the analysis of large volumes of data (big data) to identify and analyze opportunities.

Sentiment analysis has been used by some authors to propose improvements and generate new ideas. As future work, it is expected to conduct a more in-depth study on the AI algorithms being used, analyzing their results and the knowledge generated in the area of Front End of Innovation.

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Agent-Based Simulation and Ontology Integration for System-of-System Exploration

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Abstract. The increasing interest inSystem-of-Systems (SoS) for engineering applications are introducing new challenges that must be overcome at an early design stage. One of these is the integration of different tools that can be used to make predictions about a system under development and how these together can be used to predict SoS performances by comparison of parameter spaces.

The purpose of this paper is therefore to illustrate how different SoS architectures can be modeled, simulated, and evaluated throughout different scenarios by different teams of researchers following a common workflow.

An ontology is used as an overarching knowledge base where information about entities, such as scenario details, can be extracted and used for the setup of Agent-based Simulations (ABS) through a tool integration software acting as master that controls the correct execution of the defined workflow.

The tool integration software also enables additional modelling capabilities, such as a Design of Experiments (DOE) definition for design space explorations, an Optimizer with different algorithms, user-defined Python scripts, etc.

Keywords: System-of-Systems · Ontology · Agent-based Simulation · Tool integration

1 Introduction

The concept of System-of-Systems (SoS) is becoming increasingly common in many engineering applications. One of the reasons for this is the rapid increase in digitalization and the ability for different systems to communicate so as to produce results and capabilities not obtainable by individual systems alone [1]. Modelling and simulation of SoSs is consequently an important step that must be performed in order to ensure that suitable system solutions are developed for an ever-uncertain future. However, involved systems typically have their own ways of being modelled and simulated, and the ability to integrate different system models therefore becomes of increasing interest. Furthermore, the complexity increases when the surrounding circumstances, such as environmental conditions, are considered. Hence, a common procedure for definition of scenarios, systems, and parameter spaces to be studied in a simulation tool is necessary for reaching a standardized workflow. Thus, ontologies increase their relevancy for structuring large parameters spaces when a certain scenario is to be studied

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by using a model, that also includes different systems. In the study of SoSs it is of great significance to uncover emergent behaviors raising from the interactions between the constituent systems. Agent-based Simulations (ABS) are often used for this type of analysis. If the outcome of different SoSs is to be compared, ontology reasoning also allows traceability, providing the necessary data to support choices or define requirements as the needs shift toward System-of-Systems Engineering. Consequently, the purpose of this paper is to illustrate how tool integration between ontology and ABS can be performed to evaluate and explore design spaces for SoSs, allowing a common workflow independent of the exploration purpose.

Wildfire detection is used throughout the paper as an example of a typical SoS where different constituent systems are working together while being influenced by environmental conditions and varying scenario details [2]. The example is relevant since it includes evolving scenarios under different environmental conditions, different outcomes depending on the constituent systems of the SoS and possible emergent behaviors or capabilities.

2 Background and Theory

This section explains some of the background theory about involved disciplines that together make up the foundation for the presented work in this paper. The explanations of the disciplines are mainly oriented towards the design and analysis of SoSs but can be applicable from other perspectives as well.

There are many ways of modeling SoSs. One of these is to represent a domain using an ontology model, which depicts the entities involved and their relationships, with examples of previous usage of ontologies found in [3] and [4].

2.1 Ontology Engineering and Semantic Web Technologies

Ontology engineering is used to build knowledge bases that describes a domain with involved entities and their relationships in a formal and explicit manner [5]. In digital engineering, an ontology is typically built based on semantic web technologies and languages such as the Resource Description Framework or the Web Ontology Language (OWL) [6]. Like Model-Based Systems Engineering languages, such as the Systems Modelling language (SysML), OWL ontologies can be used to describe and model systems. However, OWL ontologies feature various benefits that make them more scalable and flexible to the introduction of new information. One of these are the support for description logic reasoning. A description logic reasoner, or simply reasoner, can be used to check the consistency of an ontology model but also infer implicit knowledge captured in it. An ontology model can consequently be queried using a reasoner to, for example, give suggestions on suitable constituents for an SoS as shown in previous research [7].

2.2 Agent-Based Modelling and Simulation

Agent-based Modelling and Agent-based Simulations (ABS) can be used to model, simulate, and evaluate different SoS solutions [8]. ABS can simulate a predefined world, and its environmental conditions, populated with agents that represent systems. These agents are described by a set of behavioral rules that model their design and performance. Interactions between agents in the world-environment may generate behavioral patterns difficult to foresee and not achievable by themselves alone. Even if the rules are simple, complex unexpected behaviors may appear, hence their relevancy in the study of SoSs, where the aim is to optimize its collection of constituent systems capable of fulfilling the mission requirements. The level of detail at a system level is important for observing the possible emergent behaviors at an upper realistic SoS level. ABS is especially relevant in certain research fields because the costs involved in field testing or experiments can become prohibitive [8].

2.3 Tool Integration

The Remote Component Environment (RCE) is an open-source software that enables the creation of calculation and simulation workflows with user-integrated tools [9]. RCE workflows consist of components that are connected to each other using input and output connections to describe data flows. Default components available in RCE include things such as an optimizer or a Design of Experiments (DOE) components for defining various analyses. RCE also allows the inclusion of Python scripts as components with the outcome of other components as inputs while the computed code can provide outputs usable by other components.

Tool integration can also be performed using different standards, such as the System Structure and Parameterization (SSP) standard [10]. This is a tool independent standard that utilizes Functional Mockup Units (FMU) to share models between simulation tools. Another option is to use Extensible Markup Language (XML) files, which allow to structure data, being it the parameters for the definition of an ontology and the agent-based model setup, or the results from simulations.

3 Method

The method presented in this paper is to use an ontology as an overarching knowledge base that describes the environmental conditions of the model, the SoS architecture and its constituent systems characteristics, and the simulation setup.

A tool integration software is then used to extract the information captured in the ontology. The tool integration is performed using XML files: The ontology is defined in one with different levels whose values can be extracted in different ways depending on the tool. The extracted values are then saved in another XML with the specific structure needed to run an ABS in headless mode -without the graphic user interface- from the integration software.

This information can from here be used in a workflow to for example perform a DOE for design space explorations. Agent-based simulations can thereafter be performed in order to evaluate the different SoS solutions and how these are affected by variations in different boundary conditions, such as environmental factors.

3.1 Ontology Buildup

The ontology part of this work acts as an overarching knowledge base that describes different details about the domain in question. The modeling of the ontology is partly done with respect to the required inputs for the subsequent ABS. Consequently, the ontology consists of general classes describing SoS details, but also simulation setup information for the ABS. The ontology modeling itself is done using a process described in [7]. Here, domain details are described using OWL classes, instances, object- and data properties. Different scenario classes are finally modeled to provide specific simulation cases for the workflow and ABS. This consequently generates the overarching knowledge base from which various information can be extracted and used in the intended workflow and ABS. Additionally, the subsequent results can at the end be added to the ontology model to expand the available knowledge base and to enable further processing using, for example, a reasoner.

3.2 Simulation Process and Approach

For the study of SoS working to detect a forest fire under realistic conditions, an area is divided equally in a collection of smaller squared areas. The centroid of each area can be translated to a ser of coordinates in a Geographic Information System (GIS) file to import the local elevation. The fire spread model is based on the work in [11] and defines how vegetation agents influence other agents in their neighborhood by raising the temperature until they catch on fire. The spreading is affected by the different environmental conditions of temperature, wind, and the terrain local slopes. The vegetation on fire will generate a smoke plume, modeled similar to [12], being it the main mean for detecting of a possible wildfire. A full description can be found in [2]. The constituent systems of the SoS in the ABM are a collection of aircraft with parameters such as flight velocity and equipped with sensors possessing different detection ranges. The ABS runs until detection of a fire, or a smoke plume is achieved.

4 Workflow Implementation and Case Study

The implementation of an example workflow is performed to illustrate how the method just presented can help in the early design study of an SoS. This case study implementation is based on the increasing necessity of wildfire prevention. Wildfires have seen a steady increase worldwide during the last decades. Early detection of wildfires can prevent them from becoming uncontrollable and ease their extinction without dramatic losses. A case of study is the events described in [13] where the approximated starting point of the fire, its evolution, and data about the changes in the environmental conditions throughout time can be found.

4.1 Case Study Delimitations

The following delimitations have been introduced to this case study to keep the scope at a comprehensive level:

- Only wildfire prevention is investigated as a case study. The validity of the presented workflow remains to be tested for other domains and application areas.
- The fidelity of the involved models and components are kept relatively simple so as to better illustrate the presented method.
- The number of simulations for each scenario defined by an ontology is only one.
- The number of constituent systems in the SoS is constant -three- so the ontology is small and therefore faster to define, making the evaluation of the workflow to find conflictive points easier.
- The ABS runs only in headless mode; thus, no graphic user interface is available for it, and the environmental variables such as relative humidity become fixed throughout time.

4.2 Ontology Modelling and Definition

The ontology modelling for this case study is done in OWL using the Protégé ontology editing software [5]. The process mentioned in Sect. 3.1 is used to create a class hierarchy describing the involved entities from the intended wildfire prevention domain. Classes are consequently added for available systems, subsystems, environmental conditions, locations, ABS setup details and more. The class hierarchy is then populated with individuals corresponding to specific case study details, such as specific types of Unmanned Aerial Vehicles (UAV) or geographical locations. Object properties are then added to describe the existing relationships between the modelled classes and instances. Finally, data properties are added and associated with the individuals to describe values such as UAV cruise speeds or the environment's relative humidity. Once the domain has been modelled to a desired degree of information, defined ontology classes can be implemented to describe specific simulation scenarios as individuals. Figure 1 shows an example of this where an *Example Scenario* individual has been defined with relationships to other individuals that describe more specific details. Figure 2 shows how the ontology is built at the system level, for the case of UAVS in the example scenario. UAV individuals are associated to different sensors and data properties. UAVs belong to the UAV class which in turn "is a-" Airborne System, etc. [14]. The example scenario shown in Fig. 1 involves three different UAVs and consists of different conditions such as an example fire. The definitions for this example fire can be seen to the right in Fig. 1. The definition for the *Example Fire* individual involves different data properties that describe the required information for the subsequent ABS and simulation setup. However, these data property values can also be seen as a baseline for a possible Design of Experiments setup. These could consequently also represent intervals of allowed values for the simulation and thereby also provide a design space to be explored in the workflow and through ABS.

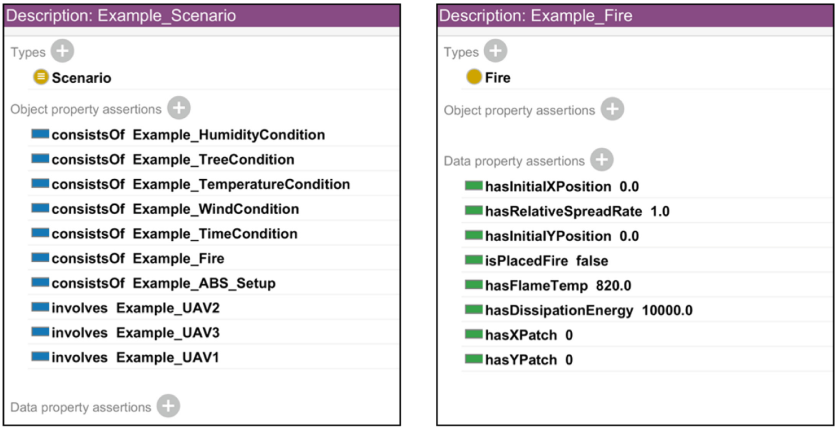

Fig. 1. The definitions for the *Example Scenario* individual (left-hand side of the figure) and the *Example Fire* individual (right-hand side of the figure).

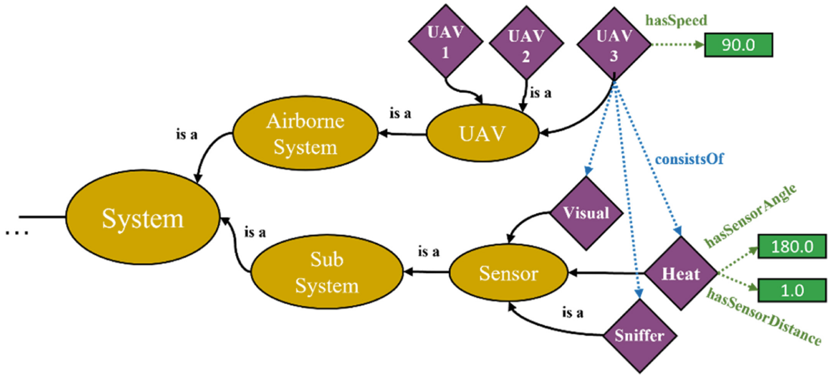

Fig. 2. Representation of the ontology build-up and overall structure. Classes are represented in yellow circles, individuals in purple diamonds, relationships with blue arrows, and data properties in green.

4.3 Agent-Based Modelling and Simulation

Netlogo is an open-source tool with high level language designed for agent-based modeling and simulation [8]. The world is modeled in it as grid of 195 $\times$ 195 cells of size 100 m $\times$ 100 m. By using the GIS extension in Netlogo for files with raster format, the centroid of each cell will be defined with an elevation that is used for computing local slopes. This feature is especially important when combined with the environmental conditions of temperature, relative humidity, and wind since it allows to represent realistic scenarios with a good level of fidelity. The graphic user interface for the model has been populated with different options for defining the simulation setup as shown in Fig. 3. Another feature is the headless mode that allows faster simulations without graphic user interface, saving computational power for running extensive comparisons of parameter spaces. In headless mode the complete simulation setup and number of runs are taken from an XML file to obtain as much necessary data for SoS analysis as needed.

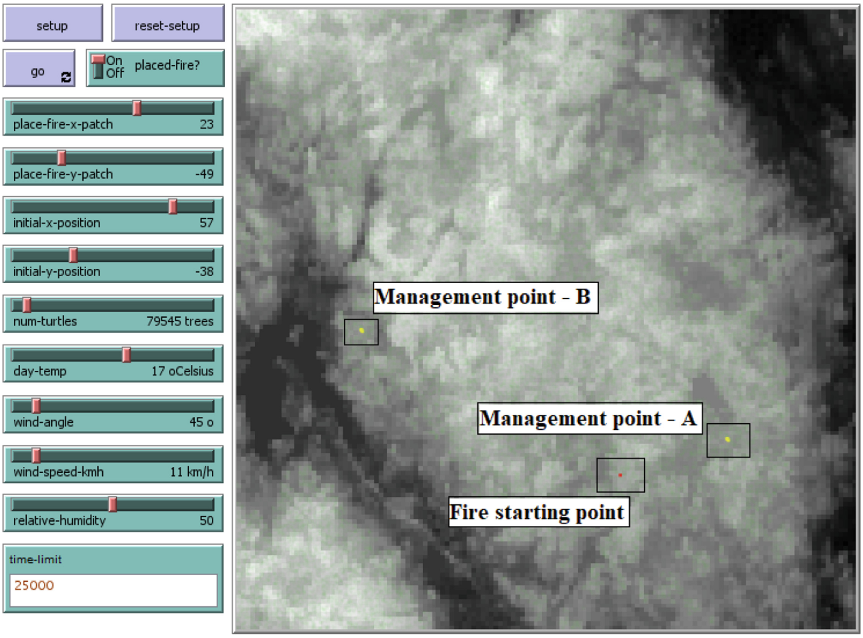

Fig. 3. Study case in a Netlogo Agent-based Simulation (ABS). Parameters shown on the left; Simulated map with the approximated points for the starting fire and the management points.

4.4 Workflow Implementation

An RCE workflow was implemented by first adding Netlogo as an integrated tool, allowing to use it as a simple component in the workflow. The workflow in Fig. 4 shows, from left to right, a block that stores a Python script for reading the ontology file; then the Netlogo block that runs the ABS, and parallel to it a block with a short Python script ensuring that the workflow waits for the ABS to be finished before running the remaining components. The results are filtered afterwards using another Python script, also in a block component, that sends the results to be written into a file to RCE's default Output Writer component. This last component includes the convenient possibility of storing the results in files with different names every time the workflow is executed.

The simulation setups in this study case were:

- Setup 1: Averaged original values (approximately) of wind velocity and relative humidity from [13], being respectively 11 km/h and 50%.
- Setup 2: Worst possible values (approximately) of wind velocity and relative humidity from [13], being respectively 22 km/h and 20%.

- The temperature was fixed for all cases at 17 degrees Celsius and the wind has a Southwest direction (45° clockwise).
- The SoS 1 involves three UAVs, one of them following the perimeter with flight velocity of 150 km/h, and the other two respectively flying North to South and East to West repeatedly. Detection range for all is 1 km.
- The SoS 2 involves three UAVs, one of them following the perimeter with flight velocity of 150 km/h, and the other two flying perpendicularly and parallelly to the wind. Detection range for all is 1 km.
- Management point – A was taken from [1] while point B was arbitrarily chosen close to a town in the map with coordinates [−60, 0] in the grid.

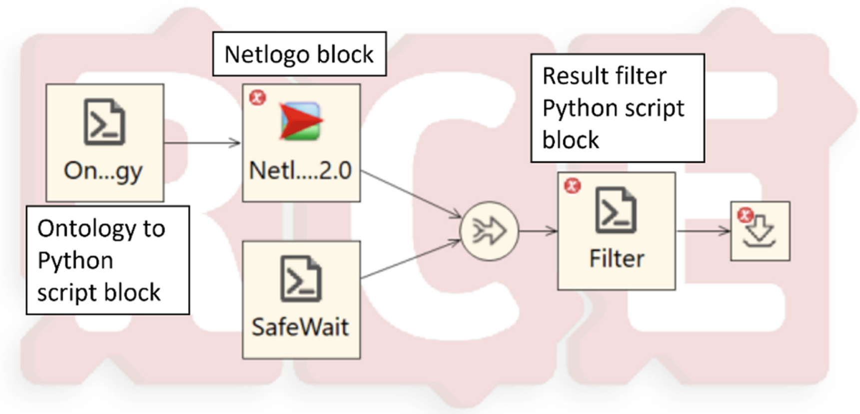

Fig. 4. Ontology and ABS integration into RCE workflow.

4.5 Results

The resulting detection times (in minutes) and areas on fire (in square kilometers) are shown respectively in Table 1 and Table 2. With the resulting detection times, it is possible to obtain the flown range by the three UAVs included in the ABS. These results can be seen in Table 3. Notice in Table 2 the bigger area on fire even though the detection time is lower. This difference comes from the randomized distribution of the vegetation.

Table 1. Detection times in minutes.

	Management point - A	Management point - B
SoS1&Setup1	4.32	23.50
SoS2&Setup1	16.57	52.25
SoS1&Setup2	4.0	23.57
SoS2&Setup2	16.53	30.67

Table 2. Approximated area in fire in square kilometers

	Management point - A	Management point - B
SoS1&Setup1	0.01	0.01
SoS2&Setup1	0.01	0.04
SoS1&Setup2	0.01	72.25
SoS2&Setup2	7.29	38.44

Table 3. UAVS distance in kilometers.

	UAV-1	UAV-1	UAV-2&3	UAV-2&3
SoS1&Setup1	10.80	58.75	6.48	35.25
SoS2&Setup1	41.42	130.63	24.85	78.38
SoS1&Setup2	10	58.92	6.00	35.35
SoS2&Setup2	41.34	76.67	24.80	46.00

5 Discussions and Future Work

The ontology part of this work was mainly used as an overarching knowledge base for the workflow and simulations. The benefits of semantic web technologies and OWL were consequently not extensively used in this study. It is therefore possible that the same knowledge base could have been provided by other means of modeling a relational database. However, a reasoner was used in this study to check the implemented model for consistency, and future expansions of this study will also be facilitated by being defined through OWL.

The ABS study case was shown to be suitable for different studies, not only SoS but also for defining requirements for the discipline of aircraft conceptual design, or for evaluation of an uncontrolled fire depending on the current environmental conditions. The ABS is limited nonetheless to constant parameters, but since [13] shows that the environmental conditions change following a sinusoidal variation, it would be possible to modify the current model to represent that kind of evolution by adding the time of the day to the model and the ontology.

This study used RCE as the tool integration environment. However, it is possible that an approach using the SSP standard could be a more suitable approach in the future. The different used models could, in that case, be converted into executable FMUs that could be simulated together in any simulation software that supports the standard. This is consequently a prominent topic for future work. Possible areas of future work involve a deeper study of the resources available in RCE to make use of the components specifically built for design of experiments and optimization.

6 Conclusions

This paper has shown a methodology for using component-based environments to integrate software tools for creation of workflows. The setup for these workflows can be defined using ontology representations stored in XML files. This allows different kinds of research and evaluations by teams interested in various topics, such as the presented case for System of Systems (SoS), aircraft design, prediction of fire evolution, etc. The use of an ontology enables standardization of the evaluation of parameters used in an ABS, improving traceability and communication among the researchers involved.

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Negative Social Impacts of Artificial Intelligence and the Main Mitigation Actions: A Systematic Review

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Abstract. The challenges faced by those working with Artificial Intelligence (AI) technologies that directly impact human social or ethical life can be divided into two main categories, encompassing philosophical concerns about the feasibility of incorporating ethics into algorithms and the technological challenges of AI development. Among the challenges are the ethical and social impacts connecting two intertwining domains, the human and technology. This study aimed to map the main social impacts of AI and the recommendations to mitigate these impacts, using the systematic literature review (SLR) as a methodological approach. Among the results, it became evident that the research for identification and analysis of social impacts has been growing in recent years, as well as the interest in mitigation actions. Through the analysis of the relationship between these two themes, it was possible to identify that one of the main impacts addressed is related to the fear of technology usurping jobs in the areas of commerce, industry, and transportation, which are the areas that already have practical examples where technology, in fact, is performing human functions. The main mitigation actions for this social impact included increasing public debate about this circumstance and creating laws, principles and methods for regulating the use of AI.

Keywords: Artificial Intelligence · Social Impacts · Mitigation

1 Introduction

The challenges faced by those working with Artificial Intelligence (AI) technologies that directly impact human social or ethical life can be divided into two main categories: philosophical concerns about the feasibility of incorporating ethics into algorithms, and the technological challenges of AI development [1]. Among the challenges are the ethical and social impacts connecting two intertwining domains: human and technology, because humans are technological beings and technology is a social entity [2]. This means that ethical and social values are not only integrated into systems, but instead are created daily in the interaction between man and machine [2]. Just as knowledge develops into technology and innovation, discussions about the social impacts of these new technologies also need to be assessed prior to their deployment. Such evaluation

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deserves to be carried out more intensely, because experts indicate that this technological revolution must be started in the right way, at the risk of the social situation degrading even more [3].

Social impact can be defined as changes in people's way of life in relation to culture, community, political interests, environment, health, well-being, personal rights, fears and aspirations [4]. The concern with the social impacts of the use of AI goes beyond the issues related to deaths resulting from the use of autonomous vehicles, and puts light on the risks involved with the most common use of this technology, such as algorithms that make decisions in selection processes, lawsuits, and even in analysis and release of personal credit, because if there is any error or prejudice inserted into the system, real people will have their lives affected [5].

It is also noteworthy that, since technologies are being implemented faster than the critical analysis of these risks, there are possibly incorrect solutions also being implemented and, consequently, risks that directly affect the people involved.

The literature indicates that the process of rework and mitigation of these impacts could be avoided if the whole procedure of evaluation and critical awareness was implemented from the development project of each system that involves the use of Artificial Intelligence [6].

This reflection has also been driven by the COVID-19 pandemic, which started in China in 2019 and has drastically altered the way people relate to each other and perform day-to-day activities, stimulating the use of various technologies to perform tasks that were previously performed in a face-to-face manner by the majority of the population [7–9].

At a time when discussions about the importance and applicability of ethics have become increasingly important and necessary, especially for AI-oriented applications, it becomes paramount to discuss the social impacts resulting from this new Industrial Revolution, as well as to evaluate the ways to eliminate or mitigate the possible negative impacts generated by such technological advances. These, then, are the objectives of this research, which will undertake a systematic literature review in order to map the negative social impacts of AI and the main mitigation actions.

The definition of AI is complex [10] and the first researcher who sought this definition was Turing. The author defined intelligent behavior as the ability to achieve human-level performance in cognitive tasks, enough to fool an interrogator. The test that the author proposed is that the computer should be interrogated by a human by means of a conversation through a keyboard, and if the interrogator cannot tell whether there is a computer or a human on the other end, the equipment would pass the test [11]. However, this definition does not separate technical knowledge from intellectual perception [10].

One of the main attempts to define AI is the proposal developed by Russell and Norvig and classified into two dimensions, the top and bottom dimensions. According to Table 1, the definitions at the top (systems that think like humans and systems that think rationally) are aimed at the thinking and reasoning processes, while those at the bottom (systems that act like humans and systems that act rationally) are aimed at the behavioral processes of AI systems. The definitions on the left (systems that think like humans and systems that act like humans) measure success in terms of trustworthiness to human performance, while those on the right (systems that think rationally and systems that act rationally) measure the relation to an ideal compared to a performance measure, called rationality [12] (Table 2).

Table 1. AI Definitions

Systems that think like humans	Systems that think rationally
"The exciting new effort to make computers think… Machines with minds, in the full and literal sense." (Haugeland, 1985)	"The study of mental faculties through the use of computer models. "" (Chamiak and 1985)
"The automation activities we associate with human thought, activities such as decision making, problem solving, learning…" (Bellman, 1978)	"The study of the computations that enable one to perceive, reason, and act." (Winston, 1992)
Systems that act like humans	**Systems that act rationally**
"The art of creating machines that perform functions that require intelligence when performed by people. "" (Kurzweil, 1990)	"Computational Intelligence is the study of the design of intelligent agents." (Pooleet 1998)
"The study of how to make computers do things that, at the moment, people are better at. "" (Rich and Knight, 1991)"	"AI… is concerned with intelligent behavior in artifacts."(Nilsson, 1998)

Source: Adapted from Russel and Norvig (2002).

Table 2. Criteria for article selection

	Scopus	Web of Science
Formula for advanced search	TITLE-ABS-KEY = ("ARTIFICIAL INTELLIGENCE" OR" AI) AND (ETHIC * OR MORAL *) AND (SOCI *)	TS = (("ARTIFICIAL INTELLIGENCE" OR AI) AND (ETHIC * OR MORAL *) AND SOCI *)
	TITLE-ABS-KEY = standard search fields (title, abstract, and keywords)	TS = standard search fields (title, abstract, and keywords)
Comments	AND = Boolean operator	AND = Boolean operator
	OR = Boolean operator	OR = Boolean operator
	SOCI = the word were used incomplete to cover social and society words	SOCI = the word were used incomplete to cover social and society words

Source: Own authorship (2021).

There is a tension between the human-centered approach and the rationality-centered approach. The human-centered approach must be an empirical science, involving hypothesis and experimental verification. The rationalist approach involves a combination of mathematics and engineering [13].

2 Methodological Approach

A systematic literature review (SLR) was used to seek answers to the following questions:

– What are the main social impacts tied to the use of AI?
– What are the main recommendations to eliminate or mitigate these impacts?

The RSL was developed in three main stages, the first being the planning stage, in which the need for the research was identified. The second stage of the RSL involved conducting the review, which was accomplished by searching the publications, selecting the articles according to the established criteria, extracting the data, validating the quality of the publications, and synthesizing the data. The final step involves dissemination of the data [14].

The academic research bases used were the Web of Science and Scopus platforms. The search filters were selected by keeping only scientific articles, of which the publications were made between the years 2000 and 2020, that the language of the publication was in English and from the areas of computer science, social sciences, engineering, business arts and humanities.

Based on the 690 publications selected from the main scientific research databases, as described in Table 1, a systematic literature review was developed. After obtaining the 690 publications, the eligibility criteria were applied, divided into three filters.

The first filter was the analysis of the titles. In this step, all titles and keywords used per author were evaluated, in order to validate the content of the article, which should be related to research and identification of principles and ethical impacts of the use of AI. The second filter was the analysis of the abstracts and conclusions. In this process, the abstracts of the publications were analyzed in order to further evaluate the objective and results of the article. The last filter used was the complete analysis of the publication. In this step, 175 articles were fully read in order to qualitatively identify the main social impacts of AI use, as shown in Fig. 1. All the mentioned steps were performed manually using Microsoft Excel.

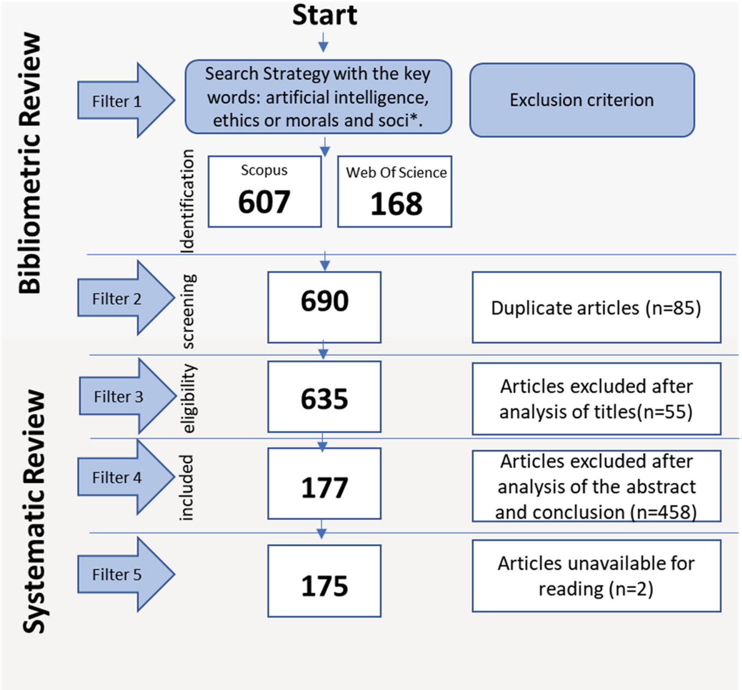

Fig. 1. Flowchart of Articles Eligibility Source: Own authorship (2021)

The distribution of publications over the years shows that this is a topic on the rise, as shown in Fig. 2.

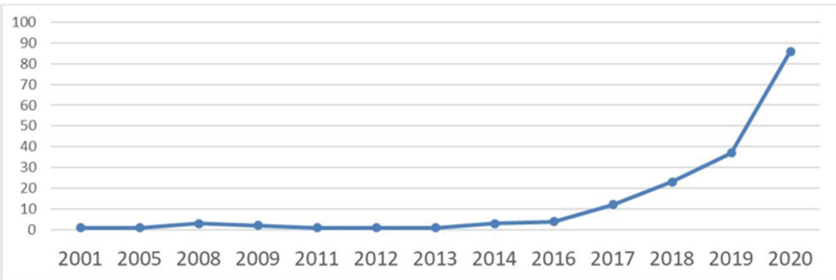

Fig. 2. Publication per year Source: Own authorship (2021)

One of the limitations of this study is related to the focus of AI impacts on society as a whole, this means that impacts focusing on individuals were not mapped or developed during the proposed analyses.

3 Results and Discussion

Regarding RSL analysis procedures, the articles evaluated were categorized according to affinity and according to the areas of AI use, so that twelve categories of analysis were identified, as follows:

i) government and policy
ii) Society
iii) Leisure
iv) Informatics and technology
v) Industry
vi) Agriculture
vii) Services
viii) Transport and logistics
ix) Commerce
x) Military
xi) Health
xii) Education

After the first categorization, the results were again distributed in nine categories of social impact, as follows:

i) Reduction of autonomy and responsibility: the decision to perform certain activities no longer requires human interference
ii) Usurpation of jobs by automation: formal jobs performed completely by machines or systems
iii) Over-dependence on technology: increased levels of stress due to over-use.
iv) Lack of transparency: uncertainty about decision criteria.
v) Environmental impacts: damage to nature caused by technology
vi) Injustice: unfair results
vii) Bias and discrimination: results based on biases of the historical data or the creators of the systems
viii) Data breach: sensitive data made available
ix) Risk of injury: harm to the human body or life

In this study, social impacts were classified into nine categories of analysis, according to the citations of the publications analyzed, and the amount of citations of each impact will be presented title by title, showing how many times this theme was addressed among the 175 articles evaluated.

In order to identify how the social impacts are distributed among the main areas of AI use, a matrix was prepared to identify the relation between social impacts and the areas where AI is used (Fig. 2). To obtain these data, all articles in this study were manually tabulated according to the categories of the systematic literature review, and each time an article mentioned an impact and an area of action, these were identified in a table.

After analyzing the publications, it was found that, despite being a relevant subject today, environmental impacts have the lowest percentage of citation, reaching at most 2%

in the areas of government and society. The impact related to prejudice and discrimination is present in all categories, with citation percentages higher than 19%, according to Fig. 3.

In Fig. 3, it was noted that there is a strong relationship between the impact related to job usurpation and the areas of industry and services. This is due to the fact that such organizations are rapidly deploying AI to manage their processes and employees [15]. Thus, the overuse of automation and systems capable of performing complex tasks can create a gap in the operational workforce [16] and the use of artificial intelligence is directly linked to the increase in unemployment rates, especially in activities that require a low level of education [17]. The social implications of AI are complex, and especially in relation to jobs related to the automation of manual or digital tasks, there is a risk that jobs will be directed to a group with greater technical ability, and for this reason it is necessary to create labor policies that can ensure the sustainability of all levels of jobs. [18].

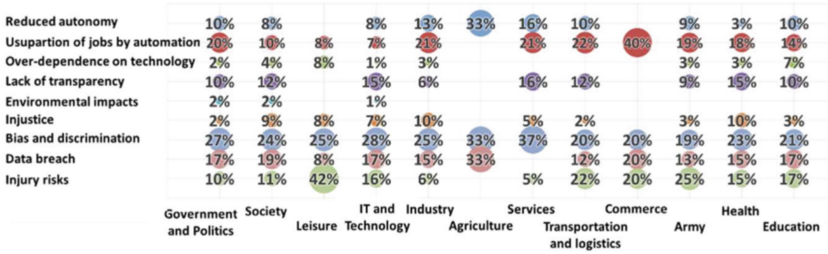

Fig. 3. Relationship between Social Impacts and AI Usage Area Source: Authors (2021)

After this step, the data, the results were again distributed in eleven categories of mitigation actions, as follows:

i) Standardization of the AI language, translating ethical principles into protocols
ii) Laws, principles, regulations or policies to ensure ethical implementation IA
iii) Breadth and depth of the public debate
iv) Translation of the main studies and reports.
v) Alternative continents for major conferences on AI research and on ethics and governance
vi) Increasing the accessibility of correct information to the public in the form of fact sheets and statements of ethical values on reliable web pages
vii) Establish joint programs and/or trainings
viii) Fees for the use of AI
ix) Creation of legally deregulated, or special zones, for research and development in robotics
x) Researchers and programmers should seek advice from ethicists to avoid mistakes (multidisciplinary)
xi) Preserving human decision-making processes for certain types of decisions

In the last stage of the analysis, the main recommendations for the elimination or mitigation of impacts found in the selected literature were analyzed, with the aim of identifying which actions have greater relevance in the publications evaluated, and identify the relationship with the social impacts mentioned. In this sense, it is identified that the most comprehensive action is related to the need to "increase the breadth and depth of public debate about the risks that the AI" can provide. Such action was evident in all categories of social impacts with percentages higher than 20%. Encouraging the understanding and sharing of information regarding AI is an urgent challenge for global society [19], and seeking to align information is a necessary and challenging task [20],,as shown in Fig. 4.

Secondly, the action of "creating laws, principles and regulation of AI use" was identified, which also received mention in all social impact categories. Moreover, in third place, the indication of "standardize AI language" with percentage results above 9%. The first three recommendations added up to 66% of the total. One of the caveats with the lowest adherence is the creation of "fees or taxes for companies that use AI systems to replace humans," with a percentage of 0.3%. The action of "increasing the breadth and depth of discussions regarding AI" highlights the importance of public knowledge, and it should be noted that this debate can bring out both the most optimistic [21] and the most pessimistic opinions [22].

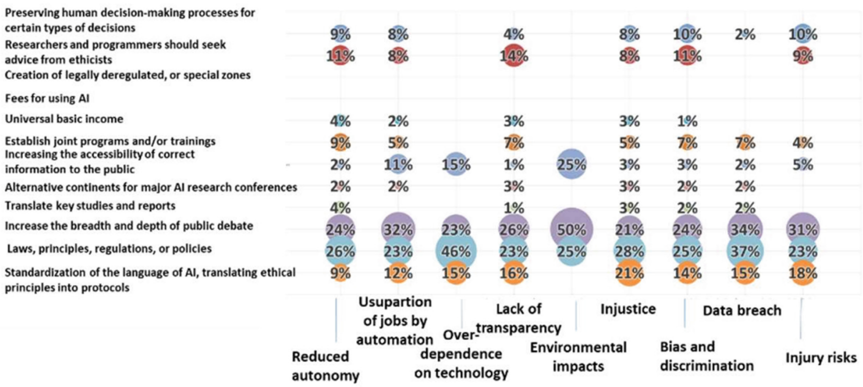

Fig. 4. Impacts x mitigation actions relationship Source: Authors (2021)

It is worth noting that despite the negative impacts, AI brings numerous benefits to society, a study conducted in the United States reported that over a 30-year period in The New York Times newspaper, the amount of articles that addressed AI in a positive way was consistently more positive than negative[23]. However, in recent years evaluated, it was indicated that there was an increase in reports with higher levels of concern [23].

The public debate about the social impacts of AI is in its early stages [21], and needs to be developed in a balanced way, taking into account opportunities and risks, in order to enable initiatives that foster innovation but also exercise control over potential risks [24].

4 Conclusion

This article showed that the research aimed at identifying social impacts has been growing in recent years, as well as the interest in mitigation actions. Through the analysis of the relationship between these two themes, it was possible to identify that one of the main impacts addressed is related to the fear of technology usurping jobs in the areas of commerce, industry, and transportation, which are the areas that already have practical examples where technology is actually performing human functions, and the main mitigation actions for this social impact is the "increase of public debate about this circumstance" and the "creation of laws, principles and methods of regulation of the use of AI", because in this way the understanding about the benefits versus the impacts will be understood and through this process, laws and regulations can be defined with the goal of mitigating them. Therefore, of the eleven mitigation actions addressed in the articles evaluated in this study, these are the two main actions, and through them the nine impacts evaluated can be mitigated. In this direction, it is evident the need for further research and relationship analysis of these two mitigation actions, in order to identify how to apply them effectively.

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Data Security Strategies in Digital Health Services: A Bibliometric Analysis

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Abstract. An increasing occurrence of facts that threaten public health, such as the COVID-19 pandemic, is driving the adoption of digital technologies, generating a large volume of data, and making the management, protection, and confidentiality of this information challenging. This paper aimed to carry out a bibliometric analysis to map data security strategies and tools in telehealth services and digital health. To this end, an exploratory study was conducted by collecting and analyzing secondary data from the Web of Science. This paper contributes to digital health providers by pointing out vulnerabilities, potentials, and trends in privacy and security of health care systems.

Keywords: Privacy · Data Security · Digital Health · Digital Service

1 Introduction

The COVID-19 pandemic has altered our society [1]. One of the biggest impacts of this crisis has been on the health care system, which, in some cases, has catalyzed innovations in service delivery. An example of this was the expansion of digital health services, more specifically telehealth [2].

Digital health is a concept that has been evolving since 2000, through internet media with an initial focus on improving medical content, connectivity, and commerce. With the expansion of the concept, new scopes were added, such as genomics, artificial intelligence, and mobile applications, also expanding the application in diagnosis, treatment, clinical decision-making process, and medical care [3].

The term telehealth refers to the entire spectrum of activities used to provide care at a distance - without direct physical contact with the user [4]. Despite all the advantages offered by a telehealth service, it is not without risks. One of the most sensitive issues in relation to the telehealth service is related to the protection of the user's confidential data, respecting the right to privacy and security as established by the General Law for the Protection of Personal Data (LGPD-Law no. 13,709 of August 14th, 2018).

Therefore, the same connectivity that makes it possible to offer the telehealth service also creates threats to users. Protecting health information and providing health services

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remotely can generate some complications. A question to be answered in this study is what telehealth services need to do to meet the requirements of the LGPD in such a way as to guarantee the security and, therefore, the adequate protection of user data? To provide a safe digital health service, specifically telehealth, it is necessary to establish best practices. For this, based on a qualitative approach, a bibliometric analysis was carried out to map data security strategies and tools in telehealth services. In addition, considering the definition of bibliometrics as the study of the quantitative aspects of the production, dissemination, and use of recorded information [5], this study provides for a bibliometric analysis to assess, in a predetermined time and event, what is being produced in relation to the present research proposal.

The contribution of this paper lies in understanding which are the most stringent security standards that healthcare organizations must follow to minimize the risks to the privacy and security of these systems, in order not to affect people's trust in telehealth services. The content of this paper is organized as follows. In Sect. 2 we presented the methodology. Section 3 explained the results, Sect. 4 we presented the main conclusions.

2 Methodology

To identify the state of the art of research on telehealth data security, a bibliometric analysis, and a construction of "Word Cloud" were performed. The literature review combined the goals of accuracy, reliability, clarity, and brevity to allow the researcher to make an efficient analysis of the state of the art [6].

2.1 Bibliometric Analysis

For the bibliometric study, a visualization structure based on five parameters was used: *Who* (authors), *What* (keywords), *Where* (countries), *When* (years of publication), and *With whom* (authors' affiliation). Furthermore, the searches were performed on the same platforms as those used for the systematic review, given the results obtained from this one. Bibliometrix software was used for scientific mapping, a tool in an R programming environment that allows the conversion, analysis, and elaboration of graphs through data exported from academic databases. Different analyzes were conducted, as well as Alfred Lotka's productivity law and Bradford's law [7]. First, it was necessary to define the research protocol, dividing it into five activities, namely: search strategy, database query, document management, standardization, and document selection.

Thus, in order to develop such a protocol, as a search strategy, the well-known Pagliosa et al. [8] method were used in this study.

2.1.1 Search Strategy

This activity aimed to establish the research topics, conducting searches through keywords. To verify the suitability of the search command, an adherence test was performed to validate the keywords. Thus, five articles were selected that had the highest number of citations and whose objectives were aligned with the research topic. In this way, the keywords of the articles were compared with the keywords used in the search command in order to verify if there was a need to improve the search in the search field. As there was no need to improve the search in the search field, the following keywords were obtained: Privacy, Data Security, Digital Health and Digital Service, highlighted in green in the table.

2.1.2 Database Query

It is essential to emphasize that originally, two databases were selected for the development of this research, Web of Science (WoS) and CAPES journals base. However, despite the CAPES periodical database having great recognition and validation, it constitutes a database of great relevance to the local scientific community, from the geographic region where the researchers are located. In this way, for the purposes of greater recognition and familiarity by the world scientific community, only the results obtained through the WoS database were prioritized.

Through a Boolean search, the selected keywords were combined, and the relationships identified between them. The date of the initial search was recorded, November 9,2021 and, first, 82 results were found in the WoS database, using the adopted keywords. It is important to note that, in this situation, the results had not yet been refined in terms of the period of publication year, free access or language used. Then, the period of analysis of publications was established for the last five years. Thus, the total number of selected documents increased to 58 in the WoS database. In addition, other filters were applied, such as for the language (English), obtaining 56 results in a WoS database. Still at this stage, it was possible to eliminate academic results with restricted access, obtaining 34 open access results in WoS.

2.1.3 Document Management

This activity aimed to organize the documents so that the filtering and analysis processes could be carried out. Within the WoS site itself, after performing the keyword search, it was possible to extract reports containing the main information of the 34 articles obtained from the WoS database. These reports contain information such as publication name, authors, authors' emails and addresses, pages, keywords, publisher, ISSN, eISSN, DOI, place of publication, language, year and month of publication, patent number, number of references and number of citations. After extracting the report from the database where the searches were performed, with the help of the BibTeX software it was possible to create a specific database. Then, the treatment of the report table generated from the WoS database was performed, to exclude columns without data or repeated, making it possible to obtain a more concise and organized report.

2.1.4 Standardization and Selection of Documents

At this stage, the files were selected by type of result, with only those categorized as "Article/Article" being selected. Therefore, 9 results were eliminated, resulting in 25 articles. The analysis for duplicates was performed using filters and commands in the Microsoft Excel platform, in which all cells from each database were selected, all of which were subjected to "conditional formatting", "cell highlighting rules" and then "duplicate values". It was possible to conclude, through this specific analysis, that there were duplicates in the generated report, resulting in a report of 23 results from this database. Then, the resulting articles were analyzed under three aspects, being (i) title, (ii) keywords and (iii) abstract. Thus, at this stage, articles could be eliminated if they did not present a research topic related to the investigated topic. The remaining articles will be analyzed in their entirety. Firstly, in terms of (i) title, it was possible to discard from the analysis for this study, those results in which the title certainly did not show the slightest relationship with the theme proposed for this paper, data security strategies in security services. Digital health. Consequently, 3 results were disregarded in the report extracted from the WoS database.

2.1.5 Analysis, Synthesis, and Consolidation of Results

This last phase aimed to analyze, develop a synthesis and consolidate the results. After all this process, it was possible to indicate all the research findings.

2.2 Construction of "Word Cloud" and "TreeMap"

At this stage, the "Word Clouds" technique was used to analyze the collected material. The keywords of the articles obtained through the systematic literature review were used as a basis. This method can be understood as a way of visualizing linguistic data, revealing the frequency with which words appear. The image construction technique consists of using different sizes and fonts of letters that vary according to the occurrence of the words, where the most frequent words usually appear in the center of the image with an increased size, while the others appear around with a reduced size. Thus, this technique contributes to the visualization of what is most relevant in the selected articles.

However, in order to generate the word cloud, it was necessary to use R programming and BibTeX formatting, installing 'RStudio', already mentioned in this article. Once installed, the command 'library(bibliometrix)' and 'biblioshiny()' were plotted, thus generating access to the 'Biblioshiny for bibliometrix' platform.

3 Results and Discussion

3.1 Bibliometric Analysis

First, analysis was performed under the parameter *Who* (authors), which shows the most relevant authors. As a result of this analysis, the authors of the article "Alavi A" were one of the authors of the article "A scalable, secure, and interoperable platform for deep data-driven health management" and "Sheikh A", one of the authors of the article's main highlight. "Health information technology and digital innovation for national health systems and learning care" and the article "Technology and Universal Health Coverage: Examining the role of digital health".

Then, analysis was performed under the parameter *What* (keywords), which shows the most relevant keywords. From this analysis extracted from the Bibliometrix platform, it was revealed that the words "care" and "security" were the most relevant. Such analysis meets the objective and theme of this article, in which data security strategies are placed under study, inserted in the scope of health care, since such strategies are related to digital health.

Soon after, analysis was performed under the parameter *Where* (countries). With this, it was possible to affirm the responsibility and scientific relevance, on the subject of this study, of countries such as the United States, United Kingdom, India, Australia and China, mainly, and in descending order of relevance.

An analysis was also performed under the parameter *When* (years of publications), under the Bibliometrix platform.

Under such analyzes generated through the Bibliometrix platform, it was possible to perceive that such scientific productions reached peaks of relevance in 2020 and 2021, revealing the importance of such topics in question, in the context of a pandemic and the importance of technology.

Finally, analysis was performed under the parameter *With whom* (affiliations), which shows the most relevant affiliations. In this way, under the generation of such an analysis, it was possible to perceive that Schwarz, Stanford University and Johns Hopkins University, all North American universities, stood out in terms of the theme of this article.

Furthermore, analyzes were performed according to Alfred Lotka's Law of Productivity and Bradford's Law [7].

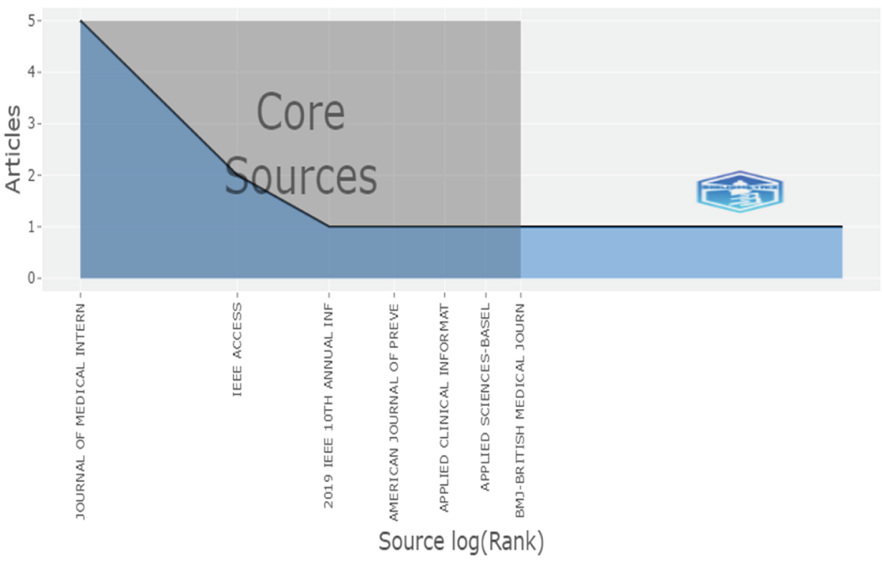

Fig. 1. Analysis generated in the Bibliometrix platform of results extracted from the WoS database, for Bradford's Law.

As Bradford's Law makes it possible to estimate the degree of relevance of journals, it was possible to analyze that (Fig. 1), under such generated images, about the results extracted from the WoS database, the journals "Journal of Medical Inter" and "IEEE Access" were the most relevant.

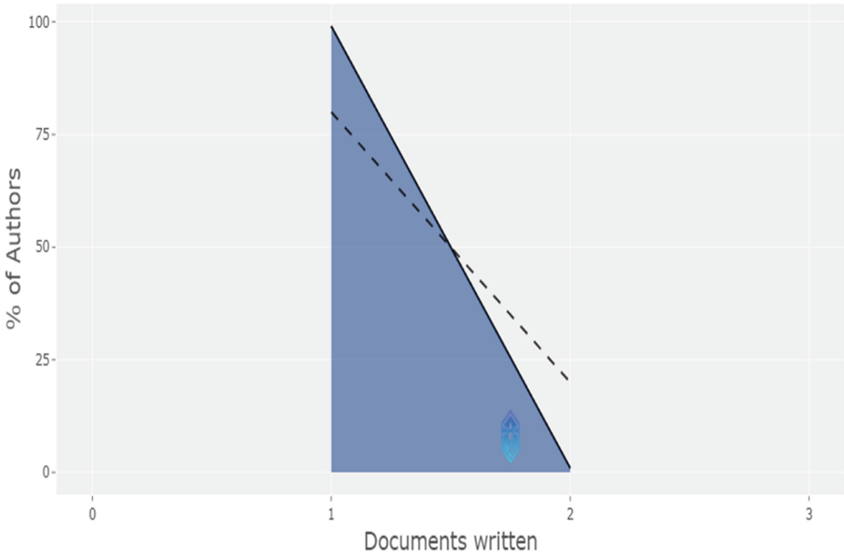

Fig. 2. Analysis generated in the Bibliometrix platform of results extracted from the WoS database, for Lotka's Productivity Law.

To conclude this stage of bibliometric analysis, an analysis of the generated image was performed (Fig. 2). Thus, with such an analysis under the parameter of Lotka's Productivity Law, it was possible to infer the level of productivity of the researchers, and little expression in terms of research and researchers was revealed. This demonstrated that the theme of this study is current, new, and has studies that are still not relevant in terms of its researchers, which, even so, does not discredit the relevance of the theme for society and the scientific community.

3.2 "Word Cloud" and "TreeMap"

Word Cloud (Fig. 3) was generated on the 'Biblioshiny for bibliometrix' platform, containing the 50 most frequent words in the 50 most relevant articles analyzed, from the Web of Science database.

Word clouds were generated, refined to single words (unigrams) as well as to two words (bigrams), generating expression, as in 'data security', for example. The following is the unigram word cloud.

In addition, 'TreeMaps' were also generated (Fig. 4), to complement the analysis in question, by revealing the percentages of each frequency of words. This consists of a hierarchical data visualization technique, using grouped rectangles, structured in a tree, justifying its name.

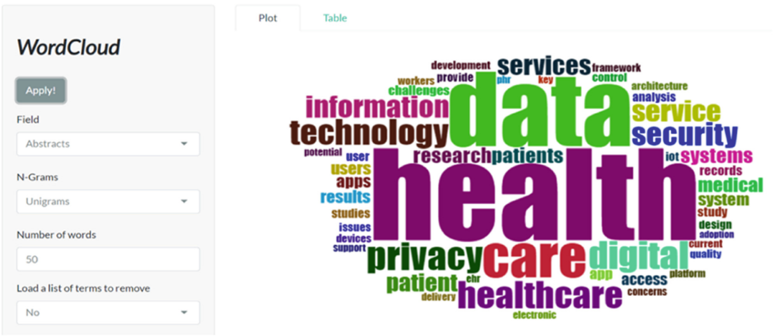

Fig. 3. Image of the first Word Cloud generated, from BibTeX software, with data extracted from WoS database and refinement to unigram words.

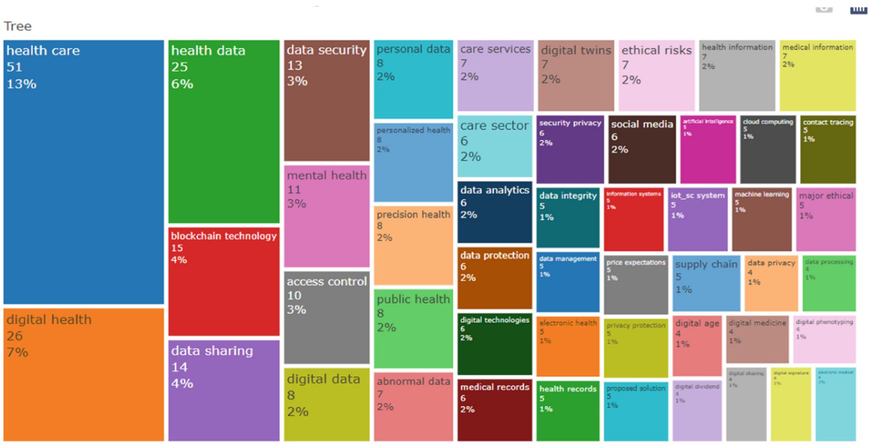

Fig. 4. Image of second 'TreeMap', generated using BibTeX software, with data extracted from WoS database (bigrams).

From Figs. 3 and 4 were possible to provide specific analysis about the results extracted from the database. Such analysis reveals that the most frequent and, therefore, most relevant words, such as 'digital health', 'data security' or 'privacy', express the central and most important themes of the articles. Such techniques thus reveal that the articles analyzed are well aligned with the line of research and the problem in question.

In terms of data privacy and security, these are constantly threatened, and need protection means to generate efficient and reliable service to users in the health sector. Currently, several techniques are suggested capable of mitigating privacy threats as much as possible, such as the master key management approach and the multi-key server approach [9]. However, this study suggests a security subject to the speed of access to data, constituting only an alternative, not a solution to the source of the problem.

Thus, having the notion of respect for user rights in relation to their personal data, such as access, modification and forgetting, it is feasible to make use of technologies such as Blockchain (BC) [10], in which sensitive data of users would be stored in trusted databases managed by the BC network. In this way, an entire state-of-the-art architecture would be developed, so that users' personal data would never be sent to service providers. Finally, BC technology proves to be promising, in addition to being an excellent option for the purpose of combating the threats of technology to the privacy of individuals, since it is a decentralized technology and eliminates several intermediaries from formal procedures, which, in turn, contribute to the vulnerability of personal data [11]. However, like all technology, it has its limitations, more specifically, in data storage and computing, which are limited and costly, impacting security, privacy, and, consequently, reliability and efficiency.

Maria Stoyanova et al., in their study about vulnerability problems in IoT systems by forensic logic, suggests a methodology for segregating processed data into two categories, which allowed, within the forensic perspective, data and privacy to be preserved [12]. This methodology, although used under a specific scenario by the author, is valid in a context of telehealth, external to the forensic theme.

To complement the analyzes carried out, a "Word Growth" chart (Fig. 5) was generated on the Bibliometrix platform, responsible for revealing the occurrence of the most relevant terms over the years. This graph is represented in the following image.

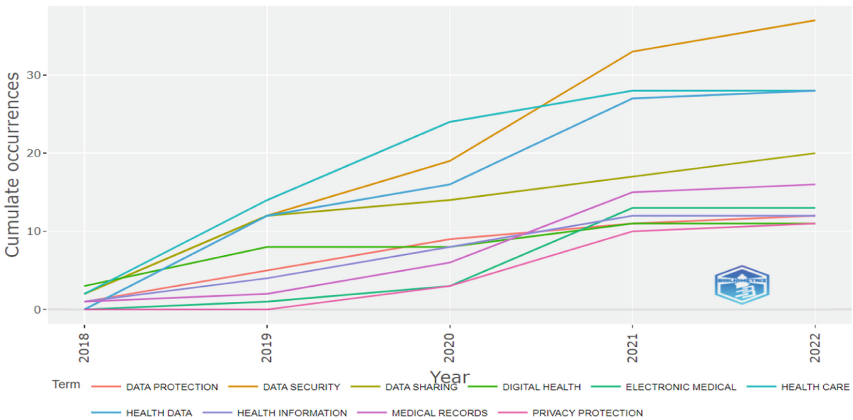

Fig. 5. "Word Growth" chart image, generated using BibTeX software.

Thus, although generated under the aspect of "bigrams", it was extremely important to analyze the considerable increase in the terms "Data Security", "Health Data", "Data Sharing", in addition to the terms "Privacy Protection". This situation demonstrated how the importance of topics such as health data security and privacy, dealt with in this paper, have gained relevance in recent years, especially after the first pandemic outbreak, revealing the degree of relevance of this study.

In "Word Growth" chart (Fig. 5) was possible to perceive that the dates of the articles obtained are summarized in the year 2020 to date, which demonstrates, as already evidenced in certain results in this research, the current relevance of this research topic for society. This even confirms the current scenario of increasing incidents involving security and privacy of sensitive data.

Comprising the results, 16 scientific articles were obtained as a final amount of research to be analyzed and discussed in its entirety, all with a high probability of high synergy with the theme proposed in this paper.

4 Conclusion

To conclude, it was possible to infer, from bibliometric analysis and literature review, that the theme proposed in this study, besides being current and still having little expression in the scientific community, has a process of natural evolution of its knowledge. And its solutions, consequently generating, as one of its many results, the method of organizing the conceptual framework in order of publication, thus demonstrating the evolution of scientific thinking.

In addition, according to bibliometric analyzes carried out, it was possible to highlight the greatest scientific advance on this subject in the United States, as well as the main affiliations, all from North American universities, such as Stanford University and John's Hopkins University. In addition, other generated analyzes led to conclusions such as the fact that the words "care" and "security" are the most influential and relevant in this study, in addition to the fact that the journal "Journal of Medical Inter" has the greatest relevance, even among the two bases. of analyzed data.

Even so, regarding the developed analyses, it was possible to highlight, in terms of "Word Cloud" and "TreeMaps", the relevance of words such as "da-ta", "privacy", "health", "security", with discrete changes in order of relevance between the two bases. This reveals that the reports used to generate such analyzes are in great harmony with the proposal of this study, "Data Security Strategies in Digital Health".

Furthermore, through the bibliometric analysis of "Word Grouth", a considerable increase in the terms "Data Security", "Health Data", "Data Sharing", in addition to "Privacy Protection" was noticed. This situation demonstrated how the importance of topics such as health data security and privacy, dealt with in this article, have gained relevance in recent years, especially after the first pandemic outbreak, thus revealing the degree of relevance of this study, both for the society and the scientific community.

More strictly, when dealing with the process of analyzing the impasse in question, it was possible to conclude that there is a need for constant improvement of the technologies in use, since their vulnerability is inherent to their existence, with the specific objective of preserving the privacy and security of users of health applications, thus generating consequent reliability on the part of society, whether user or server. However, one should not only prioritize the development of a new cutting-edge, innovative and multifaceted architecture, without a precise guideline. This development, in turn, should be directed towards a process of combining technologies, aiming at and considering the advantages of each technology, in the midst of a context of elaboration and improvement of recent technologies.

Finally, the solution to the problem in question is not simple, nor is the impasse, as the field of technologies involved is recent and under development, as well as the rights of users must be fundamentally respected, concomitantly. Seeking a balance between respecting the rights of individuals and the development of technology, even if focused on services to the community, is undeniably a challenge that can only be overcome with the mutual effort of all the sectors involved.

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Innovative Spaces for Multiliteracies

Significance of Physical and Virtual Places – The Case of Teams Meetings

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Abstract. During the last years telemeetings have become an important communication channel. Participants can select the physical place in which they participate to meetings, and also the background image of their camera video, which is virtual place of the participant. This paper focuses on what effect the alternative places has on the concentration to the discussion topic.

The research method of this paper is autoethnography in academic context. Test uses consist on Microsoft Teams meeting in two alternative physical places, i.e., an office and leisure place, and in two alternative virtual places, i.e., the background images of the office and leisure places. The topics of discussion were work, i.e., writing a paper, and leisure, i.e., planning a trip. The test users evaluated and described their feelings after the telemeetings.

The result presents that both physical and virtual place matters. When the physical and virtual places are in line to the topic is discussion, it supports the concentration to the topic. Furthermore, when the physical and virtual places are in contradiction to the topic, it complicates the concentration to the topic.

Keywords: Physical place · Virtual place · Sense of place · Telemeeting · Microsoft Teams

1 Introduction

Due to Covid-19 pandemic, people have used to teleworked and participated to telemeetings with different computer-based tools. Instead of offices, people have been working from their homes. In small meetings all participants have cameras on and in bigger meetings at least the presenter has camera on. Different people use various background effects. That can be the actual background of their working place, but that can also be their university or office image, or something related to their hobbies.

The physical place matters. It has been recognized that situational variables are essential for explaining and understanding people's acts [1], since the place relates to experiences, memories, and emotional attachment [2]. Besides of place matters in general, it also matters in the case of virtual environment and products [3], the background image can be seen as a virtual place. The studies of place are opened more at the Sect. 2. This paper discusses what kind of the feelings the actual physical place and the images of other partner's physical places give to the participants.

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The research methodology of this paper is autoethnography. For achieving research data two researchers make alternative trials and analyze their own feelings of different places. The researchers have long experience of studying the effect of physical place within using computers-based tools. Their publications of this subject start from 2013 [3]. Besides of place studies, they have studied the feeling which virtual prototypes give to the users [e.g., 4, 5]. In this study the test users are in different physical places. The test uses have been done in offices and in leisure time places, e.g., in a boat and in garden. Furthermore, the background images varied between office picture and leisure time picture. The research methodology is outlined more deeply at the Sect. 3.

The results of this study outlines participants' places effect on the feeling of the meeting and focusing on the topic of discussion. Participants own physical place make an effect: It can support or complicate concentration to the topic of discussion. Besides, the other partner's virtual place – that is presented in the background image - can support or complicate concentration to the topic of discussion. The research results are opened more deeply at the Sect. 4 and discussed at the Sect. 5.

2 Studying Sense of Place

There is a long tradition of studying people's sense of place, which presents that the places are important to people. The assumption that physical place matters is acknowledged, as it has been recognized that situational variables are essential for explaining and understanding people's behavioral acts [1]. The place in which the person is situated is important, as it relates to experiences, memories, and emotional attachment [2]. These place-related memories, conceptions, interpretations, and feelings are referred to as place-identity [6].

However, the focus of the studies has been changed during decades. The traditional way to study the sense of place is to focus on the emigrants' feelings of a new place. This way focuses on the physical place and people's feelings about it [e.g., 7]. The same physical place connected tradition is followed by studies of tourism, place, and ICT. Although computers and the internet are added to the context, the idea is focusing on the actual physical place, the place to which tourists travel [e.g., 8].

However, the other end of studying the sense of place is to focus on the feeling of place in immersive virtual environment (VE). In this context it is used the concept of presence, which means that the user feels to being somewhere else than in the actual physical place. In the case of VE the place is virtual and the sense of (non-physical or imagined) place is created with computer system and immersive technological environment. In the VE studies is assumed that VE visitors immerse themselves into a computer-created world in VE so that the ambient physical world becomes irrelevant to them [2]. In those VE studies the physical place used to be a 3D VE laboratory, but nowadays head-mounted displays are an option for this.

The third way to study the sense of place is mixing the above two: how the physical place effects on the expectations users have on virtual images and how users interpret them. The authors of this paper have studied that by focusing on virtual furniture prototypes by presenting them at a VE laboratory and a furniture fair [3]. At the VE laboratory the virtual prototypes were shown at high-fidelity, but still users mainly focused on the technology and its possible problems instead of virtual prototypes. The test use at the furniture fair utilized a low-fidelity VE technology, as the portable technology was needed. In the furniture fair the test users focused on the products, their features, and their possible development ideas. The study proves that the physical place effects on which issues the users focus on when observing virtual prototypes. The VE laboratory is a place of science and technology, so the users mainly focused on the technology, whereas a furniture fair is a place of new products and that is what the users focused on[3].

This study follows the idea that physical place matters for users' interpretations. Telemeetings give alternative possibilities for physical and virtual places. In that case the physical place is, where the participants are actually situated – as in an office, at a living room couch or in a garden, for example. Furthermore, the background effect of Microsoft Teams meeting, gives more alternatives. The background effect can be the actual background of the participants, but it can be changed to present something else, such as a picture of an office although the participant is somewhere else, like at a garden. This study focuses on how the changes of the physical and virtual place effect on the participants feelings during the meeting.

3 Research Methodology

The research method of this study is autoethnography. It is a method in which researchers' own experiments and notes of them are the main research material. It is a useful method in such cases which are hard to study with other research methods. Although autoethnography uses only one or few researchers own experiences, that is a useful method, as their feelings and interpretations are not only their private ones, but they also include the cultural shared assumption. They represent the understanding of the whole community [9].

Autoethnography is selected the method for this study as the research setting is hard to study with other methods. First, the issue that is analyzed is the feelings users have when using a telemeeting system. Feelings are very personal and sensitive issue and describing them to others is not easy. Second, for having relevant test use cases, there is needed persons who actually have co-operative working and leisure time activities so that alternative setups are possible to study.

The research method and its selection are described in the next sections. First is described the two researchers (they are called as test users) and their work. Second is described the alternative places which are used in this study. Third is described the trial uses. Fourth is described the analysis plan.

3.1 The Test Users

In selecting the test users an important issue was that there is two persons who are used to work together. That is important since in telemeetings the topic under discussion needs to be actual cooperative task. The test users, two researchers (called R1 and R2) have made studies and wrote papers together for at least 15 years. They have co-authored papers about virtual environments [see, e.g., 3–5, 10].

Besides of working together they have their own research areas. The field of researcher R1 is information systems science and she studies eCommerce [e.g., 11] and virtual environment in designing products [e.g., 12]. The field of researcher R2 is mechanical engineering. He studies fluid power technology, designing and manufacturing in addition to virtual reality [e.g., 13]. Furthermore, the researchers R1 and R2 are a married couple living together and traveling together. The basic information about them is presented at the Table 1.

Table 1. The researchers.

code	year of PhD	work title	unit	main research area	hobbies
R1	2002	University lecturer	Information technology	information systems	garden, traveling
R2	1992	Professor	Mechanical Engineering	design	boat, traveling

3.2 The Plan for Trial Uses

The theoretical background for this study is taken from Erfani's reconceptualing sense of place [14], which outlines the concept of sense of place by three elements: individual, community, and place. Individuals, on one hand, have their own emotions, beliefs and perceptions about their own home, neighborhood, city, and other places. On the other hand, individuals have social relations with other individuals, and they build socially constructed categories and shared view of places together. Sense of community means a sense of belonging to a particular area, social group, identity, emotional connection, and well-being. Because of globalization and technological innovation also non-place-based communities have been shaped. Despite of their advances, place is still a key element in shaping of our perceptions. Place is conceptualized as certain moments of social relations rather than only as areas with boundaries around. [14].

In the Teams meetings the study individuals are the test users R1 and R2. They participate to the test uses with their own life history including the earlier participations to telemeetings and research activities, their situated circumstances and feeling during the test uses. The discussion tasks consist of two topics. The discussion topic belongs either to the research work or to a leisure time. The work task is writing this conference paper, whereas the leisure time task is the planning a trip together.

Community includes both actual and normative community. The actual community is shaped by the people who are or could be present in the situation. The normative community is the assumptions and expectations which exist within the situation. In the case of the Teams meeting study, they are either other researchers or other people in leisure time activities.

The Teams meeting includes three dimensions: The physical and virtual place as well as topic of discussion. The physical place is where the test user is located. For achieving variation among physical places, the alternatives are the office in which the test user normally works and a leisure time place. The leisure places are selected based on the test users' hobbies, so the test user R1 is located to a garden and the test user R2 is located to a boat. The virtual places are those which the discussion partner sees about others' location. They are what is presented as the background picture during the discussion. The virtual places are the pictures of the used physical places. However, they are alternated so that some meetings have the same physical and virtual place and correspondingly some meetings have the opposite places. Although the topic of discussion is either work- or leisure-related and it happens in academic context. The setup for test uses is outlined in the Table 2.

Table 2. The setup for test uses.

test	date	physical place	virtual place	topic of discussion
work-1	29.6.22	garden/boat	office	What kind of photos are need for the paper?
work-2	29.6.22	garden/boat	garden/boat	What will be told about us in the paper?
work-3	4.7. 22	office	office	What kind of evidence is the purpose to get?
work-4	4.7.22	office	garden/boat	What will be told about the places the paper?
trip-1	4.7.22	office	office	The possible accommodation in trip to Norway
trip-2	4.7.22	office	garden/boat	Attractions during the whole trip
trip-3	7.7.22	garden/boat	office	The hiking plan at Kilpisjärvi, Finland
trip-4	7.7.22	garden/boat	garden/boat	The hiking plan at the north Norway

Based on Erfani's reconceptualizing sense of place [14] an evaluation form was shaped. It has the following questions:

1. What were the circumstances of the meeting, e.g., the temperature?
2. What were the general feelings of the meeting?
3. What kind of place did the discussion belong?
4. What kind of a community did the discussion belong?
5. Evaluate how well did the topic of discussion and the place fit together. Give a number between –5 to + 5 and write some reasoning for this.

Both test users fulfill the form after every test uses resulting 16 forms for analysis.

3.3 The Places in Data Gathering

The test use includes both physical and virtual place. A physical place is the place where the users stay during a test use. A virtual place is the place, that is presented in the background picture of the Teams meeting. The places are a work-related place, which is an office for both test users R1 and R2, and leisure-related place, which is a garden for R1 and a boat for R2.

The pictures of work-related places are presented in Fig. 1 and 2. Figure 1 presents the office space of R1. She works at her home office. She has been using it for writing papers also before COVID-19 time. Still, for her office background picture she uses a picture that is taken from her university office. Figure 2 presents the office space of R2. His office – both physical place and the background picture – are from his university office. In their offices both researchers have two screens. For this research purpose, it was decided that in the test uses only the single screen of laptop computer is used, however, in trip planning also the other screen for seeing maps was needs, as seen in Fig. 1. In all test uses R1 and R2 stay in a similar physical place, either in a work- or leisure-related place.

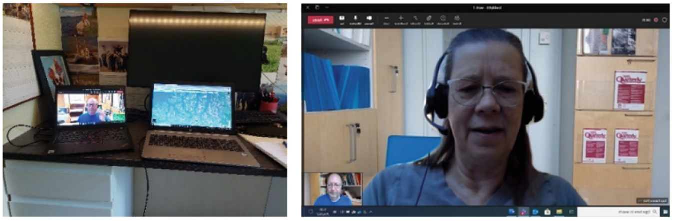

Fig. 1. The physical and virtual work-related place for the test user R1.

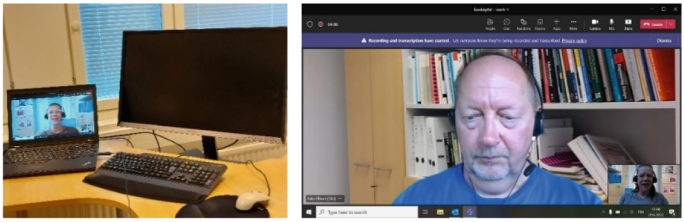

Fig. 2. The physical and virtual work-related place for the test user R2.

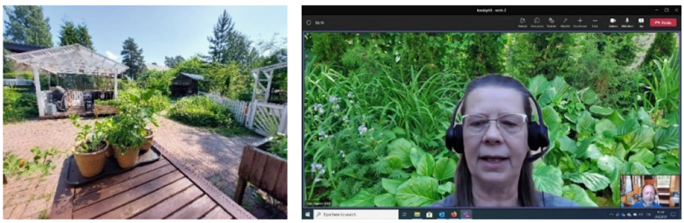

Fig. 3. The physical and virtual leisure-related place for the test user R1.

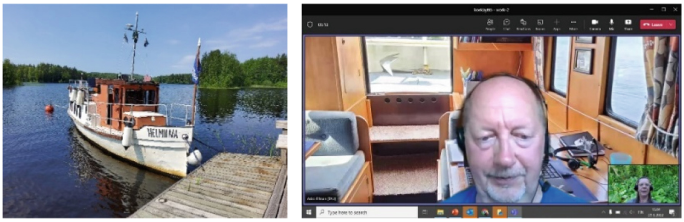

Fig. 4. The physical (boat place) and virtual leisure-related place for the test user R2.

Figure 3 presents the garden, which was the physical place for the test user R1 as a leisure-related place. She sits by the garden table. The leisure background picture is taken from the garden. That is also presented at Fig. 3. Figure 4 presents the leisure-related place of the test user R2. That is the boat by a lake. In the leisure meetings the test user R2 sits inside the boat. The leisure background picture is taken inside the boat.

3.4 The Plan for Data Analysis

There are three kinds of empirical research data for this study:

1. The forms, in which both test users have written their feelings after every test use. There are eight forms for both test users. Total number of forms is 16.
2. The videos of the discussions. All the discussions are recorded, so there are eight videos.
3. The photos of the alternative places. There are four physical places and four virtual places, which all are presented at Figs. 1–4.

The main data for analysis is the forms. In the analysis the focus is on test users' feelings what issues of a place give support to concentrating to the topic of discussion, and which issues complicate the concentration.

4 Results

The study about alternative places in Teams meetings focuses on both physical and virtual places. Participant's own physical place has effect on the participants' concentrations to the topic of discussion. Furthermore, the discussion partner's virtual place, i.e., background picture, also effects on the concentration to the discussion. First, the dimensions of the case are opened more and then is presented some elements that support or complicate the concentration in the telemeeting.

The result focuses on how alternative physical and virtual places are supporting the topic of the telemeeting. The effect is based on the dimensions of physical and virtual places. The physical place is where the person is located. The dimension of physical place presents how well the place is fitting to the topic of discussion. The virtual place bases on the image of the place that is presented in the background picture. The dimension of virtual place presents how well the virtual place is fitting to the topic of discussion.

Based on the two dimensions of the place, four categories are shaped. We observed that both physical and virtual places can either support or complicate concentrating to the topic under of discussion. The effects of the physical and virtual place on the topic of discussion are presented at Fig. 5.

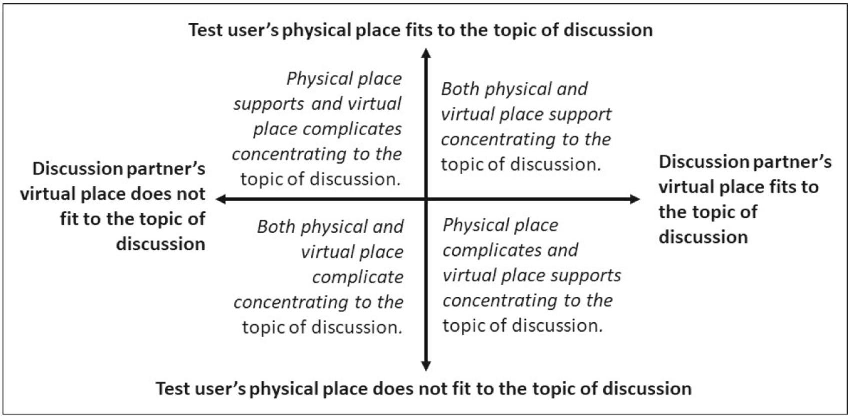

Fig. 5. The categorization of the physical and virtual places.

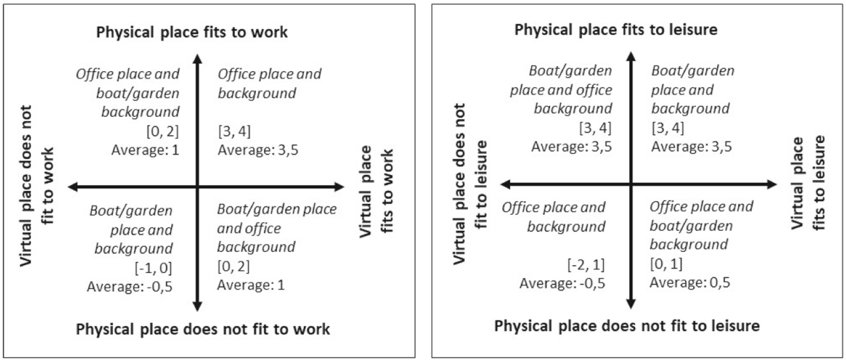

Fig. 6. The evaluation on focusing to the discussion in telemeetings based on the categorization of the physical and virtual places. In Fig. 6a the topic of discussion is work-related, whereas in Fig. 6b it is leisure related.

The analysis of the test users' focusing of the discussion in telemeetings is presented at Fig. 6. It is evaluated by using the scale [−5.. + 5]. The highest numbers were given in the cases where physical and virtual are in connection to the topic of discussion (i.e., 3,5 in average). That are the right higher corner at Fig. 6a and 6b. Furthermore, the opposite end, when both physical and virtual place are in the contradiction to the topic of discussion, the test users evaluated lowest (i.e., −0,5 in average).

The open-ended text in the forms outlines the feelings of the test users. The physical place at the office is ergonomically optimal, including few distracting elements. Also, the background image from the office is neutral. It does not produce distracting feelings.

The leisure places (i.e., a boat or garden) contain lots of distracting elements, including circumstances, as too warm or too much sun light, and disturbance, as extra voices and swinging the boat. Furthermore, the leisure background image cause positive feelings. That complicates concentrating to work discussion.

The background image did not have impact on the evaluation in the case of leisure discussion (i.e., trip planning): There the average number is 3,5 (see, Fig. 6b). The discussion about trip planning is very compelling. Furthermore, there were used also another screen, in which were maps from the area to which the trip was planned. The focusing to the map decreases the importance of background screen image. The other kind of effect in the leisure discussion was that when the topic of discussion is leisure and the physical place is the office, the test users feel guilty by misusing the work hours.

5 Discussion

This study analyzed the effect of physical and virtual place for concentration to the topic of discussion in a telemeeting. The result includes four categories based on two dimensions of the place.

The effect of physical place was surprisingly high for the researchers of this study. Both the test users mentioned numerous examples of the features of the physical place that supported or complicated the concentration. Furthermore, they also mentioned many place-related normative elements that had impact on the concentration. Although this result was unexpected, it is in line with an earlier study: physical place matters [3].

The effect of the virtual place was less significant. However, when the place of background picture was familiar, it sometimes gave for a short time the feeling that it could be nice to be there. Nevertheless, the background image is convincing. For example, in the 8th telemeeting the test user R1 supposed that the background picture of test user R2 showed his actual place. The test user R1 wondered why test user R2 had two headphones, one on his head and the other on the desk behind him.

This study continues the study of the effect of place in evaluating virtual prototypes [3]. However, more studies are needed. It is not established what kind of background images are useful for work context. For example, Tampere University offers photos for using background picture for telemeetings. Those pictures include the outside images of university buildings and common places inside of the buildings, e.g., libraries and hallways, but there are not pictures of offices or other private places.

One restriction of this study is that both test users and places are familiar to them. The situation where the participants do not know each other beforehand, should be studied. However, organizing such a study where the test users have actual co-operative task is not easy. Also, it needs to study what is a good work-related background image. For example, when designing a hydraulic device with a new colleague, is a university logo, office view or a picture of a hydraulic device, e.g., a valve, the best image to concentrate to the topic of discussion.

6 Conclusion

A telemeeting includes physical and virtual places. The physical place is the actual place, where the participant is, and it affects to his/her feelings. A background image in telemeeting forms the virtual place and it affects to feelings of discussion partner.

In out study we have found that both physical and virtual place can either support or disturb content of discussion in a telemeeting.

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Encouraging Data Literacy via an Open Academic Digital Platform

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Abstract. The aim of this paper was to find out if members of an academic online community felt empowered to form collaborative relationships with their peers, sharing knowledge and experiences and more importantly increasing their knowledge on the subject data. We were able to assess the perception on the topic of data literacy based on the information gathered through a research action approach. According to the data, the participants engaged in mutual support during online meetings and answering questions about the relationship about the topic and their experiences. Although it was clear that during the time of the pandemic, the participants prioritized the topics that were most urgent for them, we still managed to achieve the objective of increasing the knowledge of data for the students engaged. For them it was clear the necessity to align data with social issues. For future studies it is necessary to think about the creation of interdisciplinary courses where the teaching of data is closer to the reality of the students.

Keywords: Digital Platform · Data literacy · Social Technology

1 Introduction

As a response to maintain social distance measures to control the pandemic, face-to-face communications have been replaced by virtual meetings mediated by digital platforms [1]. The emergence of digital platforms to coordinate a wide spectrum of social, political, and economic activities has already become ubiquitous [2]. According to Bonina et al. (2021), digital platforms can be best described by three basic dimensions 1. Technology-mediated communications, 2. Enabling interaction between users, and 3. Users can complete required activities. Thus, digital platforms can be defined as a set of digital technologies that offers services which require the supply of information that is contextual or customized to the user [3]. The platform's specific purpose, on the other hand, is determined by the type of task that its users are attempting to accomplish [4].

Cusumano et al. (2019) proposed a taxonomy to classify the technological features of digital platforms, dividing them into transaction and innovation platforms based on the type and the purpose of the technology. A transaction platform's primary goal is to facilitate transactions between various organizations, institutions, and individuals (for example, buyers-sellers, recruiters-employees, and drivers-passengers). The underlying architecture of innovation platform is made up of modules, or building blocks, that are

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accessed through interfaces (Application Programming Interfaces) and integrated by developers (Complementors) to design new products, services, or technology that may be employed by other organizations [5].

Digital platforms are the most prevalent organizational form in the knowledge economy, and they have been intrinsically linked to business models, social technologies, and infrastructure innovation [6]. Each of these factors, as pointed by Cohen (2017), has influenced the introduction of smartphones, wearable technologies, and the Internet of Things, affecting processes centered on continuous monitoring, precise and detailed quantitative evaluation of behavioral patterns, retrieval of ongoing data flows, and the transformation of data flows into forms that are especially suitable to interpretation, and commercialization. Sensing networks have evolved from communications networks to being organized around always-on smartphones that capture and transmit accurate user data streams, resulting in the datafication- or dataism, or yet data surveillance -, of daily life [7, 8].

How can citizens deal with datafication in a democratic society? In line with Pangrazio and Sefton-Green (2020), if data education is a response to this challenge, data literacy must be the best concept to approach it. The authors found out that education in the form of data literacy has emerged as the dominant idea for dealing with the dilemma of datafication. In fact, literacy is a traditional way of producing social rules as well as illustrating the relationships between people and society, serving as a critical first step toward instituting additional rights and practices to protect personal data and privacy. In other words, in the digital age, literacy characterizes the process in which individuals gain knowledge on how to take part on the platforms that datafy them, while also delegating pedagogical authority to the platforms to transform these forms of learning, knowing, and behaving into a commodity form for economic exploitation.

Awareness and importance of the topic has recently grown, but it is still a little-known term in Brazil. According to Yamauti and Tsunoda (2021) the production of works with the term data literacy is concentrated in North American and European institutions and, despite the representativeness of the production presenting an annual growth rate of 30.55%, Brazil between 1956 and 2019 did not have any scientific production on the subject.

Once we accept the theoretical explanations for why data literacy is the best strategy for dealing with datafication, the question of how to promote data literacy in practice arises. As a result, our response to the threats of datafication posed by digital platforms also includes the use of digital platforms as a pedagogical tool. In this paper, we report our findings using the Plural Digital Platform.

The Plural-DP is an open learning network tool designed as part of a project commissioned by the Ministry of Education and hosted at the Federal University of ABC. The Plural-DP is a hybrid open learning tool that combines the functionality of a Learning Management System (LMS) with its own Social Networking (SN). The Platform is a dynamic learning environment because it allows an educator to create and deliver content, monitor student progress and participation, and evaluate student achievement. Simultaneously, the integrated social networking permit participants to engage with groups of people who share common interests.

The role of the Plural-DP is part the authors reflections on the critical issue that emerges in the face of the current historical context of environmental, and social crises, which has been exacerbated by the pandemic. As a necessary consequence, the platform should serve as a community laboratory, proposing activities that analyze the opportunities, barriers, and challenges surrounding a collaborative process of knowledge and learning exchange between academia and citizens. The goal is to raise awareness and critical understandings of research practices that recognize and promote public participation in an open university arena.

The findings presented here were based on an action research method because it focuses on generating solutions to practical problems. In this case, the Plural-DP operates as an online educational platform that delivers learning experiences that allow participants to actively engage with educational content in thematic open courses. Since the digital platform is part of a public research university, therefore not rent-seeking, participants feel motivated to share their ideas because they recognize the platform as a legitimate arena to explore knowledge-based practices.

This paper is organized as follows. Section 2 introduces terminology used throughout the paper. Section 3 describes the methodological framework used to achieve the research goals. Section 4 then combines the results from the individual stages, and their results. Finally, Sect. 5 presents our conclusion.

2 Using Digital Platforms to Enhance Data Literacy in Online Communities

In the previous section, we argued that the best way to come to terms with the risks of datafication caused by the digital platform economy would be to use the digital platform education as a source to advance data literacy. As the market has already recognized, a digital platform is, in many aspects, the optimum system for controlling the inflow, storage, and outflow of knowledge [9]. The rationale is that any type of content can be used to generate and gather data on a digital platform.

It can also operate as a broker for these contents, granting access and facilitating computational or collaborative processing. Furthermore, a platform serves as a knowledge-building interface, allowing individuals to study, learn, and stay informed. As they provide digital learning space for pedagogical practices [10], digital platforms in education act as social technology, facilitating social connection mediated by information and communication devices.

Connectivism is a theoretical framework that helps us understand this phenomenon. Despite theorists' disagreements, connectivism is one of the new theories of learning that explain how the advent of networked technologies has influenced human learning [11, 12, 13, 14]. As a result, it should be revisited and comprehended through new perspectives [15].

This is how connectivism works. Individual knowledge is composed of a network that flows into organizations and institutions, which in turn flow back into the network and continue to provide leaning to individuals [13]. Such individual-network-organizations knowledge process allow learners to keep up to date in their knowledge field by strengthening the collaborations they have made. The creation of connections around information nodes constitutes knowledge. Therefore, learning is the network and knowledge is dispersed across a network in a distributed fashion [13].

The power to build and take advantage of networks is a mandatory condition for connectivism. The following are the major connectivism principles:

- The variety of viewpoints is the foundation of learning and knowledge.
- Learning is the process of connecting specialized sources of information.
- Learning may be housed in non-human devices.
- The ability to keep learning has now become more significant than what is currently known
- Connections must be fostered and sustained to promote continuous learning.
- One of the most important competences involve the ability to anticipate connections among fields, ideas, and concepts.
- The goal of connectivism learning activities is to be a medium of exchange (precise and reliable, up-to-date knowledge).
- Making decisions is a learning lesson in itself. Deciding what to study and the significance of new information is viewed through the perspective of uncertainty. There may be a right response now, but it may be incorrect tomorrow caused by changes in the data key aspects of connectivism setting influencing the judgment.

Connectivism, thereby, embraces a wider perspective of the influencing factors as well as implications on individual perception and on effective learning, a perspective, which is complimentary with the increased access of data and social connections that has accompanied trends in digital society [16].

2.1 Connecting Online Communities Through the Literacy Process

Regardless of the positive aspects of networked learning - as pointed out by connectivism - building online communities is something different [17, 18]. A network is a set of unities connected by interactions, while establishing a community requires time [19]. Social interactions between participants in online learning, either formal or informal, because the distance creates a feeling of isolation [20] and the insufficient collaboration among participants [21].

Anyway, individuals now participate in a variety of online communities, learning through observation in some and actively participating in others [22]. Thus, widening the scope of learning to include engagement with a community and with others is becoming increasingly important in understanding personal experiences in a multidimensional, multi-membership, and in multi-identity world [23, 24] It is known that people engage in durable, social bonds in communities that are related to part of their interests and field.

The establishment and development of communities, on the other hand, is a complex process According to the social learning theory called Communities of Practice, learning occurs within a sociocultural setting, requiring both involvement and legitimization to make learning relevant [25]. The relationship between involvement and legitimization creates a social history of learning, and it is this narrative that provides informal and dynamic social structure to communities of practice.

Online communities serve as a locus for social inclusion by forming the foundation for civic digital platforms through peer-to-peer networks, participants mobilization, and collaborative engagement. Because digital platforms function as data acquisition hubs for structured and unstructured data, digital data analytics offers a once-in-a-lifetime opportunity to build capabilities within these communities [26]. The purpose of empowering communities as independent entities should be at the heart of the logic for encouraging data literacy. This can only be accomplished by recognizing data literacy as a primary determinant and a measure for social inclusion [27].

Therefore, data literacy that aims to increase social inclusion, paves the way for all individuals to understand, interpret, and manage data-driven decisions and arguments. The alternative world we must strive for is the one in which people are encouraged and equipped to control their own data [28, 29, 17]. As proposed by Paulo Freire's on the "Pedagogy of the Oppressed", more than learning technical tasks, data literacy implies the creation of autonomy through the literacy process.

3 Research Design

This paper is based on empirical and exploratory observations that seeks to examine whether participants can communicate, reflect, and make decisions based on facts in an online environment that is safe, democratic, and mediated. Here we describe the design of the project that used a Social Learning Network (SLN) platform to promote interaction between learners, educators, and modules of learning.

Action Research is the method used in this study that relies on interaction between researchers and participants to prioritize choices of the problems to be studied and alternatives to be pursued. To achieve the results, the researcher is part of the experiment through an action that performs a double action: expanding scientific theory and promoting actions that promote social improvement [30]. It is done in a cyclical, interactive, and step-by-step fashion. The cycle consists of actions such as diagnosis, planning, intervention, evaluation, and reflection, with each step conducted collaboratively by researchers and the participants involved [30]. It is important to note that it is not limited to a specific type of action, because the application is intended to increase participants' awareness and knowledge exchange.

3.1 Experiment Setup

3.1.1 The Plural Digital Platform as a Research Tool

As mentioned, the Plural-DP is the online environment that allows the participants to get together in the virtual space and engage with educational content in open courses using a SLN and a LMS, respectively.

The LMS is where the instructor can create and delivers content, monitors learners' participation, and assess her/him performance. All courses made available on the platform were organized in basic units to guide the participants in the learning process. We also used Open Educational Resources to help with the written content and one of the courses was the Data Literacy course, the one we are going to use in this study.

Every end-of-unit of the courses had a form called "Diary" that students should fill in sharing some experience they had in relation to the topic and share other content. The forms were created and made available through the Google tool, Google Forms.

Each available course on the platform has its own “Lab” or SLN. This was the place where learners socialize with their peers based on shared interests. After creating a login, the participant can enroll in the “Lab” of interest and share content learned during the course as well as comment on information received from peers. In this way, the learning social network enables engagement through its construction and use in a more collaborative and non-linear way.

3.1.2 Data Literacy Courses

The purpose of the course was to expand our understanding of fundamental concepts and applications of data so that we could think critically about the use of data as well as its flow of collection, storage, and processing aiming for social justice.

The course is organized in six units: (1) Data Literacy: introduces the thematic using texts, videos, and projects to explain what data literacy is, how to become data literate, what it means being data-driven and examples of open data projects. (2) Big Data & Analytics: explain together with the volume of data we generated on daily basis and different ways we can analyze this information more humanly. (3) Data Science and (4) Ethics & Artificial Intelligence presents the areas of study showing the mainly concepts: algorithms, machine learning, deep learning and the intersection with human sciences and ethics through examples. (5) Data Privacy: brings legal advances on privacy and data protection. (6) Social Innovation in Data Analysis, Big Data and Data Literacy: emphasizes on the urgency of the civil Society organization to mobilize public and private institutions around the development of research, projects, and action on this topic.

For all units of the course, online meetings were organized, which were mostly attended by external guests to explain the topics presented and to resolve the doubts of the course participants.

3.2 Data Collection

All courses available on the Platform were open, free, and freely accessible, that is, it was not necessary to fill in any other criteria for participation. To enroll in the course, people should fill up a form with contact information as well as other data to create the participant’s profile (gender, age, institution, and ethnicity/race). The data literacy course had 74 subscribers and from the information provided we were able to understand that most participants are teachers from public schools in the municipality or state (58%), the second large group (34%) were of people linked to the university, whether they were teachers or students. In addition, we noticed that most students considered themselves white (65%) and women (72%). The age of those enrolled ranged from 16 to 62 years old, but most of those enrolled were between 40 and 50 years old.

The course participants could also interact with the topic on the social learning network and in online meetings, but for these interactions we were not able to draw the participants’ profile.

3.3 Data Analysis

Registration forms were available for enrollment in the course. Through which was possible to obtain sociodemographic information and authorization for the use and sharing of data based on the Consent Term. In addition to the participants' profile information, collected through the registration form, there were three other ways of interaction with students: the "Diary" form, the SLN "Lab" and the chat from online meetings.

The "Diary" form was placed at the end of every unit of the course, a unit evaluation form of questions related to which would answer which items and materials presented in this unit they liked best, how the content affect or complement their life experiences and share a link to any article, video, or report about the module.

4 A Profile of the Data Literacy Course's Participants on Digital Plural Platform

After an overview of the characteristics of those who showed interest in the course and filled out the diaries and completed the course. Of the enrolled students, only 16 filled in at least one diary. At the end of the intervention, we had 6 people who completed the course, with the criterion of completing a minimum of 5 diaries. In relation to the graduating students, only four consented to the use of their data, all of them were professors. The other two did not consent and declared themselves to be linked to the university as students. From here we will report the findings about these four students.

The course participants reported that what they liked the most about the course unit were the topics raised and it could be seen that most of the time it was new to them. They also commented that the videos were important to demystify technology by exemplifying how we can transform our behaviors into quantified information, data. Due to the ease of sharing and interacting with this type of media, one of the course participants proposed using it as support in their technology classes.

It was also possible to observe the evolution of the course participants' learning through their answers. One of the students started the first unit of the course understanding what data are, in unit two that data only have meaning from our analysis and that we need to have a multidisciplinary vision for this and, finally, that our data are valuable and that when we use a product for free it is because we are selling our data.

The Lab, within the Plural-DP, had 55 members who showed interest in the subject and to learn with other people, and 38 posts were made. The highest concentration of posts (74%) was made by the organizers who were posting and sharing content. The posts showed that members were interested in the topics of data literacy, data science, types of research approach (qualitative and quantitative) and, mainly, Artificial Intelligence. In this last theme, the biggest concern involved ethics in the use of data, the theme of unit 4 of the course.

The online meetings took place synchronously so that participants could interact and share information, experiences, or ask questions. But it was also available asynchronously so that other interested people could watch. At the end of the intervention, all meetings had 1032 views and the lives with the greatest interest were about: data literacy, data science and privacy.

5 Conclusions

In 2020, the year in which this work was carried out, there was a great uncertainty. We lived the worst moment of social isolation where we were abruptly removed from our social spaces, schools, jobs, and universities. Understanding this context is crucial to reflect on the results of this research and how necessary it was to provide a space for people to continue interacting with each other in a safe and democratic way.

At the end of 2020, the action research cycle of the Data Literacy course came to an end, and it was possible to observe that from the creation of the space and the course, the participants reflected on their reality and identified actions that they could take, such as analyzing the digital tools they would use, adopting measures to protect their data, how to use a password manager. It was noted that the majority of course participants felt comfortable sharing their concerns and opinions about the topic within the diaries and online meetings.

It is also worth mentioning that the course participants were able to make a relationship with the use of data with society when they raised questions about feelings of loneliness when they do not use digital platforms. This could be one of the most pressing dilemmas in our increasingly digital society: how to protect our privacy and still participate in society. Morozov (2018) explores that privacy will be a privilege of those who can spend resources on it by paying for the service or with the time and patience to learn and master the tools.

We observed that the biggest challenge is not teaching people about data when they engage in the topic, the problem is in creating engagement. A possible solution observed in this work is to adapt data literacy to the reality of students. "According to Freire's philosophy, teaching must be contextualized, that is, it must start from the learner's experience of what is familiar" [31]. An example of this was that the course participants were able to share content that analyzed data from monitoring the pandemic and the impacts caused.

At the time of carrying out this research, it was necessary to seek humanity and understanding through support networks so that we could collectively face difficulties, design, and build together what future we wanted. Using the Plural-DP as a place that enables new ways of interaction where the focus is on people and not on their data is essential for us to imagine and create other possible futures.

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Digital Interaction: Strategy for Health Literacy and Promotion

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Abstract. The Covid-19 pandemic has increased people's digital interactions and highlighted the need to improve health outcomes, promoting education and engagement in health care. Thus, in a context in which we perceive an increase in inequality, it is necessary to discuss inclusive, easily accessible strategies that involve digital interaction and community strengthening to innovate in the process of health literacy and health promotion. Through a narrative review of the literature, this study attempted to critically evaluate and discuss digital interaction through virtual communities as a strategy to strengthen the literacy process and health promotion, in this new scenario in which social collaboration and strengthening of communities are sought. Digital interactions can be tools for health by enabling the formation of communities capable of contributing to literacy and health promotion, strengthening dialogic communication and generating positive results in clinical outcomes and disease prevention.

Keywords: Health literacy · Health promotion · Digital health · Online health communities

1 Introduction

Health literacy is the ability to obtain, process, communicate and understand information and basic health services [1]. In these ways, health literacy actions allow people to have a better understanding of the most appropriate ways to take care of their health and thus make informed choices and develop a critical capacity for the information that is received.

On the other hand, health promotion is a strategy of health professionals and the community to improve people's quality of life, taking into account social, economic, political and cultural factors that influence the health-disease process [2].

The current scenario of health care and lifestyle shows that it is necessary to develop an educational process that allows people to live longer and better. The results of the 2019 national health survey showed that the recommended consumption of fruits and vegetables among people over the age of 18 years occurs in only 13% of the population and that 40.3% are considered insufficiently active, that is, they do not practice what is considered the minimum amount of physical activity [3]. These data somehow justify

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why 7 of the 10 main causes of death in the world occur due to chronic non-communicable diseases, mainly cardiovascular dis-eases [4].

The social isolation and quarantine have contributed to an increase in sedentary lifestyles, stress, and unhealthy eating habits and the post-pandemic scenario of increased economic and social inequality results in reduced access to the labor market, education and health. Due to this new reality, it is essential to resignify the innovation, returning the gaze to the community, in order to improve social coexistence, create societies modeled as ecosystems that interact with each other and nourish each other, assuring social cohesion.

Parallel to this, the increase in digital interactions and the intensification of the use of mobile devices and other communication tools that fit on the palm of a hand are also legacies of a pandemic scenario, as well as the advancement in health with the consolidation of telemedicine and tele appointments. Technology and internet access have expanded the reach of knowledge on health and the pandemic, despite having generated much insecurity and fear of contamination, also brought new ways of doing medicine and providing care, as well as allowing the use of technological devices, mainly related to digital interaction.

According to the Center for Studies on the Development of the Information Society [5] in 2019 there were 134 million internet users in Brazil and the cell phone was the preferred device, used by 99% of the research participants. This same study showed that communication activities are the most common and that 47% of the Brazilian population searched for health information on the Internet in 2019 and that there was an increase to 53% in 2020 in this regard [5].

In this scenario, it is essential to rethink ways to promote care and improve people's lifestyles. There is a need to look at health care as something that needs to be built and strengthened with the ease of communication through the use of mobile devices and with digital interactions.

Considering the increase in the use of information and communication technologies, associated with a sedentary lifestyle and inadequate and unhealthy diet, health education through digital interactions can be a strategy for the development of health literacy and to increase people's engagement in care. Technology and the increase in digital interactions create a cyber-physical learning environment capable of promoting health literacy. According to the 2020 meta-analysis, physical activity and lifestyle interventions based on mobile technologies are effective in reducing cardiometabolic risk [6].

With digital culture, the digital interactions in communities find space, since people are at the center of care and find emotional support and seek information in order to make decisions [7]. Thus, taking advantage of the facilities offered by digital technologies has become an alternative for health professionals to get closer to their patients, in order to promote engagement through the language of digital. As such, the present study seeks to answer the following question: can digital interactions through virtual communities be a strategy for literacy and health promotion?

The main objective of this article is to discuss digital interaction through virtual communities as a strategy to strengthen the literacy process and health promotion, in this new scenario in which there is a search for social collaboration and community strengthening.

This article is divided into three parts. In addition to this introductory section, Sect. 2 will present a conceptual foundation. In Sect. 3 the methodological framework. In turn, Sect. 4 presents the discussion on the use of digital interaction in health. In Sect. 5, Health Promotion is addressed. Finally, Sect. 6 presents the conclusion of the study.

2 Conceptual Foundation

2.1 What is Literacy?

According to the National Literacy Policy (PNA) [8] of the Brazilian Ministry of Education (MEC), literacy is an internationally consolidated concept that was disseminated in public policies in 1980. The PNA [8] defines literacy as the set of knowledge, skills and attitudes related to reading and writing, as well as their productive practice, that is, traditional literacy. As such, literacy is related to the ability to acquire knowledge.

In this sense, it is important to differentiate literacy from the concept of being able to read and write. According to Gabriel (2017) [9], literacy in its most basic form consists of entering the world of writing and comprehensive reading. On the other hand, literacy is related to the construction of orthographic representations of words, which in turn is a mechanical process of the relationship between orthographic sequences and the acoustic image stored in memory, and not interpretation [9]. This same analogy can be made with digital literacy in which one can know how to operationalize technologies, but without literacy it is not possible to interpret and question the messages and content that arrive.

2.2 What is Health Literacy?

The WHO defines health literacy as: "the cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand and use information in ways which promote and maintain good health" [10]. Thus, health literacy allows the individuals to be involved in decisions to be made in relation to their health, making informed and conscious choices and therefore improving adherence to proposed therapies.

Low levels of health literacy compromise care and outcomes, as they are associated with an increase in in-patient care and the demand for emergency rooms, as well as a deficiency in self-care for chronic diseases and in health promotion and prevention actions [11].

The development of health literacy is linked to health knowledge, care and navigation in health systems, the processing and use of information related to health care and the ability to self-care and manage one's own health in association with health professionals [12]. Therefore, a communication strategy based on health literacy provides positive results for all those involved, as Palumbo (2016) [13] states, users benefit from being at the center of care, thus having their well-being valued, and health professionals have the opportunity to strengthen their ties with the user, promoting health achievements and improving results [13]. This creates the opportunity to promote user and healthcare professional satisfaction.

2.3 Types of Literacy

According to Nutbeam (2000) [14], there are three levels of literacy:

1. Basic or functional literacy:
   Basic reading and writing skills that allow an individual to carry out everyday activities.
2. Communicative or interactive literacy:
   More advanced cognitive and literacy skills that, together with social skills, can be used to actively engage in everyday activities, to extract information and meanings that allow for the application of new information.
3. Critical literacy:
   More advanced cognitive skills that, along with social skills, can be applied to critically analyze information and use that information to exert greater control over life events and situations.

More recently, with technological innovations, two other types of health literacy have been incorporated [15]:

4. Media literacy:
   Ability to identify, analyze and critique health-related content in the media, to recognize its influence on health behavior.
5. Digital Health Literacy (eHealth):
   Ability to search, find, understand, and evaluate health information from electronic or digital sources and employ the knowledge gained to solve a health problem.

An important observation is that media literacy is considered the precursor of digital health literacy, as the first concept considered non-digital media (television, print media, radio, etc.) while the second encompasses digital media (the Internet, social media and mobile technologies) [15].

3 Methodology

The present study is characterized as a qualitative and descriptive study, called a narrative review of the literature, in which it seeks to develop the "state of the art" of the subject [16]. The proposal is to debate the potential of the use of digital interactions in health and to collaborate with the update and knowledge on the subject.

The collection of material for discussion was carried out in a non-systematic way from March 2021 to March 2022, in the databases: Scielo, Lilacs, Pubmed, and was complemented with books and articles recommended by experts.

For the research, the keywords were used: Health literacy, Health promotion, Digital health and Online health communities in their various combinations and selected materials from the last 5 years. The materials found were interpreted and critically analyzed in order to respond to the objective of the research.

3.1 Sample Selection

As inclusion criteria, complete original articles were selected, available in full in full, books and government publications that addressed the topic of digital interaction and literacy and/or health promotion. Articles that were not in English and Portuguese were excluded.

From the selected articles, the first filter was performed through the title and abstract, at this stage articles related to the validation of the literacy scale and articles that referred to the use of digital products that did not involve digital interaction for health care were excluded. Articles that addressed literacy and health promotion in the context of digital interactions, mainly in online communities, were considered for the discussion of the theme, topics related to the use of mobile devices for health interventions were also considered.

3.2 Data Collection and Organization

After selection, the articles collected were read in full to extract the potential and criticism of the use of digital interactions to generate health education. With the reading of the articles, central themes were identified such as: digital interaction in health in communities and health promotion through mobile devices that gave rise to the topics covered in this review.

3.3 Data Analysis

The analysis and discussion of the themes was based on the selected references and the author's experience with digital communities via WhatsApp for lifestyle changes. The ideas of the articles were organized and complemented in order to answer the question: can digital interactions through virtual communities be a strategy for literacy and health promotion?

4 Digital Interactions in a Health Setting

Digital interactions can strengthen the health system, as they allow access to health care to be available in the palm of the hand, establishing connections with distant places and with needy communities that would not even have access to information were it not for this interaction.

Considering the importance of digital health, the WHO [1] proposed for 2020–2025 the document "Global Digital Health Strategy" which proposes to improve people's health by accelerating the development of digital health strategies [1].

Among the possibilities of digital health strategies, we can mention digital communities, which are interactive environments in which people share their practical experiences on a given subject, thus allowing members to express what went right and wrong and how they found solutions [17]. They are currently present on mobile devices, digital platforms, websites, or social media.

In addition, digital communities can be formed by professionals from a certain area who want to share knowledge about a topic or even by patients who experience a certain disease and want to find support among peers who share those experiences. Communities can also be geared towards achieving a goal and taking advantage of the space to share doubts and anxieties of the process leading to the goal, such as for people who want to lose weight.

4.1 Digital Interaction and Health Literacy

Interaction in communities has the potential to improve the psychological and physical well-being of participants and promote health literacy, since they constitute an environment of common interest, generate exchanges of information and knowledge and facilitate the communication process [18].

People have different health literacy needs throughout their lives, so the interaction with peers, strengthened by a health professional, can enhance the continuous development of skills that allow them to take better care of their health in the period of life they are going through.

Interaction through questions and shared experiences allows participants to learn about their health conditions and treatment. In addition, the simplicity of the language in which the exchanges within the community take place facilitate understanding and generate advice that is more appreciated and perceived as useful (RUEGER, 2021). In this way, communities can provide an environment for dialogic communication, collective construction, reflection on content, empathy and respect.

Digital communities can constitute a rich environment in the health education process and, according to [14], health literacy is one of the main results of health education processes. In this way, the development of health literacy through educational actions brings about positive effects for the individual and for the group: for the individual, it improves knowledge about health risks, develops motivation and self-confidence, increasing the ability to adapt to adverse situations; as for the group, participation in community health programs increases and the ability to influence social rules improves, as well as that to influence the promotion of community engagement and empowerment [11, 19].

4.2 Engagement and Empathy in Digital Interactions and Communities

The digital community environment allows people to feel safe enough to expose their anxieties and doubts and, at the same time, creates a need to support those who share the same feeling and seek answers. In this way, they constitute a space to share emotional and personal experiences, helping with emotional healing and in the process of dealing with negative experiences [20].

The value perceived by participants positively influences engagement in digital communities, and the health status of individuals is an important indicator of willingness to share information, that is, healthy individuals perceive that sharing information in the community can positively influence their health management, while for unhealthy people, like those with chronic illnesses, the search for information in communities can be more positive [7]. A phenomenon of contemporary society, the involvement in communities increases access to information and enables those involved to become protagonists of their own health [20].

4.3 Challenges of Digital Communities

Changes within a community usually present peaks of greater and lesser interaction. Given the oscillations, the challenge is to maintain a level of interest and engagement among participants, as well as to enable the profile differences to complement each other and not hamper the interaction between its members [20]. Another challenging issue for communities is controlling the quality of shared information [21]. However, even with the dissemination of health information, knowledge on the subject does not yet reach all people with quality.

A study carried out in China showed high rates of vaccine hesitancy and one of the factors that contributed to this result was the spread of false information on the internet [22]. Thus, in the context of health, investing in a moderator is therefore critical to prevent misinformation and the spread of any false content.

5 Promotion of Health, Well-Being and a Healthy Lifestyle

In 1986, the First International Conference on Health Promotion took place in Canada; the conference gave rise to the Ottawa Charter, which defines health promotion as:

"Health promotion is the name given to the process of enabling the community to act to improve its own quality of life and health, including greater participation in the control of this process. To reach a state of complete physical, mental and social well-being, individuals and groups must know how to identify aspirations, satisfy needs and modify the environment in a favorable manner. Health should be seen as a resource for life, not an goal of living. In this sense, health is a positive concept, which emphasizes social and personal resources, as well as physical capabilities. Thus, health promotion is not the exclusive responsibility of the health sector, and goes beyond a healthy lifestyle, spreading towards global well-being" [23].

In this way, health promotion goes beyond the limits of health services, must be inserted within society and is related to the empowerment of the community to improve quality of life. Therefore, digital health communities can contribute to health promotion and improve the quality of life of those involved.

A healthy lifestyle contributes to improving the quality of life, improving health and increasing the years of life without chronic illnesses [24, 25].

In a prospective multicohort study that analyzed the relationship between a healthy lifestyle and the gain in terms of years without developing chronic diseases, for 116,043 people followed for an average of 12.5 years, the conclusion was that a BMI less than 25 and at least 2 healthy behaviors (never smoking, physical activity, and moderate alcohol consumption) are associated with a greater number of disease-free years, with an approximate 9 additional years without chronic diseases [24].

The increase in life years, cited above, confirms that lifestyle-related health interventions combined with diet and physical activity are effective in preventing metabolic syndrome [26], an important risk factor for cardiovascular, cerebrovascular, and diabetes that is closely associated with inadequate diet and physical inactivity.

However, what is found, especially with the COVID 19 pandemic, is a reduction in the practice of physical activity and an increase in time in front of screens and in the consumption of ultra-processed foods, alcoholic beverages and the number of cigarettes smoked [27]. This bolsters the need to address the issue and promote health actions that contribute to improving people's lifestyles.

Nevertheless, traditional health education and lifestyle approaches are time-consuming and encumber health services, though they may be replaced by the use of mobile technology in health [6]. This could occur particularly by strengthening digital interactions. According to the results of the netnography carried out by Fernandes (2018), people who engage in the digital community have a more proactive attitude towards their health and are better able to manage chronic disease [19].

Among the benefits of using mobile devices for health interventions are: cost-effectiveness, ease of use from anywhere, the ability to customize messages for each audience, and the ability for messages to arrive quickly on a device that is "always on" [28].

Digital interaction is often made up of simple technologies, easily accessible by mobile devices and which, according to Sequi-Dominguez, are effective in promoting lifestyle changes [6].

6 Conclusion

The post-pandemic society requires a new look at health that combines health care and promotion with digital interaction and has a participatory approach based on the community capable of promoting social cohesion and equality.

The study showed that digital interaction could be a tool for health, enabling the formation of communities capable of contributing to literacy and health promotion, strengthening dialogic communication and generating positive results in clinical outcomes and disease prevention.

Understanding the individual's moment in life and their need for health literacy is essential to create digital interactions with groups that share common goals, ideas and actions, as well as having health professionals in the community who can curate the contents in order to guarantee the quality of the discussion and actions in the community.

It is hoped that this study will awaken ideas and possibilities for innovation in the process of literacy and health promotion, in order to allow the collective construction of knowledge to positively influence individual choices for a healthy lifestyle.

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A Co-creation Intervention to Support the Design of a Telehealth Service at School

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Abstract. Telehealth refers to the provision of health-related services and information via electronic information and telecommunications technologies. Health promotion programs are essential to improve health outcomes for adolescents, including improvements in their quality of life, functionality, independence, and equity. A student's access to health care providers through school-based telehealth expands and improves, allowing them to stay or become healthy and focus on learning. To achieve these results is determinant to understanding how the social surroundings among adolescents affect their understanding of a healthy lifestyle and well-being. We co-created an innovative research protocol in need of understanding adolescents by employing a student-centered approach, dialogical communication method, and a student's narrative creation of digital storytelling to help decision-makers with building a telehealth network, developing its health information exchange, and supporting an ambitious rollout of health information technology to assist a large number of adolescents through the creation of school-based telehealth initiatives by comprehending how digital health innovative strategies can address student health needs and combat growing concerns about student well-being when considering the digitalization of the Brazilian Health School Program (Programa Saúde na Escola - PSE).

Keywords: Telehealth · School well-being · Dialogical Communication

1 Introduction

Telehealth is a growing model of delivering health care [1]. Implementation of school-based telehealth programs has been widespread in recent years; they have the potential to fill new gaps in health care [2] and are efficient and effective way to overcome barriers to care and improve health for children.

With its commitment to well-being, the Health in Schools Program aims to improve the well-being of adolescents, teachers, other staff, families, and emphasizes bringing mindfulness to the community [3]. The overarching objective is to benefit everyone involved in the education and well-being of the children.

To address the vulnerabilities that compromise the full development of children and young people from the public school system, the Brazilian government established the Health at School Program (PSE) in 2007. This intersectoral policy was developed by

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the Ministry of Education and the Ministry of Health in conjunction with Municipalities to contribute to the comprehensive training of students and the school community with actions of promotion, prevention, and health care [4, 5].

We propose an innovative intervention protocol that uses a dialogical communication participatory design approach which is an important contribution to the formulation of a school-based telehealth service.

In this paper Sect. 2, discusses prior relevant. Section 3 describes the methods used. Section 4 evaluates the models and protocols that have been co-created during this research. And, Sect. 5, which presents the main research conclusions.

2 Theoretical Foundations

2.1 Health Communication with Adolescents

Concerning the crucial developmental process of preparing for and transitioning into adulthood, the significance of adolescence is highlighted. Becoming more independent and autonomous also occurs during this time [6]. The important developmental milestones are reached during this time, and the adolescent learns more about who they are and creates their self-identity.

Adolescence is characterized by increased likelihood of engaging in risky behaviors [7]. Therefore, health services need to be equipped with preventative measures, encouraging other healthy outlets for identity explorations [8].

Paulo Freire [9] takes communication as dialogue which essence refers to reciprocity. He proposed human communication as dialogue and the recognition of the other as a subject.

Communication barriers are especially problematic as many leading causes of mortality and morbidity in adolescents, such as smoking, drug use, and suicide attempts are preventable, and the damage they cause can extend well into adulthood [10].

The analysis of previous studies reported that communication barriers existed when revealing sensitive and personal aspects of adolescents' lives. These barriers were experienced by the young adolescents, their parents and healthcare providers [11]. Participants expressed feeling worried for being misunderstood or judged [12].

According to Binder [12], adolescents described that when they experienced an authentic intention for caring, they develop a sense of trust that their health care providers were working for their best interest with a non-judgmental attitude. This enabled them to more easily discuss health issues that can be often personal and sensitive. Health care provider's open-ended questions, while being sensitive to adolescent autonomy and personal choices in making healthy lifestyle changes, were strong predictors in motivating participants to make positive changes [13].

Adolescent participation in health communication often includes a personalized approach with correctly articulated, non-judgmental language. Thus they can identify their own health risks and be proactive about their health-related behaviors [14, 15].

Improvements in contact with adolescents can be anticipated when other factors such as time constraints, and staff burnouts are moderated as well [16]. It is for this purpose that health providers explain to adolescents why they are asking such questions, the type of resources they are providing, the ethical and professional standards of healthcare providers and confidentiality policies [17, 18].

In a research from Dawkins-Moultin et al. [19], they propose that public health literacy interventions integrate the principles of "socioecology" which operates on the premise that health outcome is hinged on the interplay between individuals and their environment, and "critical pedagogy" that assumes education is inherently political, and the ultimate goal of education is social change to develop interventions empowering individuals and communities. Integrating these two approaches will provide a useful frame to develop interventions that move beyond the individual level.

Sykes et al. [20], argued for community development to embrace and advance the concept of critical health literacy in order that; its potential to address inequalities in health can be achieved and to create an opportunity to embed community development more fully within health policy and practice.

2.2 Fostering Adolescents' Health Literacy with Innovative Media

Innovation is a key to confronting many issues facing humanity. It can be defined variously and tends to include problem-solving processes [21], executing novel ideas to create societal value [22] and applied creativity [23]. The capacity to refine existing ideas and challenge existing ideas is a very important and thankfully human process drawing intense interest from a range of disciplines [24, 25].

Over the past decade, new technology and media have changed the way we communicate, access information, and share content. The children of the current millennium are the first generation to own a Smartphone device during their middle childhood [26]. The American Academy of Pediatrics now encourages all pediatricians to increase their knowledge of new media and technology. Connectivity and social networking among adolescents allow potential innovative applications in health promotion. At the same time, practitioners move toward integrating new media into clinical and health education settings.

Adolescents use Smartphone to explore their identity and maintain constructive interpersonal relationships with family and friends [27]. Adolescents perceive online communication platforms as a comfortable setting for emotional self-disclosure [28]. Also, there are striking similarities between people's behaviors in real life and virtual social interactions [29].

Educators and clinicians use Smartphone-based networking such as WhatsApp and Facebook to reach out to adolescents [30] which contributes to adolescents' well-being, and most teens appreciate these efforts.

3 Research Design

In the current study, we are working in collaboration with the Municipality of Santo André concerning the schools participating in the Brazil's Health School Program, the number of participating schools in the PSE between 2018 and 2020 were 29 schools with around 6000 students divided on 7 territories connected by Basic Health Units.

3.1 Identifying Students at Risk of Psychosocial Problems

This protocol takes a rigorous analog of gathering disease-specific information in a medical evaluation. The “Anamnese School Script” focuses on assessing the student’s condition and is standardized within each study. It is designed to elicit information on the participant’s general and condition-specific medical status, management issues, and health care needs. To carry out a good anamnese, it is necessary to know how to listen. We give the chance for the parents/guardians to fill this questionnaire.We adapted the traditional Anamnese as per our study needs. It consists of the following items: Personal Data, Family, Health, Style of Life, School Records, and Communication. Our ready to validate adapted “Anamnese School Script” digital protocol is available at https://freeonlinesurveys.com/s/NCjBIATc

3.2 Assessing Students’ Quality of Life from Their Perspective

Health-related quality of life (HRQL) is a multidimensional concept that features domains associated with physical, mental, emotional, and social functioning. It focuses on the impact health status has on quality of life. A related concept of HRQL is well-being; it evaluates the positive aspects of a person’s life, such as positive emotions and life satisfaction.

HRQL is measured with a standardized, previously validated instrument appropriate to the age of study participants and the medical condition studied [31]. It implements an instrument appropriate to the condition being investigated and standardized within each study. The current study uses a general health status instrument, the HEEADSSS, which is an inclusive psychosocial assessment tool distinguishing risk and protective factors and assists health professionals create a plan in partnership with adolescents. Our ready to validate adapted “HEEADSSS” digital protocol is available at https://freeonlinesurveys.com/s/4K41zzph.

3.3 Listening to Students Through Digital Storytelling

Community-based participatory research (CBPR) was established in the past 25 years as valued research approaches within health education, public health, and other health and social sciences for their efficacy in reducing inequities [32]. In the process of cocreation, we worked with the school staff, students, and UBS to understand the student’s contexts so that our intervention becomes an evidence-based tool.

Digital stories are potent forces within the lives of adolescents as they shape opinions, assumptions, and alignments with the knowledge of everyday lives. Youngsters get much enjoyment and feel intelligent and knowledgeable as they scroll quickly through a web search on information, images, news, and stories. They are content consumers and content creators who enjoy dramatic engagements and can produce stories as communication texts [33].

We based this step of the study on an American drama comedy television series called "Everybody Hates Chris". We proposed to watch selected episodes of the series that address different topics such as bullying, health, friendship, and education, and then start open-ended questions and discussions. Everyone is expected to have their own opinion about specific episodes, and we want to give voice to these students in a safe environment where their opinions can be challenged and perhaps even changed.

During dialogic communication with the participants, we seek to relate the episodes to students' life experiences and how they can simulate the actor's narration to translate their perceptions about well-being and health.

Participants are provided initial training on camera use, visual research ethics, and storytelling short film creation. According to Chan and Sage [34], Digital storytelling is a storytelling method produced by mixing digitized images, texts, sounds, and other interactive elements, and it has been progressively used for social work and healthcare interventions.

Once the topic of the digital story is decided, it is needed to create a script and a storyboard. When writing a script, students decide what their digital story will achieve. The script or storyboard should describe the type of digital story the students will make. They then must record their script and find media for their storyboard to create their video as the final step.

Our ready to validate created "Digital storytelling" digital protocol is available at https://freeonlinesurveys.com/s/Aimk1INk.

4 Organizing the Visual Narrative Process

4.1 Training of Students

Students should be familiarized with story elements before starting the workshop of Digital Storytelling to facilitate their understanding of the process.

– What is a Story? As a starting point, Students need to understand why humanity tells stories. They need to identify the story topics, and to identify skills and difficulties they may face when telling a story.
– Atmosphere of the story. Atmosphere of story is the feeling created by mood and tone. It takes the reader to where the story is happening and lets them experience it much like the characters. Participating students need to understand the importance of building well the universe where their story will develop.
– Story's characters. Characters in a story can be either round or flat. A round character usually plays an important role in the story. They are written specifically so audiences can pay attention to them for a specific reason. Flat characters are usually perfunctory. Participants have to understand the difference between them, know what makes a character interesting, and start developing the main character of their story. -The Hero's Journey. The hero's journey (Fig. 1) is a common narrative archetype, or story template, that involves three essential stages: a hero, who goes on an adventure

  (Departure), learns a lesson and wins a victory with that newfound knowledge (Initiation), and then returns home transformed (Return). Participants must know the steps of the hero's journey and how to use it to tell a story.

– Character trial. The Character Trial is to choose a character, set up a courtroom with a team of defenders, a team of prosecutors, a judge, and a jury. Once participants are used to the idea of putting characters on trial, it can be as short or long as it needs to be.

Fig. 1. Illustration of the hero's journey [35]

4.2 Steps for Digital Story Process

Digital stories push students to become creators of content, rather than just consumers. It can be created while incorporating the 21st century skills of creating, communicating, and collaborating.

Figure 2 illustrates the steps of the Participatory Research Phase as we chose the digital storytelling as a method for doing the visual narrative in this study.

Fig. 2. Steps in Digital storytelling [36]

– Start with an idea. In our workshop, the story idea should be related to questions connected with the selected episodes of "Everybody Hates Chris". Once student has an idea, he should: write a proposal, craft a paragraph, draw a mental-map, or use any other pre-writing tool. Graphic organizers (Fig. 3) are a pictorial way of constructing knowledge and organizing information. They help student convert and compress a lot of seemingly disjointed information into a structured, simple-to-read, graphic display. It also helps students generate ideas as they develop and note their thoughts visually.

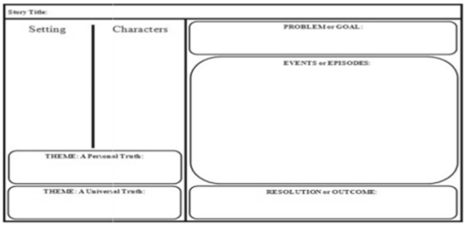

Fig. 3. Digital Story Map [37]

To create the map, the student must concentrate on the relationship between the items and examine the meanings attached to each of them. While creating a map, the student must prioritize the information, determining which parts are the most important and should be focused upon, and where each item should be placed in the map. -Research/Explore/Learn. Students need to research, explore, or learn about the topic to create a base of information on which the digital story will be built. During this process, students learn about validating information and information bias as they dive deeper into a topic.

- Write/Script. If students have a proposal, with a little bit of editing, it can become the introduction. If students research and explore a topic well, the body of the script should fall into place like a jigsaw puzzle. The pieces are already there, students just need to make them fit. A story map (Fig. 3) can be used.
- Story board/Plan. Storyboarding is the first step towards understanding sound and images. It is the plan that will guide decision making about images, video, and sound. Simple storyboards (Fig. 4) will just have room for images/video and the script. More advanced ones might even include room for transitions, and background music.

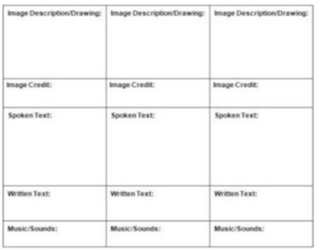

Fig. 4. Digital Story Storyboard Template [38]

- Gather and create images, audio, and video. Using their storyboard as a guide, students will gather images, audio, and video. Students should use this time to record themselves reading their scripts. Through this step in the process, they become acutely aware of mistakes and poor word choices.
- Put it all together. Students will revise their storyboard and find ways to push the technology and tools. This stage lets students understand what is necessary for a completed project and to push themselves beyond the expectations.

- Share. Sharing online has become deeply embedded in our culture, so as educators, we might as well embrace it. Knowing that other people might see their work often raises student motivation to make it the best possible work that they can do. Review with the school and then look for a way to share students' stories with a broader audience in an event such as Film Festival.
- Reflection and feedback. Too often in education, we do not teach or allow time for reflection and feedback. Students need to be taught how to reflect on their own work and give feedback to others, this is both constructive and valuable.

5 Conclusion

The objective of this research was to create an Intervention protocol to support the design of a telehealth service at school that effectively promotes students' health and wellbeing.

By knowing and understanding adolescents in school environment, we can develop better solutions that strongly contribute to health services development and innovation. The methodology of student-centered approach is central to this research and is expected to provide useful insights for the development and delivery of adolescent telehealth services at school to promote students' well-being. Student's narrative creation in the form of digital stories are potent forces within the lives of adolescents as they shape opinions, assumptions, and alignments with the knowledge.

A novel approach to providing children and adolescents who would otherwise struggle to access care, particularly in rural areas, with an easily accessible source of health care is the digitalization of Brazil's Health at School Program (PSE) supporting telehealth services. It is anticipated to be a source for addressing digital inclusion and multiliteracy access in education, health, and other areas as an innovative method, particularly for the most vulnerable neighborhoods of the city of Sao Paulo, which lack access to telecom signals and are therefore unable to access many services.

Some limitations are expected to be noted. The involved adolescents represent only a tiny subset of the total adolescents at school and may not reflect all adolescents. Furthermore, the recent lockdown periods due to the COVID-19 pandemic made us aware of limiting chances and possibilities for participation using online meetings.

The intervention protocols that were created and adapted during this study, target school and health staff to late apply it with the adolescents in future research. Once interventions are delivered, it will help to explore benefits over time. Moreover, research is needed to examine its impact on health outcomes and user's care experiences.

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Enabling Ecosystems to Foster Business Innovation

Co-creation of Entrepreneurship Learning Environment in Partnership with an Actor from the Innovation Ecosystem

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Abstract. In the educational context, elective courses focused on entrepreneurship challenge educators to adopt contemporary teaching approaches, centered on the student and with active methods that lead to learning and are lined up with market practices. Faced with the need to create a transdisciplinary educational environment, the following problem was listed for the study: "how to co-create a transdisciplinary learning environment for entrepreneurship, student-centered and integrated into the innovation ecosystem?" The objective of this research was to explain the process of co-creation of an entrepreneurship learning environment for a school subject of a Materials Engineering course, which involved the university and an actor from the innovation ecosystem. A qualitative method, action-research, was adopted, with the active participation of academic and non-academic researchers. The co-creation of the learning environment has theoretical foundations in constructivism, experiential and reflective learning, and Design Thinking (DT). The university's integration with the innovation ecosystem, with latter in protagonism from the teaching program definition phase to the execution of the discipline, has the potential to transform the classroom into a hub for connecting ideas and people and an arena for student self-knowledge and personal planning. By describing the process of co-creation, this article brings to entrepreneurship educators the transdisciplinary approach and the elucidation of practices that can be adopted in educational approaches of this kind.

Keywords: entrepreneurial education · learning environment · co-creation

1 Introduction

Entrepreneurial education (EE) acts as a central pillar of the new knowledge economies (Blesia et al. 2021) and has an important role to play as a catalyst for innovation. Although, at first, its genesis was linked to the scope of business courses, given its notoriety for economic and social development (Loi et al. 2022), the field today enters different

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areas, such as arts, health and engineering (Aadland and Aaboen 2020, Holzmann et al. 2018), the latter being the focus of this work.

In this context, university education, as a critical center of knowledge, is called upon to stimulate the formation of future entrepreneurs, who will work in uncertain arenas, permeated by digital transformation and with complex economic, social and environmental challenges. Therefore, some subjects need to be rethought and reformulated to meet the demands imposed by society that is constantly changing.

This research reveals the results of the co-creation of the Engineering and Innovation Management subject of the undergraduate course in Materials Engineering at the Federal University of Santa Catarina (UFSC) - Brazil, with a focus on entrepreneurship and innovation. The subject program was co-created by the Nucleus of Studies in Intelligence, Management and Technologies for Innovation (IGTI) of the Post-Graduation in Engineering and Knowledge Management at the Federal University of Santa Catarina (PPEGC/UFSC), in partnership with the Santa Catarina Technology Association (Acate), more specifically with Miditec - Acate business incubator. Miditec constitutes an important actor of the innovation ecosystem[1] of the Brazilian system, elected by the UBI Global 2019/2020 award as the fourth best private incubator in the world.

Based on the research question: “how to co-create an entrepreneurship learning environment in a transdisciplinary way, student-centered, and integrated into the innovation ecosystem?”, the article presents the educational foundations of the proposal, the teaching-learning methodology and the relationships established between full professor, PPEGC/UFSC doctoral students who worked as interns in the classroom, along with the mentors of the innovation ecosystem. The project’s objectives focus on improving the student’s entrepreneurial training, with greater interaction with the innovation ecosystem and also expanding UFSC’s partnerships with society.

This study intends to fill a gap pointed out by Holzmann et al. (2018) regarding the low number of studies on EE in engineering, which contrasts with the innovation potential of the area. The research also responds to calls for studies aimed at the design of learning environments in specific fields of entrepreneurship and the lack of attention to the role of educators in creating these environments (Ilonen 2021).

A learning environment constitutes the entire domain in which the student learns, be it formal (planned intentionally), informal (socialization of individuals) or non-formal (everyday and experience). It consists of objective and observable characteristics, such as programs, teaching plan, physical space and, above all, dialogic interactions between students and educators and their subjective perceptions (Frenzel et al. 2007). Ilonen (2021) defines an entrepreneurial learning environment as a self-regulated and co-created environment in which students with heterogeneous characteristics learn from each other.

Developing an EE program with a focus on the student and their learning process implies the adoption of methodologies and pedagogical practices capable of effecting the co-creation of value for and with the student. To this end, one of the approaches pointed out by EE research is the application of design thinking (DT) (Huq and Gilbert 2017, Fialho and Machado 2022). Its introduction in education generates innovation to face the challenges of the teaching-learning process (Fialho and Machado 2022).

[1] Innovation ecosystem is a network developed between actors and entities that aim at technological development and innovation (JACKSON, 2011).

In the learning environment, Gibb (2011) declares that students' exposure to the entrepreneurial ecosystem is important. Mediation with mentorships, in the author's view, is a way of expanding the limited relationships between students and teachers. This gives importance to external stakeholders in the formulation of the learning environment (Illonen 2021), and brings the challenge of establishing transdisciplinary practices, concerning the co-creation of the educational environment itself, its respective instructional design processes and classroom dynamics. of class. The perspective of transdisciplinarity, in Piaget's (1972) approach, is not limited to recognizing the interactions and reciprocity between specialized research, but a higher stage of interdisciplinarity that establishes links within a larger system, without stable borders. There is an overcoming of the reductionist paradigm in favor of the expansion of knowledge with the creation of value.

In the following section, the educational theoretical foundations are presented. Next, the method is exposed, followed by the results and their discussion. The article ends with the final considerations and the presentation of the references.

2 The Theoretical Educational Foundations

One of the first steps of the co-creation process was the definition of the theoretical basis of the program. In order to obtain a synthesis of knowledge, an integrative literature review was carried out with results embodied in the research by Kangerski et al. (2022).

Kangerski et al. (2022) pointed out constructivism as the main theoretical aspect of learning. Methods centered on the teacher, with a behaviorist basis and focused on the transmission of knowledge from the teacher to the students, give way to active methodologies, with convergence in the students and the teacher acting in the role of facilitator.

Constructivism emphasizes the creation of knowledge by the student himself, involving his cognitive aspects and his reflections from the context and his experience (Bel 2021). By providing a more effective explanation of how knowledge is created by the dynamics of entrepreneurship (Bel 2021), the constructivist educational current is referred to as an approach that is closest to entrepreneurial learning.

Kolb's theory of experiential learning - in which the student learns from lived experiences, alongside Dewey's theory of reflective learning - whose learning stems from the relationships between individuals and the tensions between habitual experiences and their environment, gain importance for foster innovation, intellectuality and creativity in students (Kangerski et al. 2022). For Kolb and Kolb (2009), experiential learning depends not only on cognitive processes, but also on a dynamic that enables the integrated functioning of the student's thinking, feeling, perceiving and acting.

Another point highlighted in the integrative literature review stage was the educational approaches to entrepreneurship. Kangerski et al. (2022) point to studies from the systematic review by Nabi et al. (2017), whose classification indicates the existence of four segmentations: i) supply (behavioral emphasis); ii) demand (constructivist, active participation in seminars, events and extracurricular activities); iii) competence (real business practices) and iv) hybrid methods. According to Nabi et al. (2017), competence would be the closest approach to the entrepreneurial experience.

As a basis for the methodology adopted in the subject, a theme that emerged from the analysis by Kangerski et al. (2022) was design thinking (DT). Its use is in line with contemporary EE needs, as it is student-centered, iteratively oriented to problem solving and creating potential solutions, encouraging students to think entrepreneurially and face the fear of failure (Huq and Gilbert 2017). The application of DT in EE occurs both as an approach to teaching entrepreneurship and for the creation of new business models (Kangerski et al. 2022). As an educational approach, Active Methodology (teaching strategies aimed at the autonomous participation of the student) and Flipped Classroom (previous study by the student before the class) are examples of the use of DT in the classroom from the constructionist perspective (Fialho and Machado 2022).

In Brown's (2009) conception, DT is based on three non-linear stages: i) inspiration, with exploration and identification of the problem; ii) idealization of the idea to research, create, develop and test, and iii) implementation of the ideas. Such phases are aimed at meeting the needs of its users, linked to six key aspects: empathy, brainstorming, divergence, convergence, prototyping and storytelling (Brown 2009).

3 Methodology

The method adopted is qualitative in nature (Creswell and Creswell 2021). It is also classified as an action research - an empirical social research aimed at solving a collective problem, in which researchers and participants in the problem situation are involved in a cooperative or participatory way. In this case, it involved researchers from the university and an actor from the innovation ecosystem in a cooperative way to create the learning environment. One of the limitations of this type of research is the development time and the impartiality of the researchers, as they are active in the environment. Regarding impartiality, the diversity of actors in the team allows for the reduction of such bias. The research was developed from December 2021 to July 2022.

As for data collection, initially, an integrative literature review was carried out by the members participating in the project and based on the publication by Kangerski et al. (2022). Fayolle (2013) argues that one of the shortcomings of EE is the lack of anchoring in a theoretical basis, which makes the area of knowledge fragmented. The results of this bibliographic research were presented in the first section of this article, and served as a theoretical-empirical lens to establish the educational bases of the project in question and will be punctuated throughout the article.

Another technique adopted was document analysis (Creswell and Creswell 2021) which used course programs, teaching plans, and dissertation and audiovisual records of team meetings.

4 Results e Discussion

The next sections are organized to describe how co-creation was established, the associated educational foundations and the teaching proposal.

4.1 The Starting Point of Co-creation

The subject of Engineering and Innovation Management makes up the curriculum of the Materials Engineering course at UFSC in the optional modality, that is, it is not mandatory. This makes it possible to enroll university students from other higher education courses within the limits of UFSC, stimulating heterogeneity in the students' profile. The workload is 72 h with a biannual offer, subdivided into 18 weekly meetings of four hours in person or remotely (when in the pandemic period). The starting point of the co-creation was to carry out an analysis of the classes already offered.

The objectives of the original subject were based on: a) preparing the student to invest in his career in an innovative way, whether as an intrapreneur or entrepreneur; b) grant opportunities to design a business plan, starting from the identification of problems/opportunities, generation of ideas to the creation of an innovation potential and, c) collaborate with the development of the student's reflective, critical, systemic thinking and collaboration.

Learning by project was the foundation of the subject. During the semester, students, working in teams, identified a gap in the market, generated ideas for solutions with transformation into a business model. The end result was the delivery of a business plan, presented using the pitch technique (a brief presentation lasting 3 to 5 min). The entire process was carried out progressively by the teams throughout the course, alternating classes of guidance and discussions, with production in teamwork. The expository-dialogue classes provided theoretical support for the development of the project, encouraging students to seek additional knowledge, according to the focus chosen by the team. The identification of gaps in the market and the solution to be designed by the teams were freely identified by the students themselves, as well as the definition of the purpose of the business. However, in the pedagogical sequences of the classes, there was an incentive to create solutions aimed at meeting the Sustainable Development Goals (SDGs) adopted by all United Nations member states in 2015, in order to create value for society.

Two central issues motivated the restructuring of the subject. The first of these was the need for greater interaction with the entrepreneurial and innovation ecosystem, in order to bring students closer to real experiences and also enable interaction with innovation habitats around UFSC. The proactivity of the external partner in providing its knowledge and that of its team of mentors, was central. The second motivating point of the project was the need to replace the emphasis on the causal approach (Sarasvathy 2003), based on developing market opportunities based on planning and predictability - a common practice of the business plan, with the effectuation approach (Sarasvathy 2003), sustained in the creation of opportunities with the resources available at the time and in conditions of uncertainty and risk.

A work team composed of eight internal members and one participant external to UFSC (Chart 1) was structured to define new competencies, knowledge and skills, deliver value to the subject for students and define learning paths. The external member acted, simultaneously, as a representative of Miditec responsible for the partnership and as a mentor in the classroom.

Chart 1. Multidisciplinar team

Degree	Institution	Role in the project
Math/PhD	PPGEGC/UFSC	Professor
Administration/MsC		Teaching intern
Administration/MsC		Pedagogical support
Agronomist Eng./MsC		Teaching intern
Social Communication-Public Relations/PhD		Pedagogical support
Pedagogy/PhD		Pedagogical support
Materials Eng./Bachelor	ACATE/Miditec	Mentorship coordinator

Source: Prepared by the authors.

In addition to the team responsible for reformulating the course plan, seven more MIDITEC mentors worked with the students. Such interactions will be discussed in Sect. 4.2.

4.2 The Co-creation of Learning Paths

The process of co-creation of the new learning environment took place from March to April 2022 through ten remote meetings with collaborative construction that redefined the objectives and competencies of the course, and the elaboration of the teaching plan and lesson plans organized into learning paths. One of the important points for effective co-creation was the conceptual and practical alignment with the external partner. The role of mentors would require alignment with internal facilitators with the partner's tacit knowledge, especially with regard to experiences, and explicit knowledge, formalized in the techniques and tools used by the business incubator to promote learning.

An undergraduate classroom and a business incubator have in common the fact that they are learning environments. However, they present different dimensions of work. The Miditec incubator emphasizes the process of creating new business models with an emphasis on company development. The subject, in turn, focuses on stimulating the student's entrepreneurial thinking and action. Understanding these different dimensions of learning and understanding the commonalities is critical. The alignment of language, concepts and practices (between professors, teaching interns and mentors) and, as a consequence, knowledge sharing, is extremely important to make student learning more fluid. Therefore, communication needs to be bidirectional, empathetic and transparent.

Four central objectives were established for the matter: i) to demonstrate the importance of innovation and entrepreneurship, sustainable development, ethical and responsible behavior in the entrepreneurial process; ii) encourage the student to seek the self-development of entrepreneurial behavior; iii) provide opportunities for innovative business modeling, and iv) stimulate reflective, critical, systemic and collaborative thinking in the student.

Three learning paths were created: i) multiple ways to start a new business and innovate; ii) from ideation to prototyping, and iii) preparation for implementation. The main educational foundations were based on constructivism, experiential and reflective learning, and design thinking, which were identified in the integrative literature review stage exposed in the second section of this article.

As expressed in Fig. 1, the first path aims to demonstrate to the student the entrepreneurial mindset and prepare them for teamwork, focusing on: self-knowledge, entrepreneurship typology, entrepreneur profile, types of innovation, design thinking, sustainable development and the SDGs. The first path ends with a technical visit by the students to the Miditec business incubator, which allows each team to interview an entrepreneur from the incubator in loco.

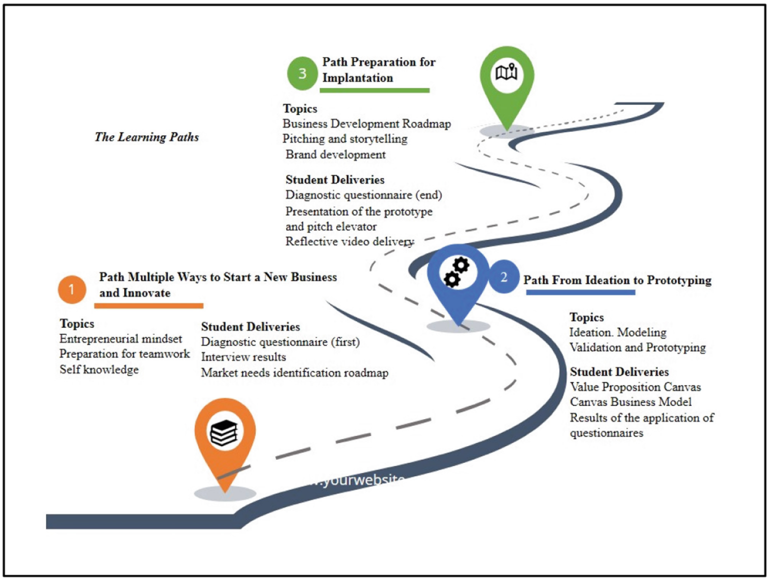

Fig. 1. The learning paths. Source: Autors.

The second learning path is predominantly practical. Classes are planned to take place in an iterative way with: dialogue-exposition of concepts, techniques and tools; applications of these by the teams in their business projects, with the support of mentorships; sharing the results of the application in class, with reflections and feedback from those involved – colleagues, professor/teacher interns, mentors. The model and type of business to be created by the teams is freely chosen, however, the stimulus for businesses aligned with sustainability or that meet the SDGs remained from the previous practice.

At this stage, teams need to identify a pain (market/society/community need), align with Track 1 content, model a solution, validate the need with the target audience (market/community) and prototype the product. At each class, a mentor from different expertises participates in the class and guides the teams, according to the theme of the class. The bridge between the subject itself and the team of mentors will be built by the representative member of Miditec, who will work in all classes. Track 2 adopts tools aimed at DT by students: IGTI Problem Analysis Flowchart and Empathy Map (to identify customer pain), Value Proposition Canvas and Business Model Canvas. A prototyping workshop was designed to present free strategies and tools for designing the first draft of the product and Minimum Viable Product (MVP) – the simplest version of the product designed with the minimum of resources in order to gain market appreciation.

Although in methodological terms there are deliveries and deadlines - as required in academic subjects, the premise was established by the subject co-creation team that the entire process is iterative and dynamic, with flexibility for subsequent changes, which is in line with the thought advocated by DT. In this way, student teams will have the freedom and flexibility to update or pivot a value proposition or a certain aspect of the business model, whether based on new validation data, information from the target audience (market/community) or the learning of the students during the program. This line of thought is also part of the co-creation group's own action. At each class, according to student engagement and feedback, the following sessions will be reviewed and, as appropriate, remodeled. It is important to point out that the classes from track 1 to 3 also adopt the flipped classroom method, requiring the student to prepare in advance to participate in the classes.

The third track – preparing the implementation, was structured for the teams to finalize their productions, learn about future steps of a business modeling, and prepare for the final presentation of the created product, applying storytelling techniques. As a final delivery, each team needs to present a pitch and a prototype of the product, which will be appreciated by a panel of mentors who will evaluate the exhibitions. Although it is the end of the course, the perspective of track three is to encourage the student to continue their entrepreneurial training, identifying knowledge gaps and the search for other opportunities for self-development in the innovation ecosystem or in the university itself.

Regarding the classification by Nabi et al. (2017) on EE approaches, presented in Sect. 2, the proposal of mixing practice demand and competence practices with activities that go beyond simulation, such as validation and prototyping.

During the reformulation process, some content and methodological practices of the original version of the subject were excluded or had their approach transformed. One of the examples was the business plan (BP) – a planning tool that led the old teaching program. In the current model, the BP would be replaced by the Business Roadmap – a tool applied by Miditec to identify confirmed hypotheses, as well as planning new validation phases and establishing MVP versions.

Anchoring the program in reflective learning, evaluation and reflection actions are foreseen for each track, involving the teams themselves and the students individually. In addition to the assessment of teamwork development at the individual level, at the end of track three, students will produce a video of up to three minutes, reflecting on their experience during the course and understanding what it means to be an entrepreneur. Such activities, in addition to serving as inputs for future adjustments or during the course of the program, give the student the position of co-responsible and protagonist of their learning environment.

Student learning assessment is designed to be diagnostic, formative, and summative. Team tasks such as: interview an entrepreneur, ideation stage, validation, modeling, prototyping and pitch, will be evaluated, in parallel, with the individual participation of students and the creation of a video (or audio) to reflect on their learning throughout the course. In the diagnostic part, in the first and at the end class of the program, students answer a questionnaire validated by Moberg et al (2014), in order to identify predispositions and knowledge about entrepreneurship. The subject is currently being offered and, at the end, a new application will be generated, following guidelines from EE researchers for pre and post evaluation of EE initiatives (Moberg et al. 2014). The first edition of the restructured course had the participation of 19 students, the vast majority from the engineering course (civil, materials, mechanics and sanitary).

5 Conclusion

The dynamics of co-creation (from the teaching program, its adaptations to execution) provided the team with reflections on entrepreneurial thinking and action, as well as updates on methodological practices, enabling a transdisciplinary look at the EE environment. Transdisciplinary work requires empathy, transparency, iterativeness, integrated and assertive communication, evaluations and adaptations. The internal members of the university are responsible for transposing the tacit knowledge of the partners, making them explicit in order to provide students with significant learning dynamics in line with the reality of the market.

In this new EE environment, students need to take a leading role in relation to their own learning. This brings challenges regarding academic engagement in the program and also in student teamwork - one of the educational principles of the subject.

DT proved to be a prolific foundation in the co-creation of the teaching program. Entrepreneurship subjects can be a student's first contact with the world of entrepreneurship and need to act as a hub, a space for student self-development and personal planning and, above all, for connecting ideas and people.

This article is the first publication of the project to remodel the program. A new survey will be carried out to bring evidence from students and mentors about the applied methodology. The development of new studies that can bring mentors to the scene is encouraged, in an analysis focused on the process of knowledge overflow. Another field to be visited is the challenge of teachers to stimulate the development of entrepreneurial skills through teamwork by students.

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Science Parks: Stakeholder Involvement in Attracting Talent

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Abstract. Science Parks convey the idea that technological innovation originates in scientific research. A triple helix configuration provides all the necessary conditions for science parks to achieve their goals. This paper aims to investigate the existing interactions of science parks with triple helix actors related to the development of talent attraction activities. Talent is a necessary resource to meet the growing demands for innovation of park firms. In fact, a firm's ability to innovate and, consequently, to be successful seems to be related to its capacity to find and retain employees with relevant skills. This study analyses five case studies on three Swedish Science Parks and demonstrates the importance of the relationship with stakeholders to ensure support and the adequate development of attracting talent to Science Parks. Also, this study showed that the studied parks carry out different activities to attract talent, and the involvement of government agents and the local university proved to be essential for developing such activities.

Keywords: Science Park · talent attraction · triple helix

1 Introduction

The first Science Parks appeared in the United States in the mid-twentieth century, favoured by initiatives such as the Bayh-Dole Act, which allowed the development of partnerships between universities and firms and opened paths for the commercialisation of research results [1]. The International Association of Science Parks and Areas of Innovation (IASP) defines science parks as organisations with specialised managers that strive to increase the prosperity of their community by nurturing the culture of innovation and the competitiveness of their affiliated companies and knowledge-based institutions [2].

For Westhead [3], Science Parks convey the idea that technological innovation originates in scientific research. In this way, Science Parks seem to be the right environment to transform pure research into a product for the market. Establishing a triple helix configuration fulfils all the conditions necessary for Science Parks to achieve their goals. Links with universities allow more direct access to qualified human capital, and networking

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with government authorities enables parks to provide adequate political support to their tenants [4]. In recent years, one element of Science Park's growth that faces obstacles is the attraction and development of talent needed to meet the growing demands of tenant firms. It is perceived that the ability to find and retain employees with relevant skills is one of the main factors that sustain the success of organisations [5].

Although Science Parks have received attention among researchers and a great interest in promoting entrepreneurship and regional development, few works focus on the relationships of Science Parks with the triple helix actors, especially when analysing their interactions for the attraction of talents [6, 7]. Thus, this study aims to investigate the existing interactions of science parks with triple helix actors related to the development of talent attraction activities. In particular, our interest is: how collaboration with stakeholders contributes to attracting talent to science parks?

This paper is organised as follows. After this introduction, a literature review section follows, where concepts about science park stakeholders and their talent attraction processes are presented. Then, a description of the empirical scenario and a presentation of the empirical evidence with talent cases from the examined parks. Finally, the conclusions resulting from this study are consolidated in the last section.

2 Literature Review

2.1 Science Park Stakeholders

Science Parks have rooted in their concept of the connections and relationships with the actors of the triple helix model [see 8] [9–11]. Science Parks are essential agents of regional development and entrepreneurial ecosystems by promoting relationships between universities, companies, government agencies, incubators, and other parks [9, 12].

Forming a triple helix configuration helps Science Parks achieve their goals, and some authors suggest that Science Parks should establish links with universities to facilitate the training of park firm employees, develop an entrepreneurial spirit among university students, and make access to students with innovative minds and scholars with advanced knowledge more efficient [3, 13]. The literature reports that student recruitment occurs in several ways [14–16], with student involvement in firm activities being one of the possible alternatives [17].

The government actor is responsible for demanding research to deliver products of interest. These requests are made through funding offers [18] that encourage the transfer of talent and technology (e.g. publications and patents) from universities to park firms [19], promoting innovation and the entrepreneurial mindset in the Science Park [20]. In addition, connections with government authorities provide opportunities for the park to offer adequate policy support to its tenants more efficiently, creating a favourable environment for attracting talent [4].

Interactions between park stakeholders can occur, for example, through the construction of informal networks to exchange information and knowledge [21], the sharing of university laboratories and research facilities [22], connecting with alumni networks [16], or disseminating university activities and firm opportunities [23]. In addition, other abstract factors, such as the park's brand [24] and its privileged address [25], also contribute to the success of these interactions and build a favourable environment for attracting talent [26].

2.2 Science Park and Talent Attraction

Science Parks provide the infrastructure and services needed to support the development of their tenant firms [13]. The capacity of a park to attract talent is connected to its innovative environment, its high quality of life and the availability of other talents to share knowledge and experience [27].

The literature presents talent as individuals with unique abilities, experience, and the drive to perform at a high level [28, 29]. They help develop the firm's culture, networks, and structure, which are elements challenging to replicate by competitors [30]. Talent skills can be expressed as creativity, competence, leadership [29], and the commitment to deliver these skills in favour of the firm results [31–33]. Some talents, like university students, do not have the expertise and experience yet, then they are called potential talents [34]. It is essential to highlight that working conditions, relationships and opportunities influence the performance of talents, so future performance should not be defined solely on the basis of past performance [34]. Therefore, the work environment will or not enable the talent to perform at their best [35].

Talent is a necessary resource to meet the growing demands for innovation of park firms. In fact, a firm's ability to innovate and, consequently, to be successful seems to be related to its capacity to find and retain employees with relevant skills [5].

3 Method and Data

The data of this study comes from three Swedish Science Parks, namely Ideon Science Park, Lindholmen Science Park, and Linköping Science Park (see Table 1). The first park contacted was Linköping Science Park because of its geographic proximity to Linköping University and good accessibility to data. The other two parks came to our attention during our interviews with Linköping SP representatives. The intention behind choosing parks located in the same country is to keep some factors in common, such as the culture and mentality of the people, the economy, political regulation, and laws.

Data from this investigation were obtained by carrying out five case studies on talent attraction activities in the three Swedish Science Parks. The case study method is considered one of the most suitable ways to connect qualitative evidence with conventional deduction [36]. For this study, the case study method facilitated the understanding of the processes and the context that led to the development of the parks' talent attraction activities, the involvement of key people, and the results achieved in each activity [37, 38].

Table 1. Swedish science parks.

	Ideon Science Park	Lindholmen Science Park	Linköping Science Park
Foundation	1983	2000	1984
City	Lund	Gothenburg	Linköping
Competencies	ICT, connectivity, Life science, cleantech, medtech, smart material and food innovation	Transport, ICT, and media industries	ICT, visualisation, simulation, medical technology, mobile broadband, vehicle safety and security systems
University	Lund University	The Chalmers University of Technology, University of Gothenburg	Linköping University
Owners	Real estate companies Wihlborgs and Castellum	The Chalmers University of Technology, the City of Gothenburg, Business Region Göteborg and the industry in Gothenburg	Linköping City
Board	Lund University, Lund Municipality, Chamber of commerce and Industry of Southern Sweden, the County Administrative Board Skåne and the owners	The city of Gothenburg, Chalmers University of Technology, Volvo Group, Volvo Car Group, Saab AB, Telenor Connexion AB, Ericsson, Consat AB	Representatives from the city's political leadership, Saab Aeronautics, NAI Svefa, Ericsson and Linköping University
Firms (2022)	400	375	352

The information collected during the semi-structured interviews was organised into tables, which underwent successive refinements until the final version, presenting a pattern of similar characteristics (see Table 2). Secondary data was collected from scientific papers and institutional web pages.

Table 2. Five talent cases

	Shadow Board	Tech Pilots	Ideon Meeting	CEVT	MSP Office Inc
Where	Linköping Science Park	Linköping Science Park	Ideon Science Park	Lindholmen Science Park	Linköping Science Park
Who	University	University	University Government	University Government	Government
What	Student board to bring together talented students and park management	Project to integrate young talents and park firms	Arena to bring people together and expand networks	Activities to support the establishment of CEVT and its international staff	Processes to develop park brand and support tenant growth
How	Building relationships with the university and the student collective to bring a youthful mindset to park management and make student board members into park ambassadors for the academic community	Creating opportunities for firms in the park and young talents to get to know each other better and develop projects and products together	Coordinating events (meetings, conferences, forums, visits) with content suitable for the public	Providing support in immigration, housing, schools, and connections with Swedish government authorities Mediating networks between CEVT and Swedish universities to enable academic talent recruitment and set research connections	Spreading Park information and opportunities internationally with the support of embassies Educating politicians about the park's roles in regional development

4 Talent Cases

Science Parks accommodate firms with different characteristics (sizes, ages, and business orientations), so their activities need to focus on each firm's needs to deliver a quality support service. Each type of company has a different need in terms of talent, so relying on the support of the local university and government agents to attract talent seems to be a reality in the studied parks. The interactions between the three studied parks with their local university and government agents seem to adopt several different approaches when performing talent attraction activities.

The involvement of the local university is perceived in the activities of technology and knowledge transfer and those related to the supply of qualified human resources. It is a fact that the university delivers an annual flow of graduates to society, which seems to be an exciting source of potential talent for the job market. In this way, the studied parks developed specific activities to interact and attract the attention of this group of individuals.

The Linköping Science Park, for example, proposed the creation of a parallel board composed of university students. The idea was initially put into practice in 2012, with the dissemination of the project inviting students to participate. The selection process aims to reach students from different university disciplines and, as far as possible, with gender equality. On average, twenty-five students apply to be part of the board, being interviewed around fifteen to approve eight to ten at the end. Those chosen will serve on the board for one year and will have the opportunity to participate in park management operations. Exceptional professional experience in board work is the main reward for student participation and dedication.

The activities and the flow of information between the two boards are simplified by having the same chairperson and having a joint strategic meeting each year. One of the main benefits of student participation in park operations is creating a two-way information channel. In one way, students act as park ambassadors to the student community and publicise the park's activities and opportunities. On the other way, students bring the needs and aspirations of their community to the park management, contributing to better decisions and making the park more attractive to young talents. This student council is still active to this day[1] and aspires to bring young and fresh ideas to park operations.

University students are not only desired by park firms when they graduate. Even after some time of obtaining a university degree and working outside the region, these alumni are still desirable, as they can contribute to the park's firms with their work and cultural experiences acquired during this period. To attract this type of talent, Linköping Science Park conducted a project to invite and select young talents and integrate them into some park firms. In a typical win-win situation, firms optimise their processes and improve their products while learning to be more attractive to young talent. At the same time, young workers have the opportunity to develop their skills and competencies further, as well as expand their networks.

In fact, the possibility of developing relationship networks is something important for the park since talents are people looking for places where they feel motivated to evolve professionally and have the chance to work together with other talented individuals [27]. Creating spaces where people can meet and get to know each other is essential to attracting talent. Ideon Science Park then built the Ideon Meeting arena to bring together people from academia, firms (park firms and firms from the region), politicians, decision-makers, and individual talents. The events promoted by the park in this arena contribute to exchanging knowledge and experiences, expanding talent networks, and providing new business opportunities. The university's academics participate in the events seeking to publicise their research, develop their research networks, and obtain partnerships. Moreover, the presence of government agents allows the needs of the university and the tenant firms to be better understood and thus seek a better solution together.

In 2013 Lindholmen Science Park received CEVT, an innovation centre created by the merger of Geely (China) and Volvo Cars (Sweden). Then, the park needed to offer

[1] https://linkopingsciencepark.se/contact/board/.

customised support services focused on particular needs to accommodate this new company composed of people from different countries and cultures. It was necessary to provide workers from China with support related to housing, schools, and connections with government authorities in areas such as immigration and residence and work permits. Moreover, to keep this relationship with CEVT more lasting, the park has also strengthened the company's relationship with its local universities to establish research links and facilitate the recruitment of academic talent.

In its early years, Linköping Science Park, still called Mjärdevi Science Park, needed to demonstrate to local politicians how the park could be a tool for regional development. During this period, the park also suffered from a lack of experienced business professionals in its management team (MSP Office Inc). This gap hampered support for tenant firms and the park's growth, so the park had first to attract talent to its team and then work on expanding its network of contacts and strengthening the brand. With the support of the Swedish embassies, the park participated in conferences to disseminate information and opportunities about the park to place itself on the international stage.

5 Conclusion

This paper aims to investigate the existing interactions of science parks with triple helix actors related to the development of talent attraction activities. Interactions with the local university can occur in different ways, but always with a focus on academic talent, whether they are graduates or researchers. This strategy aims to bring these university talents closer to the park, either to spread the park's opportunities or to capture their desires and interests. Interactions with government agents, in turn, aim to support the attraction of companies (and their talents) to the park as well as for the processes of internationalising the park's brand.

Finally, this study showed that the studied parks carry out different activities to attract talent, and the involvement of government agents and the local university proved to be essential for developing such activities.

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Mipymes: New Private Economic Actors in Cuba and the Challenge for a Feasible Socialism

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Abstract. Cuba is the object of investigation of many studies that seek to understand how the only socialist country in Latin America has endured for more than six decades. We assume that the economic restructuring policies intensified after 2008 are part of the continuity strategy. Thus, the aim of this paper is to explain how the legalization of private Micro and Small Enterprises (Mipymes) in the context of the 2021 crisis falls within the frameworks of updating Cuban socialism. The methodological approach of the research was of a theoretical-explanatory nature with analysis of data collected from primary sources. We verify that the expansion of non-state management has advantages, but also systemic and political-ideological problems that will tend to coexist for a long time to come. Although the adaptive measures incorporate market characteristics, the local development projects generated by the revolution still rule the system. Finally, we understand that the historical pendulum movement between centralization and economic flexibility adopted by the Cuban regime is part of what we understand as feasible socialism or sustainable socialism.

Keywords: updating socialism · Lineamientos · Cuba · private enterprises · crisis

1 Introduction

The objective of this paper is to draw a general panorama of the creation of Cuba's Small and Medium Enterprises-SMEs (Mipymes in Spanish) one year after their legalization. Specifically, we intend to problematize the expansion of these economic actors in the Cuban context, understanding this measure as a challenge in the face of the historical paradox that is configured, that is, the need for economic restructuring without mischaracterizing the original socialist project in the face of market economy pressures.

Although the subject of Mipymes is recent, it is significant for understanding the framework of updating Cuban socialism that has been in place since the Raul Castro administration, but made official in 2011 with the so-called *Lineamientos de la Politica Económica y Social*. A moment in which the country rethinks its "economic reinsertion under the new conditions of the international economy," and begins to focus "on the development of a sustainable socialism" [1].

Thus, the importance of this work resides in its actuality and in the fact that it seeks in the readjustments of the Cuban socialist model a plausible conception for the

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construction of a viable society, without, however, giving up the socialist project as a model for overcoming capitalism.

In order to develop the arguments, we will start from the following questions: How is the new framework one year after the decree law number 46/August 2021? What does this transformation represent for the Cuban economy?

We assume that, although Cuba is "an irrevocable socialist state of law" based on planned economic centralization, the relative decentralization of production through the expansion of non-state management models demonstrates that this would be a path towards the so-called feasible socialism [2].

Preliminary data show that the inclusion and expansion of Mipymes arise to boost labor activity on the island, in addition to complementing the productive economic chain, shaken during the Covid-19 pandemic. However, they still face some difficulties in implementation and adaptation to the context.

For this work, we consulted primary sources, specifically the list of Mipymes created and released monthly by the Ministry of Economy and Planning (MEP). We also consulted the Legislation and official reports in order to gather complementary data regarding labor occupation, the price index, food production, and construction activities.

As a theoretical contribution, we used the concept of feasible socialism developed by Alec Nove, as well as a literature review on the transformation process of the Cuban economy developed by Carmelo Mesa-Lago and other authors.

Thus, in order to follow a methodological path that responds to the problem posed, we divided this paper into six parts. Section 2 outlines the data collection procedures used to formulate this paper. Section 3 introduces the theoretical debate about the concept of "feasible socialism" based on Alec Nove. Section 4 presents a brief structural historical contextualization on the opening of the Cuban economy to private actors. Section 5 presents the main results obtained in light of the systematization of the data. Finally, the conclusion in Sect. 6 presents the main challenges for the Cuban economy in the face of the new set of economic actors.

2 Materials and Methods

This paper has a theoretical-conceptual approach and uses the deductive method. It seeks to describe, explain and prove some changes underway in the socioeconomic context of Cuba, based on the case of the legalization of Mipymes. We associate the exploratory-qualitative character (fact-finding) with the descriptive-quantitative character (data collection from primary sources). For this, we define the sample, as well as the data collection, organization and analysis.

2.1 Sample

The sample of companies selected in this work was based on the 50 lists of Mipymes disclosed by MEP through the New Economic Actors Channel, of Telegram. The choice for Telegram was an alternative to the MEP's official website, whose connection is impossible in Brazilian Territory. The 50 lists cover a period of September 2021 to September 2022, i.e. the period of one year after the legalization milestone. Based on

MEP figures, this period has seen 5,165 economic actors approved since the start of the process in September 2021. Of these, 5,056 Mipymes were private, 51 state-owned, and 58 cooperatives. In their origin, 52% represent reconversion of existing businesses while 48% correspond to new ventures. For this work, we considered only private companies, since this is the specific object of the analysis. The sample covers 15 provinces, and most of the companies are based in La Habana (1963 Mipymes).

2.2 Data Collection and Organization

The data from each of the 50 lists was collected manually and catalogued month by month. This process was done between April and September 2022. The lists were organized by months and then summed up at the end. Private companies were separated from state companies and cooperatives. The total summation was done based on the private companies only. At the end, we produced a tabulation of the main activities constituted in the first year of legalization of Mipymes, the result of which was represented in a chart and divided into the following categories: construction, gastronomy, food, ICTs, vehicles, clothing, furniture, and other services.

The classification into categories is based on the nomenclature made by MEP, but differs somewhat from the proposed cataloging. This is because the intention is to broaden the scope of the activities analyzed, in order to offer a more complete dimension of the companies' areas of activity. Thus, for example, if for "IT activities" the MEP considers only companies that produce software, in this work we expand the term to "technology-based enterprises or ventures" which, in addition to software production, also incorporate ICT-related services in general, such as rental, sale or repair of microcomputer equipment, website and application design, and development of commerce via platforms.

2.3 Data Analysis

For the data analysis, we selected the four main areas of greatest concentration of private enterprises, namely: construction, gastronomy, food, and ICTs. In addition to the already mentioned category of technology-based enterprises, in which the area of ICTs is included, in the construction sector both the production of materials and the provision of services were considered. The gastronomy sector is specifically focused on services. The food sector considered the production of meat, fish, shellfish, vegetables, fruits, bakery products, confectionery, olive oils, milk, and non-alcoholic beverages. For each of these four areas we used the historical and conjectural analysis supported by official governmental reports such as Gaceta Oficial, Oficina Nacional de Estadísticas (ONEI) and ECLAC. We also used information from official online channels such as Granma, Cubadebate, Agencia Cubana de Noticias (ACN), as well as video interviews and government conferences released via Telegram or Youtube. In addition, the analysis of this work was based on Alec Nove's theory of "feasible socialism," for whom the decentralization of the socialist mode of production through the presence of a small non-state sector could guarantee the survival of the system.

3 Planned Socialism: Theoretical Basis

The discussions about socialist planned economy permeate a series of theories built on historical experiences throughout the 20th century. Since the establishment of the USSR in 1917, the debates ranged from the adequacy of an alternative economic plan to the market economy with the use of economic calculation or not (Bukharine, Preobajensky, Piatokov), to the importance of technological incorporation in productive processes, bringing to light the possibility of a socialist cybernetic economy (Leontieff, Kantorovich, Lange). These and other formulations reverberated in some experiences in Eastern Europe, China, and Latin America.

In Cuba, the figure of Che Guevara was essential for the implementation of an economic debate with Cuban characteristics. This brought among other concerns the criticism of the use of the law of value in the USSR, the need to combine a pragmatism absent of bureaucracies [3], as well as the adoption of entrepreneurial management techniques, adopting even some more advanced administrative capitalist forms [4].

A brief resumption of the theorizations regarding the Island's socialist economy is important even because, as Nodarse [5] states, Cuba today represents one of the few nations that maintains the condition of centrally planned economy, according to the United Nations classification. Ellman gives us a more precise definition: "what is common to planning in all state socialist countries is the use of state property as a means of production and planning of the national economy" [6].

The discussions that followed immediately after the Revolution about which ideal economic model to incorporate passed through the debate of two systems that coexisted together in the second half of the 1960s: the Financial Budgeting System ("Financiamiento Presupuestario") and the Economic Calculation model [7]. The former, refers to "state control of all production units". The State is the sole owner of the means of large-scale production, and private property is only the small ownership of land for subsistence. The second, on the other hand, "adopts self-management and self-financing of production units, and advocates a more expressive non-state sector" [8].

This balance is fundamental to understand how the sectoral reforms implemented from the crisis special period, and with more vigor from the frameworks of the *Lineamientos* in 2011, have converged to an update of Cuban socialism that is very close to the systematization suggested by Alec Nove [2]. Although Nove bases his arguments on the Soviet context, his formulations are important because they point to some contradictions in the plans that led to the disintegration of the "really existing socialism".

Therefore, it is possible to ask whether the author's systematization could be applicable to the Cuban case, considering that it is very similar to a prophylactic measure that combined market action with state control of companies [9]. In other words, one could also think of a reformist vision as, according to Ellman [6], some economists from Eastern Europe (such as Kornai, in Hungary) did. In this way, one hopes to combine some advantages of socialism (end of exploitation, socialization of economic decisions, full employment, inflation control, and social security) with the advantages of the market (innovation and technical progress, attention to individual consumption, end of scarcity, and increase of intermediate products) [6].

This challenges the Marxist-Leninist economic fundamentals on which economic growth is a unified process between production, distribution and consumption, being the centralization of productive processes the key element for the maintenance of socialism. For Ellman [6], the problem is that by establishing management on a national scale, the plan reduces the complexity of the process to a "giant factory" logic administered by technicians capable of establishing a social rationality based on collectivization and nationalization of the means of production.

Also for Nove [10] the Soviet experience made the mistake of organizing productive relations on a large scale and delegating to the State the control of all economic processes. Therefore, within what he called "the economy of feasible socialism", Nove (1989) proposes the coexistence of several economic scales in the productive sphere, which would also imply a variety of techniques and organizations fostered by political participation. Thus, the author suggests a structure of socialism based on a mixed model consisting of: 1) centrally controlled and managed state enterprises; 2) state-owned or socialized enterprises; 3) cooperatives; 4) small-scale private enterprises; and 5) "individuals"(freelancers) [2].

Thus, to understand the representativeness of Mipymes in the current context of Cuba, it is important to recover some historical milestones of the incorporation of private actors into the socialist economy. These policies have oscillated between the expansion and reduction of these forms of management. Mesa-Lago states that since the Revolution, the island's economic periods have been marked by alternating cycles of political idealism and market pragmatism [11].

However, even if the larger-scale liberation of non-state management models expands the possibilities of economic restructuring, it will not mean the final solution to the crisis. As Nove rightly states, "a government with a socialist tendency must have control over the purposes for which investments are made […] A socialist development plan depends a lot on size, resources, and circumstances" [2]. This means that despite political efforts, Cuban socialism will need to manage the contradictions arising from the economic reforms themselves, such as the increase of inflation, product scarcity, input deficit, and bureaucratic obstacles to the emergence of new actors.

4 Private Actors in Cuba'S Economy Trajectory

The history of private enterprise in Cuba follows the logic of the "pendulum" stages, of which *cuentapropismo* or self-employment (TCP) is a part. Although the term became popular in the 1990s, during the so-called Special Period, the existence of small-scale private businesses is not new on the island.

Even with the nationalization of property after the triumph of 1959, the new government allowed some self-employed activities very restrictively. With the relative stabilization achieved by the revolutionary policies and faced with the framework of labor informality, they would adopt a more lenient stance between the years 1970 and 1985, legalizing self-employment in some services such as carpenters, mechanics, engineers, and doctors [12].

This sector would reach the early 1990s with some restrictions: the impossibility of salaried hiring and the inaccessibility to bank credit [13]. In addition, until the turn of the 1990s, government policy was oriented to promote the integration of companies in a vertical way, so that the final decisions followed the central model. A trend contrary to the so-called productive restructuring that in this period strengthened the "participation of small, flexible units" [13].

This scenario would begin to change in the initial years of the crisis characterized by the dissolution of the Eastern European socialist bloc, the end of COMECOM (Council for Mutual Economic Assistance of the Socialist Countries), and the intensification of the U.S. embargo through the Torricelli Act/1992 and the Helms-Burton Act/1996. According to the ECLAC report (1997) [13], the opening to small-scale activities during the Special Period was determinant to absorb the surplus labor resulting from the economic collapse.

Mesa-Lago [11] states that during this period, the closure of companies caused the productivity of the labor force to fall. By 1995, between 500,000 and 800,000 workers in the state sector were idle. They needed to be rationalized, or voluntarily relocated.

This again required the government to be flexible with respect to non-state employment, as Cubans, faced with shortages of food, fuel, transportation, and other services, began to create their own livelihoods. At this point, the decentralization of the vertical integration apparatus made it possible to sectorize auxiliary activities that could both absorb labor and produce lower-cost, better-quality components.

The 1992 constitutional reform brought an advance in this sense, by including the principle of complementarity among Cuba's economic actors [14]. The production of the state company ceased to be exclusive and began to support other economic subjects to guarantee the effectiveness of productivity. In 1993, by means of Decree Law 141, self-employment was significantly expanded [15].

However, it was with the arrival of Raul Castro in 2008 that Cuba's economic reforms intensified the market character, especially with the expansion of activities allowed for private actors. In 2010, in order to reorder the "available workers", a relaunch of the TCP came into force and that already foresaw among other things "other forms of non-state employment" [16].

Vidal& Villanueva assure that in this period, the new actors had "a positive impact on the supply of consumer goods and services, mainly the elaboration and sale of food and transportation. For some families, this constitutes an alternative source of income to state salaries and pensions" [17].

Figure 1 shows that in 2010 and 2011, there was a significant jump in *cuentrapropismo*, resulting from the expansion of permitted activities from 117 in 1993 [15] to 178 in 2010 [16]. The number of TCPs remained stable, with no major significant advances for a decade (1999–2009), until the turn of the second decade of the 2000s when there was a 172% increase, advancing from 143,800 *cuentapropistas* in 2009, to 391,500 in 2011.

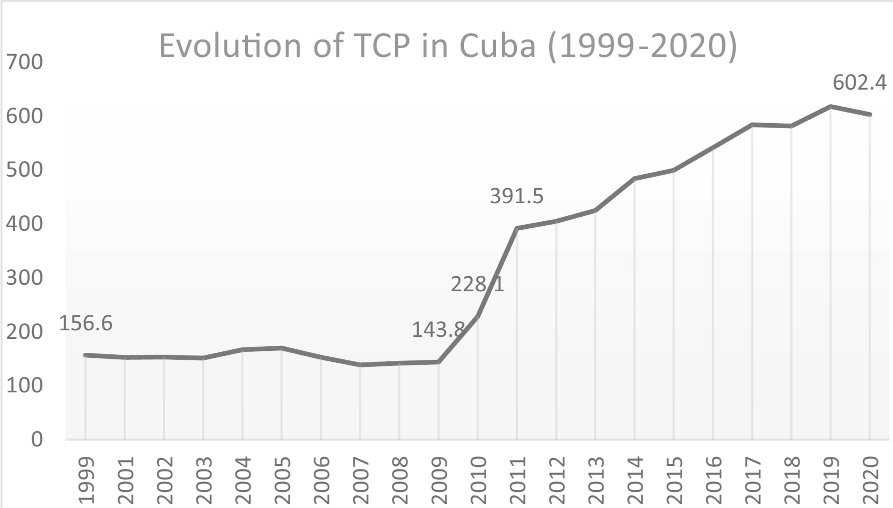

Fig. 1. Source: Author's estimates based on ONEI/Employment and Wages-2020

Thus, over many years of experiments and rearrangements, finally it is with the frameworks of the *Lineamientos*, promulgated in 2011 on the VI Congress of the Communist party, that "the command of the revolution has become more pragmatic". They no longer saw *cuentapropismo* "as an activity allowed in case of urgency, but rather as something important in the construction of the new business" [18]. The official document recognizes the new forms of management as a way to promote productive efficiency [19]. Which, in turn, does not mean the promotion of private property in Cuba.

In 2016, on the VII Congress of the Party, as well as the updating of the *Lineamientos*, Raúl castro was emphatic in stating that the spread of private models does not mean the return of capitalism on the island, given that the concentration of ownership and wealth of non-state management forms is not allowed. It is, in another way, "calling things by their name and not taking refuge in illogical euphemisms to hide reality" [20], recognizing, in this sense, that TCPs, in practice have triggered the formation of small and medium enterprises without legal personality, but fundamental to the subsistence of entire families.

The flexibilization of private enterprises gains another dimension in Miguel Diaz-Canel's government. In addition to the measures to tighten the economic blockade enacted by the Trump government in 2019, the covid-19 Pandemic further deteriorated the socioeconomic scenario of the island, forcing the current government to recognize the legalization Mipymes as complementary activities to state production.

5 One year Later, What do the First Mipymes Represent?

The Covid-19 pandemic has led the country into the worst economic crisis in 30 years. According to the acting Minister of Economy, Alejandro Gil, GDP will shrink by about 13% between 2020 and 2021, [21] the worst result since 1993 when GDP retreated by

13.6% (ECLAC, 1997) after the dissolution of the Comecon. The balance sheet presented during the National Assembly of People's Power in October 2021, shows some impacts caused by the crisis between 2020/2021: [21].

– the inflow of dollars reached only 60% of what was established in the plan ($700 million less)
– exports met 68.7% of the plan while imports reached 65% of what was planned
– drop in exports of services (67% of the plan), represented mostly by tourism
– failure to meet sales of tobacco (91% of the plan) and rum (85% of the plan), two of the country's main exportable goods.

This scenario led to the accelerated implementation of some economic reform processes, such as the legalization of Mipymes, which can be state-owned, mixed, or private. The officialization of these occurred through decree law number 46, published in August 2021, which defines them as "economic units with legal personality, which pose their own characteristics, and which have as their object to develop the production of goods and the provision of services that satisfy the needs of society" [22].

Mipymes constitute a milestone in the updating of socialism, as they expand the scope of the so-called "second economy" [13] characterized by greater market liberalization and the incorporation of non-state enterprises as complementary actors to the production chain. In this sense, Gil points out the importance of their role in driving the development of the economy and the need to create a link between state and private production, dispensing with any kind of duality. "There is no 'them and us,' we will not win if there is no link between state and non-state. This is not a parallel market, but part of a whole process" [21].

The creation of a Mipyme is restricted to the constitution activities legally authorized by the MEP, the so-called essential activities such as electricity, telecommunications, education health, among others remain managed by the government. The first round of authorizations prioritized food production, exporters of goods and services, local development projects, projects incubated in science and technology parks, circular economy and recycling, and technology-based ventures [23].

As of September 19, 2022, the MEP counted 5165 approved economic actors since the start of the process in September 2021. Of these, 5056 Mipymes were private, 51 state-owned and 58 cooperatives [24].

In their origin, 52% represent reconversion of existing businesses while 48% correspond to new ventures. With this number of economic actors, the government estimated the generation of 87,872 new jobs in the Cuban economy. [24].

Figure 2 shows the overview of Mipymes formed one year after their legalization. The tabulation considers only private Mipymes, without considering cooperatives and state-owned ventures.

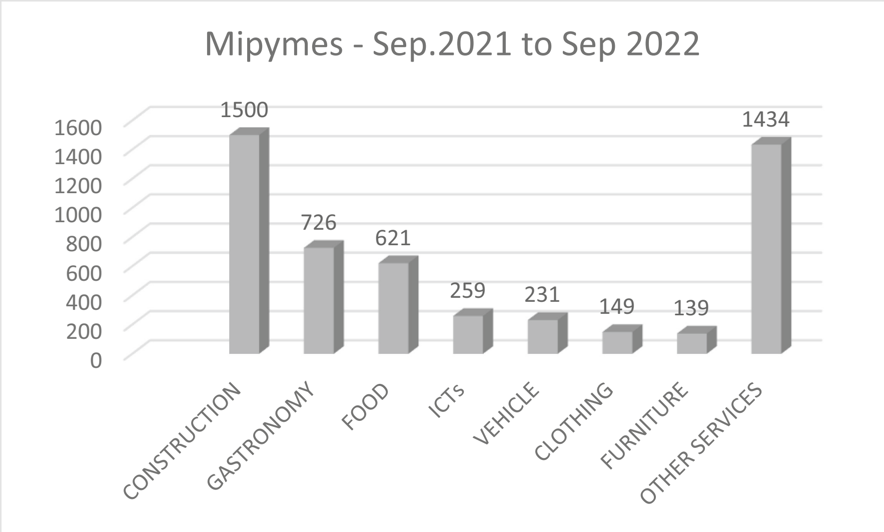

Fig. 2. Source: Author's estimates based on 50 lists released by MEP

From the quantification of the activities constituted with the Mipymes, it is possible to verify that after one year, the construction enterprises constitute the majority of this scenario, representing practically one third of the total of private Mipymes. Next come gastronomy and food production services. An interesting fact concerns the establishment of technology-based companies, which generally occupy the fourth place in the ranking. According to MEP, this is the only sector where the majority of new businesses outnumber the creation of companies by reconversion (66% are new companies), which reveals how promising this activity can be for Cuban society.

Before problematizing the constitution of Mipymes circumscribed to the Cuban scenario, we will move on to a brief overview of the four sectors with the highest incidence of Mipymes creation in order to consolidate the explanations.

5.1 Construction

With a total population of just over 11 million Cubans, "the main cumulative social problem facing the island today is the problem of housing" [25]. According to data from the Housing Policy, approved in 2018, Cuba showed a deficit of 929,695 dwellings [26]. Starting from joint efforts between state and population, the program proposed that year predicted a recovery of the housing deficit within ten years. However, the country still faces difficulties in meeting the annual goals. By May 2022, the government had completed 7,914 houses out of the 37,740 planned for this year, or only 21% of the plan [27].

Among factors that explain difficulty of the Cuban government in solving this social problem are: a) the natural order - the island is vulnerable to climatological phenomena such as tropical storms and hurricanes, in addition to deterioration caused by the sea air

[28]; b) organizational problems that result in delays and failure to meet the targets set [29]; c) shortage of construction materials [30].

So that Mipymes in the construction sector are essential within the productive chain to, together with the State, carry out the National Housing Program and remedy the housing deficit [31].

In order to enhance the work of these new actors in partnership with the State, the Ministry of Constructions (MINCON) incorporated them to the computer application *AiBalan*, created in 2008 for the Balance of Constructive Resources [31]. This is an economic planning tool whose objective is to facilitate the so-called "calculation of the construction and assembly capacity" of economic actors. In addition, it allows for the review of consumption rates, compliance with technical standards, and the feasibility of projects and investments. The calculation of construction and assembly capacity for 2023 already has 170 Mypimes registered, which add up to more than 5,800 million Cuban pesos in construction capacity (calculation base updated to June 2022).

Currently one of the difficulties lies in the lack of preparation of entrepreneurs to operate *AiBalan*, and assimilate the tool as a work concept. Another problem is the cost spent by companies to acquire the application's license, which causes some resistance in relation to its adhesion.

5.2 Food

The food and live animal products category ranks third in the country's import balance. In 2019, before the pandemic, food accounted for about 20% of total import spending, trailing behind fuel (about 25%) and machinery (about 23%) [32].

However, the shortfall in these elements, deepened by the context of the pandemic and the economic blockade, has intensified the insufficiency of food production in the country, making the situation "very complex" [21]. This resulted in the failure to meet targets in most food production lines, such as rice, corn, beans, and especially milk, which at 63 million liters, was far below the forecast between 2019 and 2021 [21].

Add to this the inflationary collapse and the rising cost of living, especially after the so-called *Tarea Ordenamiento*, which among other things put an end to dual currency and indefinitely suspended the circulation of dollars in cash. The currency ordinance, carried out during the Covid 19 pandemic and after Trump's financial sanctions, raised of the cost of living due to the decreased inflow of foreign exchange. Among other things, Trump's measures caused the closure of more than 400 Western Union branches, the main legal way for Cuban emigrants to send remittances.

The cumulative change in the CPI in December 2021 was 77.3% compared to 7% in the same period in 2020. The food and non-alcoholic beverage category was well above the overall index accumulating 113.95% in 2021.

The worsening shortages in 2021 made it impossible to support population diet levels, investments for food purchases in the same year were $1,348 [21], well below the $1,800 average for previous years [24]. So much so, that the creation of Mipymes focused on food production became one of the priorities especially for a country with high external dependence on food imports.

5.3 Gastronomy

Gastronomy is one of the pillars of tourism on the island. Since 1968, the state sector controlled all gastronomy activities until the economic opening in the early 1990s, when the so-called "paladares", restaurants created by private initiative, emerged [33].

The crisis of the special period, forced the government to reverse the concentration of the previous period on tourism activities, and thus ensure the attraction of foreign exchange. The centralized state management method proved incongruous to increase the effectiveness of such a dynamic sector "given its fragmentation, it requires a lot of flexibility, creativity and innovation to remain in the taste and preference of customers" [33].

The expansion of the so-called "second economy", with more services offered by small-scale private enterprise, was one of the factors that contributed to stimulating the sector. In 2019, on the National Assembly, the Minister of Tourism, Manuel Marrero Cruz, reinforced the importance of the non-state management model as a "necessary ally for the development of tourism in the country" [34]. By mid-2019, almost 28,000 TCPs were exercising their activities in the sector.

Already by early 2020, the number of gastronomic establishments exceeded 5,000, including restaurants, bars, snack bars, and cafes, which demonstrates the diversity of the sector [33].

The closing of the borders in March of the same year paralyzed tourism activities on the island, one of the key sectors of the Cuban economy. In addition to being one of the main sources of foreign exchange for the state, the tourism sector constitutes one of the main sources of income for Cubans. In 2019, the sector represented 10.3% of GDP [35]. Already in 2020, the crisis caused by the pandemic has reduced the inflow of foreign exchange (convertible pesos) by 56.4% and approximately 75% that of the general flow of tourists [36], affecting the more than 270,000 workers who account for 6% of occupations in hotels and restaurants [35].

Thus, it is significant that the emergence of new private players in the gastronomy sector is fostering the recovery of tourism after the crisis.

5.4 Technology-Based Ventures

Technology-based economic actors begin to gain space from 2010. At first, private enterprises dedicated to this sector were not on the government's discussion agenda [37]. However, between 2010 and 2021 the number of private startups jumped from 1 to 25 ventures. Part of this expansion is due to the arrival of mobile data internet, which by 2021 reached 6.6 million users. "The activities they are engaged in are diverse, such as: additive manufacturing, marketing, bitcoin, transportation, robotics, e-commerce, social networking, messaging, etc" [37].

In 2020, the restrictions imposed by Covid-19's preventive measures caused many ventures to come to a standstill whether state-owned or self-employed businesses forcing them to migrate to online platforms that had significant growth during the isolation period.

Take for example the creation of private sector startups such as *Pa'Mi Casa*, *Alamesa*, and *Mandao*, which offer gastronomic services in homes; also the so-called Cuban ubers such as *Bajanda, Cuber,* and *Sube*; as well as businesses that rent accommodation for tourists, such as *RentalHo*. State initiatives also appeared *Apklis*, a “store” that hosts apps developed in Cuba, and the fintechs *Tranfermóvil* and *Enzona*, used for payments of services, transfers, and creation of bank accounts.

The legalization of technology-based Mipymes means a milestone for the expansion of this sector, previously restricted to TCPs. This is because one of the biggest controversies involves the activity of the so-called Computer Equipment Programmers (PEC). Allowed since the opening promoted by Raul Castro in 2017, the government suspended the activity of PECs along with 26 other activities. In 2018, a new measure reopened the frozen licenses, with the exception of PECs because it was necessary to “specify their scope in a policy drawn up by the Ministry of Communications” [38]. In 2021, the PECs returned as *cuentapropistas*, and in the face of the Mipymes framework, they also began to act as private micro entrepreneurs.

Currently, we can group technology-based private actors into activities ranging from computer programming, through the manufacture, sale or repair of computer equipment, platform design, to the commercialization of services via the web.

6 Mipymes and the Challenges for a Feasible Socialism

Decades of revolutionary policies “characterized by pendular shifts between the plan and the market” [11] explain to a certain extent Cuba’s historical economic instabilities. On the other hand, despite the comings and goings and the external structural pressure led by the US, the regime manages to maintain itself, mainly because it seeks to adhere to the plan with an adaptive dynamic to meet the demands of the social body.

The progressive adherence to economic policies of openness allows for experimental changes that serve, first: to reorganize the decision-making of the governing body itself in relation to the investment of time and resources with new projects. As Nove reiterates [8], a socialist government that sets out to mobilize internal and external funds should not pretend to take a “leap forward” and incur “the dangers of excessive enthusiasm and the plunge into projects at the cost of disorganization” as revealed by the Soviet experience in the 1930s and the Chinese in the 1950s.

Secondly, the gradual changes in economic scope create channels of expression between government and population, since, in the case of the Mipymes, it is possible to organize subgroups of debates and periodic meetings between ministries and sectoral representatives of private enterprises. This makes it possible to diagnose the imperfections that arise during the implementation process of the Mipymes.

Despite the possible contradictions that emerge with the expansion of the so-called second economy in Cuba, this paves the way for the implementation of a “desirable realism” within a “feasible socialism”. “When the state planning system cannot efficiently handle certain activities, the regime tolerates (sometimes even encourages) secondary (parallel) jobs that fill this void” [8].

This movement leads to some optimistic interpretations of the advantages obtained. Besides the dynamism that the Mipymes can introduce in the productive chain based on the complementarity of the state sector, such enterprises can have a decisive impact on the organization of labor in Cuba. For young people, Mipymes can mean the opportunity to create personal projects, obtain their own income, create job openings, and get out of informal jobs. Not coincidentally, 25% of the Mipymes created by June 2022 had members under the age of 35 [39].

This is significant, especially for a country whose aging rate puts it first in Latin America and the Caribbean: 21.6 percent of the population is over 60 years old [40]. At the same time that aging has caused a decrease in the economically active population [41], it is estimated that a portion of this same population of reproductive age is part of the annual migration picture [42], causing a lag in the productive force.

Add to this a progressive decrease in state-owned enterprises, which between 2011 and 2018 have suffered a reduction of just over 500 units [43]. What explains this is the measure of dismemberment between state and business functions foreseen in the *Lineamimentos* of 2011, which resulted in the creation of the Superior Organizations of Business Direction (OSDE) and in the Business Base Units (UBE). The aim of the relaxation was to improve efficiency and decrease the annual losses of state-owned enterprises, which led to the merger of some units and the extinction of others.

In the same period there is a relative decrease in the total number of employees in the state sector while there is a gradual increase in the non-state sector (TCPs and Cooperatives), as shown in Fig. 3. So that the so-called complementarity process can also alleviate the expenses of the state sector where some companies have been operating at a loss [44].

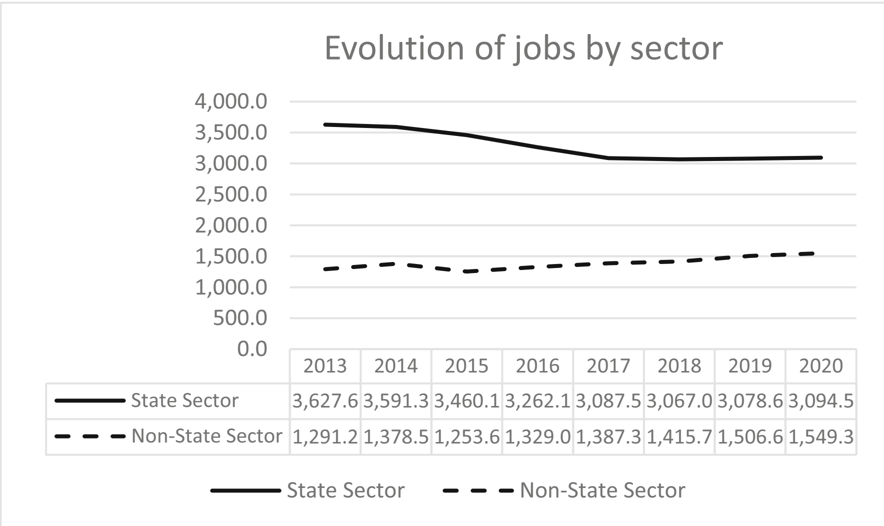

Fig. 3. Source: Author’s estimates based on ONEI/Employment and Wages-2020

Although the state sector remains predominant in terms of employment, by 2020 private enterprises already represented one-third (33.36%) of the number of jobs. This means that after the legalization of Mipymes, this incidence will tend to rise, since 47% of them represent the constitution of new enterprises.

Another advantage of legalization frameworks is the greater capillarity of technology-based enterprises, and ICT-related services. In this sense, the alliances between the different forms of economic management are important to carry forward the digital transformation of Cuban society [45]. The goal is to enhance the incorporation of Mypimes focused on IT activity in the state sector, and to encourage young graduates in the area to develop national software to boost both the digital economy and the export of technological services [46].

The creation of Mipymes for export and import is also a bet of the Cuban government to increase the GDP; they can operate as long as the state entities mediate their activities. However, there are some difficulties related to bureaucratic obstacles, delays, and many times the lack of preparation of the mediating entities to deal with the new configuration of private entities [47].

Thus, the legalization of Mipymes also reveals some problems that may a priori be of a:

(a) systemic, that is, characteristic to the very model of government conduct, which despite progressive liberalization, subjects private actors to a controlled process in order to preserve the hegemony of the state sector as a socialist foundation. Some of the most common obstacles are the difficulty of financing, the lack of incentives for innovation, a costly tax policy, and mainly the concern about the scarcity of inputs that mostly need to be imported [48]. In addition, the process of forming Mipymes lacks an advisory and consulting system that supports future entrepreneurs mainly regarding the feasibility of the project and the elaboration of a cost sheet to avoid distortion of cost calculations.

b) political-ideological - one cannot ignore the concern that individual projects may feed the capitalist logic of the autonomous entrepreneur and the desire for profit and private property. This jeopardizes the original plan of the chain, which is to boost local development and the economic and social programs created by the Revolution. The suspicions increase as the pressures of global capitalism, mainly in the figure of the USA, focus precisely on the private Mipymes of strategic sectors such as technology. In May 2022, as part of the measures to relax the sanctions imposed on Cuba, Biden announced the “increased support for Cuban independent entrepreneurs” [49]. The measure aims to encourage ventures disengaged from the state sector through access to cutting-edge technology such as cloud storage, e-commerce and e-payment platforms, and access to microfinance training. This raises two issues that deserve attention: first, through the technical and operational base, the US would have free access to the flow of information about Cuba’s economic policy. Second, such influence could trigger more reactive political attitudes from the counterrevolutionary movement, which would raise internal tensions and put the foundations of Cuban socialism at risk.

The incorporation of technologies on the island constitutes the turning point of the Cuban government. It is a historical and controversial discussion that involves everything from the hacking of the Cuban Internet network by an American account to defamatory speeches promulgated by the US media in the 1990s (on the subject see Hoffman, 2003) [50]. The Communist Party’s distrust of the spread of ICTs on the island is not without reason, so from the beginning the government has adopted a pragmatic stance, in which the digitalization of society must primarily serve revolutionary priorities such as education and health services. Today, with greater access to these technologies by the population, and with the possibility of 100% Cuban production, the government continues to bet on science and innovation as an engine of socio-economic dynamism.

The debate intensifies with the arrival of Miguel Diaz-Canel in 2018. Recognizing that the efforts in Science and Technology (S&T) created by the Revolution have not obtained a practical impact for the development of the country [51], the then president proposes a system of government management capable of meeting human demands. In 2021, with the creation of the National Innovation Council, the Cuban government takes a step forward in this direction, trying from this advisory body to create an integration between state, S&T and society. Promoting the capillarity of ICTs is clearly a necessity, but for the Party, the appropriation of this process needs to occur from a "proper conceptualization based on the socialist construction in Cuba, from our vision of social sciences and the Marxist vision" [52]. Therefore, even though the technology-based Mipymes indicate important changes such as the decentralization of the production chain, technological development is far from being completely handed over to private initiative. For the Cuban government, it is up to the State, in its sovereignty, to promote the techno-scientific bases and their integration with the multiple sectors of the economy. The idea of developing a digitalized society based on revolutionary values will undoubtedly continue to be one of the great challenges in the face of the economic and social transformations already underway on the island.

7 Conclusion

Cuba, as an underdeveloped nation and the only socialist model in Latin America, represents a paradigmatic case. Therefore, any kind of investigation about its reality needs to consider its historical particularities. This presupposes the analysis of internal determinants, that is, the persistence of the regime and the efforts to preserve the legacy of the Revolution, and external determinants: the structural crisis represented by the US and the constant pressures from global capitalism to weaken the Cuban model.

This paper has dealt with the legalization of Mipymes within the context described above. We conclude that, despite the pragmatic difficulties for the implementation of new economic actors, this is a recent process, as much as the officialization of the updating of the socialist model. Considering that the revolutionary process is little more than six decades old, and the updating of socialism under Raul Castro in 2008 is little more than 10 years old, it would be very simplistic to reduce the case of Cuba to the "failure of socialism".

Mainly because when adopting a reformist economic project that combines state control with market characteristics, the risk of imperfect results is assumed. In this sense, we understand that the sustainability of a Cuban socialist economy involves the challenge of adopting policies geared toward the transformations of its time, capable of dialoguing with the needs of the social body while seeking to avoid the dysfunctions caused by inequalities and social injustices resulting from the globalization of the capitalist mode of production.

In other words, policies are still rooted in revolutionary ideals, and the goals of any conceptualization measure must be oriented towards the development of the potentialities of local actors without individual values prevailing. Which leads us to infer, finally, that the contradictions and conflicts of the updating process will take time to be resolved.

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Collaboration and Trust: The HHK Testbed Approach to Building Sustainable Systems

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Abstract. This paper presents an ethnographic action research study where we have interpreted data collected in and around a cluster organisation focused on innovation and change-making. This paper examines how organisations within a triple helix of innovation can unite and work to establish a common platform in the form of a test bed, where the challenge of a green transformation can be addressed from all participants' perspectives. Test beds represent an experimental and co-creative approach to the construction of an innovation policy that aims to test, demonstrate and promote new socio-technical systems and associated modes of governance in a model environment under real-world conditions. The examined cluster includes industry, local- and regional government, academia and a state-owned research institute. Trust is crucial to building collaboration within the triple helix model of innovation and trust takes time to develop and to spread within the triple helix. Trust enables communal investments, such as the construction of technology demonstrators, based on shared research. These physical artefacts can be seen as evidence of the value of collaboration, which in turn further strengthens collaboration efforts.

Keywords: Innovation governance · Sustainable Transition · Testbed · Collaboration · HHK

1 Introduction

The transition to the digital age is also beginning to transform fluid power systems. According to Linjama [1], digital fluid power can be defined as a hydraulic and pneumatic system with individually evaluated components that actively controls the performance of the system. In other words, the design of digital fluid power systems does more than just use the digital control of analog systems [2, 3]. While there are some challenges in component development, control modelling, simulation, and dynamic effect processing, technological development of some basic components such as digital pumps, digital cylinders, and transformers has already been achieved [4].

At the same time, companies working with fluid power technologies have faced the symbiosis between digitalization and electrification [5]. Electrification can be defined as

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the process of replacing technologies that use fossil fuels (coal, oil, natural gas, etc.) with systems that operate on electricity. Another way to explain electrification is to think of it as a source to decarbonize final energy consumption in all sectors of the economic system [6]. As a result, the benefits of electrification can be assessed by reducing greenhouse gas emissions, ensuring an affordable and safe energy supply, improving energy efficiency, improving urban air quality, and recruiting new, high-quality jobs through the only well-planned transition. More than that, achieving carbon neutrality may decrease the risk of climate change.

It seems clear that on the technology level, research on digital fluid power system design has advanced well. However, what is not clear is how innovation managers, product engineers, policy makers, and the civil society have prepared themselves to deal with the transition to electrification and digitalization. Having this challenge in mind, the aim of this paper is to investigate how to encourage advancement inside the setting of a cluster of small and medium enterprises? How to foster an organisational ability to use both the capacity to simultaneously operate in markets where effectiveness, control, and incremental change are prized and to likewise contend in innovations and new markets where adaptability, autonomy, and experimentation are required [6].

The aim of this paper is to examine how organisations within a triple helix could unite and work to establish a common platform where the challenge of a green transformation can be addressed from all participants' perspectives.

To answer this question, we used the action research approach to present the case of Hudiksvall Hydraulics Cluster (HHK). HHK is a group of companies, all situated in and around the town of Hudiksvall, Central Sweden. The companies in HHK are relevant to the question because they are transitioning from petroleum-based technologies to low-carbon technologies, such as electrification. Our assumption was that trust and collaboration are core values in this change process.

The remainder of this paper was organised as follows. In Sect. 2, we briefly introduced the concept of ambidexterity and the main trends on testbeds. Section 3 presented the methodology used to answer the research problem. In Sect. 4 we proposed an analytical framework that can help innovation managers enable collaboration. In Sect. 5 we present the concluding remarks.

2 An Overview of Testbeds for a Society in Transition

The principal versatile test confronting firms was the need to both endeavour existing resources and capacities (exploitation) and to accommodate adequate innovation (exploration) to abstain from being rendered superfluous by changes in business markets and technological change [7]. Considering the possibility that diverse structures are required for exploitation and exploration, the literature on the topic recommended that for long run survival, companies are expected to engage in both.

To become an ambidextrous organisation, it is recommended that this could be refined by setting up self-sufficient exploration and exploitation subunits that were basically isolated, each with its own arrangement of individuals, structure, and procedures focused on guarantee the utilisation of assets and skills simultaneously. But how to do so in a fast-changing world?

Testbed – and similar concepts such as “living labs” or “real world labs” – emerged as an approach to structuring and stimulating innovation by testing new sociotechnical configurations in situ and at a meso-scale [8, 9] These methodological approaches have been used to promote innovation in geographic regions and in emerging technological domains. They are an evidence-based response to face three major interconnected challenges: climate change, the growing deficit of decent work opportunities, and the need to drastically alter the energy matrix, reducing the consumption of fossil energies. Appropriate policy responses to these challenges will require drastic transformations of technology and society.

In this sense, test beds represent an experimental and co-creative approach to the construction of an innovation policy that aims to test, demonstrate and promote new socio-technical systems and associated modes of governance in a model environment under real-world conditions.

As real and physical spaces, test beds can be used for open innovation, facilitating co-creation with the different actors interested in its result. Living Laboratories are methodologically organised into two levels. While an overall structure provides stability and continuity, a second level below allows for spontaneity within projects [10]. Likewise, the structuring allows and determines the implementation of methods within a testbed [11].

3 Research Design

To answer the problem posed in the paper we have proposed to use the ethnographic research action method which allows the researcher to be an active participant in the process. Action research (AR) can be described as adaptive, pragmatic and solution driven. Action research pursues two outcomes: action (change) and research (understanding) [12]. Because it is participative, action research enables change and that often happens together with other change processes. Action research can also be regarded as a learning cycle that is relevant for advocating change. “The research is achieved by being responsive to the situation and by searching strenuously for disconfirming evidence. At the heart of AR is a cycle which alternates action and critical reflection. Action and research enhance each other” [12]. In addition, action research is the correct research methodology if it is a situation in which there is increasingly:

- Power sharing and the relative suspension of hierarchical ways of working, in a conscious move towards social and industrial democracy.
- Collaboration among members of the group as a ‘critical community’.
- Self-reflection, self-evaluation and self-management by autonomous and responsible persons and groups [12].

3.1 Participants

We focus this study on a limited group of HHK-members and associated organisations. They have been chosen because of their role within the triple helix:

- Hiab, Huddig and HSP Gripen (industrial manufacturing members)
- Research Institutes Sweden AB (research institute)
- Linköping University (academia)
- Hudiksvall's kommun (municipal government)
- Region Gävleborg (regional government)

Hiab is a global company and part of the Cargotec group. They are a leading manufacturer of loader cranes worldwide and have approximately 3.500 employees. Hiab has a target to halve CO2-emissions from products and operations (2019 levels) by 2030. Electrification is considered one of the most important tools to reach the target.

Huddig is the only complete system manufacturer in HHK and they were among the first on the market to produce a full electric hybrid back-hoe loader, presented to the public in 2016. Huddig has 120 employees in total and Hudiksvall is the only site for manufacturing and R&D.

HSP Gripen is the smallest company in the sample. They produce large grapples for forestry and manufacture almost the entire product in-house.

Hudiksvall's kommun is the municipal government where HHK is active and it is a non-active member of HHK. The municipality is in 2022 managed through a coalition between social democrats and moderates.

Linköping University's (LiU) Fluid and Mechatronic department has had a standing collaboration with HHK since 2016. The university is one of Sweden's most important centres for applied industrial research with around 32.000 students. LiU has been a part of the HHK board of directors since 2018.

Region Gävleborg is the governing body in the region where Hudiksvall is situated. The regional government is responsible for creating a regional development strategy (RUS), a regional steering document that outlines the orientation of the region's future development. The strategy's five target areas are:

- Attractive and accessible locations
- Socially beneficial, circular and bio-based economy
- Competitive businesses and sustainable labour market
- High knowledge and innovation ability
- Equal and egalitarian society

3.2 Data Collection

Data was collected during studies, in-depth-interviews, technical-, strategic- and tactical workshops, board meetings, conferences and events. The researchers have been part and present in activities concerning HHK from the first pilot study initiated in 2012 and published in January 2013. Material has been collected in the form of commissioned studies, marketing materials, digital media, presentations, meeting notes, self-documentation, artefacts, audio, video and photography.

3.3 Data Analysis

Data has been organised and interpreted according to the ethnographic action research model. Interpretive research can be described as when the researcher is immersed in a particular social setting and has deep knowledge of the people involved and an understanding of their worldview. Social knowledge is produced from all encounters, conversations and arguments that interpretive researchers have with the people they are studying [13].

The interpretation of the data requires an understanding of the context. The data analysed in this study was not captured or produced for a single purpose. A video can first have been used for documenting an event and later the same video could appear in marketing material or in a social media post. The researchers are not only retrieving and studying the data – they are also central to running day-to-day operations in HHK and central to establishing a testbed for transformation.

The data has continuously been reassessed with the emergence of a better understanding of the context, following the tradition of cultural analysis which can be described as "guessing at meanings, assessing the guesses, and drawing explanatory conclusions from the better guesses" [14].

HHK's purpose guides the organisation and informs all of its decisions and actions. The purpose is important to understand in order to analyse and draw conclusions from the data. A definition of purpose is proposed as "an aspirational reason for being which inspires and provides a call to action for an organisation and its partners and stakeholders and provides benefit to local and global society" [15]. Business is seen to consume trust rather than to generate trust. NGOs on the other hand enjoy a higher level of trust than commercial businesses. It is also suggested that companies should pursue a purpose beyond purely financial gains to increase trust [16, 17]. Since HHK can be defined as a non-profit organisation that operates independently of the government, but with members from local government, academia and business – a strong organisational purpose is considered paramount by the organisation to enable collaboration. HHK's purpose has been described as:

> *"To create conditions for a constant search of knowledge that can make us economically, socially, and environmentally sustainable."*

HHK aspires to create those conditions by providing a playground for professionals, where they can step outside their day-to-day obligations to realise their full potential in a safe space where failure is accepted.

4 The Experience of Transition in the Hudiksvall Hydraulics Cluster

In 2016 the cluster accelerated its operations when global industry groups moved production from Hudiksvall to low-cost countries. It became apparent that closer cooperation within local industry was necessary to strengthen competitiveness, to increase innovation and to make it easier to recruit talents. Direct competition between companies in HHK is almost non-existent.

Collaboration within HHK is solely built on trust. There are no formal documents that regulate interaction between the members and communication on the shop floor between the members is generally encouraged by managers. Relationships within Linköping university and with officials in Region Gävleborg that work closely with HHK are also trust-based. This model has been highly successful and can be considered as part of the business culture in Hudiksvall.

Currently the most important project in HHK is to establish a national testbed for “electrification of complex machines and for green transformation” in Hudiksvall. The project, which is in the making, is designed around collaboration between industry, government and academia. The project title is “Testbed for transformation: Electrification of Complex Machines in Complex Environments”. The project has entered the second of four phases. In the second stage the project is set to deliver A.) a deeper understanding of different needs within the triple helix, B.) increased cooperation within the triple helix around a testbed, C.) increased knowledge of factors that affect social sustainability considering electrification and D.) a working business model and financing plan for a testbed.

4.1 Experiences of Collaboration and Testbed Design

Cooperation between industry, academia and government has been described as the triple helix model of innovation. The triple helix model forms a prominent part of the Swedish innovation system where academia, industry and government cooperate to identify, research, and develop innovative technologies and services that meet the nation’s needs [18]. To increase the potential for innovation and economic development the role of academia should be more prominent and there needs to be a “hybridization of elements from university, industry and government”. This creates the potential to generate new ways to produce, transfer and apply knowledge [19].

The planned testbed is a nexus of HHK’s electrification journey that started with new innovations from member companies. Huddig initiated the development of the Tigon electric hybrid back-hoe loader in 2012. In 2014 Hiab started developing the ePTO (electric power take-off) electrified loader crane-platform, in collaboration with Volvo Technology AB. These initiatives inspired the formation of the research project STEALTH (Sustainable Electrified Load Handling) in 2016 – a joint effort between HHK and Linköping University (LiU). LiU became an academic partner to HHK in the process and as a consequence holds a seat on the governing board.

4.2 STEALTH: Research as a Catalyst for Broader Collaboration

With academic research, knowledge-sharing increased within HHK and that led to improvements to existing products in HHK. This has happened primarily at Hiab and Huddig, which are at the forefront of electrification in HHK. When local industry so visibly focused on electrification, the Hudiksvall municipality could also draw on a strengthened local brand in this particular field. Battery cell manufacturer Northvolt courted several Swedish regions in 2020 as they planned for a new factory. The HHK brand was by now so strong in the field of electrification that it was used by two local governments in a bid to attract investment from Northvolt in two different regions.

4.3 SkwX: Bespoke Innovation Method to Drive Unity

The transition to electrification has also aided HHK in developing a proprietary innovation methodology (SkwX), specifically as a tool to boost innovation across organisational borders. SkwX as a workshop and method takes many characteristics from traditional design thinking tools. What makes a difference is that SkwX is a brand and a method for innovation that stems from within HHK, with the intent to increase innovation across company borders. Because it is a proprietary method, created in-house, and reliant on trust between stakeholders; it lowers the threshold for legacy industries within HHK to work with innovation in unorthodox ways.

Simplified, it can be said that product development within HHK and the fluid power-industry in general has traditionally put a premium on continuous power increases for components and systems. In electrified systems, where instead a premium is put on energy efficiency, this thinking is outdated. By working on innovation across company borders, manufacturers of components and subsystems that form part of a complete system (e.g., a truck with a hydraulically controlled loader crane), can better understand how value for the end user is created with electrified products.

4.4 Rapid Commercialisation of Innovations

The participation of academia in SkwX-workshops has been a key success factor for the STEALTH-project and for the commercialisation of new engineering solutions. The different perspectives of engineering, business and research become visible to everyone, and the experience brings people together. As a result, the time for results from academic research to reach the market has proved to be short, ca. 3–6 months. The Hiab e-roller crane, launched in 2021, is a result of this – as is new functionality being added to coming generations of the Huddig Tigon. During its development, Huddig gained explicit practical experience in building battery packs due to the Tigon machine development. With the help of Huddig, Hiab could rapidly create new experimental battery packs. In turn, Hiab assisted Huddig with design calculations.

4.5 Education and Transition

Education of specialists and academic research is a long-term investment, and it is vital to deal with- and to understand the multitude of new aspects the transformational challenge brings. Industry has an urgent need for specialists, best illustrated in HHK by Hiab which has committed to reaching the 1.5 °C-target by 2030 [20]. Digitization and electrification in combination creates an area that will likely create a need for more specialists within industry. New technologies in combination can create new opportunities only to be explored, understood, and embraced with the creation of new professional roles.

4.6 A Culture of Trust as a Driver for Transformation

The strategic intent is that by investing in a testbed for transformation built on the trust-model that has shaped HHK and that channels the needs of industry, government and academia; would reduce barriers between stakeholders, increase shared knowledge and reduce risk, which is inherent in a transformation. To achieve the same level of trust between all three stakeholders would be hugely beneficial, yet difficult to achieve. The challenge can however be alleviated if stakeholders are included gradually into the existing culture of trust.

The traditional boundaries of responsibility between academia, government and industry might not be applicable, or even desirable, in a testbed for transformation. These institutions can all contribute to generating innovations, but for that to happen a "consensus space" is needed "where the actors in the three spheres can come together in the spirit of mutual understanding and trust". Systemic innovations can happen in the consensus space via technology transfer, collaboration and conflict moderation, leadership, and networking [21]. The preliminary design of the testbed is meant to create such a consensus space.

The triple helix can also produce 'hybrid organisations', which spring up at the intersection between sectors, such as public- and private, civil- and public, private- and academic. Hybrids can be established as platforms for sharing resources and for creative purposes. They can also contribute with technical and social innovations that can handle complex and "wicked" problems [22].

The green transformation can arguably be defined as a "wicked" problem. Wicked problems cannot be definitively formulated, they can all be regarded as symptoms of other problems and there is no way to ultimately test a solution after it has been implemented, as any solution will generate waves of consequences over an unforeseeable future [23]. These complex and fluid problems have to be handled with flexibility, reflexivity, and learnings [24].

5 Concluding Remarks

A testbed for electrification can create knowledge for individual organisations (e.g. testing of technical systems and components). It can also create shared value for all stakeholders in a triple helix – as a result of collaboration and increased levels of trust. Each stakeholder holds a piece of the green transformation-puzzle and with perspective-taking and communication, the collective can use the testbed to see the whole picture.

Industry, public office and academia are highly specialised in their respective tasks. When all sectors in the triple helix work separated from each other, insights will not be shared and the transition to a CO2-neutral society moves at a slower pace. Policy decisions can for instance hinder the overarching goal of achieving a climate neutral society. An example of such a mismatch in Sweden is that public organisations are not obliged to buy services (e.g., road maintenance, construction, logistics) delivered using machines with a low carbon footprint. It results in increased cost for machine manufacturers and weak markets for sustainable machines.

A testbed with the purpose of being a shared platform for understanding the impact of action and inaction across the triple helix can help stakeholders share perspectives so decisions can be aligned, thus increasing efficiency and speeding up the green transition. A testbed with this purpose can help the organisations that are on the "inside" to make better decisions and it can aid a broader group of stakeholders on the "outside" by showing what works and what doesn't work. The testbed would act as a storefront for the broader society where methods, experiences and solutions can be shared.

Experience shows that the process of transformation and systemic change is challenging to understand. To create a broad understanding both within and without the testbed, we believe that it is vital for it to enable the creation of prototypes and demonstrators, involving all sectors of the triple helix. Seeing is believing. With these prototypes, the impact of decisions can be made visible across the triple helix and the shared perspectives will help stakeholders enable new solutions – be it in the fields of technology, policy, society or financing.

In this scenario the testbed is a meeting place, where proof of concepts are created and vetted within a triple helix to better understand the implications of strategic decisions to enable transformation. Successful proof of concepts that can speed up the transition to a carbon neutral society can be further developed and researched outside of the testbed to reach higher technology readiness levels. We suggest that to enable the recruitment of a broad stakeholder group for a testbed based on the triple helix-model further work could study how to uncover and visualise potential values of a testbed based on the triple helix. Furthermore, it would be beneficial to further research how to strengthen and increase trust between stakeholders in a triple helix.

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Escalating Towards a Circular Economy Transition

Challenges of Start-Ups Developing Circular Business Models

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Abstract. The circular economy aims for an effective and efficient resource use. Thus, application of the concept can benefit the sustainability performance of companies. Specifically, business modelling is a key enabler for the transition to a circular economy. However, the related research is dominated by a focus on incumbent companies and their transition from linear to circular business models. This focus risks missing out on actors such as start-ups who can experiment with and develop potentially more radical circular business models. Thus, using interviews with 37 start-ups developing circular business models, we analyzed their characteristics and challenges. Our findings reveal that, such firms encounter general challenges related to circular business modelling and new venture development. Furthermore, such start-ups are often dependent on an ecosystem of actors to create, deliver and capture value based on circular principles. Thus, they encounter challenges to scale up their business based on their liabilities of smallness and dependency. Altogether, these challenges of "circular start-ups" call for a holistic approach to understanding their development process.

Keywords: Circular Economy (CE) · Entrepreneurship · Barriers

1 Introduction

Earlier research has shown that start-ups are more receptive to disruptive thinking and tend to embrace radical circular business models compared to incumbents [1]. Young firms adapt more easily to a circular economy (CE) than incumbent firms due to their agility and the lack of existing business models and investments. This is not to say, however, that start-ups developing circular business models do not face any obstacles. The attendant liabilities of size and newness to the market can impede their development due to limited resources and influence on a larger business ecosystem.

The knowledge gap addressed in this paper lies in uncovering the early growth and development process of "circular start-ups", in their development of a circular business

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model that can promote a widespread circular economy. Circular entrepreneurship is still a recent phenomenon in the literature [2]. Present research defines circular start-ups as “new, independent and active companies pursuing a circular business model” [1]. In this paper we aim to explore in more depth the early growth and development processes of circular start-ups. In this way, we seek to systematically analyse the challenges of circular start-ups. We have chosen to focus on the following research questions i) What characterises the early development process of circular start-ups? ii) What does it take for a start-up to be considered circular? iii) What challenges characterize a circular start-up? By this we strive to establish linkages between practical and scientific approaches to develop a circular economy. Moreover, policy actors interested in supporting the transition to circular economy can adopt results from this study as input for their engagement with start-ups.

2 Start-Ups Developing Circular Business Models

The concept of a start-up has been developing in parallel in both research and practice during the last thirty years as entrepreneurship has increasingly come to be viewed as central to economic activity and industrial renewal. In its most simple form, a definition of a start-up is that it “is looking for a business model” while existing firms “execute a business model” [3 p. 67]. Therefore, a start-up is “a temporary organization designed to search for a repeatable and scalable business model” [3 p. 67]. Meanwhile, the “EU Startup Monitor” that has studied start-up ecosystems in Europe takes three variables into account in its definition: low age, innovativeness, and growth intention (startupmonitor.eu, 2022).

The interest in start-ups has been growing due to its increased importance for entrepreneurs, and entrepreneurial ecosystems, as well as policymakers. Start-ups are in many instances relied upon as vehicles for transformation in developing fields such as digitalisation, cleantech, or creative industries. Fritsch [4] has summarized the general “supply-side effects” that start-ups tend to stimulate in the economy through providing alternatives to established business models: productivity increases, structural change, innovation & creation of new markets, and greater variety of available products/solutions. Hence, a lot of research interest has been directed towards what makes start-ups successful and how their development can be encouraged. Common topics that have been studied include e.g., success factors on both individual and firm level, financing of start-ups [e.g., 5], as well as the context and support surrounding start-ups [e.g., 6]. In a similar vein there has also been a lot of research interest into what kind of obstacles that start-ups face and how they can overcome these [e.g., 7]. For example, barriers related to specific demographic groups such as young people or students have been identified; as well as those related to specific aspects such as financing [8].

Since start-ups are highly dynamic phenomena they are challenging to study. An established model that can be applied to study their creation and development is Gartner’s framework from mid 1980-ies [9]. This model contains four interrelated nodes that make up the basis for understanding and analysing this process in a holistic way. It was an early attempt to organise the large number of characteristics that were used to describe the early development of new businesses. Gartner’s model was based on an extensive literature review of previous entrepreneurship and new venture research while simultaneously striving to move beyond a unidimensional view of entrepreneurship and introducing variety within the phenomenon of entrepreneurship and new venture creation. The Gartner model enables us to understand the complexity of new venture creation through the four nodes (individual(s), organization, environment, and process) that need to be viewed together and that form distinctive combinations of circumstances. With the help of the model each new venture can be analysed and compared to others. The model recognizes that new venture creation is dependent on both individuals that act entrepreneurially and the organisation itself while constituting a process that develops over time within an environment where a marketplace exists with both opportunities, various resources, and risks. In this paper we use the Gartner model to describe our selected cases.

2.1 Circular Business Models (CBMs) and Barriers

Circular economy in general is a concept that encompasses a higher degree of "closed loops" through e.g., prevention of waste and resource efficiency as well as dematerialisation and utilisation of goods instead of ownership [10]. Subsequently, circular business models are models that aim at closing resource loops or extracting value from resources for as long as possible by applying circularity - or R - strategies. These include the regeneration of ecosystems through products and services, the reduction of scarce input materials, the focus on reuse of resources/products and the recycling and recovery of embedded value or materials at a resource's end-of-life. Such business models can be implemented by both new and established firms, and to a varying degree (e.g., as an "add-on" or side business or a central operation). While the R-strategies are not mutually exclusive - e.g., a bio-material producer (i.e., reduce) might also recycle the by-products of their production processes - a dominant R-strategy can typically be identified when scrutinizing a firms' business models. The dominant R-strategy is typically the strategy that receives the most budget in research and design and that creates the most revenue [1].

While insight into barriers for circular start-ups is scarce, the generic barriers for circular business models are scrutinized by a variety of studies. There are studies which investigate the challenges that small- and medium-sized business face when implementing CBMs but - similar to the dominant perspective on large corporations - these studies take on a business model transitions perspective and do not focus on 'grassroots' business activities [11]. While the barriers for CBMs that recent literature identified are of both endemic and systemic character, the magnitude of external barriers tends to outweigh internal barriers in this context [12]. This is not surprising given CE's systemic character [13]. The typical external barriers relate to required changes in linear supply chains, lack of market readiness on supply and demand side, and a mismatch between CE practice and regulatory frameworks. Internal barriers are typically dominated by financial/resource, organizational and knowledge/technology dimensions. This study argues that the nurturing of bottom-up innovation - and particularly start-ups - in CE requires a more comprehensive perspective than only an environment and organizational view. As such, the role of the individual (i.e., the founder or entrepreneur) as well as the process perspective deserve more attention and an in-depth review in the context of 'grassroots' circular entrepreneurship. The founder motivation and identity play a key role in a venture's development path and success. Furthermore, we already outlined above that a processual view is required to structure and conceptually grasp the phenomenon of a start-up.

3 Method

The empirical data was collected using semi-structured interviews with start-ups developing circular business models. To identify start-ups for the interview study, we developed selection criteria based on existing literature. Start-ups selected for the interview, were: (i) registered firms with operational years of up to 6 years, (ii) profit-seeking ventures, (iii) independent ventures, not a subsidiary of an incumbent, (iv) focused on developing circular business model strategy (ies) as proposed by Bocken et al., [14]. Thus, we interviewed start-ups developing circular business models based on: (i) access/performance model, (ii) extension of product value, (iii) classic long-life model, (iv) encourage sufficiency, (v) extension of resource value, and (vi) facilitation of Industrial Symbiosis (IS). In total, we interviewed 37 start-ups in Europe. Out of the 37 cases, we have selected five illustrative examples for this paper. These five cases are selected based on a diversity strategy and thus cover the entire typology of circular business model strategies proposed by Bocken and others [14]. The interview questions covered a description of the business model the company was developing, their challenges while developing such a model and potential relation between the business model components and the challenges. All interviews were recorded and analysed thematically.

To answer our research questions, we define the start-up as our unit of analysis. Thus, we analysed holistically their challenges when developing circular business models. To do so, we adopted an existing model of new venture creation Gartner [9] which synthesizes four aspects as characteristic of new venture creation. We used this model to categorize the different challenges we identified from our interviews. Finally, we analyse these challenges against the background of existing literature on the challenges of circular business modelling [e.g., 15] and new venture development.

4 Empirical Findings

In this section, we present challenges of selected start-ups each developing different types of circular business models - as indicated in the parenthesis in the subheading.

4.1 Case 1 (Extension of Resource Value) – GoCirkulär

The start-up describes their purpose in the following way: "At Go Cirkulär, we manufacture high-quality skincare products that are upcycled, gender-neutral, and 100% natural" (gocirkular.se, 2022). Currently the start-up makes two cosmetics products that are both based on upcycled coffee waste (a body scrub and a body oil). Coffee waste for their production is sourced from local partners such as cafes. Production is small-scale and done by the firm itself in a lab in Malmö. They sell directly to consumers in Sweden and rest of EU via their own homepage and indirectly via other firms' stores (such as partner cafes) and online web shops.

Challenges Related to the Individual(s): The founder describes that being a female and immigrant entrepreneur is challenging. This is partly related to a lack of contacts and networks which the founder describes as being very important when doing business in Sweden. Partly it also implies being taken less seriously as an entrepreneur.

Challenges Related to the Environment: The company is dependent on partners to source coffee waste, but this is not viewed as a major challenge since a lot of coffee is consumed in Sweden, so a shortage is not likely. Since the company plans to expand their product line in the future new partnerships are needed so that other upcycled ingredients can be sourced. Being in cosmetics industry and striving to be circular means that the company is not well understood by actors in e.g., business support and funding. The founder describes that it is a challenge to "get people onboard" with the business idea. For example, the company might be viewed as mainly altruistic and not a potentially profitable business. There is a difference from how other sustainability related industries, e.g., "cleantech", are viewed. The founder feels that she needs to work against stereotypes when developing the business. The founder also mentioned that cosmetics is a regulated industry. This implies having to fulfil strict requirements which can be challenging for a start-up.

Challenges Related to the Organization: The business needs to operate as a lean organization and use their limited resources in an efficient way which is challenging. As mentioned earlier, the founder states that personal contacts and referrals are important when developing a business in Sweden. Now a lot of the founder's time goes into networking since this has been identified as vital.

Challenges Related to the Process: As the company develops it is considered a challenge to balance a local business model with scaling up and international/global expansion. Expanding and growing would probably mean having less control over the ingredients and other aspects of the business according to the founder. Finally, it is challenging to develop new products to make their product range broader. This requires research of potential ingredients that can be used in cosmetics, followed by product development, and complying with regulatory requirements.

4.2 Case 2 (Access/performance Model) – Jonnabike

Jonnabike is a start-up that assembles, owns, and leases bicycles to customers for a fixed fee per month. By retaining ownership of the bicycles, the company can service, repair, and re-use bicycle components. The company has only one bicycle model with the idea to be able to recover and interchange components and thus prolong bicycle life span. The value proposed to their customers is the availability of a functioning bicycle at their disposal for a fixed fee. The company targets both long term customers who seek reliability and short-term customers who seek flexibility.

Challenges Related to the Individual(s): No challenges have been mentioned during the interview.

Challenges Related to the Environment: Cash flow and profit margins connected to leasing bicycles are relatively small and thus financers are reluctant to engage with the company. Risk capitalists struggle to evaluate the residual value of bicycles due to lack of data. Financiers such as banks are more familiar with traditional business models such as buying and selling products. As the interviewee puts it “the approach to own and lease out bicycles is difficult to understand by the financial sector” and thus “the more you come closer to the linear model, the more the banks understand the business model”.

Challenges Related to the Organization: A challenge characteristic of start-ups is the limited number of employees. The company has three employees some of whom work part-time with Jonnabike. An important challenge in organizing the business is reverse logistics to deliver bicycles to customers and to recover dysfunctional bicycles. Reverse logistics related costs can be high and restrict the business to a particular territory beyond which it becomes unprofitable. There is also the need for collaboration and dependence on several third parties such as insurance companies to realise a functioning business model.

Challenges Related to the Process: The company has labour and cost intensive processes since they assemble the bicycles in-house and provide repair and refurbishment if needed. A further challenge for the company is to prove the circularity of their business model. Leasing bicycles is part of their circularity claim, however, how long their repair and refurbishment activities will prolong the life span of their bicycles is yet to be validated. Finally, due to the leasing model, the cashflow is also distributed over a long period of time which makes it challenging for the company to increase the amount of bicycles in their portfolio which requires a high upfront investment. Another challenge relates to the need to engage with customer education since customers are more used to owning bicycles. The company thus must work actively with communicating the value of their business model to potential customers.

4.3 Case 3 (Extension of Product Value) – Kamupak

The business model of this company consists of running a deposit return system for packaging of takeaway food and drinks that enables reuse of packaging containers with a high level of control and hygiene. The company views itself as delivering packaging as a service and has built a system for that. Restaurants join the system of the company and pay for a batch of reusable packaging. A customer buys food from the restaurant in the reusable packaging, pays a deposit fee and can return the packaging after use at any restaurant that is part of the system. The company has an overview of all packaging and where they currently are and charges the restaurants for each use cycle of each packaging item.

Challenges Related to the Individual(s): No challenges have been mentioned during the interview.

Challenges Related to the Environment: Restaurants are usually not used to or interested in exclusive packaging partner deals which might hamper adoption of packaging from the start-up. Furthermore, the company states that the supplier of packaging containers has long delivery time (3–6 weeks) which slows down their expansion to include new restaurants.

Challenges Related to the Organization: One main challenge consists of overstretching of staff since they are a small team, with issues such as exhaustion and limited time of involved individuals. Since the company is still new it has had limited resources with which to increase the team. The company has little control over the production of the packaging. This implies for example long delivery times and potential challenges to increase the proportion of recycled materials in the production process. Previously collecting of used packaging and organizing of centralised washing was a big cost and challenge for the company. This has partially been managed by switching from servicing grocery stores (that required centralised washing) to only takeaway restaurants (that mostly do the washing themselves) which has diminished the logistical challenges.

Challenges Related to the Process: The company has little contact with end-users (only through their app which is optional for the end-user) and little control over the packaging when it is with the end-user. The packaging can therefore e.g., stay with the end-user instead of being returned into circulation. The choice of packaging material that the company uses (plastic) might be criticized by environmentally conscious consumers. There are other alternative packaging materials that restaurants or their customers might prefer. The company has had a lot of interest in their business and has been able to get both funding, business support, and enroll partner restaurants into their system. However, with limited resources they find it is difficult to take advantage of all that interest since they need to make contact personally with e.g., new restaurants. It has also been challenging to sort out how the system should work and understand how restaurants work with the packaging in different ways. The company has been experimenting with different ways of setting up the deposit-return system to make it work in an appropriate way. The company is interested in growing further as a platform provider for reuse but is unsure about how to organize it (e.g., through franchising or licensing) which is currently a challenge for them.

4.4 Case 4 (Facilitation of Industrial Symbiosis) – Symbios of Sweden

Symbios of Sweden is a start-up which works with mapping flows of energy and material resources in a territory to find potential synergies for industrial symbiosis. Their value proposition is to identify and facilitate collaboration for symbiotic resource use. Their target customers include municipalities and companies seeking to valorise their waste resources.

Challenges Related to the Individual(s): The start-up is newly registered (only 2 months old at the time of interviews) and thus the founder had very limited business development experience. Furthermore, certain specific competences, e.g., related to big data computations, must be sourced externally.

Challenges Related to the Environment: Legislation is also a challenge to realizing industrial symbiosis. The founder indicated that mapping resource flows often identifies several potential synergies but not all such synergies can be realised because of legal restrictions regarding the use of waste and restrictions regarding construction permits. Furthermore, some of the industrial symbiosis collaborations are new and there are no established legislations regarding how those industries should be connected and this can serve as a challenge since there are no guidelines to follow. Funding has been challenging. Financiers are often not so willing to fund a service company which does not have a tangible product. Furthermore, the founder indicated that her business activities are broad and cross-sectoral making the outcomes complex for financiers to comprehend. It is often challenging with getting potential customers to commit financial resources to symbiosis project since it is a side activity to their core business. So, even when these potential customers see the value of symbiosis, there are not always resources to commit to such activities.

Challenges Related to the Organization: The founder and CEO is the only employee in the start-up. Thus, the start-up has very limited resources. Moreover, facilitating industrial symbiosis builds on collaborations, social contacts and trust which can be resource demanding for a start-up to develop and maintain.

Challenges Related to the Process: The company's approach of mapping material and energy resource flow in a particular territory using interviews and field visits is unique for each project and adapted to the local context. Thus, the business is challenging to scale up since it is dependent on the skills and personal contacts of the founder. Also, the company must communicate actively their value addition to potential customers and be updated about their activities to be able to find potential synergies and collaborations. This is challenging for a start-up and new actors on the market.

4.5 Case 5 (Encourage Sufficiency) - Unwrapped

Unwrapped is a start-up that packages, sells and delivers high quality organic food in reusable containers as well as household items. The start-up has both an online and a physical shop together with a warehouse in Stockholm. Customers pay a deposit fee which is refunded once they return the containers. Their customers are often vegan or sustainability conscious customers who want to avoid single-use plastic packaging.

Challenges Related to the Individual(s): The interviewee expressed their need to develop more competence in new venture creation.

Challenges Related to the Environment: The founders mention that it is costly with reverse logistics since the postal service doesn't have any cost reduction for the return of empty containers from customers. This means that it can be equally as expensive to send the packaged container with food as to return the empty container. Thus, the reverse logistics is not well supported by the current charging mechanisms from the postal service. It is also challenging for the start-up to compete with larger suppliers and distributors with well-established and functioning networks.

Challenges Related to the Organization: The start-up has only two employees, i.e., the co-founders and thus very limited resources to engage in different kinds of start-up development activities.

Challenges Related to the Process: Since the business is dependent on customers engagement to return the packaging organizing the reverse logistics can be challenging for the start-up, especially when attempting to scale up. There is also a strong need for customer awareness and education to get them interested in and to engage in returning containers into recirculation. The start-up also faces challenges when it comes to establishing strategic partnerships which would enable scaling up of the business model both in terms of geographical coverage and the variety of food offerings. Such key partnerships can include for example logistics companies and food suppliers.

5 Concluding Discussion

In this paper, we have studied start-ups striving to develop circular business models to understand their characteristics and challenges. Our study shows that firms developing circular business models have many similarities with start-ups in general but also certain characteristics that makes them unique. The first observation is that start-ups developing CBMs are often experimenting with different ways to address potential customers needs with different approaches to create, deliver, and capture value based on circularity. To be considered credible and gain trust they need to validate the circularity aspects of their business model and adjust to the realities of the market's response to their concept. A second observation is that circular start-ups often operate in an ecosystem and thus may become dependent on other actors that are unable to close their material resource loops themselves. Thus, start-ups in such situations should be able to establish and maintain synergistic relations with such actors and be able to demonstrate the value of such co-dependency and seek to become irreplaceable. We have also found that, these types of start-ups often seek to create a high customer involvement in their day-to-day operations for the business model to function as intended. This implies that the circular start-ups need to invest in customer relationship management as well as develop their storytelling.

Another issue studied in this paper is what it takes to be considered a circular start-up. We have seen that these firms have a strong opportunity to experiment with different business models. What we also see is that such firms seldom have control over an entire resource loop and thus may struggle on their own to recirculate resources effectively. Consequently, their contribution to systemic changes may be limited, but they can be essential contributors to closing existing resource loops and make them more circular. Based on these observations, we define a circular start-up as a firm that strives to address an identified linear resource flow problem by experimenting with alternative solutions that can contribute to more effective resource use in closed loop systems.

Moreover, we identified several challenges that circular start-ups might face, both generic and more specifically related to circularity. The pronounced challenges include the vulnerability of such firms based on their dependency on other actors for their existence and business model to function. For some start-ups, this could mean that they are dependent on "waste" resources from other firms that can be used as input in their production processes. This dependency is often addressed by win-win collaborations in which the start-up can help the incumbent improve their circularity while the incumbents focus on its core business. Another pronounced challenge for such start-ups is related to the challenge to scalability of circular business models due to factors such as the interdependency between several actors, cost and complexity of reverse logistics, and several other factors which are outside the control of the start-up. Another limiting factor to scalability is the existence of systems that are established and predictable and can thus limit the demand for circular solutions that might not be fully validated. Furthermore, there is also a risk of environmental rebound effects from scaling.

Based on this study, we have identified some potential future research avenues. A potential study could adopt a process approach to analyze how circular start-ups manage the different challenges they experience over time. Another potential area for a future study is the embeddedness of circular start-ups in a regional entrepreneurial ecosystem and the competence of such ecosystems to support circular start-ups. Finally, the relationship between circular start-ups and incumbents in scaling up circular business models could be an interesting research focus.

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Improvements in the Construction, Start-Up and Use of a Domestic Food Waste Digester

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Abstract. The aim of this work is to develop, improve and operate a domestic anaerobic digester as an open hardware apparatus to promote decentralized energy and nutrient recovery. A brief introduction to the concept of decentralized energy and nutrient recovery is presented and its connection to the Water-Food-Energy Nexus, which claims citizen participation in the process is highlighted. The construction and use of an Open Hardware anaerobic biodigester named Boitatá was based on communities of interest, so as to permit its replication in hackerspaces, fablabs, etc. The developed reactor was tested in real life conditions for a family of three people and their pets, and some improvements were proposed and implemented to make it easier to build and operate. During the field testing period it has managed to treat all the organic waste daily generated in the household (around 800 g) with a specific biogas production of around 0,710 Lbiogas/gSV, which covers about 21% of the family cooking energy demand, demonstrating the viability of the apparatus for the descentralized anaerobic digestion in urban households and small enterprises.

Keywords: Decentralized anaerobic digestion · Anaerobic reactor · Food waste · Communities of interest

1 Introduction

Despite the sanction of the National Solid Waste Policy in 2010 [1], which predicts the hierarchy in waste management of not generation, reduction, reuse, recycle and adequate final disposal, and considers energy recovery and composting as some of the adequate treatment technologies, municipal solid waste (MSW) management in Brazil has not achieved reasonable standards so far. Recycling rates are still at the level of around 3% [2] and almost 45% of the MSW collected in the country still have inadequate final disposal [3] consequently, there is an increasing demand for areas in the city outskirts for implementation of landfills or even illegal dumping sites.

Both aerobic (composting) and anaerobic digestion (AD) of the organic fraction of municipal solid waste (OFMSW) are techniques used to stabilize and convert this material in organic compost, with completely different characteristics from the OFMSW. Besides the stabilized material (digestate), AD also produces a methane rich gas (biogas),

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characterizing it as an energy recovery process. If the compost or digestate meets the requirements of the Normative Instruction n°61/2020 of the Ministry of Agriculture, Livestock and Supply, it is classified as a biofertilizer.

Biofertilizer is a fundamental input for food production, so, energy recovery through AD and nutrient recovery through both AD and composting allied to other aspects such as the land use in the peri-urban space and water management, allows characterizing the relationship between OFMSW, energy and food production within the Water-Energy-Food-Ecosystem nexus (WEFE) [4, 5], which is embedded in the framework of the United Nations Sustainable Development Goals (SDG). The WEFE nexus involves 14 of 17 SDGs [5] and its approach and methodology is a recognized way for the implementation of the SDGs.

The 4 pillars related to the WEFE nexus are complex, as they must consider the various stakeholders [4], thus, contrary to what is advocated by the neo/ultraliberal management model in which the minimum interference in the lives of citizens must be carried out, the resolution of the relationship between waste and energy must necessarily consider citizens' participation.

The research area of decentralized energy and nutrient recovery (DENR) can thus be characterized, which is embedded in the WEFE nexus, seeking an environmentally and socially fair solution, since it considers a fundamental stakeholder: the citizens. There are several other stakeholders related to this nexus, such as governments and companies, which are also influenced by citizens.

Anaerobic digestion is an effective way to perform the DENR, for which anaerobic microreactors and the concepts of decentralized anaerobic digestion (DAD) are used [6, 7]. There are several substrates that can be used in urban space, FORSU, is among then but notably food waste (FW) has a good biochemical methane potential (BMP) [8–10].

However, there are great challenges present in DAD, such as the enormous variability in terms of quality and quantity in the generation of domestic food waste in an individual household, besides other relevant aspects such as variation in ambient temperature, reactor acidification, problems related to reactor odors, possibility of attracting unwanted animals, among others [6, 7].

One of the current ways in which people organize themselves is through communities of interest [11, 12], as can be seen in Hackerspaces, FabLabs, Makerspaces, among others. This practice usually occurs based on the construction of apparatuses and applying the concepts of open and citizen science, that is, with the use of free software, good documentation, encouraging spaces for interaction, as in the examples of the Open Source Hardware Association [13] and also the GOSH [14]. In general terms, the developed apparatus must be presented in such a way that any interested person can reproduce it.

The usual method applied in many spaces where interested communities meet (hackerspaces, fablabs, makerspaces, etc.) is based on "hands-on" activities [12], possibly derived from the long tradition of software development, notably straightforward methods such as the SCRUM [15]. There are several initiatives to transpose this method of software production to material production [16] and to scientific practice methods such as LabSCRUM [17].

A bibliographic survey was carried out using the "Web of Science" (WoS) database and binary search keys, using the search keys "decentrali* anaerobic digestion" AND ("Food Waste" OR "dog" OR "cat") and "Micro-scale anaerobic digest*" [7].

Both keys returned few publications (7 and 6 respectively) and with h-index equal to 4, however there is an increase in publications in the last 3 years, suggesting that despite being a small research area, there is a growing interest on the theme. It is also possible to observe that most of the articles published are outside the field of engineering, indicating a gap in the research and development of devices that can be used in the DENR concept, mainly in terms of anaerobic digestion.

The advantages of the DAD are still under scientific analysis [7, 21, 22], however in this work this practice is assumed to be advantageous due to the involvement of people, who are key stakeholders in the WEFE nexus.

The objective of this work is contribute to development of an open source hardware apparatus that can be applied for the DENR in households and other small scale organic waste generators in an urban or semi-urban context, and which can be replicated and improved by communities of interest.

2 Materials and Methods

As a more general conceptual framework for this research, the prototyping method was used, derived from SCRUM and the interest group method [12, 23], which implies focusing on solving a problem in a concrete way, even if the solution is partial.

Other three methods were used to achieve the objectives. The first is related to the long-term analysis of the reactor, which was carried out in the field and therefore with several limitations, including those resulting from the pandemic. The second refers to analyzes and characterizations of the substrates used, including the series of solids and BMP, which were carried out at the Laboratory of Processes and Production of Biogas (LPPB) at the São Bernardo do Campo, São Paulo, Brazil. UFABC (Federal University of ABC). Finally, a mathematical model was developed to optimize the reactor adaptation period.

2.1 The Boitatá Reactor

In 2018, some anaerobic digesters of the completely stirred tubular reactor (CSTR) type were built, named Boitatá, based on communities of interest [18] in the Baixada Santista (a metropolitan area on the coast, close to the city of São Paulo). Its design was based on a work presented by Peterson (2018) [18]. The materials used were readily available in the local market and total cost was approximately U$ 100,00. A general scheme can be seen in Fig. 1 and its main characteristics are presented in Table 1.

2.2 Field Analysis

With the worsening of the Sars-Covid-2019 pandemic, one of these reactors was transported and used by one of the researchers at his residence in the municipality of Praia Grande-SP. Over a period of 14 months (October 2020 to November 2021) the reactor was submitted to the steps of inoculation, start-up, adaptation and regular operation.

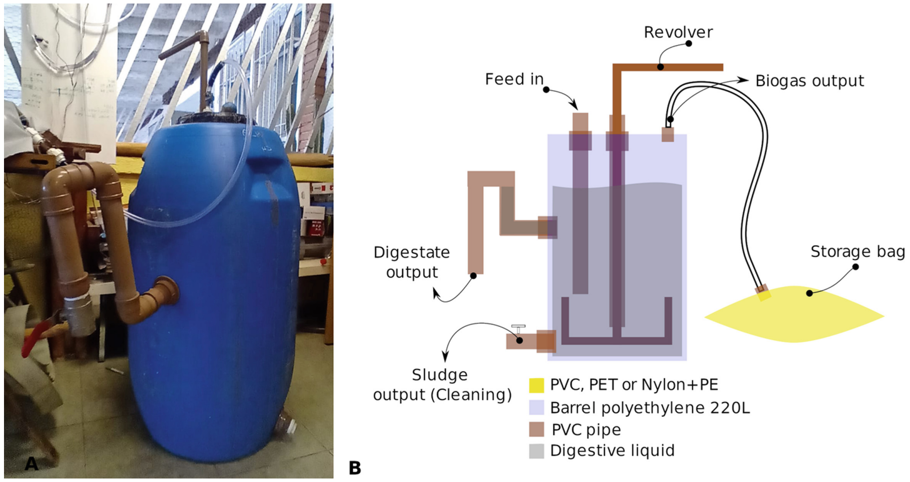

Fig. 1. A) Picture of the reactor object of this study B) Schematic representation of the Boitatá reactor.

Table 1. Main characteristics of the anaerobic microreactor Boitatá

Property	Value
Hydraulic retention time (HRT)	110 days
Useful reactor volume (Vreactor)	220 L
Daily feed of diluted substrate	2 L/dia
Maximum theoretical volumetric organic charge	2,7 gVS/Lreactor.day

The reactor was inoculated with about 40 L of digestive liquid from a bovine manure reactor, and was fed daily until the level of 220 L was completed and the gas produced was able to maintain a flame (flame test), which was considered the end of the start-up phase.

During the adaptation phase the feed rate and composition of the substrate was kept constant during a month and increased and diversified monthly, as presented in Table 4. A kitchen scale with an accuracy of ± 5 g was used to weight the substrate fed. A Philips-Walita blender model RI2008/3 L, with a maximum capacity of 1.5 L was used for grinding and homogenizing the FW. The measurement of pH and total alkalinity in the field was carried out using colorimetric strips for swimming pools (Hth brand) (alkalinity measurement in a 10% digestate solution).

A PVC bag with a volume of 75 L $\pm$ 10 was used for storage and estimation of the biogas produced.

A period of one month (month 5) was chosen to make a more detailed analysis of the Boitatá performance (period of analysis). Biogas production was monitored during this period using a gas flow micrometer (Ritter milligascounter MGC-1).

After the inoculation and start-up period, adaptation was carried out, which is a long period in which the complex system in the reactor acclimatizes to the substrate that is fed. This period was considered completed when all the daily organic residue available in the household was used to feed the reactor. Presently the reactor is being fed with FW from a family of 3 people and the waste of 2 dogs (*Canis lupus familiaris*) from Dachshund breed and 2 guinea pigs (*Cavia porcellus*) which represents an average of 800 g of waste daily.

During the adaptation phase, the main goal was to avoid acidification of the digester, since this is one of the main problems in the use of FW as substrate [19, 20].

The fundamental problem tackled was the feasibility of building and operating an anaerobic microreactor in urban space [24], for which a Boitatá reactor was used. The improvements of the apparatus followed the prototyping method derived from SCRUM.

Two iterations of development were made on the equipment: its assembly, the start-up and adaptation were carried out empirically, and an improvement (new iteration) in the adaptation of the reactor are presented in this work.

2.3 Characterization of the Substrates and of the Biogas

A total of 5 groups of waste were used, which were characterized separately: food waste (FW), dog waste, cat waste (*Felis catus*), guinea pig waste and white ginger lily (*Hedychium coronarium*), the latter was used as an unconventional food plant (UFP) by the family.

The characterization of the substrates and biogas was carried out with samples collected during a period of one month. The substrates were analyzed according to Standard Methods EPA 2540G/1997 for the total solids, volatile solids and fixed solids, and according to the technical guidance of the German engineers (VDI 4630/2006) for the realization of the biochemical methane potential (BMP) test.

All weight measurements were made using a Shimadzu model BL320H scale with an error of 0.01 g. For pH measurements, the DIGIMED pHmeter model DM 22 was used. For the analysis of the biogas composition, the Landtec GEM5000 portable gas analyzer was used, which measures CH4, CO2, O2, CO and H2S, with an accuracy of $\pm 0.5\%$ (vol) (CO2 and CH4) and 1% (O2) and 2% (H2S) [25].

The BMP was performed using the Automatic Methane Potential Test System (AMPTS II) from Bioprocess Control Systems, with a repeatability of $\pm 1\%$ for the methane measurement [26]. Specific methane production data are presented with an experimental error equivalent to the standard deviation of the mean of triplicate measurements (according to VDI 4630/2006 guidelines).

2.4 Optimized Adaptation

The reactor adaptation process was based on previous experiences of small laboratory bench reactors. The experimental data obtained were subjected to data processing, and an optimized substrate consumption rate was obtained, and an improved initial feed rate was proposed.

During the adaptation process, the reactor feed was started with a very low organic load rate (OLR) that was increased monthly. The pH and alkalinity were measured weekly using a colorimetric tape used for swimming pool water analysis. The pH was maintained between 6.5 and 8 and total alkalinity between 1000 and 2500 ppm. There was a need for pH correction in two episodes, using calcium carbonate (CaCO3) at a dosage of 500 mg/L_{reator}. Biogas production was also monitored, since in stable operation of the reactor, there is an increase in biogas production during the 24 h after feeding.

Empirical data from the adaptation period of the Boitatá digester analyzed served as the starting point for the optimization.

Despite the limitations due to the variability of the substrate and the conditions surrounding the reactor, a simplified modeling was made by fitting the experimental data to a function, based on the cell growth function. In general terms, it can be assumed that the population increase is proportional to the substrate consumption by the population, according to Eq. 1, so the modeling of the substrate feed rate (considering that all the substrate fed is consumed) is proportional to the population increase rate [27].

$$Y_{x/s} = \frac{dX}{dS} \tag{1}$$

The solution and linearization of Eq. 1 using the least square method (LSM) for fitting it to the experimental data is presented in Eq. 2. The increase rate of maximum substrate feeding was obtained (η_max) using the free software Calc.

$$lnS = lnS_0 + \eta_{max}.t \Rightarrow f(t) = Y_0 + \eta_{max}t \tag{2}$$

3 Results and Discussion

The results of total and volatile solids can be seen in Table 2.

Table 2. Characterization of the 5 types of domestic waste used as substrate during the analysis period.

Substrate	Total solids (gTS/Kg)	Volatile solids (gVS/Kg)	TS/VS (%)
Food waste	377 ± 3	359 ± 3	95
Dog waste	314 ± 10	241 ± 3	76
Cat waste	436 ± 7	305 ± 9	70
Guinea pig waste	750 ± 54	662 ± 5	88
Hedychium coronarium	112 ± 4	101 ± 4	90

The BMP results of the 5 tested substrates is presented in Table 3. They are presented in descending order and it is noticeable the high potential of the FW and also of the dog waste.

During the analysis period (5th month), the weight of the 5 groups of fed substrates was registered separately, which is shown in Fig. 2. Based on these data, the average volatile solids content of 0.23 gSV/g of the substrate used to feed the reactor was

Table 3. Specific methane production of the 5 substrates analyzed.

Substrate	Specific methane production ($L_{methane}$/kgSV)
Food waste	410 ± 12
Dog waste	327 ± 10
Cat waste	265 ± 8
Guinea pig waste	266 ± 16
Hedychium coronarium	209 ± 7

estimated. The total production of biogas in the period was 818.35 L, so the specific production of biogas in the period was estimated at 0.710 L_{biogas}/gSV. The average concentration of methane in the biogas was 63,1%.

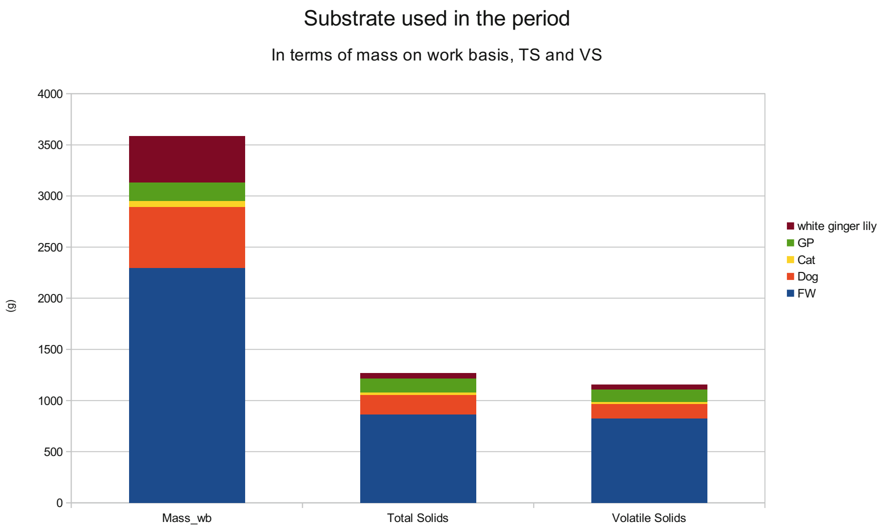

Fig. 2. Mass of each of the 5 wastes fed to the Boitatá reactor during the analysis period.

During the adaptation period, the reactor was fed by keeping the mass and composition of the substrate approximately constant for a month and gradually increasing it monthly, as can be seen in Table 4. In the first month, simple substrates such as rice and beans were used. Gradually, with the increase in mass, a greater variety of substrate was offered. From the 5th month on, the variety of substrates shown in Table 2 was offered, and from the 7th month on, all types of organic domestic wastes were fed, with the mass control still being carried out. From the 13th month onward, feeding was carried out without any mass or variety control, using all the organic waste produced by the household, just avoiding some substrates (orange and lemon peel) and large quantities of a single type of waste, by portioning it to the subsequent days. The daily input mass (diluted substrate) has been limited by the volume of the blender cup (1.5 L).

Table 4. Feed rate and OLR increase during the adaptation period.

Month	Mass of daily feed on work basis (g/day)	OLR ($gSV/L_{reactor}.day$)
1	40	0,042
2	100	0,105
3	160	0,167
4	180	0,188
5	200	0,209
6	260	0,272
7	300	0,314
8	320	0,335
9	300	0,314
10	300	0,314
11	300	0,314
12	400	0,418
13	600	0,627
14	800	0,836

3.1 Reactor Design Improvements

Three improvements were made to the reactor design. The first was the insertion of a ball valve at the exit of the digestate, as can be seen in Fig. 3. Originally it was designed so that the exit of the digestate was made by increasing the level in the reactor, by communicating vessels, thus ensuring a mass balance process in a steady state operation of the reactor. In the original design a PVC cap was used to seal the digestate outlet, however this made the operation difficult, requiring constant lubrication with vaseline. A good seal in all parts of the reactor [6] is essential to prevent the entry and proliferation of vectors.

The digestate outlet valve presented important advantages: greater ease of operation and increased reactor level allowing the use of fatty substrates that form a supernatant that needs a longer retention time. There is no evidence of disturbance or instability of the reactor due to the use of this valve, the removal of the digestate follows approximately the same volume of diluted substrate added.

The second important improvement was in the reactor feed inlet. In the original design the feeding was made directly into the 50 mm tube, however during the operation several times the diluted substrate ended up falling out of the tube, causing a bad smell and fly larvae proliferation outside the reactor. The improvement of the feeding system was the insertion of the PVC adapter from 50 to 100 mm diameter, which can be seen in Fig. 3, and which generated a small elevation, improving the dynamics of the insertion. To effect the sealing, a cap without rubber was used, which caused a noticeable reduction in the smell.

Fig. 3. A) Improvements of the reactor feed inlet B) and safety valve C) improvement in the exit of the digestate

Finally, a common type of accident can happen due to the blockage of the biogas outlet (when the biogas bag is full) which can cause the digestive liquid to leak through both the mixer seal and the feeder. To avoid this, a safety valve was adapted to depressurize the reactor. Such a valve is built with a PVC bottle and a hose tee, as can be seen in Fig. 3 (center). The materials needed for the proposed improvements and those suppressed, in relation to the original design can be seen in Table 5.

Table 5. List of materials added and suppressed by the three improvements proposed and tested.

Description	Material
Digestate exit - add	Ball valve 50 mm diameter
Digestate exit - suppress	3 × 90° PVC elbows 50 mm diameter
Digestate exit - suppress	PVC cap 50 mm diameter
Digestate exit - suppress	50 cm length PVC 50 mm diameter
Feeder - add	PVC adapter 50 mm diameter
Feeder - add	100 to 50 mm diameter PVC reduction
Feeder - add	PVC Cap 100 mm diameter
Safety valve - add	Internal Tee 3/4″ diameter

3.2 Modeling the Feeding Rate of Adaptation Period

The adaptation period can be characterized between the end of the start-up and the stable use of all available substrate. In terms of cell growth it could be recognized between the lag phase and the exponential phase, but still far from the theoretical the carrying capacity limit of the reactor (maximum OLR) (2.5 gVS/L.day).

From the empirically obtained data of feed rate used in the adaptation period (Table 4) it was possible to fit the linearized model proposed in Eq. 2 for the substrate consumption rate, presented in Fig. 4.

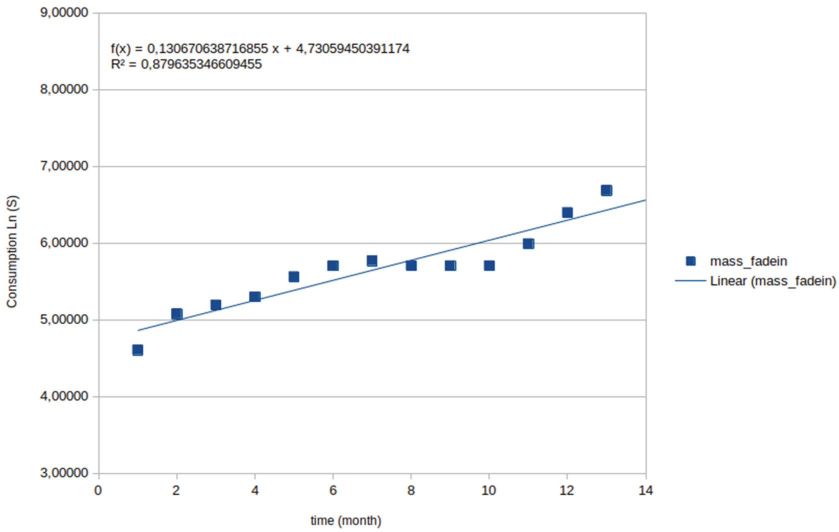

Fig. 4. Fitting of experimental data to linearized model of Eq. 2.

The use of Eq. 2 with the same empirically obtained data of Table 5 made it possible to obtain η_max = 0.13067 with S(t = 0) ≊ 118g. This shows that the initial feed rate used, of 40 g/day could have been three times higher. The correlation between the experimental data and the modeling finds a good fitting ($R^2 = 0.879$), which can be seen in Fig. 5.

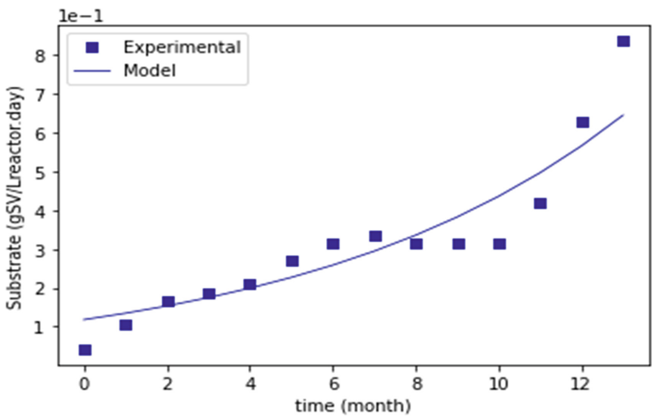

Fig. 5. Model and experimental data of substrate fed in

In Table 5 and Fig. 5 it is possible to observe an inflection between months 8 and 10, which correspond to the winter months, this has been reported as a great challenge for microdigesters, which consists of having strategies that allow them to operate with the same range of substrate consumption during the whole year.

3.3 Conclusion

The results of this research point to the feasibility of DAD, since a low-cost microreactor has been developed and successfully operated digesting the domestic waste of a 3 people household, which demonstrates that this practice can be carried out successfully. It is necessary, though, to think about new relationships between university research and extension and the spaces of interest groups. People interested in having a food waste biodigester in their family must have access to the necessary instructions to build and operate it and to share its development.

Traditional innovation pathways have a lot of development steps while a citizen-driven approach through communities of interest, open hardware, WEFE Nexus and stakeholders participation, as presented in this article, tend to be more straightforward in solving people's demands. This approach has proved adequate in this case of biodigester for decentralized anaerobic digesters.

The biogas produced is used daily for cooking, using an adapted stove directly connected to the PVC biogas bag though a plastic hose. Due to the low pressure (controlled through the use of weights disposed on the bag) and the small amount of gas stored (75 L representing the same amount of energy in 100 ml of ethanol) no extra safety requirements were necessary than those usually taken in a regular kitchen.

Considering the period of one month, the biogas produced represented 18,53 MJ, produced from 3,59 kg of organic family waste, which means a rate of 5,2 MJ/kg of residue. A 13 kg bottle of liquified petrol gas (LPG), commercialized in Brazil has an energy content of 600 MJ, so, using anaerobic digestor Boitatá with a daily waste production of 0,8 kg, it would be possible to substitute around 21% of the LPG needs of the family.

Boitatá has succeeded in providing a reasonable part of the cooking energy requirements for a 3 people family, an adequate treatment for the stabilization of the FORSU and a biofertilizer for improving productivity of the vegetable organic family garden.

The developed open source hardware Boitatá has shown to be a viable alternative for DENR, based on citizen-driven approach. It also proved to be a powerful tool to make waste segregation at the generation point which can be used for households and other small scale organic waste generators.

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Scenedesmus sp. Cultivation in a Synthetic Fertilizer-Based Culture Media: Biomass' Lipids and Proteins Profile

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Abstract. The microalga *Scenedesmus* sp. is a microorganism with great potential for the production of compounds applied to a variety of processes, as example for food, nanocomposites, bioplastics, micro aggregates for polymeric bases. Our goal was to evaluate different concentrations of the medium formulated with the fertilizer Plant Prod® for *Scenedesmus* sp. cultivation, and to verify this biomass' proteins and lipids profile. The experiments were carried out in blocks, in a 3 × 2 factorial design with 3 repetitions, as follows: three different concentrations of fertilizer 8, 10 and 12 g/L, in the presence of two carbon sources, glucose or sodium bicarbonate at 12 g/L. The culture was aerated with a continuous air flow of 4.7 L min^{-1}, average light intensity of 5.104 lux, pH 8.7, at 30 °C. The experiments were monitored daily by measuring biomass concentration and the cultivations were concluded at the 18^{th} day, when the biomass was collected and dried at 50 °C for total lipids and proteins extraction and quantification. The dry biomass and protein production were statistically higher for the conditions 12 g/L of Plant Prod® fertilizer and sodium bicarbonate carbon source, while the best cultivation condition for lipid production was 8 g/L of Plant Prod® fertilizer for both carbon sources. Thus, it was found that Plant Prod® fertilizer is a good alternative for this microalga's classic media replacement, for cost reduction as well as better use of nutrients.

Keywords: *Scenedesmus sp.* · Fertilizers · Lipids · Proteins · Microalgae

1 Introduction

Scenedesmus is a green alga that grows in a variety of habitats and it is widespread across the planet. It can survive under different stress conditions, and it has the capacity to re-establish new populations, by their flexible metabolism. For example, some species of algae may well survive in inhospitable environments for a long time and re-establish themselves when the conditions are back favorable to their growth. As an example, dehydrated dehydrated green desert algae can survive in the dark and then recover photosynthetic activity in 1 h of rehydration [1, 2].

Microalgae biomass is composed of lipids, carbohydrates and proteins [3]. If the lipid content increases, there must be reduction of protein or carbohydrates content or both.

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Nitrogen restriction often increases lipid synthesis and reduces carbohydrate content [4, 5], and it is not well explained how light intensity can favor or not microalgae biochemical composition [6].

Single-celled photosynthetic organisms (microalgae and cyanobacteria) have been studied and applied due to the interest as potential sources of alternative food and feed. These organisms belong to more than 11 phyla and they are biologically diverse, ranging from marine prokaryotes to freshwater eukaryotes [7]. Despite this microorganisms' relevance, there is a lack of studies that describe these microorganisms composition when compared to crops. It is expected that the research efforts for proteins from microalgae sources develop in the same way as those for proteins from seeds such as soybeans, peas and lupine carried out over the last 50 years [8].

Enabling the production of microalgae is a major challenge to be overcome. Many alternatives are being researched to find nutrient sources focusing on these microorganisms' nutritional requirements [9]. The fertilizers as additional nutrients for microalgae culture media can result in biomass and lipids yields equal or greater than the standard culture medium, and they can be added in different composition, process cultivation, and applied to different microalgae species [10–12].

In this work, an inorganic fertilizer was used to prepare the culture media as it is commercialized in the market, with no extra formulation needed, which turns it an innovative feasible alternative. Unlike plants, microalgae are able to metabolize fertilizers more efficiently in liquid culture medium, and transform them into high value-added products. It is also important to note that one of the microalgae industry biggest bottlenecks is the culture medium cost. Fertilizers, in addition to being cheaper than standard medium, they are offered to the market in greater quantities, which makes them viable for application in this production chain [13].

This paper is organized as follows: *Scenedesmus* sp. sampling and isolation, microalga cultivation in different concentrations of the culture medium prepared from the Plant Prod® fertilizer as the only nutrient composition, and this biomass protein and lipid quantification.

2 Materials and Methods

2.1 Strain Sampling and Isolation

Scenedesmus sp. was sampled from the geographic coordinates 7° 29′ 40.1″ S 38° 04′ 56. 6″ W at Pedra Branca – Paraíba - Brazil. For sampling, a mesh net with 10 μm of pore size was used, the samples were stored in glass flasks of 200 mL, previously sterilized, later successive filtrations were carried out to separate phytoplankton from zooplankton, after this process the sample was kept for a week at room temperature of 25 °C, with continuous light intensity to increase cell concentration in the collected water, obtaining a cell concentration of $2{,}7 \times 10^5$ cells/ml.

Isolation was performed on plate of Petri as described by [14]. 100 μL of the sample was spread using the Drigalsky loop on a plate containing solid WC [15] culture medium. The single colony technique was repeated several times until pure culture was obtained. Then, colonies were placed individually in test tubes containing growth medium and kept at 25 °C. The culture was observed in an optical microscope model Olympus, and the identification was done through the Atlas of cyanobacteria and microalgae from Brazilian continental waters [16].

2.2 *Scenedesmus* sp. Cultivation Conditions

The cultivations were carried out during 18 days using a closed photobioreactor with a final volume of 2 L, an inoculum of 10%, and equivalent to 2.5 mg/mL of dry biomass. The culture was aerated with an air flow of 4.7 L min^{-1}, average light intensity of 5.104 lx, pH 8.7, temperature of 30 °C. The cultivation followed the conditions used by Baumgartner et al., 2013 [17], with some changes: the cultivation medium was prepared using the fertilizer Plant Prod®20-20-20 at concentrations of M_1 (8.0), M_2 (10.0) and M_3 (12.0) g/L, combined with the carbon source F_1 (glucose 12 g/L) or F_2 (sodium bicarbonate 12 g/L). The fertilizer Plant Prod®20-20-20 is composed of: nitrogen (N) 20%, phosphorus (P_2O_5) 20%, potassium (K_2O) 20%, iron (Fe) 0.10%, manganese (Mn) 0.10%, zinc (Zn) 0, 10%, copper (Cu) 0.05%, boron (B) 0.02%, molybdenum (Mo) 0.02%, EDTA 1.72% all chelated and water soluble elements. The growth curves were constructed through daily sampling in triplicate from day 0 to 18 days, the dry weight and lipids and protein quantification was determined for each culture, accordingly: M_1-F_1, M_2-F_1, M_3-F_1, M_1-F_2, M_2-F_2, M_3-F_2.

2.3 Total Lipid Quantification

The harvested biomass from each cultivation condition was prepared in triplicate by the high energy milling in a NOAH NQM 0.4 L planetary ball mill (China) containing 400 ml milling stations and 10 mm stainless steel balls, rotating at 400 rpm for 5 min, according to [18], with modifications. Subsequently, the lipid extraction was carried out in a Soxhlet-type extraction system [19] using hexane (60 °C) as solvent, which was recovered in a rotary-evaporator under vacuum at 65 °C according to [20].

2.4 Total Protein Quantification

The total protein content was determined in triplicate, using the powder dry biomass, through the method (micro-Kjeldahl), according to the protocol [19], using the nitrogen conversion factor N = 5.75 as described by [21].

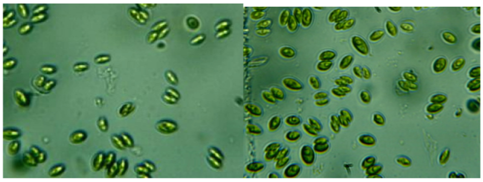
2.5 Statistical Analysis

The results were analyzed by ANOVA (Analysis of Variance) and statistical significance was evaluated by the descriptive level (p). The results were considered statistically significant when $p < 0.05$ (confidence level of 95%). The applied statistical software was ASSISTAT 7.7 [22].

3 Results and Discussion

3.1 Microalga Strain Isolation

As shown in Fig. 1, the applied technique for microalga isolation worked as it was observed a pure culture of the probable *Scenedesmus* sp. strain, without contamination from other microorganisms. The pour plate and single colony techniques are in fact good techniques for isolating strains in a short time, in addition to being simple and low-cost techniques [16, 23, 24].



(a) (b)

Fig. 1. Image of *Scenedesmus* sp. microalgae at the beginning (a) and at the end of cultivation (b), taken from microscope observations at 400x of magnification.

3.2 *Scenedesmus sp.* Cultivation Conditions

The effect of fertilizer different concentrations on the growth of *Scenedesmus* sp. in the period from 0 to 18 days showed a typical sigmoidal behavior, in all treatments, according to the cell growth curves presented in Fig. 2. Initially the culture presents a short adaptive (lag) phase, between 0 and 3 days, for all treatments. However, from the fourth day onwards, the logarithmic phase begins, which extends up to 14 days, followed by a short stationary phase, and at 16 days a decline phase starts until the end of cultivation (Fig. 2).

The carbon source was a relevant variable for the increase in biomass during the *Scenedesmus* sp. cultivation experiments, which was also observed by [25], who in an open-air cultivation of *Scenedesmus sp.*, found that the increase of the carbon source amount was able to increase in biomass concentration, as well as greater stability in the cell growth.

The highest cell concentration of 2.77 g/L was reached for M_3F_2 treatment, using sodium bicarbonate as carbon source. This result was followed by the M_3F_1 treatment, with glucose as a carbon source, reaching 2.64 g/L of cell concentration, as shown in Fig. 3. The results demonstrate that 12 g/L of Plant Prod® combined with 12 g/L of sodium bicarbonate (M-F) were more efficient for *Scenedesmus sp.* growth, reaching the highest value of cell concentration, in relation to glucose (Fig. 3).

Typically, a standard growth medium used for *Scenedesmus* sp. provides high reproducibility, but not always high productivity. In addition, the cost is generally higher when compared to alternative cultivation media, which in many cases can make its application in industrial-scale crops unfeasible [10, 26]. This work tested the efficiency of the

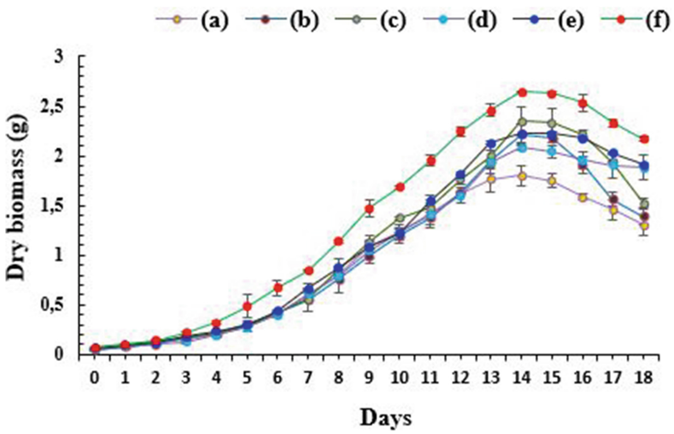


Fig. 2. *Scenedesmus* sp. growth curve at different concentrations of Plant Prod® fertilizer, during 18 days of cultivation: (M_1 8 g/L; M_2 10 g/L; M_3 12 g/L; F_1 glucose; F_2 sodium bicarbonate) (a) M_1F_1, (b) M_2F_1, (c) M_3F_1, (d) M_1F_2, (e) M_2F_2, (f) M_3F_2.

culture medium formulated with fertilizer, and it was verified that the production was satisfactory in biomass, proteins and lipids, showing that this medium can be applied to the production of *Scenedesmus* sp.

In the literature, there are several researches on *Scenedesmus* cultivation, and its production in standard cultivation media. For example, Choix et al., 2017 [27] carried out different cultures with the cultivation medium C30, bold 3M, Bristol and C30-M, with carbon source in different compositions with CO_2, atmospheric air, argon and methane, and the best result was achieved with the medium C30-M carbon source of $CO_2 + CH_4$, biomass yield of 4.63 g/L. Therefore, the authors demonstrated that the nutrient balance incremented the CO_2 fixation and proteins production. In another study [28], *S. obliquus* was cultivated in BG 11 and YM media with 2% of $CO_{2,}$ which resulted in maximum biomass productivity of 757.14 and 20.20 mg/L/d. Therefore, it is important to highlight that the microalgae culture viability is associated with the culture medium composition cost, together with the value of the products obtained at the end of the process.

On literature, *Scenedesmus* sp. cultures with fertilizer-formulated media [9] presented the highest biomass yield when using media in a combination of NPK and urea, which achieved 265 mg/L d of cell productivity, when applying the highest concentration of NPK fertilizer (1.25 g/L). The most significant cost for the culture media formulation is nitrogen, followed by phosphorus and potassium, but it may vary. In the present study, maximum concentrations of N of 2.4 g/L were used, resulting in the production of 2.77 g of dry biomass. In the literature, some strategies are used with the aim of reducing costs, such as the use of urea and ammonia as carbon sources in reduced concentrations of N (up to 1/3 lower than the BG11 medium) to formulate two modified media B4 and L4. The cultivations reached an average productivity of 1.4 g/L of dry biomass in *S. obliquus* cultures [10]. These comparisons suggest that the culture media formulation based on fertilizer mixtures is an alternative to solve cost problems in the industrial microalgae production.

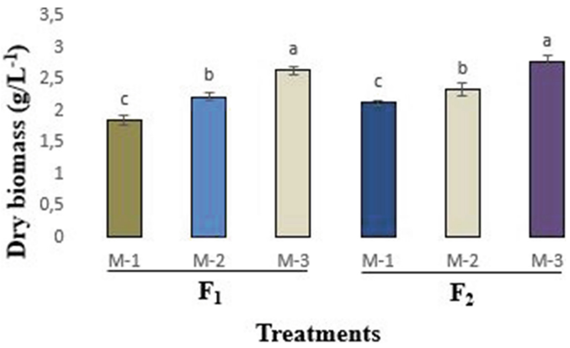


Fig. 3. Biomass production of *Scenedesmus* sp. cultivated in different concentrations of fertilizer Plant Prod® and two carbon sources at 14 days: (M_1 8 g/L; M_2 10 g/L; M_3 12 g/L; F_1glucose; F_2 sodium bicarbonate), M_1F_1; M_2F_1; M_3F_1; M_1F_2; M_2F_2 and M_3F_2.

3.3 Total Lipid Quantification

Scenedesmus sp. lipid content in the cultivation of the F_1 and F_2 treatments were measured at the end of 14 days of cultivation, as shown in Fig. 4. These results suggest that both carbon sources supported the synthesis of total lipids, and while the highest fertilizer concentrations promoted greater protein synthesis, the lowest fertilizer concentrations was responsible for the highest percentage lipid accumulation as the following lipid percentages in the total biomass: 21.6% for M_1F_1, 17.9% for M_2F_1 and 14.9% for M_3F_1; and for F_2 treatment it was quantified 22.2% for M_1F_2, 15.9% for M_2F_2 and 14, 17% for M_3F_2. Duan et al. 2020 [29] presented a lipid production in the range of 22 to 23%, using different sodium carbonate concentrations and BG11 cultivation medium, for a cultivation time of 14 days. The same authors also tested *Scenedesmus* cultivation in a medium composed of effluents trying to simulate the standard BG11 medium, and they obtained similar results to the standard medium used in the previous experiment. Another work carried out by Conde et al., 2021 [30] presented different microalgae species cultivation, including *Scenedesmus* in Guillard F2 medium, and the lipid production was 11.1% of the dry biomass. It was possible to detect that the lipid production does not depend only on a poor in nutrient culture medium, but on adaptations related to environmental and chemical factors [31].

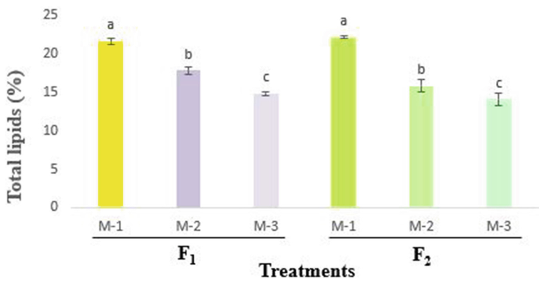


Fig. 4. Lipids production from *Scenedesmus* sp. cultivated in different fertilizer concentrations and two carbon sources at 14 days: (M_1 8 g/L; M_2 10 g/L; M_3 12 g/L; F_1 glucose; F_2 sodium bicarbonate), M_1F_1; M_2F_1; M_3F_1; M_1F_2; M_2F_2 and M_3F_2.

3.4 Total Protein Quantification

In this work, the higher the fertilizer concentration the higher the protein percentages. In Fig. 5, it is possible to observe the results of protein production at 14th day of cultivation. The M_1F_1 medium presented the lowest protein production of 18.3%, followed by the M_2F_1 medium (21.1%), and the highest protein percentage for this treatment (F1 glucose) was the M_3F_1 (29.4%). While the treatment F2 with sodium bicarbonate as carbon source, resulted in the following percentages: 20.8% for M_1F_2, 23.7% for M_2F_2, and the highest production for all treatments was the M_3F_2 with 32.7%.

The results show that higher concentrations of nitrogen favor protein synthesis in this alternative fertilizer-based media with the same concentration of two different carbon source. It was observed similar results when comparing the protein percentages of this work with studies carried out with standard media. Afify et al. 2018 [32] obtained concentrations in the range of 34.45 to 39.55% of proteins in dry biomass of *Scenedesmus obliquus*, cultivated at 25 °C, aeration of 0.04% of CO_2, light source of 24 photons grown in Bold Basal Medium (BBM) medium. In another study [33], *S. obliquus* was cultivated in BBM culture medium at 28 °C, pH 7.5, light intensity of 3500 lx, culture time of 14 days, which resulted in the production of 34.2% of total proteins.

When comparing protein production in synthetic fertilizer-based culture media, there are no major differences in the percentages when compared to standard media. Therefore, it is possible to think about increasing the biomass yield using fertilizers as raw material for media formulation. Finally, the relevance of this research is directly related to the development of viable alternatives for microalgae cultivation, adding that fertilizers are supplied in agriculture, and therefore easy available in the market. [34].

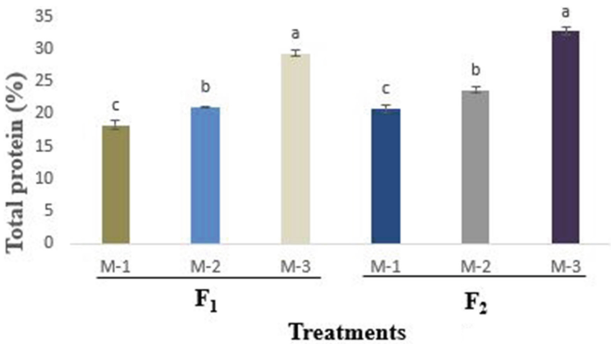


Fig. 5. Protein production of *Scenedesmus* sp. cultivated in different fertilizer concentrations and two carbon sources at 14 days: (M_1 8g/L; M_2 10g/L; M_3 12g/L; F_1 glucose; F_2 sodium bicarbonate), M_1F_1; M_2F_1; M_3F_1; M_1F_2; M_2F_2 and M_3F_2.

4 Conclusion

In this work, we demonstrate that the hydroponic fertilizer Plant Prod®, when used in concentrations up to 12 g/L favors the microalga *Scenedesmus* sp. growth, being a viable alternative to promote this biomass and its proteins production. The same fertilizer used at 8g/L was able to increase this biomass lipids concentrations. The use of a commercial fertilizer as the only component for preparing the culture media justifies its use on a large scale, due to its formulation containing all the salts necessary for the development of the culture, and at the same time, presenting good solubility in water and easy to prepare. Thus, this can be an alternative to replace the formulation of classic culture media for microalgae production.

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Product Development Based on Circular Economy Premises Using Polymeric Residues from a Manufacturing Process of Pencils

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Abstract. Society's awareness of environmental issues over the years caused improvements in the way that the world consumes natural resources and then sustainability surged up. In this way, many business models have been created, and Circular Economy is considered one of the newest models, which is where the idea of the Circular Product emerged. In this research, a product was created with the fundamentals of circularity, where: its material composition is not raw but contaminated polystyrene (PS) collected from residues of pencil manufacturing; the manufacturing process must be clean and efficient because it is essential not to generate more waste. With this, it is possible to maintain human and environmental safety and at the same time, meet the consumer's expectations.

Keywords: Circular economy · Circular product · Polymer recycling

1 Introduction

Environmental concern became a present agenda in the social environment after scientific studies about the deterioration of the environment, especially in 1987 with the launch of the Brundtland Report. In this report, it is already scientifically evidenced that millions of hectares of forests are destroyed annually and that the burning of fossil fuels emits greenhouse gases, for example.

With these problems, the concept of sustainable development was formulated with the objective of imposing limitations based on the present state of all-natural resources, integrated with the biosphere's ability to absorb the effects of human activities and, from that, it was understood that sustainability aims to conduct actions that respect the ecological part of the planet [1]. However, more than three decades after this milestone for the environment, humanity still faces the exacerbated consumption of natural resources together with the consequences of these acts, showing that transforming the current lifestyle of the world to a sustainable one is an arduous and difficult task that requires collaboration from all sectors of society [2, 3].

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In this work, it is aimed to create a product applying the Circular Economy (CE) where the economic and environmental value of materials are preserved for as long as possible to keep them in the economic system and these actions are carried out in a sustainable way, as they contribute to the reuse and recycling of waste that causes adverse impacts on the environment [4, 5].

2 Literature Review

2.1 Circular Economy

The circular economy emerged as a solution to contribute to sustainable development. This model does not have an extremely defined concept, however, the thinking of several authors on the subject is similar [6]. According to [7], CE is an example of biomimicry, as it is based on the laws that govern nature. The lesson provided by nature that based this methodology was to follow the natural cycle of organic life, where the dead organic material ends up becoming a resource (nutrient) for the next generations of organisms. In other words, bringing this approach to the economic business scenario, the new law that will govern "dead products" (which are waste such as, for example, gas emissions resulting from production processes) will be to insert it back into the production chain.

CE is an economic-sustainable system that aims to reverse the current scenario of the linearity of the product's life cycle (extract, process, consume and dump), transforming it into a closed cyclical loop. This means that the objective is to keep the product/material always available to be used, instead of dumping them, so that the consumption of resources and energy are minimized. In addition, the logistical processes of distribution and packaging must be also rethought in a sustainable way [8, 9].

One of the CE paradigms involves five phases: material input, design, production, consumption and management of resources at the "end of life". Products and processes are designed not to become tailings quickly and, when there are tailings, it is agreed that they must be reused to extract the most of their value and that they return to the production cycle or then return to the biosphere in a safe way [6, 10, 11]. In addition, it must be used renewable energy, eliminate the use of toxic chemicals and eliminate whatever can become waste in material, product design and systems [12].

To facilitate the design of a product or circular system, eco-design methods help the product to reuse, reform and recycle. what governs this technique is the importance of maintaining resources efficiency and having the attributions of being durable, repairable, recyclable, and upgradable (functional or parametric changes in a product) [6, 10, 13].

2.2 Circular Product Design

CE proposes that the value of the materials be maintained for a longer life of the products or by looping them back in the system to be reused. The creation of value through design must include strategies that integrate economic and environmental value and so the economic system can reuse products, however, the product remanufacturing process cannot emit pollutants or consume fossil fuels because there will still be strong adverse impacts on the environment and circularity will not be met [4, 14, 15].

For circularity to exist, all the resources that entered this system must remain useful throughout its life cycle, everything must be designed so that there is no waste, however, he states that there will always be losses because there is a flow of materials where it is extremely difficult to recover and natural systems must be regenerated [4, 15].

[4] mentions that when designing a circular product, designers must prevent a product from becoming obsolete and ensure that materials are recovered with the highest level of integrity possible. A product is circular when these goals are achieved using the ideals of design for product integrity or design for recycling. The concept of design for recycling is quite widespread and simple, as the objective is to ensure that the materials that make up a product can be recycled as efficiently and effectively as possible so that it returns to the economic chain [4].

A product has a circular flow of materials when: a product has a technological cycle (designers aim to keep material or "technical nutrients" to be continuously and safely recycled; designed for a biological cycle, (in this, materials are biodegraded to start a new cycle); designed for dis- and reassembly [16]. These strategies belong from closing loops.

3 Methodology

Bibliographic research was carried out in Scopus with the objective of gathering information about the current concepts of Circular Economy and about polymers recycling. With this, a brainstorming was made in order to planning and develop a product with the technology and other resources restrictions.

Beyond that, the selected strategy of Circular Product Design was the closing-loop, since one of the focuses is to recycle material and enable reuse. In this way, the material used to compose is a contaminated polymer, more specifically, polystyrene with other residues of other types of polymers. Since the material is mostly composed of thermoplastic polymers, it is possible to heat and mold it to transform in a product without significant degradation of the polymer in a cheaper way, and a prototype was created based on this.

Following these premises, brainstorming was used in order to define what type of products would be possible to manufacture from these leftovers of the production process and then the CAD was used to design the products.

4 Results

The process used to manufacture the prototype was the remelting process. The plastic was heated in a furnace with the temperature about 230 °C until the polymer became a viscous liquid and then it was molded by being pressed into a metal plate. After this, the prototype was cooled and, consequently, solidified (Fig. 1).

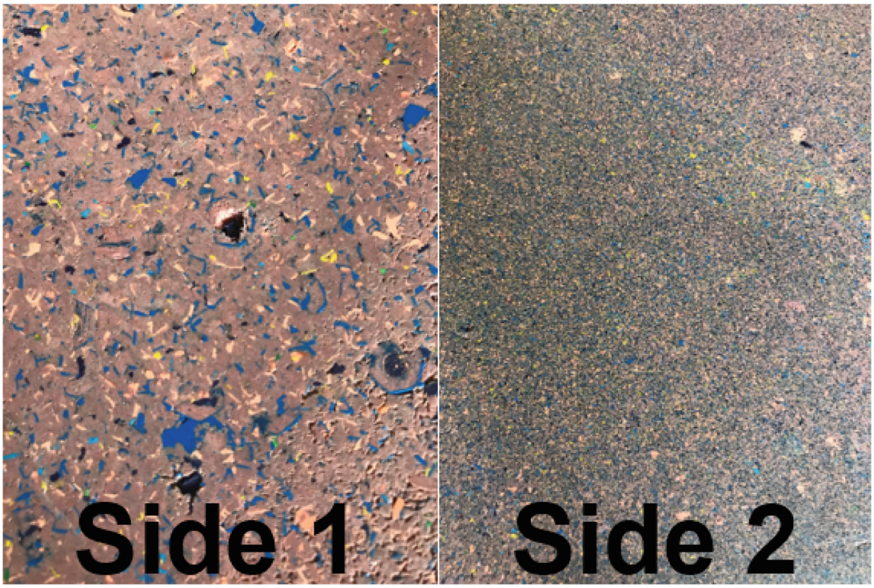

Fig. 1. Prototype.

After seeing the behavior of the plastic, designs were proposed in Autodesk Fusion 360 which are (Fig. 2, Fig. 3, Fig. 4, Fig. 5):

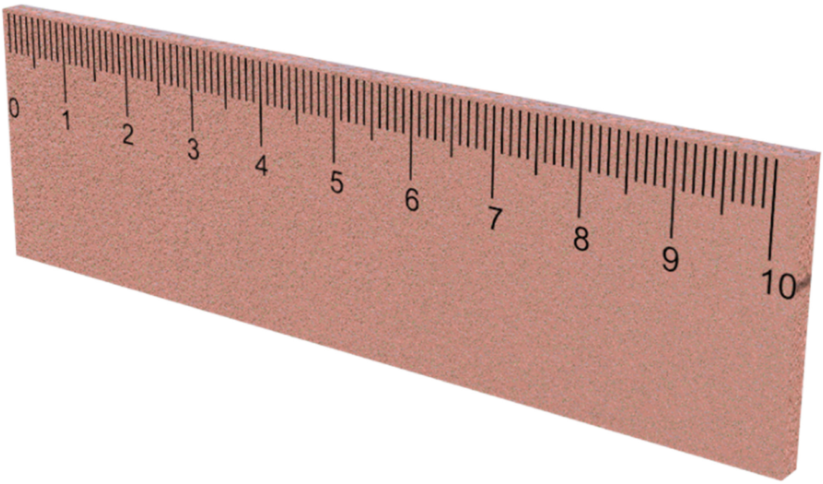

Fig. 2. Ruler.

The stool was the developed with the support of a sustainable woodshop company to maintain the circularity of reusing and recycling. And the seat base was decorated with the recycled polymer as shown in Fig. 6.

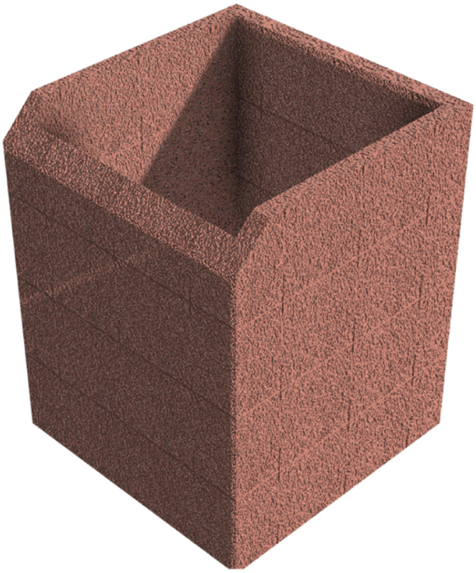

Fig. 3. Storage holder.

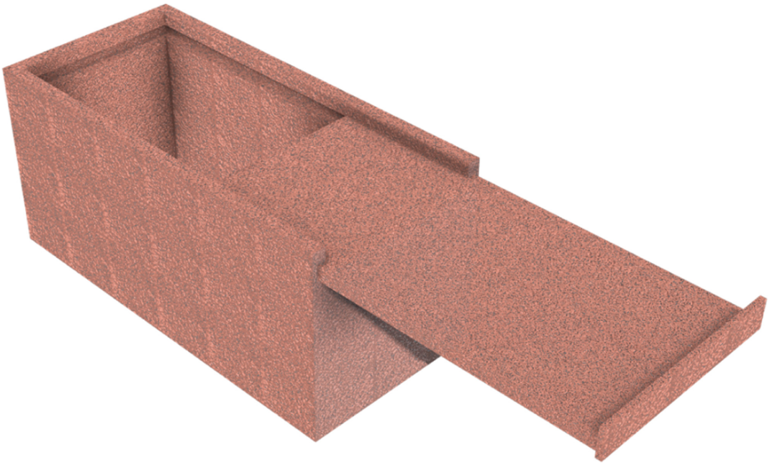

Fig. 4. Pencil case.

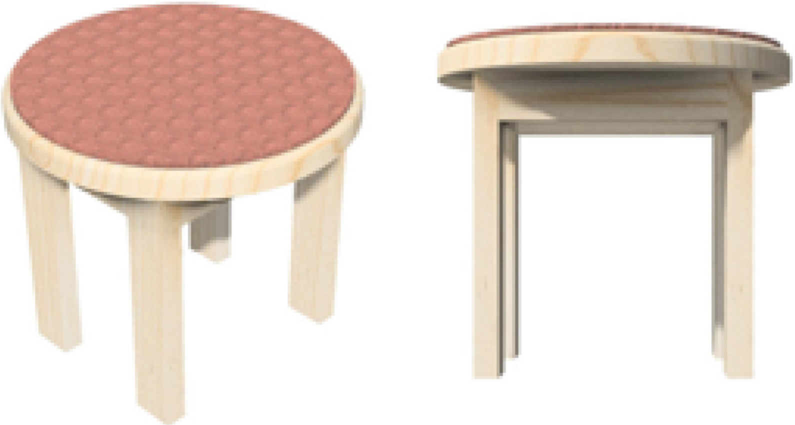

Fig. 5. Stool.

Fig. 6. Stool manufactured with recycled wood and residues of colored pencil as the seat base.

5 Conclusion

The replacement of raw material by a material that is reused, recycled or compostable is important for the development of innovative and light materials, which reduce the exploitation and consumption of fossil materials, and the entire emission of pollutants that occurs throughout the cycle of a product's life. It is known that polymer is a challenger type of material to recycling, but this specifical material received from a company behaved as a simple thermoplastic that can me remolded and it is ready to remanufacture and that means that this company is having a big cost of opportunity. Furthermore, the waste used in this work was considered difficult for the company to reuse but, as shown previously, it was easy to reuse.

Another important factor in moving towards circularity is that, in the last 50 years, the production of non-recyclable consumer materials has grown dramatically to the point that, annually, there are adverse environmental impacts on large scales, such as plastic, which at least 8 million tons, "leak" into the oceans and this has direct consequences for all existing life in that place [17]. In addition, the stimulus and insertion in the circularity model is important for the advancement of technology, as it is necessary to have technical resources to enable the production of a circular product, in addition to using "cleaner" resources so that there is maintenance of the circularity sustainability.

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Design Approaches to Boost Innovation

Framework for Concurrent Design Model for Multipurpose Furniture

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Abstract. The main objective of this work was to produce a multifunctional piece of furniture for the dining/living room. The Concurrent Design Model possibilities to generate a system for the production of flexible furniture from the Concurrent Design Model; other projects that have the same objectives this system can employ the said model. Finally, it was possible to create a reconfigurable and flexible use furniture, adaptable to the most common applications of living and dining rooms.

Keywords: Framework · Multifunctional furniture · Concurrent Design Model

1 Introduction

Smaller housing is becoming more popular all over the world [1]. In Brazil, this is particularly intense because the government extends its influence through social housing programs such as the "*Minha Casa, Minha Vida*" Program, which is also widely used in Brazilian cities. These residences typically have small internal spaces, necessitating special consideration in the production of specific furniture for this market gap [1, 2].

Modularity appeared to be the only way to deal with small spaces during the Modernism period by assembling a series of different structures using uniformed modules [3]. However, new methodologies for broad (re)signification of everyday objects we must develop [1, 2, 4].

Previous scientific studies found that words like "flexible furniture" and "multifunctional furniture" are the most common. From 2015 to 2022, the subject's literature search followed the pattern of "furniture" and "innovation". During the pattern extraction phase, the phrases "framework", "production", and "customization" were also present. The study made use of three databases: World Wide Science, Science Direct, and Capes (Brazil). During the pattern recognition phase, World Wide Science discovered 442 relevant publications; Science Direct transmitted 194 articles, and Capes sent 102 scientific works. Figure 1 displays the study's findings and serves as the study's theoretical framework:

Figure 1 highlights the tendencies for furniture design research over the years, in special with the peaks on 2017 and 2020. It is important to take note that the majority of the previous works is from 2017, and the mentioned works contribute to the construction of this framework. It is important to display the works of Scherer et al. [1], Pezzini,

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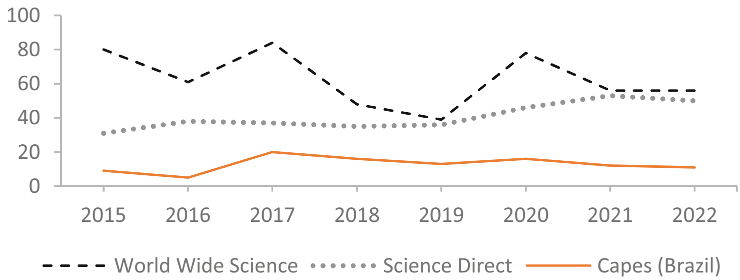

Fig. 1. Results of research through three different databases, results of published scientific works from 2015 to 2022. Source: Elaborated by the authors

Schulenburg, and Ely [2], Araújo and Vergara [4], and Frossard and Pessôa [5] due to the study of the ergonomics of the space built for these small residences in Brazil. Those researchers pointed to the use of human centered design as a way to meet human needs within Brazilian smaller homes. The findings of previous studies argue that versatile furniture must consider user experience. [2, 4, 5] and that design is a multidisciplinary practice [6] that can use many evolutionary processes to solve difficult problems [2, 4].

The purpose of this article is to give a technique that will assist individuals who desire to innovate in the field of furniture design. The following sections comprise the outline of this paper: Sect. 2 Concept Overview; Sect. 3 Methodology; Sect. 4 Results; and Sect. 5 Conclusion.

The goal of this research is to look at the elements that influence the development of furniture with various uses. The sought-after response to this query is to give a framework that can improve creation design processes based on the Concurrent Design Model.

2 Overview of Concepts

To begin, it is necessary to define the term furniture. Furniture, often known as furnishing, is the decorating for any place that pertains to many styles and/or designers and may aid in storage or any other human activity [7]. Furniture, according to Lucie-Smith [8], holds an uncertain place among all things manufactured by man since it is an important object for living. Because furniture is an item and not just a picture of something, it has a very powerful and obvious material component in everyday life, [9] and has consequences tied to the inclination to quit the nomadic living style [10].

The adaptability of a piece of furniture reflects the settling and consistent relationship of individuals with their houses [10]. Furthermore, given the rapid changes in behavior and, as a result, activities of people within their homes, a piece of furniture that performs many functions can greatly extend its useful life [10].

The notion of flexible furniture has been popular since the early movements of Art Deco, Art Nouveau, and Arts and Crafts, particularly following the Victorian era [8]. As the Modern movements emerged at the turn of the nineteenth and twentieth century, furniture became more adaptable to any area, folding or storable, to minimize cluttering in tiny dwellings [8, 9]. Nonetheless, this new perspective on furniture was not limited to private settings, but was also used to public spaces, such as the Aleksandr Rodchenko

[11]. Later in the twentieth century, Scandinavian furniture designs aimed to emulate the versatile international style, but using wood as a feedstock [12]. The use of wood also connects to the do-it-yourself mentality that is prevalent on social media sites like *Pinterest* and *Instagram.*

Hernandis's [13] Concurrent Design Model uses the broad idea of systems and seeks to express it for the creation of creative products. This model investigates all agents who can intervene in the design process to restrict the product project [13]. A rigorous evaluation of a product's formal, functional, and ergonomic features can identify the subsystems that will affect the product's design and conceptual qualities.

Following those idea definitions, the goal of this project is to employ the Concurrent Design Model to build furniture items with multiple applications.

3 Methodology

The purpose of this paper is to explore a framework to produce multipurpose furniture. At this stage in the research, the central phenomenon is furniture design, specifically regarding the creation of pieces that can serve more than one purpose, applying the Concurrent Design Model as the main methodology. The scientific approach was conceptual and empirical, via deductive methods of data analysis and design application [14].

The example [14] for this case study is the design of a flexible and interactive piece of furniture that can serve the dining room and the living area while attempting to address fundamental human requirements inside a tiny dwelling. This paper's data gathering [14] was mostly exploratory, utilizing qualitative and quantitative research. The data collection technique was empirical and inductive, resulting in solutions to the core challenge of furniture innovation.

The Concurrent Design Model proposed by Hernandis serves as the study's design methodology [13]. Mota, Pacheco, and Hernandis used this systemic model because of the ability it provides to study the factors required for product design, taking into account the dynamism and continual updating that the goods must have in order to survive in the market or fascinate other markets [15]. The concept also enables information feedback and continual replies via an active and regulated system [15].

The Concurrent Design Model may be adapted to produce flexible pieces of furniture that meet at least one of the following criteria: material utilization; functions; shapes; assembly; and durability. The first step is to define the exterior system, which is usually furniture or furnishings. The second phase involves identifying the input variables, which are as follows: symbolic content-cultural, familiar, practical, comfort, home; mastered production technique-wood, plastic, metal; many price ranges; economically feasible production and sale; manufactured globally.

As the input variables entered, the reference system may identify flexible and changeable furniture. For the system to function, a piece of furniture must strive for three objectives. The formal objective refers to goals that manifest via image, shape, and structure, such as substituting materials to facilitate reuse and/or recycling. Furthermore, it is a key goal to use basic forms (Cartesian planar geometry), avoid utilizing colors, and not change the appearance of the material. The functional goal is concerned with the practical degree of services offered by the design component. The functional level is concerned with estimating the product's long life; the furniture must suit more than one demand for the dining room or living room; and the mass customization process (variation in the number of modules). The ultimate goal is ergonomics, which includes (but is not limited to) maximum and minimum anthropometric standards used in Brazil; simple assembly and disassembly; minimizing accident risks during interactions; and estimating required mechanical and spatial abilities to utilize the device.

As a basic subsystem, each aim produces a subsystem that feeds back on itself. Action variables and information variables will also feed back to the system, allowing it to produce novel solutions to the wicked issues encountered during the design process. The formal subsystem is concerned with simplifying the use of only two distinct types of materials at most, exposing the constructive phases of the part-construction process, and simplifying the ways to reproduce the same building module numerous times.

The functional subsystem is concerned with the material(s)' durability, function simplification, the use of QR codes to demonstrate how to assemble the item (collaborative learning and teaching procedures), and the pursuit of the best possible product at the lowest viable cost. To avoid accidents, the ergonomics subsystem refers to measuring each of the anthropometric characteristics, and the product must have rounded edges and rounded handles.

The Concurrent Design Model offers us straightforward output variables. The first variable is to suggest the deliberate use of materials; "one piece of furniture is worth as many," which means that all components may apply for different purposes and that the structure is interchangeable. The second variable is to innovate in the utility of furniture, with an emphasis on compact homes. The third variable is to design interchangeable furniture by mass-producing replacement pieces that customers can readily purchase and install.

The fourth variable is the production of furniture for middle-class customers. The fifth and sixth factors, feasible production and sale, are related. The adaptation to the small housing market is the final variable. The Concurrent Design Model for Flexible/Changeable Furniture is depicted in Fig. 2.

The Concurrent Design Model assists in navigating through many concepts and combinations in order to develop manufacturing lines for prototypes of the proposed furniture. What are the human requirements in the living room and dining room? This question necessitates various plausible responses. (I) the furniture must be flexible; (II) the furniture must serve more than one purpose; (III) the furniture must be adaptable in the event of a spatial rearrangement or a sudden change of address; and (IV) the furniture must satisfy the changing demands of the home's owners.

4 Results

We created two separate furniture prototypes to verify the suggested design methodology for flexible/changeable furniture. The first was given the name "*Balaústra*" while the second was given the name "*Sobobe*".

To explain the usage of materials and shapes, the *Balaústra* (Fig. 3) model employs a fundamental module. The structure incorporates elements of the Japanese carpentry building figure known as *juuji-mechigai-tsugi*, which is a design with eminently ornamental characteristics but also pertains to the transfer of forces from top to bottom,

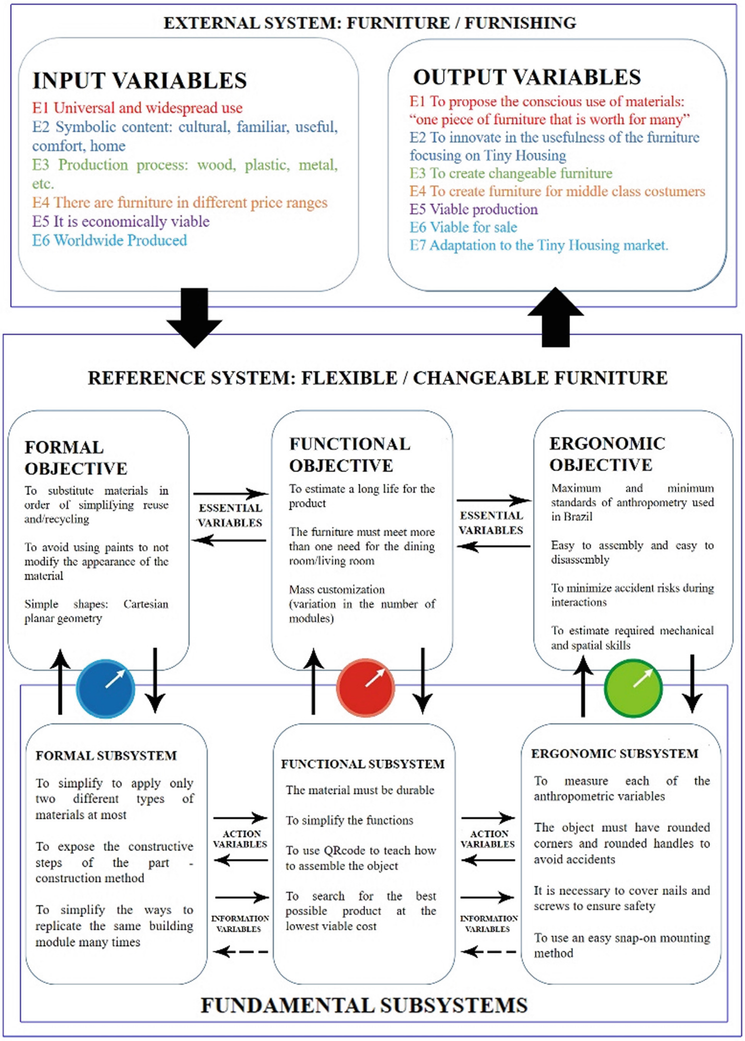

Fig. 2. The concurrent design model for flexible/changeable furniture model. Source: Adapted from Medeiros [16].

dispersing the torsional force throughout a platform [17]. However, in terms of Brazilian architectural semantics, the most analogous figure is the balustrade (hence the name "*Balaústra*") seen in balconies and other garden constructions.

The prototype stage produced a delicate component that can withstand the weight of a 150 kg human sitting on the framework (force applied to the structure: approximately 149 kgf). Because of the project's basic forms, it was feasible to infer that it was simple to mass-produce during this phase. This also makes the product more versatile and saleable. The prototype is a 0.16 m^2 wooden block piece (Fig. 4), demonstrating its adaptability to the tiny house market.

Fig. 3. *Balaústra* piece: 3D models. Source: Adapted from Medeiros [16].

Fig. 4. *Balaústra* piece: prototype. Source: Adapted from Medeiros [16].

The *Sonobe* concept is a triangle foundation for modular building. This model is a three-dimensional design in which the shape of origami expanding it into sequences of slats that form a prism-like geometry (Fig. 5). This design option also facilitates assembly and disassembly, with an eventual change in slat height, with height alterations by changing slats directly. It then reflects on the variations in module use, noting that different slat heights serve varied purposes.

We chose slats with heights of 35 cm, 45 cm, and 60 cm, taking into account human body measurements, to allow for the assembly of benches, seats, and armchairs. The module assembly, with the slot of the slats in the triangular bases, with the least amount of effort to stack the modules one on top of the other (Fig. 6). The construction is light enough for anybody to carry and structurally strong enough to withstand the weight of a 150 kg person sitting on it thanks to the use of wood with a *Janka* hardness of more than 200 kgf as raw material (force applied to the structure: approximately 149 kgf). The joint chosen to secure the foundation pieces for square fitting was *jigoku-kusabi* or even *jigokuhozo,* in which triangular dowels are used to make the joints, which serve as an alternative for the dovetail connection since it allows for opening in small spaces [17].

From September 18, 2020 through September 30, 2020, there was a validation procedure [16]. Because of the global COVID-19 epidemic, the health standards for the internet format for validation, exhibiting videos and photographs, and using a systematized form to gather replies have changed. For people interested in participating in this

Fig. 5. *Sonobe* piece*:* 3D model. Source: Adapted from Medeiros [16].

Fig. 6. *Sonobe* piece*:* prototype. Source: Adapted from Medeiros [16].

evaluation, invitations were sent out via the digital platform Twitter, reaching 20 people from all around Brazil [16]. People gather from various backgrounds in order to form a diversified analysis group that may provide unique responses regarding their own perspectives. Each participant got three files: a file containing project photographs; a video demonstrating the construction, disassembly, and components of the project; and a brief memorial summarizing the effort. The second phase included thirteen investigations. Nine were positive responses on a 5-point scale, where 1 indicated absolute disagreement with the statement and 5 meant total agreement with the language. The first 10 questions were required. Finally, there are three open-ended questions. Table 1 contains the following affirmations and results:

According to the findings, the participants interviewed believed the furniture item to be intuitive and obviously functional. Furthermore, the piece of furniture piqued the curiosity of the respondents, who expressed a desire to learn more about the peculiarities of the pieces as well as the complete creative process. This curiosity was evident in the past three free-response queries. One commenter suggested that the ludic aspects of the furniture, as well as the ability to make it more colorful, could make it useful for schools and libraries. Another suggestion was to create a line for plus-size people in order to fulfill a market share that is sometimes disregarded by the large furniture firms [16].

Table 1. Results of online validation process held on September of 2020.

Affirmations	Answers
It is clear that the given object is a piece of furniture for residential use	65% of respondents agreed totally with the statement, and 35% agreed somewhat completely
The offered furniture has an appealing form	55% of respondents agreed entirely, 30% agreed with the statement, and 15% were unsure
This piece of furniture's installation and disassembly, in my opinion, is straightforward and intuitive	65% of respondents agreed entirely, 20% agreed slightly, and 15% were unsure
I feel that this piece of furniture may be used in a variety of ways	90% of respondents agreed completely, while 10% agreed slightly
When disassembled, I suppose this piece of furniture takes up little room	85% of respondents agreed completely, 10% agreed slightly, and 5% chose the intermediate option
This piece of furniture features ludic and enjoyable aspects that make assembling a game	60% of respondents agreed completely, 25% agreed slightly, and 15% were unsure
This piece of furniture may serve a variety of purposes in the home	85% of respondents agreed completely, 10% agreed slightly, and 5% chose the intermediate option
This piece of furniture has a DIY feel to it	75% of respondents agreed completely, 15% agreed slightly, and 10% chose the middle option
I would buy this piece of furniture	65% of respondents agreed completely, 30% agreed slightly, and 5% were unsure

Source: Elaborated by the authors.

5 Conclusion

The mini-housing system is dependent on furniture that is flexible to this circumstance and requires reconfigurable furniture that can adapt to changing needs and can be repurposed. Both modules are straightforward to assemble and remove, making the design simple to comprehend and create. The user may also opt to interact with the modules using other things, making the adaption to other furnishings the owner already possesses even more sustainable.

The validation procedure, which took place from September 18, 2020 to September 30, 2020, demonstrates the public's interest in the furniture developed in this study [16]. Both items' design processes aided in the evaluation and validation of The Concurrent Design Model for Flexible and Changeable Furniture. The prototypes are adaptable to any given application and can be simply mass-produced, using simple replacement components that extend the piece's lifespan. The prototypes were also relatively cheap to produce, making both manufacturing and sale feasible. The forms make things basic, and each module is straightforward to disassemble.

The Concurrent Design Model for Flexible and Changeable Furniture has proven to be a valuable asset in the process of building intelligent furniture. This study intends to serve as a foundation for the application of this approach to both scientific matters and the furniture industry. Because designers confront several wicked challenges during the design phase, it is critical to give them tools to assist them in achieving the desired answers. As many tiny households require furniture that meet the changing demands of their owners, there is a market niche for flexible and changeable furniture.

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Application of the Engineering System for Building the Packaging Design for Solid Shampoo and Conditioner

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Abstract. This study investigated, from the exploratory approach, the development of the design of a sustainable packaging of solid shampoo and conditioner, for a vegan cosmetic company. A scoping review of the literature highlighted the main authors and products that have been developed under the ecodesign perspective. The approach indicated that the innovative companies researched primarily use packaging design and type of material as a form of communication and expression with users. In the context of the study, considering the process of developing the packaging design, as well as the type of material used in the construction. The Engineering System methodology is used according to the stage of product innovation. The stages such as ideation and design have already been developed and the prototyping is in the final development phase. Finally, the experimentation of the packaging materials, support information for the final stages of the design creation process of the solid shampoo and conditioner packaging.

Keywords: Packaging · Innovation · Cosmetics · Design and Product Engineering System

1 Introduction

The growing demand of the cosmetic market, especially natural cosmetics, is gaining notoriety and care in its various categories: hair, facial, and skin care. Data indicate that of all the new cosmetics launched in Europe in 2015, 14% are vegan[1] or organic[2] and between 2013 to 2015, new vegan product launches grew by 150% on the European continent [1]. This data points out that consumers are not only looking at the content of the product, but also the entire manufacturing, packaging and disposal process.

The question for natural cosmetics, refers to a new concept of lifestyle that is associated with the well-being of consumers, according to data pointed out by Nielsen [2], 3

[1] Vegan cosmetics: products used in their formulation are not of animal origin and have not been tested on animals.

[2] Organic cosmetics: have at least 95% certified organic raw material in their formulation, the rest of the formulation (5%) can be composed by water, natural or organic raw material.

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styles of trends to be highlighted: natural, personal and connected. The market growth focuses on simpler ingredients, excluding the artificial [3].

The natural cosmetics identified as most used in Brazil are from the hair care category, accounting for 8% of the total sample of the category and accounting for 5% and 4% of the skin care categories respectively [4]. This same research points out that one of the relevant aspects is to find the balance point between the micro trend and the macro need of the consumer, focusing on innovative products.

Regarding innovation Godin [5] describes that innovation is an injunction and everyone should innovate. Innovation is also a panacea. The author Godin [5] exposes that the result of innovation is based on: progress, development, growth and change. The historiography of innovation, attributes the academic origin and the study of the concept to the economist Joseph Schumpeter [6], because he used a concept that was becoming popular, as many others did in the first half of the twentieth century.

In the drive for sustainability, ecological packaging is gaining notoriety and relevance in the theme. The ecological parameters for the development of packaging, the life cycle of packaging have been considered in the design [7].

Cosmetic packaging, has the tendency to value well-being and sustentability, as reported in ABRE[3] [8], the two strands are merging intensely, as consumers seek products that are good for themselves and for the planet. The company Sulapc, manufacturer of compostable bio-packaging without microplastics, because they started their activities with the intention of generating inputs where sustainability is considered from the raw material onwards in all operational phases. With the increasing development of innovation in packaging manufacture,

The cosmetic line, especially the hair line, which in turn uses mostly plastic packaging, has been the target of consumers who claim what is the organizational position, given the sustainable development of the same. The Taiwanese brand O'right has launched a shampoo called "Tree in the Bottle", made of biodegradable materials (fruits and vegetables), which can be naturally degraded and planted.

In 2021 Euromonitor [4], reported that beauty consumers favor efficacy, accessibility and multifunctionality and clinical positioning supported by science. The Ministry of the Environment [9] highlights the importance of Ecodesign, which justifies its relevance, because it is a competitiveness tool used by companies in the areas of architecture, engineering and design, both in the domestic and foreign markets, meeting new models of production and consumption, contributing to sustainable development through the replacement of products and processes by others that are less harmful to the environment.

According to the Ministry of Environment [9], the concept of ecodesign is based on "the activity that, by linking the technically possible with the ecologically necessary, gives birth to new proposals that are socially and culturally acceptable."

This case study aims to propose a methodology for the development of a sustainable packaging, composed of the following stages of the engineering system: pre-development, development and post-development, having as a result the development of the packaging design for solid shampoo and conditioner, which in turn are composed of: packaging commonly made of paper (in some cases biodegradable), weight ranging from 60 to 100 g, instructions for use, natural ingredients in its composition.

[3] ABRE: is the acronym for Brazilian Paper Association.

Compared to using liquid shampoo and conditioner for solid, one 80 g bar of solid shampoo is equivalent to 60 washes of liquid shampoo. Solid shampoo uses fewer chemical additives than liquid shampoo, and because of its solid, dry format, solid shampoos save on water usage. Another factor is the issue of transport, because solid shampoos can be accommodated and transported more easily than liquid shampoos. On the other hand, the main characteristics of the packaging of traditional (liquid) shampoo and conditioner are: plastic packaging (ranging from 70 ml[4] to 1 L), liquid composition (usually contains petroleum derivatives and sulfate, among other chemical variations), cap, label with instructions for use, weight around 200 g[5] to 1 kilo and some cases the shampoo and conditioner comes in a rigid paper packaging.

Faced with this dilemma, it is important to review and discuss such replacement, because the use and inappropriate disposal of packaging has become a cumulative and harmful problem to society. To think of an intelligent society that adheres to sustainable and durable products, is to think of a consumer who interprets the packaging design as a converter of futuristic ideas, which combines innovation with versatility.

Considering the importance of all phases that involve the design of cosmetic packaging, as well as the acuity in the choice of material, especially in the case of natural, organic and vegan cosmetics, and taking into account the gradual development of the market for these products, this study proposes to develop the packaging of solid shampoo and conditioner for a bio-cosmetic company, based on concepts of Product Engineering Systems and making use of its tools.

With this, it is intended to contribute to clarify issues regarding the proposal of the Engineering System (ESS) in the development of packaging, from the perspective of the fundamental pillars of this concept, which are: business analysis, requirements analysis, product design and architecture, development or programming, quality assurance and delivery, corrective-adaptive maintenance and evolutionary maintenance [10].

The idealization of this case study is to make the user's needs met through intelligent and sustainable design, permeating the way of the System Engineering (SE) to find such a solution. This thinking is built through scientific knowledge, prototyping, and user interaction.

This paper is organized as follows: the first section presents the introduction, where the objective and justification of the case study and the importance of sustainability in cosmetic packaging are presented. The second section is about the methodology, where we present the architecture of the possible solution of the final project. The third section describes the results and discussions, showing the three possible packaging designs. In the fourth section, we end with the final considerations, which reflect the importance of this case study.

2 Methodology

With respect to the research method of a scientific project, in order that the form, procedures or techniques to be applied are conducted in a cohesive manner, it is imperative that a two-level analysis be produced [11]:

[4] ml: Symbol for milliliter, the thousandth part of a liter: 1 L is 1000 ml.

[5] g: Weight equivalent to a gram.

1. Logical-structural coherence of the articulation of the reasoning, the steps of the demonstrative process posterized within a continuity of logical articulation;
2. Consistency with the methodological principles adopted.

A search on the Web of Science site (through the CAPES/CAFE platform) was conducted between March 27 and 28, 2021, with the keywords: Sign, Cosmetics, Packaging and Organic, which generated a total of 68 articles, which permeated the scientific path for this case study.

It is of utmost importance that the general objective be aligned with the chosen methodology [12]. To this end, the three types of research that the author classifies [12] were analyzed: exploratory, descriptive and explanatory. This study is oriented as exploratory research, because:

- **Goal**: Refining ideas or improving intuitions [12]. The main idea of this case study is to develop the packaging design for solid shampoo and conditioner.
- **Planning:** Adaptable, allowing the most varied considerations relative to the studied fact [12]. The product will follow different stages according to the progress of the research.
- **Content:** Exploratory research has 3 essential steps: (a) literature survey; (b) interviews with people who have had practical experience with the research problem; and (c) analysis of examples that "stimulate understanding" [12].

In addition to the user questionnaire, a QFD (Quality Function Deployment) matrix was prepared to assist in the packaging planning process. Three packaging models were developed in kraft paper, based on geometric shapes (square, hexagonal and rectangular), coated with bio-packaging made with beeswax. This coating was necessary so that the packaging could have greater durability according to its use, since the packaging will not have glue in its closures and unfoldings. These processes are in the final prototyping phase.

Relative to the product development process, the line proposed by autors Rozenfeld et al. [13], explains about 3 phases of the Product Development Process as well as the subsystems namely: Pre development, Development and Post development. In order to align the technical and managerial procedures of this project, the WBS[6] model was built, incorporated to the Product Engineering System, as shown in Fig. 1.

3 Results and Discussion

The publications surveyed in the scoping review were analyzed to identify evidence of the importance of the interaction of *design,* material type, and user experience in the process of choosing and using solid shampoo and conditioner.

It is possible to note the concentration of works relating the evolution of cosmetic design, technologies on materials reuse and the economy in manufacturing processes [14]. It should also be pointed out that there are still gaps of knowledge and study in the field of cosmetic packaging design for solid products.

[6] (Work breakdown structure), in project management means: Project Analytical Structure (PAB).

Fig. 1. WBS Model, 2022. Source: Own authorship

The interaction with consumers and the competition of ideas have been preoccupied by companies that consider the relevance of the consumers' opinion important, for a better definition of their products [15].

Considering the theoretical analysis and the answers obtained by the interviewees, we began the process of creating and developing the construction of a visual packaging pattern. For this process, three models were suggested, as shown in Figs. 2, 3 and 4, which refer respectively to model A (prototype printed on Kraft paper coated with the wax bio-embossing) and model B (prototype printed on Kraft paper). The prototypes were built via SolidWorks software.

The SolidWorks software is a computer graphics software that allows the formation of objects with three-dimensional modeling. In this case study, the modeling in the software was fundamental to dimension the packaging areas, simulate the movements, and visualize the detailed design.

Fig. 2. Square package printing, 2022. Source: Own authorship

Fig. 3. Hexagon package printing, 2022. Source: Own authorship

Fig. 4. Rectangular package printing, 2022. Source: Own authorship.

Resulting from projections, ideations, prototyping, choice of suitable materials, opinion research with users, packaging design development, and scientific literature analysis, this case study has designed draft versions, so that the efforts employed are consistent with the desired scope.

4 Final Considerations

The main objective of the study was to develop the packaging de-sign for the solid shampoo and conditioner. Based on the analysis of scien-tific literature, projections, ideations and prototypes, it is believed that this study can contribute to the application of knowledge about sustainable cos-metic packaging, especially in the context of organizations that aim to add and expand their products to the ecologically appropriate line.The replace-ment of 3 bottles of liquid shampoo for 1 sustainable package of solid shampoo, besides being an economic factor for the organization, causes the environmental impact to be minimized, either by the extraction factor to manufacturing processes. It is in this aspect that the focus of this case study lies, by drawing attention to an elementary aspect, but perhaps one of the most important in the innovation process: constantly developing process improvements and reducing costs. Consequently, it is possible to achieve market differentiation by improving the user experience. Inherent in the en-gineering system is the fact that each step of the packaging development process was developed following the logical order of the system, such as: concept development, preliminary design, detailed design, engineering de-sign and prototyping, test and evaluation, production, and customer support. Through these stages, it was possible to broaden the knowledge about the management process and technological innovations.

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Application of Quality Tools in the Stock Sector in a Company in the Automotive Sector: Case Study

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Abstract. The main objective of this work was to diagnose non-conformities in the stock sector in an automotive company, applying quality tools based on the pillars of the 5S program so that the work environment is reflected in more optimized processes, considering the safety of all collaborators. As a methodology, a quantitative and qualitative approach was adopted with the application of a case study. In the execution of the case study, the quality tools called Check List, Key Performance Indicators (KPI's) and 5W2H were used to diagnose and propose improvements. As results achieved, the work resulted in an effective improvement in the organization of the sector, in addition to facilitating the communication of the area manager in communication with its employees. Finally, it was noticed that the improvements implemented not only can but should be applied throughout the company, not just in the sector studied.

Keywords: Quality Management · Continuous Improvement Inventory · Performance Indicators

1 Introduction

Nowadays, it is necessary for companies to keep up to date, especially in the context of adjustments, to adjust and meet market needs, adjust the process, and a product with continuous quality. From this, several companies can stand out in the management of the position of the processes and quality management, becoming competitive.

For Imai [1], to increase the improvement of the goals and increase the performance, a continuous implementation of the improvement of its goals and cost reduction, as a result of the profitability and cost reduction.

The study was carried out in a company in the metallurgical sector, specifically in a stock of automotive components, where the components are stored that are distributed to internal customers so that they can continue their assembly processes, finishing with

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the painting, later, being packed from the package and later sent to external customers. However, they are important in buckets like other parts, like other boxes, in both boxes, as in both boxes, which are a problem related to the lack of the sector that contributes to the company.

This aims to assess all the problems presented by the company and the application of solutions so that the work environment is optimized for everyone's safety, considering the consideration of all employees. And specific, the proportion of work support focused on the sector of the use of tools directed to the sector based on the pillars and communication of KPI's programs for better control, notes and increase of productivity and benefits conditions of use.

A work methodology focused on research on innovations and on the development of qualitative graphic methods or results tools method, due to the functionality processes and the improvement of sales possibilities in relation to the organization, management monitoring.

2 Theoretical Reference

2.1 Quality Management

According to Carpinetti [2], the management of quality characteristics is important for managers in the analysis and assessment of consumer needs. I also emphasize that until the middle of the last century, quality management focused only on production and control of production results, limited to manufacturing processes.

For Saremi et al. [3], an improved quality management system is a form of competitive advantage, optimizing the entire process of improving products and services.

Corredor & Goñi [4] explain that quality management is a viable and concrete alternative in the search for improving organizational performance.

According to Oliveira [5], it is essential to develop and implement management management, in order to guarantee quality in organizations with the objective of achieving excellence in the company's products, improving their continuous improvement.

Juran & Gryna [6], comment that the adequacy and organized execution of a quality program in organizations will result in significant improvements in terms of efficiency, safety, quality control and managerial performance.

According to Idrogo [7], it is part of a set of knowledge that is generated from a base of methods for determining areas such as analysis, strategy and management.

2.2 Continuous Improvement

According to Araújo & Rentes [8], after the Second World War, the industry developed a set of continuous techniques and continuous improvement tools that helped to significantly increase its competition.

Arnaiz, FD et al. [9], identified the Critical Success Factors (CSFs) of continuous improvement projects and how they are perceived by the people directly involved in their management is of vital importance to be able to optimize human and material resources when prioritising actions and to be able to implement measures to ensure the success of these projects.

According to Bhuiyan N & Baghel A. Na [10], knowing the presence or absence of these improvement factors within the organization by whom can be by senior management to anticipate and prioritize successful management projects used as weakest.

Frefer, AA et al. [11] comment that the methodology of continuous improvement allows the conduction of a process of learning and improvement of innovations, acquiring the necessary knowledge to build the process, supported by the conditions of transforming the product with competitive advantage, eliminating waste, reducing costs and time.

2.3 Inventory Control

According to Slack, Chambers and Johnson [12], inventory is nothing more than the stored accumulation of material resources in a production system.

For Klipel [13], the term stock is comprehensive and can be considered as any physical good that is conserved for some period of time. He also comments that there are different types, such as: raw materials, products in process, finished products, among others.

According to Filho [14], programming, planning and control activities have played an important role in effective inventory management, an essential factor to guarantee the quality and reliability of work. He also points out that there are great opportunities for improvement in inventory controls, but that it is necessary to know how to measure them.

2.4 5 SENSES Tool

Silveira [15] explains that the 5S tool is a lean production methodology that, through an organized environment, it is possible to identify problems and generate opportunities for improvement in order to reduce waste and operational resources, generating more income for the company.

The junction of the number "5" with the letter "S" comes from five Japanese words that start with S, Seiri (sense of use), Seiton (sense of organization), Seiso (sense of cleanliness), Seiketsu (sense of patterning) and Shitsuke (sense of discipline). The 5S program works with the following aspects:

Seiri: The main objective of the first stage of the 5S program is to make the work environment more useful and less polluted, both visually and spatially. For this, work objects or materials must be classified according to the frequency with which they are used, reorganizing them or placing them in a properly organized disposal area.

Seiton: The focus of this phase is on simplification by giving less used objects a place where they are organized and labeled, streamlining processes and saving time.

Seiso: This phase consists of cleaning and investigating the workplace in search of routines that generate dirt or imperfections. Any element that may cause any disturbance or discomfort (such as a bad smell, lighting failures or noise) must be repaired.

Seiktsu: This phase consists of maintaining a cleaner environment, there are great chances that employees will also seek greater care with their appearance and personal health, ensuring even more balance and good performance at work.

Shitsuke: This stage focuses on discipline, which can be considered the key point of 5S, it exists when everyone plays their role in improving the work environment.

2.5 Key Performance Indicators (KPI's) and Tool 5H2H

For Castro [16], KPIs are indicators chosen by the company itself, which measure the performance of management processes and allow the evaluation of progress of operations in relation to the defined objectives.

Fiore & Alencar [17], explains that performance indicators assist in decision making in several areas, providing information for the company to decide to maintain, modify or abort activities or the project as a whole.

According to Pinna et al. [18], particularly, the customer-oriented factor has the effect of reducing the importance to increase the agility of the supply chain and, particularly, "introducing a new product.

5W2H is defined as a tool used for each task by its employees. Through organization and good planning, you can create a spreadsheet with all the information collected by brainstorming. The following questions are added to the 5W2H tool: What, Who, When, Where, Why, How and How Much.

According to Polacinski [19], this tool consists of pre-established activities that need to be complemented with greater functionality such as a mapping of these activities. It also aims to answer seven questions and organize them. The intention of the spreadsheet is also to merge the sector team and make companionship and proactiveness encompass both.

3 Methodology

The methodology of the work used the quantitative method through research tools developing graphs of results, and the qualitative method seeking to diagnose possible points of improvement in the studied organization. A flowchart was developed to guide the application of the tools in this study, Fig. 1.

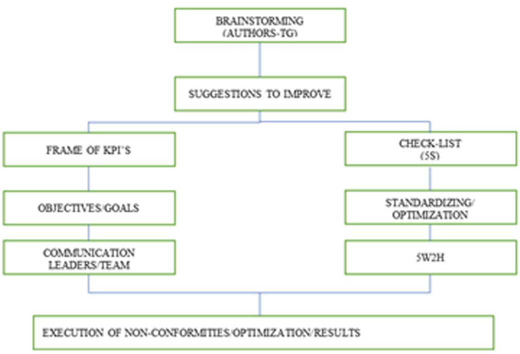


Fig. 1. The flowchart presents organization, planning, orientation of phases, application of tools to obtain proposals for improvements and optimizations in the sector. (Source: Authors, 2022).

The study was developed in a company of the automotive sector, located in the region of Vale do Paraíba in the interior of the State of São Paulo.

4 Results and Discussion

4.1 Check List

The checklist elaborated was based on the pillars of the 5S program, Table 1.

With the implementation of the checklist, several points of improvement were observed, where they were recorded as shown in Fig. 2(a) and (b).

The second factor occurred when the can buckets have two-way fittings, being stored in the same place. The main problem was that the buckets did not fit together, which could cause an incident, or even a serious accident, if a fall occurred between them, Fig. 3(a) and (b).

The third and last problem highlighted was that there were many people inside the stock to remove the parts when assembling the kits and, as they did not have an adequate place to store the cards, it was very difficult for the card to arrive at the assembly, Fig. 4(a) and (b).

To improve the process, a panel with input and output for storing cards was developed. With this, the information necessary to understand the work of the assemblers assigned to the cards is left at the entrance so that they can pick up the card and proceed with their work. After completing all the assembly of the kit, the assembler returns to the board and places the card at the exit, waiting for his team to come and remove the assembled cart, along with the card signed by the stock controllers.

4.2 Key Performance Indicators – KPI's

The developed KPI panel aims to facilitate and improve communication between the team, with exclusive criteria in addition to suggestions for improvements indicated by employee, Fig. 5.

Dashboard was divided by three indicators to volume, with an appropriate space for enhancements, all trademarks for enhancements, all were registered by three indicators to volume.

4.3 Key Performance Indicators – (KPI's) Analysis and Improvement Opportunities

This indicator was developed to control the buckets used in the sector with a focus on balancing the quantities of stacked buckets, ending an acceptance target of 5 stacked units, Fig. 6.

Table 1. Table captions should be placed above the tables.

CHECK LIST PROGRAM 5S		
Responsible:		Date:
Subtitle: C= COMFORM NC= NO COMFORM		
1°S SEIRI - Use	**C/NC**	**REMARKS**
Items to evaluate		
1-Are all the components in the correct amount?		Inventory.
2-Is there non-conforming material in the workplace?		Transfer to the proper location.
3- is the visual aspect pleasant?		Assign a better organization in general.
4-Do employees try to discard unnecessary material so that there is no accumulation?		All material that is not suitable for stock must be discarded.
5- Are there any air, water, oil, or power leaks?		Verification of the whole environment.
2° SEITON- ORGANIZATION	**C/NC**	**REMARKS**
Items to evaluate		
6- Are there materials spread out in the corridors, floor, table, etc?		Routine organization in general.
7- Are the materials well stored, free from deterioration, oxidation, moisture, falls, and are they identified?		In case of rain, cover with bubble wrap.
8-Are the materials in proper and well-located places, facilitating their access?		Adaptation of component identification.
9- In general, is the visual aspect of the sector organized?		Verification of the entire environment in order that it is appropriate for the beginning of the workday.
10-At the end of the day, is the organization standard maintained?		Set aside 10 final minutes for the completion of which a fine-tooth comb was made in the area.
3° SEISO- CLEANING	**C/NC**	**REMARKS**
Items to evaluate		
11- Are there equipment, utensils, tools, devices, dirty or in poor condition?		Oxidized, deformed parts, printers and computers in good condition.
12- Is there oil, water or chemical spilled on the floor?		If this happens, clean it with a cloth and water.
13- Are the existing products in the process dirty to the point of harming or compromising their quality?		Do not leave the internal transport trolleys full of oil or dirt, clean the buckets for storing parts.
14- Is there garbage in general scattered on the floor?		Garbage bags, cardboard.
15- Do walls and equipment in general need maintenance or cleaning?		Check shelves, equipment, warped buckets.
4° S SEIKETSU - HEALTH	**C/NC**	**REMARKS**
Items to evaluate		
16- Are the lamps, luminaires then clean and working?		Checking area lighting.
17- Are the uniforms clean and appropriate for the sector?		Maintain individual cleanliness.
18- Do the employees ensure the cleanliness of their work environment?		Always maintain discipline in all aspects so that there is a collective result.
5° S SHITSUK - SELF-DISCIPLINE	**C/NC**	**REMARKS**
Items to evaluate		
19- Are the system information being used and are the records up to date?		If necessary, apply a fix.
20- In the workplace, are all conditions safe, free of accidents?		Boxes, parts, irregular shelves.
21- Are there conditions for signs, accessories or items that add to the general control of the sector?		Identify all processes within the area.
22- In general, does the sector give the impression of being a disciplined environment?		Team when it has the same objective, the result will be satisfactory to all.

(Source: Authors, 2022).

Before (a) After (b)

Fig. 2. (a) and (b). Cardboard For the entire Internal Assembly Process. (Source: Authors, 2022).

Before (a) After (b)

Fig. 3. (a) and (b). Suitable place for buckets. (Source: Authors, 2022).

Before (a) After (b)

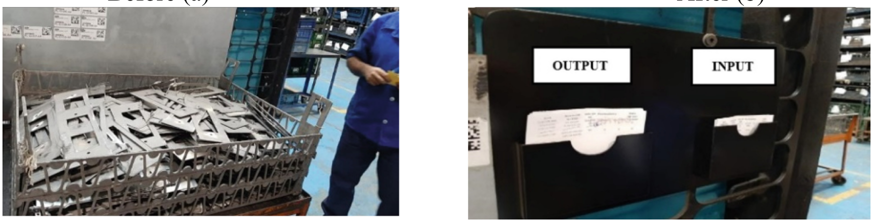


Fig. 4. (a) and (b). Cardboard for Input and Output Kit Assembly. (Source: Authors, 2022).

Another factor, observed with the application of the work, it was identified that the sector had the need to acquire its own equipment to transport buckets and materials from the sector, as this equipment was borrowed from other sectors, causing delay in the execution of the work. Given this scenario, a KPI was also created to perform the time dimensioning to analyze the degree of importance for the acquisition of equipment for the sector.

Waiting time indicator for each request for equipment in the sector, with an acceptable time of a maximum of 40 min, due to the evolution of equipment that are forklifts and electric pallet trucks that are involved in other processes, Fig. 7 (Fig. 8).

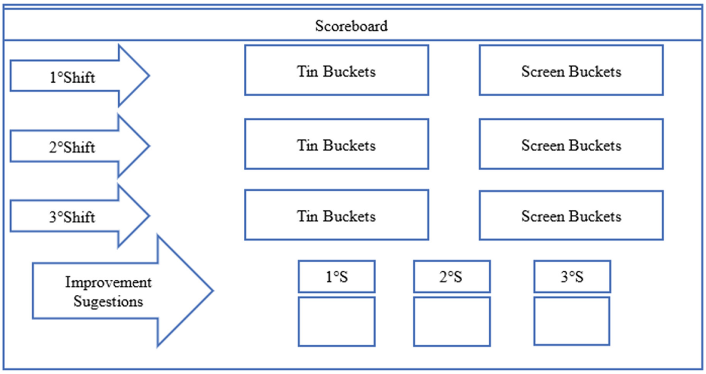


Fig. 5. Sequencing of the Development of the Panel Project with the data the KPI's. (Source: Authors, 2022).

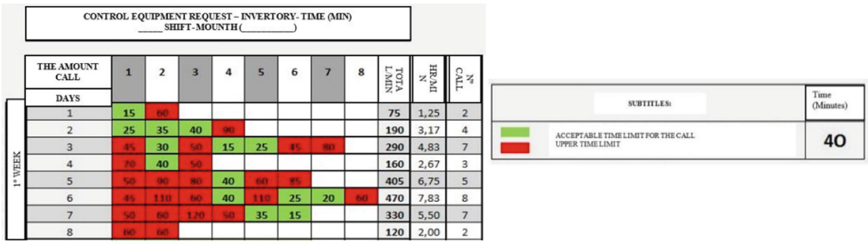

CONTROL SCREEN BUCKETS IN STOCK
_______SHIFT-MONTH (________________)

The Amount / Days	1	2	3	4	5	6	7	8	TOTAL
1									5
2									5
3									4
4									7
5									5
6									8
7									5
8									3

1° Week

SUBTITLES
LIMIT UP TO 4 IN THE SECTOR
ACCEPTABLE LIMIT OF UF TO 5 IN THE INDUSTRY
UPPER BOUND 5 IN THE SECTOR

Fig. 6. Key Performance Indicators (KPI's), Bucket control indicator. (Source: Authors, 2022).


CONTROL EQUIPMENT REQUEST – INVERTORY- TIME (MIN)
_____ SHIFT-MOUNTH (__________)

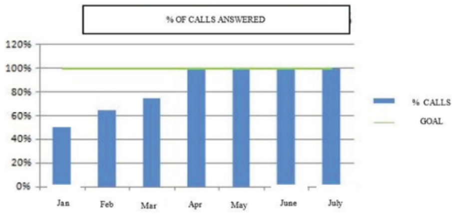
THE AMOUNT CALL / DAYS	1	2	3	4	5	6	7	8	TOTA L/MIN	HR/MI N	N° CALL
1	15	60							75	1,25	2
2	25	35	40	90					190	3,17	4
3	45	30	50	15	25	45	80		290	4,83	7
4	70	40	50						160	2,67	3
5	50	90	80	40	60	85			405	6,75	5
6	45	110	60	40	110	25	20	60	470	7,83	8
7	50	60	120	50	35	15			330	5,50	7
8	60	60							120	2,00	2

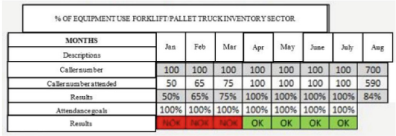
1° WEEK

SUBTITLES:	Time (Minutes)
ACCEPTABLE TIME LIMIT FOR THE CALL UPPER TIME LIMIT	40

Fig. 7. Key Performance Indicators (KPI's), request wait times in minutes. (Source: Authors, 2022).

In the image above, it is possible to objectively visualize difficulties encountered in the sector in the service of the requested equipment, evidencing some moments that services are not carried out. Through the initial notes, results in the sequence were becoming positive, compared to the previous numbers.





% OF EQUIPMENT USE FORKLIFT/PALLET TRUCK INVENTORY SECTOR

MONTHS / Descriptions	Jan	Feb	Mar	Apr	May	June	July	Aug
Caller number	100	100	100	100	100	100	100	700
Caller number attended	50	65	75	100	100	100	100	590
Results	50%	65%	75%	100%	100%	100%	100%	84%
Attendance goals	100%	100%	100%	100%	100%	100%	100%	
Results	NOK	NOK	NOK	OK	OK	OK	OK	

Fig. 8. Key Performance Indicators (KPI's) of call numbers and their percentages. (Source: Authors, 2022).

5 Conclusion

It is concluded that, according to the previously established objectives, this work contributes to the development of an economically viable and standardized inventory management in the inventory sector in the company studied.

With the execution of the work, it was also realized how important it is to carefully select the quality tools, so that they are truly useful in surveying opportunities for improvement, considering the needs and priorities of the sector.

As a scientific contribution, this article will serve as a basis for further studies so that other authors can replicate the quality tools used here, in addition to helping other managers in their use in their respective companies.

Finally, in order for the implemented improvements to be improved and to be effective over time, the company's area must be monitored monthly by the manager, making updates whenever necessary, in a flow of continuous improvement.

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The Circular Economy in the Perspective of Sustainable Joinery: Product Development and Design

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Abstract. This article explores the concept of the circular economy based on the use, as base material, of wood residues from the production process of a company that operates in the hygiene and cleaning products sector based at the Manaus Industrial Pole. These residues feed the manufacturing process of a Sustainable Joinery, which, in turn, manufactures custom products, as well as those from its catalog. It is intended to explore the manufacturing process in the context of the pillars of the circular economy. The methodology of this work consisted of exploring the stages of its manufacturing process, the process flows, the chain involved, and the waste management of this process. In this study, the life cycle stages of raw material supply and end-of-life pathways of wooden pallets were assessed environmentally from different perspectives with lifecycle assessment (LCA). In addition, it reveals the potential to be explored in the region due to the economic opportunities and social and environmental impacts since, considering only the year 2019, 21 tons of wood were reprocessed, representing an average monthly revenue in the order of $5,000. Moreover, it was possible to create new products from residues of the process and to make possible earns from that.

Keywords: Circular Economy · Joinery · Sustainable Joinery

1 Introduction

With the advent of new technologies and increasing demand for products, our linear economic model becomes unsustainable and puts the survival of future generations at risk, given that we live on a planet with finite resources. In this way, a counterpoint is created to question the progressive model of development that, for many years, was disseminated in the form of a right for all without, however, assessing the excessive exploitation of natural resources, with the consequence of the commitment to the environment.

In addition, we are a population that does not receive adequate education and training to minimize damage to the environment due to our current lifestyle. Because of this, it is

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necessary to use natural resources responsibly, mitigating their extraction and promoting the use of waste generated as raw material for new products.

The increase in the world population and its concentration in large cities has resulted in the growing demand for products on a large scale, together with the lack of a holistic view on the part of the government, leading to a time of economic losses, causing negative natural impacts [1]. Indeed, the population needs to be educated based on new paradigms, mainly about their responsibility to the environment, the consequences of consumption, and the need to minimize waste generation.

According to the report on Waste Management in Latin America and the Caribbean, the generation of solid waste in this region tends to increase considerably, from 541,000 tons per day, resulting in an average of 1 kg per day per person in 2014. It is estimated to reach 670,000 tons a day by the year 2050, that is, an increase of 25% in our waste generation [2]. This prediction puts society in a serious situation, as we are leaving liability for environmental degradation for future generations, greatly compromising the necessary natural resources that maintain an ecosystem on Earth and guarantee a full and healthy life.

The transversal concepts between Sustainability and Circular Economy [3] particularly those that relate the premises of the circular economy - reuse, remanufacturing, and recycling, with the sustainable development objectives of United Nations Organizations [4] - industry, innovation and infrastructure, sustainable cities and communities, responsible consumption, and production, has been the greatest challenge for the modern world. In addition, a great paradigm, as part of the premise of finding a balance between the economy of a country and the lifestyle of people.

Moreover, actions for the other areas foreseen by government agencies are interconnected insofar as they have a cascading effect, one in relation to the others, such as the search for cleaner solutions in the manufacturing industries in general and services, interconnected with industry 4.0 initiatives and reverse logistics [5, 6]. Actions in search of sustainable cities that will impact the better use of water, and soil, the search for energy efficiency, clean energy, and reduction of the emission of polluting agents in the environment [7–9].

In innovation, when looking for new uses, new materials, increased product reliability, and development of new products with a sustainable footprint [10–13]. In education, when looking for a new way of thinking and acting responsibly regarding our consumption and behavioral patterns and their effects on the social chain [14–16].

In many countries, the counterpoint to all these initiatives is still found in the barriers related to legislation [17–19]. The economic interests or the preservation of their market, and with the growing discussion of how to reconcile sustainable development with new forms of production and habit consumption with a focus on the preservation of resources and the environment, become facts that are in the process of improvement [20–22].

This research addresses the specific problem of the management of wood waste faced by a large multinational industry that operates in the industrial pole of Manaus-Amazonas, in the sector of cleaning products. It intends to present the actions related to the performance of a small company called Sustainable Joinery, which uses the disposal of wooden supports as food for its manufacturing process.

The joinery focuses on the manufacture of various wooden products, either on-demand or from its portfolio, formed based on the order history, exploring the premises of the Circular Economy, giving sustainable disposal to the waste of its partner as well as to its waste. In addition, it intends to conceptualize its role in the generation of jobs and income based on the vision of sustainable production as a model for the viability of new extracts of economic performance with less impact on the environment. The study of the logistics chain, from the moment of wood discarding in the industry, going through the entire production process, processing, and finishing of wood to transform into products, concluding with the delivery of a quality product/service to customers, using the recycling process is an object to be explored in this work.

2 Literature Review

2.1 Circular Economy

Since industrialization appeared, our production processes have been conceived in a linear way, where the raw material of nature is extracted, and good is produced from it and, after use-consumption, it is generally discarded into the environment. In addition to this cycle of use, there is the disposal of waste arising from the production process of this consumer good, as well as after its use and disposal.

The use of this systematic part of the unreal premise that nature is an inexhaustible source of natural resources and, as consumption increases, there is also a systematic increase in the extraction of natural resources and consequently, generated waste. In this sense, as pointed out by [23], the linear economy, derived from previous industrial revolutions, and based on the extraction of production and disposal, is gradually being replaced by the circular economy.

Furthermore, [24] maintain that there is already a consensus that we are going through a period of severe depletion of our natural resources and that the current linear socioeconomic system, characterized by the disposal of the product at the end of the product's useful life, is one of the main causes of this natural depletion.

The main concept of the circular economy is to eliminate the term waste. What was previously considered waste must now be seen as a raw material for another process, and this must be maintained continuously in a closed cycle. In effect, from a new perspective, from waste to resources, we have a new open economic field with the potential to be used for a new process or product.

Therefore, the circular economy is based on optimizing the flow of goods, maximizing natural resources, and minimizing waste production, with the creation of value, movement from one production chain to another, and the creation of a new economic flow with impacts across the social spectrum [25–27]. In addition, actions related to the circular economy are not limited only to industrial processes but also to service processes and other different business models, as pointed out by some researchers [28–30].

2.2 Sustainability and Wood Sector

According to the UN, sustainable development designates an economic model that seeks to reconcile economic development with the preservation and maintenance of available natural resources. That is, it is defined as "that which meets the present needs, without compromising the capacity of future generations to meet your own needs" [4, 31]. In this sense, the principle of sustainability proposes that economic growth should not lead to environmental degradation or the depletion of natural resources.

Regarding the processes that use wood as raw material, the scarcity of natural resources and the generation of waste without a proper destination are worldwide concerns related to the linear production model [32]. Although it is considered a renewable resource, the speed at which forests have been explored, not following the natural cycle of some species, places this resource at a high degree of risk.

In their studies on the impact of wood waste on Australian furniture industries, [33] show that around 7 to 50% of material is not used in the production process. This total is becoming waste and points to greater awareness of the use of this resource, in addition to emphasizing the costs resulting from such waste and alternatives for recycling and better destination of the generated waste.

In the context of the reuse, remanufacturing, and recycling approach, [23] points out that remanufacturing, for example, enables sustainability and economy without compromising the quality and durability of a product. The potential of reducing waste in manufacturing processes, in which the resource is wood, reveals a range of possibilities for using the generated waste [34, 35].

Applications from power generation [36, 37], composite material [38, 39], and managing construction [40, 41] are some of the ways to apply the 3R principles to wood waste.

3 Methodology

Based on LCA analysis, the methodological path developed in this work consisted of an exploratory approach to the flows related to the Sustainable Joinery production process, from the acquisition of the raw material, the logistics involved, the manufacturing process, and the distribution of finished products and the disposal of its own waste. In this study, the life cycle stages of raw material supply and end-of-life pathways of wooden pallets were assessed environmentally from different perspectives with lifecycle assessment (LCA).

Therefore, it is a case study on the management of solid waste that is generated from the productive activity of the company Sustainable Joinery. For a better understanding of the process, it was necessary to create a chain flow showing all the actors involved and their participation, with the aim of explaining how the circular economy flows as well as the generation of waste in the sustainable joinery production chain. An action plan for the correct disposal of company waste can be carried out. The period covered comprises the years 2016 to 2019.

The joinery develops a partnership with a multinational company in the chemical sector that operates in the Industrial Pole of Manaus (PIM), which supplies discarded wooden pallets from its process. Data collection took place from the input control worksheet of the company studied and the volumes of pallets collected monthly, totaling about 74 tons for the period reported in this study.

The products manufactured in the joinery are consumable items, decorations, and furniture that have pine wood (*Pinus Elliottii*, *Pine-American Wood,* and *Pine Wood*) as the main raw material, residue from the manufacturing process of an installed American multinational chemical industry at the Manaus Industrial Pole, which has sustainability as one of its strongest pillars.

This company acts to promote the circular economy, and its main objective is to enable a more accelerated transition to the circular economy, where it establishes this theme as an agenda in the agendas of the three main axes: government, private companies, and academia. In this context, it acts following the main principles of the Circular economy when it promotes the activity of recycling its waste through the company Sustainable Joinery, placing as one of its main pillars the promotion of circular business initiatives.

4 Results

From 2016 to 2019, approximately 74 tons of wood waste were collected, sent by the partner company to the company Sustainable Joinery, with collections being carried out monthly.

All production processes, direct and indirect, were considered in this survey concerning the generation and destination of solid waste from the company Sustainable Joinery, not considering the reverse post-consumption channels. To guide this work, some questions related to the activities of sustainable carpentry were considered, whose main objective is to operate as directing questions for the analysis and discussions of the collected data:

- What residues are generated in each link in the Sustainable Joinery chain?
- Are they dangerous? If so, what are the dangers they pose?
- Are there possibilities for treatment, appropriate disposal, or reinsertion into the production cycle?

Regarding the destination of the waste generated in the process, these occur at different levels, ranging from the sending of solid material for recycling at the Association for Recycling and Environmental Preservation (ARPA) to the collection company Residue Celeste, which produces fertilizers, as well as sent for composting to the vivarium of the Federal University of Amazonas (UFAM). Inorganic materials and wood scraps are in the process of developing actions for their proper disposal and, for now, they are destined for the city's landfill.

Below we detail the types of waste generated in the production process:

- Sawdust: waste is generated in the planning process, commonly called sawdust, which for Sustainable Joinery has no significant economic value, as it is a waste from its production process that needs to be discarded, and for this to be done, it generates a cost of cleaning the joinery. This organic residue with no commercial value for the joinery is destined for the vivarium of the Federal University of Amazonas, which has the activities of creating mice experimentation for application in scientific research of students who are starting scientific research in undergraduate courses as well as master students. Doctoral students. Following the company's principles of staying in the loop of the circular economy, since the beginning of supply, which dates from Feb/19 to the present day, 30 sawdust bags with an average of 2.5 kg were supplied, totaling the amount of 75 kg of sawdust correctly.

- Dust of wood: a residue generated in the sanding-cutting processes. For every 10 kg of sawn wood, an amount of 50 g of sawdust is generated, totaling the amount of 230 kg of sawdust generated.
- Wood chips: waste generated during the production process in two moments, the first, in the beneficiation process called "Cut to Width" and at the time of assembly "Tracer," where the wood is cut to the correct sizes for the process of assembling the items.
- Wood chips with a staple: waste generated at the beginning of the process, when the wooden structures are disassembled, and the staple shavings are taken from the slats so that they follow the process, this being the first process of wood processing to be transformed into material for use. It is a product that also follows the line of organic waste and cannot be reduced since it is part of the wood that needs to be removed for processing. Despite being wooden stumps, they are contaminated with metal staples, which make them inorganic.
- Plastic Packaging: the main generation of plastic waste is glue packaging, both white and yellow, used in the item assembly process. Conduct, as bags and packaging of consumable materials, are to ARPA - Association of Recycling and Environmental Preservation for a new production cycle.
- Cardboard Packaging: generated from the purchase of screws that come in boxes, and when the goods are delivered to the joinery, larger boxes come packing small items in a box to characterize a volume. The volume of this material is very small, and this item is also destined for the collector available in the joinery. Later it is sent to ARPA - Association of Recycling and Environmental Preservation for a new production cycle.
- Metal Packaging: generated from the consumption of chemical items for finishing the joinery products that are Thinner and Sealer, the same when finished are also destined to ARPA - Association of Recycling and Environmental Preservation for a new production cycle.

The company's product portfolio is based on a production plan based on customer demand (generally using customization and in-house ideas) and, for high-demand products from its portfolio, based on sales history.

The evaluation of the company's manufacturing process allowed identifying opportunities for improvement in its processes. It consisted of disciplining its production flow based on demand, organizing its portfolio, and systematizing processes.

In addition, it allowed the development of actions concerning waste from its processes, such as the correct destination of sandpaper, wood scraps, sawdust, and cans of paint and thinner.

5 Conclusion

Maintaining the production system based on the linear economy as a standard result in two major problems. First, our natural resources are finite, and consequently, their irresponsible use will put future generations at risk; second, we have a high generation of waste, both in the production of goods and in post-consumption, which is disposed of inappropriately in the environment.

Considering the volume of waste treated by the company Sustainable Joinery the impact on the economic chain is quite relevant, as it can generate six (6) direct jobs and foster employability with its partners. In addition, the waste sent to companies that belong to this loop also contributes to the generation of jobs and income in the community.

The average monthly revenue calculated in 2019 was U $5,000, which reflects the importance and the economic and social impact of these initiatives. In this sense, the reflection takes place concerning the high volume of waste generated in all industrial centers and the potential economic reflexes should this circular system become reality and a natural part of the region's economic cycle.

In addition, a new economic matrix is projected, based on sustainability and efficiency, promoting actions that reduce or eliminate waste and its impact on the environment and promote new consumption habits. It is in this context that Sustainable Joinery is found, seeking to be an agent for transforming the social fabric and promoting good production practices.

Although there are controversies about sustainable models using wood as a raw material, where there is no common sense among researchers, it is important to emphasize the importance of the chain involved and for the processes the premises recommended by the circular economy since it affects in the application of the 3R's concepts (reduce, recycle and reuse), since the practices involved in the presented case study focus on the recycling of material that would be sent to the city dump or another destination (burning of the material), as well as in its reuse to manufacture common-use products, custom applications or even small application development.

The evaluation of the company's manufacturing process allowed identifying opportunities for improvement in its processes. In addition to improvements in the process itself, to be more specific, wood waste gave rise to new products, allowing for the maximization of the use of raw materials and the possibility of increasing revenues, adding value to the woodworking business.

In this context, the leftovers that gave rise to briquettes (ecological coal) are a potential substitute in activities that require wood burning. So, such actions allowed the joinery to have a more circular footprint in its processes.

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The Future of Sustainable Aviation

Fast Hierarchical Bi-criteria Multivehicle Flight Planner for UAV Surveillance Missions

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Abstract. In this work we address the simultaneous flight planning of a fleet of UAVs. This Multi-vehicle routing problem (MVRP) has some particularities, including: the number UAVs used in a given mission has to be minimized, launching and landing sites are coincident; the number of visiting points tends to be large; the routes must be separated and well balanced among the UAVs, to promote collision avoidance and mission completion time, respectively. The resulting bi-criteria (minimum time and minimum total traveled distance) problem is solved by a two-level hierarchical algorithm. In the upper level, the algorithm finds the number of UAVs to be used in the mission and the visiting sites are aggregated into one disjoint balanced set per UAV. In the lower level, all UAV routes are computed in parallel. Although any TSP method might be applied, the authors found the convex hull incremental allocation algorithm of particular interest. The proposed algorithm, implemented in Java SE, is able to distribute up to fifteen hundred way-points among four vehicles and compute the respective routes in less than one second in an off-the-shelf 64 bits i5 processor with 4 GB RAM notebook.

Keywords: Multi-Objective Decision Making · Unmanned Aerial System · Multi-Agent Path Planning

1 Introduction

This work addresses the problem of routing a small fleet of hand-launched UAVs to overflight specific areas in the Amazon rain forest at a minimum time. Typical missions include, but are not restricted to, fire detection, deforestation mitigation, seek-and-track targets, and rescue support. However, it is virtually impossible to recover a small UAV in the deep jungle in the occurrence of failures. Therefore, besides minimizing the execution time, one has also to consider to apply as fewer airplanes as possible to reduce the risks for the fleet. These objectives are clearly conflicting, and the resulting multi-criteria multi-vehicle combinatorial optimization problem constitutes the scope of this paper. An aircraft flight plan is usually defined by a set of way-points in geodesic coordinates. Considering a fleet of UAVs, the flight planning phase may be seen as the vehicles routing

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problem (VRP) [1], known to be NP-Hard. The problem will have to take into account the number of UAVs required to do that mission in a feasible distance and time. Some works solve the problem of VRP using meta-heuristics approaches [2–4]. Despite of the fact that these approaches can provide near-optimal solutions in a feasible time, they demand a large amount of computational effort.

The *k-means* clustering was used by [5–7] as a pre-processing strategy, providing performance gain, and minimizing the complexity of problem. Since the m vehicle route problem is inherently more complex, most of the works are focused on converting it into m decoupled TSPs, which has a large set of well-known near-optimal algorithms [8]. However, these methods tend to produce intersections between the generated paths, which is not acceptable in the present context. To deal with this situation, we developed a clustering method that will result on disjoint sets, promoting non overlapping routes.

The main contributions of this paper are: *i)* a novel formulation of the routing problem of a fleet of vehicles, considering the simultaneous minimization of the number of vehicles and the total mission time; *ii)* a hierarchical approach to balance the load among vehicles while promoting collision free routes.

This paper is organized as follows: Sect. 2 formulates the problem, provides the fundamental concepts, and the related works. Section 3 details the proposed algorithm to address the routing problem, showing the steps towards the solution. Section 4 will present the experimental results. In the last section the authors conclude the paper.

2 The Multi-objective Vehicle Routing Problem (MOVRP)

If one has to overfly an area for surveillance or monitoring missions, probably he will consider the typical zig-zag route. However, such mission profile is not suited for the rain forest, for at least two reasons: 1. The areas-of-interest are too large, comparable to the size of most European countries; 2. Points-of-interest are scattered and separated by hundreds of meters or even kilometers. Therefore, a more efficient approach is to plan the route to overfly all points-of-interest defined as a set of way-points and distributed not to one UAV, but, rather, to a fleet.

Although the VRP problem supports multiples depots [1], usually it assumes that there is one coincident starting and ending point. This problem is a generalization of the well-known traveling salesman problem (TSP) for the case where there is more than one seller. Accordingly, let VRP be defined as an undirected graph $G(V, E)$, where $V = \{0, 1, \ldots, N\}$ is the set of nodes, and $E = \{(i, j) : i < j\}$ the set of edges. Vertex V_0 represents the starting point for all M vehicles, while the other nodes are related to the client's position (e.g., cities, locations). A non-negative cost (distance or time of traveling) c_{ij} is defined for each element in E.

In this paper the authors will work with a multi-objective formulation, combining criteria that capture different aspects of the mission. In general, given a vector of n objectives $J(\cdot) = [J_1(\cdot), J_2(\cdot), \ldots, J_n(\cdot)]$ evaluated over the set S of all feasible solutions $s \in S$, a multi-objective problem may be stated as: $\min_s \mathcal{V}(J(s)), s \in S$, where the Value Function $\mathcal{V}(\cdot)$ incorporates the decision maker preferences about the Pareto Optimal solutions [9]. Among all existing methodologies to define $\mathcal{V}(\cdot)$, either implicit or explicit, we will use the no-preferred approach based on the difference from the vector $J(s)$ to the ideal vector $J_u = [J_{u1}, J_{u2}, \ldots, J_{un}]$ measured by the normalized Euclidean (l_2) norm, or

$$J_{ui} = \min_{s \in S} J_i(s) \text{for all } i = 1, \ldots, n, \tag{1}$$

with

$$\mathcal{V}(s) = \|J(s) - J_u\|^2. \tag{2}$$

Such $\mathcal{V}(\cdot)$ is justified by its simplicity, and the lack of a clear priority among the objectives. To define the set feasible solutions S, let $G(V, E)$ be a graph composed by V vertices and E_{ij} edges with cost c_{ij}, and M be the total number of vehicles in the fleet.

2.1 MOVRP and the Flight Route of UAVs

Then, we formulated the problem of finding a flight route of a fleet of UAV as the following multi-objective problem:

$$\min_{\mathrm{r_k} \in G(V,E)} \|J(r_k) - J_u\|^2 s.t. \tag{3}$$

$$\sum\nolimits_{j=1}^{N} \sum\nolimits_{k=1}^{K} x_{0jk} \leq M \tag{4}$$

$$\sum\nolimits_{j=1}^{N} x_{0jk} = \sum\nolimits_{i=1}^{N} x_{i0k} \leq 1 (k \in U) \tag{5}$$

$$\sum\nolimits_{\substack{j=0 \\ j \neq i}}^{N} \sum\nolimits_{k=1}^{K} x_{ijk} = 1 (i \in T) \tag{6}$$

$$\sum\nolimits_{\substack{i=0 \\ i \neq j}}^{N} \sum\nolimits_{k=1}^{K} x_{ijk} = 1 (j \in T) \tag{7}$$

$$r_k \leq D_k (k \in U) \tag{8}$$

where

- $U = \{1, 2, \ldots, M\}$ is the set of all available UAVs;
- $T = \{1, 2, \ldots, N\}$ is the set of all visiting way-points;
- $V = T \cup \{0\}$ aggregates the launching point 0 (or the depot in the VRP) to the set of visiting way-points;
- D_k is the maximum distance U_k can fly ($k \in U$);
- x_{ijk} are the decision variables, given by:

$$x_{ijk} = \begin{cases} 1 \text{ if } U_k \text{ moves from target } i \in V \text{ to } j \in V, i \neq j \\ \quad 0 \text{ otherwise} \end{cases}$$

and

$$r_k = \sum_{i=1}^{N} \sum_{j=1}^{N} x_{ijk} c_{ijk}$$

is the lenght of the k-th route of the set of K valid routes in graph $G(V, E)$. Constraint (4) ensures that the number of UAVs in the mission (K) is no more than M available in the fleet. Constraint (5) guarantees that every UAV returns to the same launching position at the end of the mission. Constraints (6) and (7) ensure that all and each way-point is visited only once. Constraint (8) ensures that the maximum distance traveled by each UAV will not be exceeded.

In this work we define two optimization criteria:

- J_1: The number of UAV in the mission, to optimize the resources spent to accomplish the mission, which is directly related with the number of vehicles used. Furthermore, in operation scenarios like in the Amazon rainforest, it is important to use as fewer vehicles as possible for at least two reasons: *i)* to reduce the risks, as in the deep jungle it is impossible to recover a missing mini-UAV; *ii)* to reduce the readiness time for the next mission;
- J_2: Mission execution time. For a multiple-vehicle formulation, the mission finishes when the last vehicle returns to the basis. Therefore, the mission execution time is related to the longest route. The minimization of the execution time is a key objective when time is critical, like in rescuing missions, surveillance, fire detection, among others.

Their respective representations are given by:

$$J_1 = \sum\nolimits_{j=1}^{N} \sum\nolimits_{k=1}^{K} x_{0jk}, \quad J_2 = \max_{k \in K} \sum\nolimits_{i=1}^{N} \sum\nolimits_{j=1}^{N} r_{ijk} \tag{9}$$

As mentioned before, the ideal vector J_u is a non-reachable objective vector composed by the minimum of each criterion individually, as if it was the only one to be optimized (Eq. 1). This ideal vector will be set as reference to the current solution. The squared of the Euclidean metric will be used in the Value function. To avoid dimensional issues, we normalized the distance by its respective ideal value. The conflicting between J_1 and J_2 can be understood by considering that, to minimize the mission execution time, less way-points will be applied to each vehicle, and then, more vehicles will have to be launched to visit all way-points, and the total route length tends to increase. It is also worth to mention that, under the assumption of a constant cruiser speed, the bi-objective formulation of J_1 vs. J_2 is correlated to the classical time vs. energy problem. Thus, the Value function $\mathcal{V}(P_i)$ for the MVRP is given by:

$$\mathcal{V}(P_i) = \|J_d\|^2 = w_1 J_{d1}^2 + w_2 J_{d2}^2 \tag{10}$$

were,

$$J_{d2} = (j_2 - J_{u2})/J_{u2} \tag{11}$$

is the normalized deviation of J_2 (the largest convex hull area) to the ideal value J_{u2}, the largest convex hull area when the whole fleet is flying. For J_{d1}, as the ideal value is $k = 1$ (only one UAV flying), the deviation is simply the additional number of UAVs $(K - 1)$. And, w_1 and w_2 are weights to reflect the relative importance between the criteria. We will use the convex combination $w_2 = (1 - w_1)$, $w_1 \in [0, 1]$.

3 Two-Level Hierarchical Approach

The approach divides the solution of Problem 3 into two hierarchical levels (Fig. 1). The upper level decides the K number of routes (and thus vehicles) and the respective points to be visited. The lower level, on its hand, will compute the K routes.

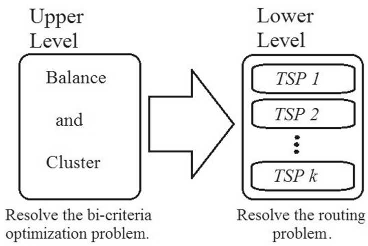

Fig. 1. The two-level hierarchical approach: Upper level solves the bi-criteria problem and balances the way-points among k UAVs. The lower-level computes all k routes.

3.1 Upper Level: Clustering in Polar Coordinate

The Upper-Level algorithm is summarized in the Algorithm 1, below.

$WP = wp_i, i = 1, \ldots, n$, a set of way-points; $wp_0 \leftarrow$ launching point;
$m \leftarrow$ no. of UAVs;
Initialization
Sort WP by its polar coordinate in ascending order, having the larger angle gap as initial point.
Apply k-means to find two clusters of points according to their angles.
Main Loop
Increment the number of clusters and apply *k-means* again.
Compare the sum of the areas of the sets with the previous one.
Keep incrementing the number of clusters until the sum of areas does not present an acceptable improvement.
Return
The last computed clusters of points; The number of clusters.

Algorithm 1. Upper-Level Algorithm

The strategy used to separate the bi-criteria decision making part from the routing process is to modify J_2 to measure the area of the circumscribed convex polygon (convex hull) covered by each vehicle:

$$J_2 = \max_i \{A_i\}, i = 1, \ldots, k \tag{12}$$

were

$$A_i = \frac{1}{2} \sum\nolimits_{j=0}^{P_k - 1} \left(x_{jk} y_{j+1k} - x_{j+1k} y_{jk} \right) \tag{13}$$

is the area of the convex polygon with counterclockwise ordered vertexes P_i formed by the points located in the convex hull of cluster k. In practice, the approach decouples the two levels by parameterizing the route length k with the area of the convex hull of the way-points in the cluster k. The k-means clustering in Cartesian space as in [5] does not prevent overlapped routes. Although for ground vehicles this might not be an issue, in the case of aerial vehicles, collision avoidance is an important aspect to be promoted, especially for fixed-wings UAVs in cruiser speed. In the present application, each UAV will overfly the canopy at a lower (and safer) altitude as possible, and defining different cruiser altitudes is not an option. Therefore, non-overlapping routes are mandatory. To ensure that the resulting flight plans are separated, we worked out an alternative algorithm, clustering the points in polar coordinates using the area of the convex hull as a heuristic to find the best-balanced sets.

Each visiting way-point (Fig. 2a) is defined as the pair heading angle and distance to the launching position. We initialize the algorithm by sorting the way-points counter-clockwise and set as zero the heading angle with the higher difference with its predecessor (Fig. 2b). In practice, we are rotating the space around the launching point and reducing to the minimum the heading span among all way-points. The initial solution is the 1-dimensional *k-means* applied to the angle in the ordered way-points set (Fig. 2c). In doing so, one will find k clusters with best balanced. This initial solution has two advantages; it is quickly computed and it provides a good solution for launching points located in the center or outside the waypoints convex hull, which is a reasonable situation in actual missions (see Section Results for details). The clustering algorithm will interactively reduce the larger convex hull by one point and increase the smaller convex hull by one point (Fig. 2c). This process is repeated until the first regression is shown, when the configuration of the set returns to a previous state. Given that the possible combinations of non-repeatable k clusters pairs is ${}_kC_2$, and a recurrence is said to occur when a previous cluster with the largest convex-hull area becomes the cluster with the smallest convex-hull area, one only needs to store the last ${}_kC_2$ previous states.

3.2 Lower-Level Algorithm: *m*-decoupled TSP's

The lower level will receive as input m disjoint sets of waypoints. Therefore, to compute the routes one can implement and run in parallel any TSP algorithm for each set.

By construction, the clusters are disjoint, thus, each set forms a mutually independent TSP, and its resulting routes do not cross with each other. As each TSP can be solved in parallel. Indeed, we are developing the algorithm to a hand-held Android Tablet based

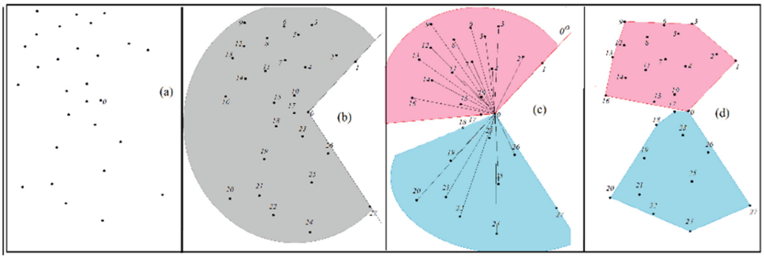

Fig. 2. Upper-level Algorithm: (a) The launching point 0 and the set of 27 visiting way-point; (b) Way-points are ordered counterclockwise, from smaller to larger heading; (c) Headings are clustered by 1D K-means algorithm; (d) Points moves from one cluster to the other to balance the area of the convex hull.

on a Cortex 9 processor with four cores and two-level caches and preliminary results are encouraging.

Any TSP method might be implemented. In this paper we applied the convex hull incremental allocation algorithm, illustrated in Fig. 3 for a set of 16 points and the starting point at 0 (Fig. 3a). The external convex hull is the initial route solution, and the convex hull of the internal points + launching point has the candidate points to be included in the route (Fig. 3b). The selected point is the one that will produce the smallest increasing in the current route according to the triangle inequality computed in the subset of visible segments from the point candidate (Fig. 3c). The visibility subset is found by the sign of the vector product of the triangle sides formed by the candidate point and its candidate segment to be inserted. In Fig. 3c, for point 2, the visible segments are 01 and 13. The minimum gap in the triangle inequality for point 2 is 12 + 23 13. The minimum gap among all points in the internal convex hull is when point 6 is inserted in the cur- rent segment 36 (Fig. 3d). Therefore, 6 is now part of the route, the internal convex hull is closed, starting from its predecessor (point 2) up to its successor (point 12. The procedure continues until there is no internal points left to be evaluated (Fig. 3e).

Although this method does not ensure optimality, it has interesting properties.

- The triangle inequality is computed only for the points located in the internal convex hull and only for the visible segments in the current route;
- Whenever a point is moved from the internal convex hull to the current route, the hull does not need to be computed again, but fixed around the neighborhood of the leaving point;
- The previously computed visibility set and triangle inequality gaps are still valid for those points that are not visible from the new points inserted in the internal convex hull.

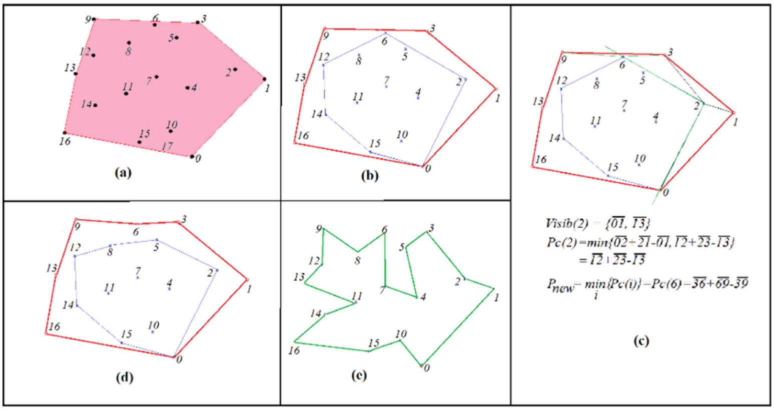

Fig. 3. (a) A balanced set of waypoints; (b) External convex hull, and the internal convex hull of points candidates; (c) Point 2 is candidate to be inserted in its visible segment with the smallest triangular inequality gap (in this case $\overline{13}$). In this interaction, point 6 was inserted in the route, in segment $\overline{39}$; (d) The internal convex-hull is closed with the remaining points; (e) The procedure repeats until there is no internal way-point left.

4 Results

To validate the algorithm, we implemented it in Java SE, JDK 1.8.0 and run on a 64 bits Intel© i5 based notebook with 4GB RAM. First, we evaluated the time spent to distribute 1000, 1500 and 2000 random way-points and compute the TSPs for a fleet of 10 UAVs maximum. The results are presented in Fig. 4. Note that the execution time of one route is around the double of the others. This is explained by the fact that the algorithm cannot benefit from the multicore architecture to execute TSP in parallel. The fluctuation in time execution for $k = 2$ to $k = 10$ is a combination of SMP execution and memory configuration for this specific architecture.

We also validated the using of the convex hull area as a parameter to balance the routes and to decide the number of UAV in the mission. To do so, we investigated the behavior of the trade-off (i.e. Pareto) between the larger convex-hull area and the number of UAVs (i.e. number of clusters), and compared with the behavior of the larger route (after the TSP) for 500, 1000, 1500, 2000 random points. In all cases the shapes of the Pareto curves were highly correlated. In some cases, it is visually impossible to distinguish between both (Fig. 5). This is an important result for the proposed method, as it confirms the suitability of the clustering based on polar coordinates.

Finally, we run some of the data-set benchmarks proposed by [10] and widely used by the scientific community. We compared the proposed methodology (Method 1) with the results of [7] (Method 2) and [5] (Method 3) in Table 1. The optimal clusters are related to the minimum of Eq. (2). It is expected that the coefficient of variation (C.V.) should be larger for the proposed method due to the non-overlapping requirement imposed to the routes. Despite a tighter set of constraints, the C.V. is still in the same order of the other two methods for most cases. Figure 6 shows the resulting routes for 4 selected data-sets. It is important to remember that any TSP algorithm might be implemented in the lower-level. We adopted the one based on the convex hull as starting point due to its interesting branch and cut possibilities.

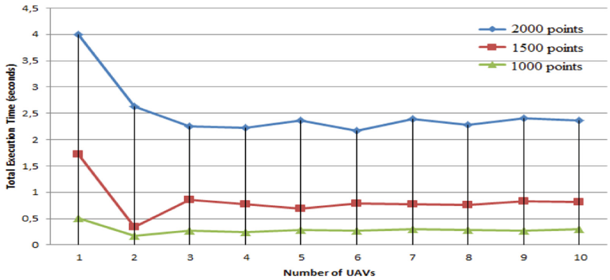

Fig. 4. Execution time of the two-levels algorithm for 1000, 1500 and 2000 points.

Table 1. Comparing results: The proposed method (1); Proposed by [5] (2) and by [7] (3).

Dataset	Cities	Clusters (1)	Clusters (2)	Clusters (3)	C.V. (1)	C.V. (2)	C.V. (3)	Balancing Ratio (1)	Balancing Ratio (2)
A-n33-k5	32	3	2	7	0.076	0.069	0.05	0.88	0.929
P-n55-k15	54	2	2	2	0.088	0.017	0.03	0.88	0.938
P-n60-k15	59	3	2	10	0.014	0.003	0.03	0.97	0.980
A-n64-k9	63	2	2	3	0.10	0.149	0.01	0.98	0.820
P-n76-k4	75	3	2	6	0.042	0.060	0.03	0.92	0.850
P-n101-k4	100	2	2	2	0.12	0.043	0.01	0.83	0.933

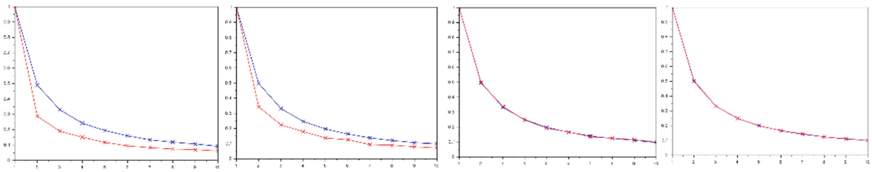

Fig. 5. Pareto curve of convex hull (red) and resulting route length (blue) for different number of points showing the adequacy of the convex hull area metrics to balance the load among UAVs.

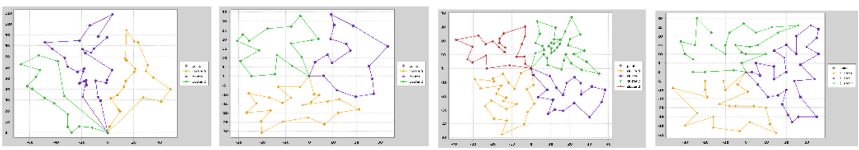

Fig. 6. From left to right, clockwise, the resulting flight routes for the A-n64-k9, P-n55-K15, P-n76-k4 and P-n101-k4 data sets.

5 Conclusion

In this paper we proposed a bi-objective multi-vehicle planner for a fleet of UAVs that minimizes, simultaneously, the number of UAVs applied in a given mission and the estimated mission execution time.

Furthermore, the method promotes the load balancing among the UAVs and separation of the allocated set of visiting way-points. This later property is important as collision free routes are mandatory in our application scenarios.

The method was implemented in two hierarchical levels, being the upper level responsible to resolve the bi-criteria problem, deciding over the number of UAVs and the balanced load. The lower level will implement k decoupled TSPs in parallel. Any TSP algorithm can be used. The two levels are separated by the area of the convex hull, which is closed related to the length of the respective route. The proposed method has an average execution time that outperformed all implementation we tested. The implementation runs in Java SE (JDK 1.8.0).

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Urban Air Mobility (UAM) and the Urban Circulation Space: Evaluation Proposal for the Reduction of Social Inequalities

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Abstract. Urban Air Mobility (UAM) is a disruptive new technology ready to be deployed in the coming years. By reducing travel time and alleviate traffic congestion with low carbon emission using eVTOL small vehicles suitable for intercity low-altitude flights, UAM promises to reshape urban mobility. Expectations are high, as most major players and investors are betting that, in the next decades, large cities in developed countries will have fully operational UAM services for intercity flights. However, in developing countries, this technology will impact the urban circulation space and, depending on the initial policies adopted, can help either to promote solutions to reduce inequalities related to transport or to deepen inequalities even further. This social aspect, despite its relevance, has not been addressed in most part of the related literature, which focuses mainly on technical-functional aspects. In this contribution, we seek to identify key elements in which UAM, as a new modal, could contribute to reduce transport-related inequalities in large cities in developing countries. The present work is the initial part of an ongoing research project dedicated to the study of UAM integration to help reduce social inequalities related to urban mobility.

Keywords: Urban Air Mobility · circulation space · social inequalities

Introduction

One of the biggest challenges facing urban areas today is to overcome the problem of road congestion and overcrowding in urban transport, mainly due to commuting trips, freight transportation and city sprawling. As the demand for travel increases, the tendency is for the service and its supporting infrastructure to deteriorate even further, as policymakers need to meet legal requirements and environmental targets, as well as maintain a balance between the economic and social aspects of their operation. A known fact resulting from the action of transport on the environment, especially in developing countries, refers to social inequality.

This work seeks to analyze this social problem through the evaluation of the impact of transport in the urban circulation space with regard to the function of providing transport services - immediate action - and its action in the organization of urban space -

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mediated influence. This work also aims to analyze how UAM as a new urban transport mode can help to promote effective solutions instead of deepening social inequality. The objective is twofold, first, to alert to the possibility that, once implemented, the UAM framework ends up reinforcing the relationships of dependence and subordination of the less privileged classes, increasing disparity and, therefore, social inequality. Secondly, to highlight the possibility this new modal creates a system of positive feedback between UAM, circulation space and social development, which could make it possible to reduce social disparities. This goal can be achieved by the application of theoretical-methodological references of geographic science, specifically the space theory, with the support of areas related to the humanities and the transport sector itself. All these tools could allow the assessment of the impact of UAM on the social level, as well as guide preventive measures to be considered in future plans for the provision of services for this new mode of transport.

This work is organized as follows. In Sect. 1 is introduced a brief theoretical framework of the discussion on urban mobility. Section 2 presents the justification for this contribution. In Sect. 3 is discussed the relation between UAM and urban circulation space. Section 4 outlines some principles that can help to assess the potential of UAM to reduce inequalities. Finally, in Sect. 5 we present our final remarks.

1 Theoretical Framework

Urban Mobility – related to the displacements in the urban environment, including information on the quantitative and qualitative aspects that affect motorized and non-motorized transport modes. The concept of urban mobility also involves aspects such as the impact of mobility on the economy and society, in order to propose solutions for transport to act positively on the supply and demand of the service. In recent years the impact of sustainable urban mobility has also been included in the central debate of local development issues [1, 2].

Urban Circulation Space – corresponds to the organization of space in order to meet urban mobility needs. As a space, it is linked to its structure and functionality, it is also related to the underlying social and economic interests and to the preference for certain modes of transport [3]. These elements determine dispersion, disparity and diversity of urban land use by different groups and classes of society. The active role of these groups reflects in the urban landscape and consolidates the current geographical space pattern, by reinforcing its oppressive characteristic upon its population, or, by other hand, by releasing the space for the social group that uses it. Within the spatial spectrum of which urban circulation is inserted, geographic space must have the main role of promoting everyone's life in all its potential, not just serving as a simulacrum of reproduction of social production relations.

Urban Air Mobility – the readiness of electric vertical take-off and landing technology, along with high-density batteries and fuel cells allow the design of a new kind of aircraft suitable for urban and suburban low altitude flights. The concept of Urban Air Mobility (UAM), which involves an entire ecosystem built on this type of vehicle, encourages academic researchers, manufacturers and investors to envision a new safe and sustainable air transport system for passengers and cargo in urban environments [4].

According to the World Economic Forum [5], UAM promises to reshape the future of urban transport, with a global market potential of US$74 billion by 2035 [6].

Geographic space - determines the physical and social conditions for the organization of society. It is the necessary substrate for social reproduction, where the structures are set for the development of human activities. Space already has an initial configuration - its primary nature, or "non-domesticated" space, which changes when man interferes to develop his economic activities. However, space does not passively accept the impositions of human actions. Space has a friction that opposes the adversities [7], the changes that society imposes on it, until a certain balance is reached between the imposed and the reactive forces. Geographic space is, therefore, a field of antagonistic forces where actions of socioeconomic groups face each other.

The geographic space as part of the economic structure is selective, as it prioritizes some areas to the detriment of others, centrality areas become attraction hubs and peripheral areas become emission hubs. This spatialization can produce extremes of concentration in some regions and scarcity in others, increasing the distance to different services and opportunities, intensifying locational and social segregation, generating wealth, abundance and valorization in some areas and impoverishment and scarcity in others. This spatial organization, when structured only by economic forces, tends to be configured with a pattern that privileges the dominant forces of the economic system.

Social inequality arises when the prevailing socioeconomic system privileges groups or classes over others, through difficulties imposed on access to facilities or opportunities. Mobility difficulties, due to transport deficiencies, tend to reinforce social inequalities [8], in this process, the dominant forces work to give a natural character to this inequality. This hides the fact that this process comes from unequal conditions crystallized in the socioeconomic space through repeated unconscious practices of citizens that lead to alienation. Lack of participation in key activities has been identified as the main result of social exclusion, to evaluate the impact of urban transport in promoting inequality some techniques have already been introduced in the literature [9].

2 Justification

The numbers show that the urban mobility rate in Brazil, which is around 1.65 trips/inhabitant/day according to ANTP [10], has remained stable in the last decade. Most of this mobility corresponds to private modes in the higher income class, while public and non-motorized modes, which are more affordable, are mainly used by the lower classes. However, in recent years, transportation expenses have increased in the budget of Brazilian families, rising to the second place with 18.1% of the family income [11], according to the 2017–2018 Family Budget Survey. In the budget of families with an income of less than two minimum wages, transportation expenses are in the third position in the ranking (14.6%). The mobility profile of the low-income class shows signs of lack of access. Within a circulation space adapted to corporate and market interests that privileges consumption, especially private motorized modes, these numbers reflect the gap in the cost-benefit ratio of the transport service.

Circulation defines the geographical pattern, as it commands changes in value in space, configuring a spatial pattern of segregation and inequality, since circulation space is selective, differential and complex [7]. The rule on this field of forces is of dispute, because the supply of space is not unlimited, while the demand is varied in a space-time scale. In this competitive scenario, UAM emerges as a potential new field that can help both to mitigate the problem of social inequality or to exacerbate it.

From a capital perspective, expectations are high, as most major players and investors are betting that in the next decades, large cities in developed countries will have fully operational UAM services for intercity flights [6]. However, researchers and consulting firms point out that for this new vision of UAM to become a reality there are some aspects to be overcome, which include the readiness of aircraft technology, the infrastructure and its integration with the ground transport system, the regulatory framework which include the air traffic management, and the social acceptance that may be concerned with the high level of noise emission in the vicinity of residential buildings, with aircraft safety and also with privacy, since most prototypes include sophisticated camera systems for navigation [12]. These are significant barriers that must be overcome primarily by stakeholders and investors.

In any case, the most important feature of UAM is speed, allowing people to move in ways that were previously impossible, which represents an important competitive advantage. Once the initial obstacles are overcome, this mode may provide an increase in circulation flow, a disruptive scenario of commuting. This fact can generate a distortion of forces in favor of social groups capable to use it in detriment of other groups that will not have access to it. To avoid a possible imbalance of forces in a sustainable way, it is important to develop a regulatory framework for this new mode to assure a stable balance of power between groups, so inequality does not intensify even further. Unfortunately, most of the literature related to this specific topic only focuses on the technical-functional aspects of UAM regulation [13].

If the problem is left in the hands of the market, privileged groups will be able to acquire more advantages with this new modal. The benefits for disadvantaged groups will mostly just meet their vital needs. In this scenario, it is essential to establish bases for the study and evaluation of regulatory framework and conditions of - yet unexplored – space of circulation usage to guarantee balanced, social cohesion, and consequently, prosperity for every groups.

3 UAM and Urban Circulation

Geographic Space is composed by form and content [4]. Circulation through this space, in which urban mobility takes place, is the lever of this dynamics. It can be said that space, in its two-way relationship between form and content, has a purpose in itself, as it moves towards an end, a "should be", to achieve goals that will define new and readapted forms and contents. Nonetheless, this space is not inert in the economic-social relations, in the same way that it undergoes the modifications of the imposed forces that modify it, it will also act on these external forces either passively accepting the changes or creating barriers, delaying the readjustment of the form – remorphization - in relation to its content. Therefore, the form of geographic space is not the void. What determines whether relations of domination and inequality prevail, will be the actions carried out in their spatial structures, which are the result of economic-social relations, mediated by the nature of space and by the instances of power and existing historical conditioning [14].

Accordingly, it will be in this space that socioeconomic conditions can act more effectively to reinforce an existing pattern, such as inequality, or seek to curb the pattern of submission to domination and impose a new social logic that acts to mitigate oppression. The urban circulation space suffers from attempts to empty all its social content, so as not to reflect the social inequalities imprinted on it by the spatial organization [15, 16]. It is in this space that the disadvantaged classes can obtain conditions and opportunities to overcome the present barriers to reach access to the same goods and social equipment as the more privileged classes. In this sense UAM has the potential to provide services not only for passenger transport purposes, but also in a wide range of activities including delivery of goods, public security, emergency services, last mile freight, medical services, etc., improving better quality of life [17].

Urban Spatiality and the Demarcation of Inequality
Social inequality can be demarcated geographically, as economic forces establish a process of spatialization in which the interests of the forces of domination locate interests and privileges. The population with lower purchasing power tend to be concentrated in the so-called "peripheral" areas, characterized as neighborhoods far from the urban center or centralities. This periphery lacks a wide variety of services and access opportunities to urban services and equipment, having a lower land value than the more central areas.

The expansion of urban areas together with the processes of segmentation, economic specialization and fragmented geographic expansion [18] - in which some regions become specialized in services such as commerce, health, education - summarize the discriminatory process between centrality and periphery [19]. Services and products of public and social nature also end up being established in privileged regions, which have better offer of transport, making the availability of existing transport and services a determining locational factor. Thus, in the urban configuration, selective valorization followed by the process of segregation of services and commerce in more affluent areas, promotes gentrification [20] in view of the expulsion of lower-income population to peripheral areas.

The difficulty of access can be considered one of the bases of social inequality, in a process that has been intensifying, given that productive and consumerist specialization grows continuously, making it difficult for the peripheral population to access more specialized goods and public services such as education and health.

Reversing the Limited Access Scenario for the Lower-Income Population
It is a fact that a large part of the peripheral population moves for reasons of study or work to areas far from their place of residence. In most cases, these trips allow the population to use the specialized goods and services available in abundance in these centralities, but with the inconvenience of overcrowded trips and strenuous travel time. One way to mitigate this scenario is to design urban circulation for ease and convenience in the temporal and spatial scales of the daily rhythm. This can include access to specialized goods and services through a mode of transport that allows for more daily commutes, while still taking care of mandatory activities such as work and education.

UAM as a Commuter Travel Provider
UAM is a mode of transport capable of crossing intercity distances quickly, this service

could allow the peripheral population access to specialized services, that would otherwise never or rarely be accessed. By providing the right of access under the same conditions as the higher-income population, the service by itself could fight the prejudice of this population to the lack of access. It is in this context that UAM, as a means of high-speed air transport and access facilitator, can help this population to access these services with a frequency and availability that are currently very limited [21].

Methodological Basis

The proposed UAM role to mitigate social inequalities is based on three instances, which form the tripod to assess the system's performance to reduce social inequalities:

1. **Technological:** responsible for evaluating the vehicles technology and the infrastructure needed to make the service feasible. This scope involves aircraft characteristics such as: payload, e-vtol capacity, autonomy, level of environmental impacts and pollution (waste, noise, emissions), cost/km or /weight, standardization, if it is manned or not, and so on. The assessment will also include the air traffic management, the location of the vertiports and vertipods, and services deployed.

   Much of the effort from the academy and industry have been focused in technological aspects such as in aircraft designing [22, 23], airspace management systems (AMS) [13, 24] and the integration with the ground transport system [25, 26], additionally, major aircraft manufactures such as Boeing [27], Airbus [28], Embraer [29], and ride-share companies as UBER [30] are working in conceptualizing the UAM network and designing prototypes to test the technological readiness.
2. **Geographic:** responsible for determining the demand characteristics. It considers the potential users, based on socioeconomic conditions and those determined by the criteria of social inequality; the degree of need for this mode of transport; the morphology and urban structure that may favor the use of UAM, in order to be more adaptable into a unique geographical context; location and distribution of their displacements, with the purpose of establishing a pure or integrated network with other modes of transport [31].
3. **Public Authorities:** responds as a system manager and representative of society. It is responsible for establishing the UAM's regulatory framework in the public interest, establishing the type of services implemented. It will be also responsible for determining the forms of funding. As a result, it will determine the capacity to be offered and establish suitable criteria for distributing this offer. For this, a broad open discussion with stakeholders must take place.

4 Principles and Foundations for the Evaluation of UAM's Operation for Reducing Social Inequality

It is assumed that without adequate planning that includes the needs of the lower income population, the implementation of UAM will strengthen inequality. Thus, to assess the role of UAM as a reducer of inequality, we have to consider:

A) The UAM from a social point of view, should not be limited to only the transport of residents from the periphery to the central areas, but also the other way around. It should be expected that the peripheral space, with the availability of this new modal, can also be equipped with goods and specialized services, which attract the higher income population. This, on the other hand, could increase land costs forcing gentrification of the area, which would imply ejection of the low-income population to even more peripheral areas;
B) Assess existing policies applied to urban mobility, geographic space and circulation, and how these policies impacted inequality. As an example, to evaluate the actions that intensified the mass use of private cars (mode of transport and a fetishized merchandise), and the impact caused in the organization of urban space and its consequences for economic and social development;
C) Rethink a more inclusive circulation space with UAM, providing a better quality of life, combined with aspects of dignity, physical and mental security, justice, and equity; for the fulfillment of citizens' rights and duties, allowing equal opportunities, improving the space of proximity for social cohesion [32], integrated to a broader and accessible UAM network;
D) The UAM needs to offer access to urban equipment and services, distributed within the geographic space in which they are located, providing: 1st) spatial displacement; 2nd) useful on a daily cycle time scale; 3rd) allowing trips to be carried out for various activities within the dailytemporal-spatial scale, for reasons like: work; consumption, health and education, culture, leisure, sport, etc.;

5 Final Considerations

This contribution intends to present possible forms of intervention and evaluation of the UAM modal. Urban Air Mobility as a new urban transport paradigm can bring about a new economic and social order. This role must be agreed with three instances: the scientific-technological basis, the geographical and spatial constraints of a local and global basis; and the action of the public authorities at different levels of regulations. With support from the first two, the third can decide and act based on data, information, subsidies and reliable arguments.

The promotion of social inequality and the possible benefits UAM can provided have been briefly addressed. In general, the use of a theoretical-methodological scope that supports the interventions for a previous adequate organization of the structuring of the UAM network is necessary for a broader analysis. The organization of the system must be followed by the public authorities, interested in the collective well-being, respecting the principles of sustainability and quality of life, mitigating the damage caused by the lack of accessibility space.

The implementation of UAM as a new mode of transport implies a significant investment effort. As such, it will require decisive action, supported by technical-scientific feasibility studies on transport and spatial analysis to ensure a vitally important activity, in accordance with social aspirations to reduce inequalities and promote economic development.

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A Figure of Merit for the Assessment of Electrification in Transport and Vehicle Applications

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Abstract. The purpose of this study is to give an overview of the feasibility of electrification in different domains of vehicles for transportation and construction at a vehicle level. To achieve this an analytical framework for estimating the requirement domain in which a technology combination can be used in a system. Looking at key properties of technologies such as specific energy and power. This results in the definition of a figure of merit in the relationship between performance and cost. In this paper it is used on electric aircraft technologies, i.e., battery electric and hydrogen fuel cell aircraft, on heavy road vehicles and on work machines.

Keywords: Technology assessment · specific energy · critical technology · cost-benefit factor

1 Introduction

A technological system that emits no or very little carbon dioxide is referred to as "carbon-neutral" (CO2 neutral). Indeed, climate change pressures have made it mandatory that an energy-efficient design be entirely based on renewable energy [1, 2]. This is precisely the challenge that designers have faced when attempting to improve the energy efficiency of vehicle systems [3, 4], and to include them is a system of renewable energy. What technologies should be included in the system? How should they be assessed? Because it is perceived as complex and uncertain, this integration is extremely difficult. This is one of the aspects that necessitates efforts at innovation and experimentation in order to reduce risks and increase companies' comfort in the transition process. In this paper the focus is on electrification as a part of a chain needed to implement a society based on fossil free energy, even though it is realized that electrification by itself do not necessarily solve the climate problem unless the source energy is fossil free.

A formal method to estimate the feasibility of a technology for an application area was introduced in [12]. One of the initial premises was that first is necessary to determine the specific set of requirements for the technology. Second, it's critical to understand what kind of system the new technology could be useful for. After examining these questions,

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we proposed a structure for mapping the valid region of requirements that would identify the applications in which a new technology system could be used. Simultaneously, this model should indicate which regions the design would be viable in. Characteristics such as the design parameters associated with key technological capability, application, market segment, and sustainable transition values are highlighted in this process.

It should be noted that electrification is investigated here at a vehicle perspective with respect to the feasibility with the premise that fossil fuel technologies are not viable options or are at least penalized at a level corresponding to their environmental impact. Otherwise, it is hard to compete even at the present fuel prices, since even small differences in cost effectiveness can be decisive. Furthermore, issues related to infrastructure is largely the beyond the scope of this paper.

2 Comparison CO2 Producers in Sweden

To put the applications described here in perspective, the case of Sweden is used since it is an example of a highly industrialized nation. In Table 1 can be noted that flying both national and international, is at about the same levels as cars. Also, this is about the same as the emissions from steel production in Sweden. Work machines, although less, is still about a third of that of road cars, while heavy road transport is at about half that of road cars.

Table 1. Comparison of CO2 producers in Sweden (2019).

CO2 producer	Possible sustainable solution
Swede's flying 2019 approx. 10 million tonnes CO2	Hydrogen (burn or fuel cell)/SAF
Swede's car use 2019 approx. 10 million tonnes CO2	Battery
Heavy road transport 5 million tonnes CO2	Battery/hydrogen fuel cell
Work machines 3.5 million tonnes CO2	Battery/hydrogen fuel cell
Ships to and from Sweden, 8 million tonnes of CO2	Hydrogen (burn or fuel cell)/SAF
SSAB's direct CO2 emissions of 9.8 million tonnes of CO2	Hydrogen

3 Specific Energy and Specific Power

The specific energy and specific energy of the energy and power sources are of critical importance to understand the feasibility of a technology for a certain application. In Table 2 the specific energy of various types of energy storage is shown. It is clear that electric batteries suffer from a huge disadvantage when it comes to specific energy. It is also evident that high pressure hydrogen storage has only about an order of magnitude higher energy density than batteries and falls in a category between diesel and batteries, even though hydrogen has a specific energy almost three times higher than diesel. However, energy density can also be an issue and here hydrogen is at an advantage with a energy density just about a third of that of kerosene (Fig. 1).

Table 2. Specific energy of various types of energy storage.

Type of energy storage	Specific energy [Wh/kg]	Energy density [kW/l]
Diesel (about the same as petrol and kerosene)	12 600	10.7
Battery (Tesla, pack level)	170	0.450
Hydrogen (liquid)	33 000	2.79
Hydrogen high pressure storage (700 bar)	1700–3300	1.5

Table 3. Specific power of various sources of power. (Compilation of data from manufacturers).

Power source	Specific Power [kW/kg]	Efficiency
Truck diesel	0.7	0.4
Petrol engine (with turbo)	1–8	0.25
Turbo shaft engine	6–10	0.5
Electric motor	1–3 (10 peak)	0.95
Fuel cell (incl. syst)	0.5–2	0.5–0.7
Battery	0.4 (2 peak), (2–10C)	0.96
1932 Pratt & Whitney	1.2	0.2

Fig. 1. The effect of specific. The Gee Bee racer from 1932 (left) with a piston engine with 1.2 kW/kg, where the engine is about half of the empty weight of the aircraft, and the Saab 340 (right) with turbo shaft engines with about 8 kW/kg. Both have a comparable top speed of 476 km/h and 502 km/h respectively.

4 Cost Benefit Factor

In Krus and Pereira [12] a framework for technology driven design was introduced. A key concept is the identification of the degree of criticality a technology possess. Three regions were define; critical, technology sensitive and technology comfort zone. If the technology is in the critical region, it is unlikely to be used unless there are no other alternative. It usually means that a technology needs to be developed further in order to be viable. This has very much been the case for e.g., batteries for electric cars, where we have seen dramatic improvement both in performance and, for that application even more important, in cost. As a measure of the degree of criticality, the *cost benefit* factor was introduced and used as a figure of merit. It represents how much it cost to increase a performance attribute in relative terms. I.e., if a performance attribute is to be increased one percent, how many percent will the cost of the whole system increase. This can be expressed as:

$$\kappa_i = k_{0p} k_{0c}^{-1} \left(\frac{x_i}{p} \frac{\partial p}{\partial x_i} \right) \left(\frac{x_i}{c} \frac{\partial c}{\partial x_i} \right)^{-1} \tag{1}$$

Here p is a performance attribute, c is the cost of the system (or in this case, vehicle) and x_i is a design parameter, e.g., the size of a component. k_{0p} is the normalized sensitivity of performance with respect to the design parameter, and k_{0c} is the normalized sensitivity of cost with respect to the design parameter. A definition used is that a system is technology critical if:

$$\kappa = max\ \kappa_i < 1 \tag{2}$$

The *technology comfort zone* is the region where it is easy to select parameters, i.e., the region where the requirements can be met with a comfortable margin. In this region, it is not necessary to particularly optimize the product for performance. Instead, to get a competitive product, other aspects need to be emphasized. In the technology comfort zone, the performance is, more or less, directly proportional to the design parameters. Here, this is defined when the cost benefit factor is more than half an order of magnitude larger than the critical, i.e., $\kappa > 3$. In the region in-between we say that the system is *technology sensitive.*

The assumption made here is that changing the size of a component to change its performance, does not involve any development of the technology as such. For instance, increasing the size of a battery to gain capacity does not imply that the technology is more advanced. However, if the energy density, which is the amount of energy that can be stored in a battery of a given size, can be boosted, this requires an improvement of the technology as such.

5 Applications

The applications chosen for this study where trucks, work machines, and aircraft. These are all areas where massive efforts are being made for electrification. Cars was left out since we already see a massive penetration in some markets already, clearly showing the technical and economic feasibility of electrification. Furthermore, it was also studied in [12].

5.1 Electric Trucks

Long-haul trucks have a rather well-defined work profile. A driver can work for a maximum of 4.5 h and is required to have a 45 min break before the next drive. To have some margin and have a 30 min recharge time means that a charge rate of 2C is required, which is reasonable for the battery technology. However, the problem is the rate of power needed at the charging station, considering that there will be many trucks recharging at the same time. Therefore, hydrogen storage and fuel cells could be an attractive solution at least as a complement. There are already some battery electric trucks on the market, so it will be interesting to see how the charging infrastructure will be developed.

For a typical 40-ton truck in EU the energy consumption is roughly about 1.4 kWh/km [14]. At a speed of 90 km/h this means that during 4.5 h of driving 567 kWh is consumed. The part of the truck that is not payload and battery is assumed to be 13 tons leaving 27 tons for payload. To have some reserves and to not fully deplete the battery, it needs, however, to be larger than that. I.e., only 80% of the capacity should be used. With 710 kWh this means that a battery of about 4170 kg is needed. This is 10.45% of the total weight.

The range can be expressed as:

$$R = \frac{E_b}{F_r} = \frac{m_0 \phi \varsigma_b}{F_r} \tag{3}$$

The normalized sensitivity to performance from the design variable is then

$$k_{0,p} = \frac{x_i}{p}\frac{\partial p}{\partial x_i} = \frac{\phi}{R}\frac{\partial R}{\partial \phi} = \frac{\phi}{\frac{m_0 \phi \varsigma_b}{F_r}}\frac{m_0 \varsigma_b}{F_r} = 1 \tag{4}$$

Here ϕ is the battery fraction and ς_b is the specific energy of the battery. The cost per kg payload, is here simply expressed as the total mass of the vehicle divided with the payload mass. A more elaborate cost model could of course be used, but as first approximation this is used here.

$$c = \frac{m_0}{m_{pay}} \tag{5}$$

The payload can be written as:

$$m_{pay} = m_0(1 - \phi - \beta) \tag{6}$$

where β is the fraction of the total weight excluding payload and batteries. Hence:

$$c = \frac{1}{1 - \phi - \beta} \tag{7}$$

The sensitivity with respect to ϕ is then:

$$k_{0,c} = \frac{x_i}{c}\frac{\partial c}{\partial \phi} = \frac{\phi}{c}\frac{\partial(1/(1-\phi-\beta))}{\partial \phi} = \frac{\phi}{1 - \phi - \beta} \tag{8}$$

This finally yields.

$$\kappa = \frac{k_{0,p}}{k_{0,c}} = \frac{1 - \phi - \beta}{\phi} \tag{9}$$

In this example $\beta = 13/40 = 0.32$ and $\phi = \frac{4170}{40000} = 0.1045$. This finally yields:

$$\kappa = 5.46 \tag{10}$$

This is clearly in the technology comfort zone for batteries i.e., to increase the range 1% only would cost less than 0.2% more (in overall weight). This means that it is plausible to use, even though the load capacity is slightly reduced.

However, to charge the battery 567 kWh in 30 min requires a power of 1.134 MW. As a comparison the state-of-the-art chargers e.g., Tesla Supercharger, can charge 250 kW. In addition, the resting areas for trucks holds a large number of trucks, that all needs to be charged with this power, which means new high-capacity electric infrastructure is needed. An alternative here would therefore be hydrogen and fuel cells. However, it must be considered that using hydrogen as an energy carrier will be several times more expensive than using electricity directly. It should also be noted that we can see autonomous trucks in a couple of years that do not need any rest, other than for recharging the batteries. This means that the requirements will change dramatically.

5.2 Electric Work Machines

Work machines such as excavators and backhoe loaders are comparable to trucks in many ways. The energy consumption of an excavator varies a lot depending on the application but about 10 l diesel/h could be realistic as a typical value of a machine of 15 ton. With a diesel engine efficiency of 30% this means that 1 l diesel corresponds to 3.2 kWh of electric energy. This means that 32 kWh is used per hour. With an 8-h workday and using only 80% of the capacity means that a battery of 320 kWh is needed with a specific energy of 170 Wh/kg for the battery pack, this will result in a battery back of 1900 kg. This is probably an increase in weight of not much more than 1000 kg since the diesel powertrain is replaced. A work machine in general does not have the same kind of weight budget as a truck do with a regulated maximum weight, although there might be limits due to the handling and logistics of the machine. The conclusion is that with the present state of technology a work machine is within the comfort zone for electrification at the vehicle level.

5.3 Electric Aircraft

There is a strong push for electrification of aircraft, no doubt inspired by the success in the automotive sector. However, aircraft are very different in that performance is so dependent of weight.

In [4], it is also argued that electric propulsion is becoming increasingly interesting for larger aircraft. In [6], hybrid propulsion system and pure electric propulsion systems are studied as options for future aircraft. A critical performance parameter for aircraft applications is range. Both references deal with performance calculations including range, but here the simple approach in [5] is used. There are many technical issues to be resolved in order to have electric propulsion in commercial aircraft but perhaps the most critical performance parameter for the aircraft applications is the range. For a battery-powered aircraft, this can be calculated from first principles as:

$$R = \frac{\varsigma_b}{g}\eta\left(\frac{L}{D}\right)\frac{m_b}{m_0} \tag{11}$$

This is very similar to the Breguet range equation except that in the case of fuel, the weight of fuel gradually diminishes during flight. Here ς_b is the specific energy of the battery in J/kg. The takeoff weight (mass) m_0 is: $m_0 = m_e + m_b + m_{pay}$. Where m_{pay} is the payload m_b the battery weight and m_e is the rest of the mass. (L/D) is the aerodynamic efficiency, lift over drag at cruise and η is the propulsive efficiency. Note that the term ς_b/g represents the altitude to which the battery could be lifted if all its energy was converted to potential energy. Introducing:

$$m_b = \phi m_0 \tag{12}$$

Furthermore, introducing the structure weight (empty weight with battery excluded):

$$m_s = \beta m_0 \tag{13}$$

The takeoff weight can be written as:

$$m_0 = m_s + m_b + m_{pay} \tag{14}$$

The payload can be written as:

$$m_{pay} = (1 - \phi - \beta)m_0 \tag{15}$$

Using the battery fraction ϕ as the design variable the range can be written as:

$$R = \eta \frac{k_b}{g} \left(\frac{L}{D} \right) \phi \tag{16}$$

The cost (per kg of transported gods) is considered proportional to the takeoff weight divided by the payload. Again, a more elaborate model could be used but this is not to bas as a first approximation. Hence:

$$c = m_0/m_{pay} = 1/(1 - \phi - \beta) \tag{17}$$

the normalized sensitivity to range (performance) with respect of the design variable ϕ is:

$$k_{0,p} = \frac{x_i}{p} \frac{\partial p}{\partial x_i} = \frac{\phi}{R} \frac{\partial R}{\partial \phi} = \frac{\phi}{\eta \frac{k_b}{g} \left(\frac{L}{D} \right) \phi} \eta \frac{k_b}{g} \left(\frac{L}{D} \right) = 1 \tag{18}$$

The normalized sensitivity to cost is in the same way:

$$k_{0,c} = \frac{x_i}{c} \frac{\partial c}{\partial x_i} = \frac{\phi}{c} \frac{\partial c}{\partial \phi} \frac{\partial c}{\partial x_i} = \frac{\phi}{1/(1 - \phi - \beta)} \frac{\partial (1/(1 - \phi - \beta))}{\partial \phi} = \frac{\phi}{1 - \phi - \beta} \tag{19}$$

Hence

$$\kappa = \frac{k_{0,p}}{k_{0,c}} = \frac{1 - \phi - \beta}{\phi} \tag{20}$$

Solving ϕ for range, κ can be expressed as a function of range, R.

$$R = \frac{\phi\eta(1-\beta)k_b(L/D)}{(\phi+1)g} \tag{21}$$

Here the following data are used. $\beta = 0.4$, $(L/D) = 20$, $\eta = 0.9$ and $g = 9.82$ [m/s^2]. The battery specific energy k_{eb} is here assumed to evolve over time with an increase of 5% every year. According to (Misra, 2018) a more optimistic view on the development of power density driven by the need in aerospace, could be expected. However, this is very difficult to predict but looking at historical data it is not an unreasonable assumption to use 5% per year. As a starting point a value of 200 Wh/kg (720 kJ) at pack level is assumed in 2022.

$$k_b = 720000 \times 1.05^{y-2022} \tag{22}$$

As can be seen, if the battery weight is increased beyond a certain point the design will leave the comfort zone and at some point, it turns into a critical technology. In order to investigate the criticality of the technology, typical values representative of some of the best aircraft in operation are used in the equation. Using these values means that other technologies are also kept within their comfort zone. Here $\varsigma_b = 200$ Wh/kg at pack level for 2022 is assumed, (corresponding li-ion technology batteries of Tesla), the propulsive effectiveness, $\eta = 0.9$, the aerodynamic efficiency, $(L/D) = 20$. An increase in (L/D) would directly affect the range, but it would also mean leaving the technology comfort zone of aerodynamic design, since (L/D) of already 19 already represents very good commercial aircraft. The structural fraction $\beta = 0.4$. Even though all of these values can be improved they can only be so incrementally and are already represents highly optimized technologies.

The plot in Fig. 2 shows the normalized sensitivity. It should also be noted that the range is the maximum range without any reserve, that would be necessary for operation. Another performance that is of interest is the cruise speed. The cruise speed is highly dependent on engine power, but power also drives weight which in turn increases drag. Therefore, the specific power of the power plant can become critical. Looking at Table 3 it is clear that a combination of fuel cells and electric motors that is needed to convert hydrogen into propulsive power has a specific power that is not more than a piston engine, which severely limits the achievable cruise speed to of the pre-gas turbine era.

It is clear from the Fig. 2 that battery electric aircraft for the foreseeable future is practical only for very short missions. Electric fuel-cell aircraft powered by high pressure hydrogen can have a more practical range and could be used for short and medium range. For longer range hydrogen in cryogenic tanks could be used and burn the hydrogen directly in gas turbines instead to achieve a higher specific power for higher performance. For long range, the low volumetric density of hydrogen starts to become a problem and some other sustainable aviation fuel is needed. This shows that from the applications that have been investigated, aviation is by far the most difficult to electrify.

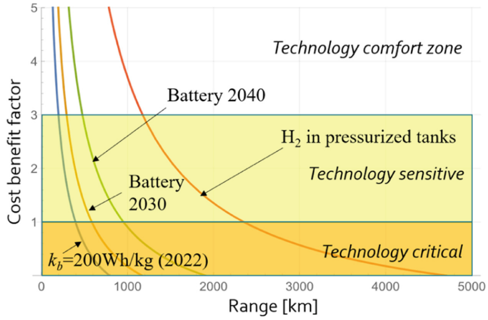

Fig. 2. The cost benefit factor as a function of theoretical range of electric aircraft, with batteries at (today) 2022 and forecasted values for 2030 and 2040 and for hydrogen in pressurized tanks.

6 Conclusions

In this paper an analytical method to assess feasibility of electrification, based on cost-benefit factor as a figure of merit, is described. It is used on a range of applications that have considerable CO2-foot prints. There is already a very quick penetration of electric cars in the market, especially in Europe e.g., in February 2022 60% of all new cars sold in Sweden were either battery electric or plug-in-hybrids. This is increasing the expectations to other types of applications to follow suit. However, the potential and difficulties can be quite different. While ground based application can be more or less readily be electrified with available battery technology, at least looking at the vehicle platform itself, it is quite different for aviation. Here, anything but very short rang, only accounting for an insignificant share of transportation can be powered by batteries. Electric aircraft powered by hydrogen through fuel cells, can be used for regional flight, but for long-haul, where most CO2 emissions come from, there is no electric technology in sight to make it feasible as a replacement. Here some other form of sustainable aviation fuel is required.

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The Transdisciplinary Evolution of Learning, Innovating and Working

Transdisciplinary Innovation: Advantages of Fusion Between Innovation and Transdisciplinary

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Abstract. The search for effective solutions to increasingly complex problems arising from a changing, agile, and connected world has brought about the fusion of concept of transdisciplinary with innovation, originating the concept of transdisciplinary innovation, interconnecting the knowledges. Accordingly, the purpose of this integrative literature review was to investigate which are advantages that the transdisciplinary innovation can do emerged in the contexts presented from the analysis of the documents. The results pointed out that transdisciplinarity helps innovation. For example, organizations, both those that deliver products and those that deliver services, are eager to remain active and sustainable. This fusion will can improve them. Moreover, make it clear the need to break the disciplinary barriers, culturally embedded in academia and beyond it. Thus, transdisciplinary innovation can be a promising path for the parties involved, because as complex and connected problems appear, transdisciplinary innovation creates better solutions. Finally, a table is presented with its basic characteristics and some suggestions for best practices of transdisciplinary innovation.

Keywords: Transdisciplinarity · innovation · transdisciplinary innovation

1 Introduction

With the speed and uncertainties of modern life, it is impossible to survive without innovating, making it part of our daily lives. For example, problems are increasingly complex, open, dynamic, emergent, and networked, and it is up to organizations to evolve in the same way, becoming open, dynamic, and networked [1, 2]. Innovation is a complex construct with different dimensions and applied to different contexts, allowing organizations to improve [3]. Transdisciplinarity (TD) refers to the ability to understand other disciplines and facilitate the breaking down of barriers that hinder innovation. In this way, a flow of transformations is initiated between unified knowledge and its application, making it more dynamic [4, 5].

Part of the speed and ability of organizations to respond to market changes and innovate lies with people [6]. Academia considers transdisciplinary research as learning that involves coproduction by interconnecting knowledge [7–9]. This disciplinary diversity

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accompanies innovative people as they bring knowledge and skills from different areas to problem solving, aggregating practices, coproducing and creating value [6].

Therefore, the success of the organization and academia in their transdisciplinary innovation (TDI) journey is the ability to manage multidisciplinary and dynamic teams [10] to quickly extract the best results from this collaboration. Given this, increasing the production of studies and content on TDI may be the beginning of a transformation in the way of innovating. Thus, this study investigated how TDI has benefited academia, organizations, and society.

2 Overview of the Concepts: Innovation and Transdisciplinarity

INNOVATION can be understood as an improved or new product, service, or process that differs from the original, developed and recognized from opportunities to add value [11]. According to Schumpeter [12], innovation creates a rupture in the economic system, changing production patterns. There are types of innovation, for example, open innovation and continuous innovation.

Open innovation aims at applicability, economy, reduction of product life cycle, reduction of failure rates, and use of knowledge with which companies relate [11]. Lopes & Teixeira [13] emphasize that in open innovation the ideas, projects, and technologies do not remain unused, since there is a growing interaction with external sources, enhancing their commercialization and their economic exploration. In the view of scholars Tidd & Bessant [11], open innovation advocates that companies acquire resources from third parties and share internal resources for the development of new products and services.

Continuous innovation, another form of innovation, is defined as the ability to combine operational effectiveness and strategic flexibility (15). Operational effectiveness (exploitation = exploiting to get the most out of it) is the built-in ability to meet current customer demands and can be associated with incremental innovation. Strategic flexibility (exploration = explore to discover something new) is the potential to do something different, or innovate to meet a future demand, which is associated with radical innovation [11].

Innovation management can be built on the culture of the organization. It is a complex and systemic process, and its practice runs through several functional activities [3]. The process of managing innovation comprises the ability to mobilize resources to reduce and transform uncertainty into knowledge, effectively a balancing action. Thus, managing innovation is to plan, improve, recognize, and understand the activities and routines that contribute to generate innovations [3].

TRANSDISCIPLINARITY is one of the disciplinary phases [4]. These phases present a delimited evolution and can be related to the types of problems proposed by Snowden [2]. The relation can be seen as: disciplinary and multidisciplinary or pluridisciplinary phases associated to easy problems, interdisciplinary phase, to difficult problems and the transdisciplinary phase, to complex problems. TD can also be characterized by the "wicked problems", such as sustainability, which needs creative solutions, trust among stakeholders, and engaged and socially responsible science [1].

Complexity, as in a complex system, evolves from the simple (reductionist view) to the complex (interdependence of phenomena). The complex system is a process that regulates the environment by which systems adapt to changes to ensure their survival. It is dynamic and manifests itself through the interactions of systems with each other and with the environment and cannot be understood through isolated analysis. It is a whole and at the same time part of other systems and its needs are regulated interdependently and concurrently at various scales of organization [14].

The discipline has boundaries. The multidiscipline and the pluridiscipline maintain the singular characteristics of the disciplines [4]. The interdiscipline presents interaction between the disciplines. Sommerman [4] considers TD as the ability to understand other disciplines and create unity of knowledge, a reflection and integration of knowledge from various fields. Klein [15] considers that the process does not end when knowledge is generated, but aims at a flow between knowledge and application, giving to knowledge the latter the mutable and dynamic characteristics. He also proposes five classes of keywords for his categorization: (a) meta-level conceptions of interdisciplinarity, (b) mutable nature and unity status in the discourse of the TD approach, (c) new alignments with participatory and collaborative research oriented to problems, (d) forms of knowledge that involve the TD approach, and (e) transgressive imperative that interrogates the existing structure of knowledge, culture, and education [15].

3 Research Method

This integrative literature review article [16], with an exploratory-descriptive and qualitative character, investigated how TDI has benefited academia, organization and society. Below is a description of the steps.

Step 1 - Choice of research topic: Transdisciplinary Innovation, and choice of search term: “transdisciplinary innovation”.
Step 2 - Choice of databases: *Scopus*, *Web of Science*, *Scielo*, and two 2018 editions of the *Technology Innovation Management Review* journal.
Step 3 - Selection of articles: the search took place between September 27 and October 3, 2019. The raw portfolio had 35 documents, 11 from *Scopus*, nine from *Web of Science*, four from *Scielo*, and 11 articles from the issues of the journal. After elimination of duplicates, 24 documents remained. After previous reading the title and abstract, nine documents were excluded for not corresponding to the conceptual interest of this study. The selected documents, a total of 15, are shown in Table 1. On April 3, 2021, a new search was performed following the same criteria. However, in this new search the time was used as inclusion criterion, since it was an update. *Scielo* returned two articles, *Web of Science*, two, and *Scopus*, four. After removing the duplicates, six articles remained. After previous reading, two articles were included in Table 1 (numbers 16 and 17). The exclusion was due to the lack of relevant information to enrich the debate beyond those already mentioned.
Step 4 - Full reading of documents and categorization: the analysis was performed according to the synthesis matrix [17] and the categorization, with the help of thematic analysis [18].
Step 5 - Results and Discussion and Step 6 - Synthesis.

4 Results and Discussion

Table 1 presents the selected documents.

Table 1. Selected Documents

N.	Title (reference in parentheses)	Year
1	Redrawing soil salinity innovation-focused stakeholder interaction for sustainable land management in Khorezm Province, Uzbekistan – [19]	2018
2	Transdisciplinary innovation and future – [20]	2018
3	Mixing Practices to Create Transdisciplinary Innovation: A Design-Based Approach – [21]	2018
4	Exploring the Transdisciplinary Learning Experiences of Innovation Professionals – [22]	2018
5	Using Constructive Research to Structure the Path to Transdisciplinary Innovation and Its Application for Precision Public Health with Big Data Analytics-[23]	2018
6	Transdisciplinarity at the Crossroads: Nurturing Individual and Collective Learning – [9]	2018
7	How to Develop Innovation KPIs in an Execution-Oriented Company – [24]	2018
8	Q&A. Innovation and Entrepreneurial Ecosystem Research: Where Are We Now and How Do We Move Forward? – [25]	2018
9	The Prime Mover Matrix: A Conversation Piece for Building Strategic Innovative Capacity – [7]	2018
10	The Role of Middle Managers in the Implementation of a Corporate Incubator: A Case Study in the Automotive Sector – [26]	2018
11	A Topic Modelling Analysis of Living Labs Research – [27]	2018
12	From Importing Innovations to Co-Producing Them: Transdisciplinary Approaches to the Development of Online Land Management Tools – [28]	2018
13	Transdisciplinary Research in the Built Environment: A Question of Time – [8]	2018
14	Transdisciplinary Innovation: Connecting Ideas from Professional and User Networks – [29]	2017
15	Increasing the adaptive capacity of organic farming systems in the face of climate change using action research methods – [30]	2016
16	Transdisciplinary Innovation in Irrigated Smallholder Agriculture in Africa – [31]	2020
17	5G as a Driver for Transition of Digitalization in Ecosystem-Based Development – [32]	2020

Source: Prepared by the authors.

From the integral reading and thematic analysis [18] of these documents, the following categories were arrived at: (1) Theoretical Research on innovation and transdisciplinary, (2) Empirical Research on innovation and transdisciplinary and (3) Transdisciplinary innovation. All presented below.

4.1 Theoretical Research on Innovation and Transdisciplinarity

The concern of theoretical researchers about innovation and transdisciplinarity is seen as a strategic way of coproducing and interconnecting knowledge to solve complex problems in a rapid manner. Hoppe [7], Femenías and Thuvander [8], and Riedy et al. [9] state that transdisciplinary research involves learning, collaboration, action, and high levels of awareness about the complexity of problems.

In this regard, Femenías and Thuvander [8] presented practical suggestions: (1) know the theory on the subject, (2) establish partnerships, (3) plan and maintain interest over time, (4) describe the objectives and lead through TD, (5) establish criteria for working in smaller groups representing the largest group, (6) solve real cases, (7) engage the participation of public and/or private organizations, focusing on innovation, (8) unite academic and non-academic, and (9) establish networks.

In this context, importance is given to creating collaborative spaces, which can be built in formal and informal ways, local or international, where practitioners in their own transdisciplinary learning journeys come together in dialogue to share, reflect, question, imagine, challenge, and synthesize their experiences [7–9]. Ferrara [20] states that TDI, through the introduction of technologies, is based on collective work. This learning consists of processes that occur in the person as a whole (thoughts, feelings, behaviors, actions, worldview, self-knowledge, consciousness, and spirituality) causing irreversible changes in the way the person interacts with reality and with the world [33].

To support TDI, one needs to understand how to help professionals become transdisciplinary and not just teach them to use innovation methods and tools. This question could be examined in the phases of the learning experience to explore how innovation professionals have changed from their original rule-based practice to transdisciplinary ways of working. The three phases are: pre-learning (interest in various areas, influenced by family), during learning (learning by doing), and post-learning (a learning cycle, rather than a linear shift from traditional discipline to transdisciplinary approaches) [22].

As problems have become complex, dynamic, and networked, the organizations need to have the same attitude to tackle them. To address the situations requires analyzing them to understand how they have been structured and exploring alternatives that may lead to different types of solutions. One way to do this is to think about the problem in a systemic way. Thinking about innovation from this perspective leads to the adoption of entirely new practices with the capacity to create open practice dialogues, abandoning disciplinary structures [21].

For example, a recent review of five case studies on agricultural production that requires irrigation and entails multifactorial and multisectoral challenges noted that these case studies support the application of the transdisciplinary concept to innovate. They add that, by involving all stakeholders, the transdisciplinary approach enriched the project and provided a multi-stakeholder approach [31].

4.2 Empirical Research on Innovation and Transdisciplinarity

Lakiza and Deschamps [24] are concerned about the difficulties of measuring the success of innovation and the importance of keeping the company's innovative capacity updated.

The theoretical studies of Hoppe [7] and Riedy et al. [9] corroborate these points, as they show the concern with maintaining continuous innovation in companies.

In this scenario, key indicators were developed to measure the success of innovation. For this, the organization must develop three basic requirements for the creation of indicators: minimum level of maturity of innovation processes, strategic alignment, and commitment to innovation. It is a fact that a failure in the development of these indicators can hinder innovation. Also, it is important to note that when companies grow, they tend to lose their innovative capabilities because they focus on the execution of routines. If on the part of the companies, there is an encouragement of innovative culture they can increase the possibilities for the development of key indicators of performance and innovation success [24].

When researching innovation ecosystems, Ritala and Gustafsson [25] found that this concept expands and is seen by most interviewees as useful, whether in the academic or the market environments. Because it is an open-border concept, there is a lack of preparation to understand it. Moreover, due to the practical relevance there is a growing number of entrepreneurs and politicians migrating to its use, generating a diversity of applications of the term, making it difficult to understand.

The same concern occurs about the TDI, whose use is beginning to emerge, but with a lack of relevant information to assign it a definition and a delimitation to its concept. Consequently, more research is needed that takes into account that its main aspect is stakeholder co-participation.

Other authors such as Baumber et al. [28] and McGregor [23] investigated how digital tools are being used from the point of view of innovation and transdisciplinarity and stated that stakeholders, when involved in co-production, reflection, and mutual learning, accelerate the solution of problems, and concluded that TDI brings benefits to human welfare. Still regarding technologies, Ruohomaa et al. [32] pointed out that TDI occurs through the digital innovation ecosystem and creates profitable business models.

Another path that TDI can take is expansion through incubators. They act as strategic innovation tools to enhance the experiences and knowledge of new leaders and managers. They act on individual challenges such as adaptation to the new work environment, rapid changes, need for security, micro-management, and need for new skills. In this context, team engagement is important for innovation to be bottom-up, and training and top management support for these leaders is essential [26].

To contextualize how comprehensive TDI can be, Beckett and Vachhrajani's research [29], based on three case studies on the food industry, states that dissimilar professionals and communities can work together, in different academic research and in different countries.

4.3 Transdisciplinary Innovation

As mentioned, the world has become connected and changed, and so have the problems, making it difficult to solve them from the point of view of disciplinary boundaries [1]. It is accepted that current problems require an interconnection of knowledge from different areas to find an effective solution, and transdisciplinarity will help a lot in this. From this point, one can think of innovation appropriating TD and rethink it as transdisciplinary innovation. The various definitions of this approach present some consensual characteristics, for example, they are action-oriented, future-focused, participatory, systemic, and transcend disciplinary boundaries and individual practices [5].

Because it has these characteristics, innovators increasingly use TD, moving innovation to a society-centric rather than customer-centric perspective, assigning learning and knowledge creation as an inherent part of it. Its impacts on research, researchers, the people involved, the collective, social implications, and practices will always be interconnected [10]. Both Dorst [21] and McPhee et al. [10] state that current problems do not allow for reductionist or disciplinary solutions. This means that professionals will need to learn how to continually adjust their practices to make them collaborative, using transdisciplinary approaches that enable comprehensive reflections [22].

Reflection is an important topic for TDI and was addressed by Riedy et al. [9], who emphasize the importance of reflective spaces in which practitioners can share, reflect, question, imagine, challenge, and synthesize their experiences from distinct areas. The purpose of breaking the boundaries is to nurture innovation with the experiences of transformative and continuous learning. Ferrara [20] presents these characteristics in his studies when he states that basing on the principles of collective work facilitates finding effective solutions, by bringing together diverse disciplines, integrating images, and bio-analysis in a platform format.

Complex social challenges require a diverse combination of resources and skills from different disciplines to create transdisciplinary innovation solutions. By having a structured pathway, the bottom-up method demonstrates how a set of innovative collaborations progresses from disciplinary innovation to ITD, both in organizations and in research [23]. With similar arguments, Hoppe [7] argues that change is something continuous and natural in society and that companies should follow the same path to expedite their innovative strategies.

The concern of Westerlund, Leminen, and Rajahonka [27] was directed to living laboratories. They stated that collaborative innovation is a way to overcome the challenges of these laboratories. Hirte [26] strengthens the findings by Westerlund, Leminen, and Rajahonka [27] with her research on the behavior of leaders and managers and noticed the need to develop the individual skills of leaders and managers to work with TDI. Also added that leaders and managers agreed on the importance of team engagement generating innovation, admitting that it is bottom-up.

Understanding personal and emotional experiences before, during, and after learning and how the transition from positivist approaches to transdisciplinary practice of innovation occurs can shed light on how TDI is experienced and how to incorporate it into the workplace [22]. It is noteworthy that the various types of transdisciplinary research coexist and can lead to higher levels of awareness about solving complex and current problems, changing the cultural way of solving them [8]. Two surveys reported the importance of innovation with a transdisciplinary approach to solving complex problems, one on the problem of soil salinization [19] and the other on climate change [30]. Both studies concluded that everyone's involvement resulted in effective solutions.

To exemplify that borders can be overcome in today's world, connected, networked, and with TDI, Beckett and Vachhrajani [29] concluded after a study that different researches in different countries can come together. These authors followed the technological deployment in India, which was developed in other countries and resulted in social benefits for India. Encouraging collaboration and knowledge integration for innovation allowed transdisciplinary approaches to provide better strategies, stakeholder inclusion, and increased use of technological innovations [28]. McPhee et al. [10] and Zafeirakopoulos and Van Der Bijl-Brouwer [22] state that TDI goes beyond looking for the solution: it involves learning and integrating disciplines to explore and develop novel solutions or technologies.

5 Summary of Results and Discussion

In the category of theoretical studies, the recurring concern involved the issue of bringing together the various areas of knowledge. The authors cited in the discussion state that the joining of stakeholders facilitates co-creation and the generation of effective solutions. In the TDI category, the authors' concern was in relation to the journey from disciplinary innovation to its transdisciplinary structuring. They stated that both the scientific and the professional can coexist and that this brings improvements, change of disciplinary cultural paradigm, overcoming resistance, and unification of knowledge. To facilitate the visualization of the findings and better contribute, Table 2 presents some basic characteristics and some practical suggestions.

Table 2. Transdisciplinary innovation and its basic characteristics

Transdisciplinary innovation (TDI)	Characteristics	Best practices
	Participatory (Co-participation and Co-production)	Communities of practice.
	Bottom-up	Consider everyone's participation important.
	Most effective solution	Solve complex problems, and in a network with the participation of all involved.
	Systemic vision	Develop competencies to have a comprehensive view, even when the problem is localized.
	Action-oriented	Strategic tools for teaching, incubators, communities of practice, learning alliances
	Focused on the future	Seek continuous improvement.

(*continued*)

Table 2. (*continued*)

	Society-centered	Prioritize society and not just the customer.
	Creates knowledge	Integration of knowledge emerging a new one.
	Reflective	Collaborative spaces for reflection. Share lived experiences.

Source: Prepared by the authors.

6 Final Considerations

To walk hand in hand with progress, it is essential to change the way of acting. Suffice it to say that complex, networked problems require systemic ways to solve them. Innovative people are those who cross disciplinary boundaries and bring knowledge and skills from various fields to add value. For example, professionals need to be agile in their learning to work with the complexity of challenges in contexts with few resources, short deadlines, and demand for quality results. Transdisciplinarity offers a promising approach to innovating and meeting this need.

This review has shown that transdisciplinarity can be, from now on, a beneficial approach to innovation. It provides the potential to reinvigorate scientific inquiry both in academia and in society and in organizations. The studies analyzed showed that this merger promotes participation, encourages co-production and an action-oriented systemic vision. However, it still lacks studies that help its understanding, its management and its applicability. Among the few empirical studies found, the most recurrent application was in agriculture and in the food area, thus, there is an urgent need for studies in other areas, especially those that are focused on improving society. In this way, one must consider as the focus of future empirical and theoretical studies, the necessary of to break off the social and cultural disciplinary barriers, change the vision of knowledge use, improve with respect to the complexity of problems and their dynamism, and create appropriate tools to monitor this way of learning and continuous knowledge use.

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Impacts of a Transdisciplinary Approach to Practice-Based Learning on Students' Success Skills

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Abstract. To enhance students' success skills, we immersed the students in transdisciplinary practice-based learning that was not constrained by traditional curriculum structures. In this case, students experienced working collaboratively on unbounded, un-scoped authentic global challenges with a diverse group of people - professionals, practitioners, entrepreneurs, and artisans including students from different disciplines. The study examined the overall changes in critical thinking levels exhibited by the students in the transdisciplinary practice-based learning compared to students in an interdisciplinary approach to practice-based learning. Our preliminary findings could inform instructors and instructional designers about how to use the transdisciplinary team approach in practice-based learning to address global challenges and trigger a higher level of critical thinking among undergraduate students.

Keywords: Transdisciplinary · Practice-based Learning · Critical Thinking · Sustainability

1 Introduction

Success skills such as communication and critical thinking have been identified as core competencies required from graduate students transiting into the world of work (Hollis & Eren 2016). One way to advance success skills is through active learning approaches (Morgan et al. 2006; Pugsley and Clayton 2003; Coker 2010). Practice-based learning is a learner-center approach that requires students to integrate theory into practice through the application of knowledge and skills to develop a viable solution(s) to a defined problem (Kennedy et al. 2015; Schulz et al. 2018; Edwin 2021; Mann et al. 2021). Most time, practice-based learning approaches create experiential learning for the students. Bohn and Schmidt (2008) explained that experiential learning occurs when students participate in a real-life activity to enhance their understanding by using critical analysis skills in obtaining knowledge, meaning, and insight from the real-life activity experience. Different frameworks of practice-based learning approaches have been developed to boost teaching effectiveness and improve success skills. Anvik et al. (2020) incorporated a practice-based learning and innovation approach in a nursing home to study the interplay between formal and informal learning situations. Hollis and Eren (2016)

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incorporated real-world industrial case studies into a food science course to improve student success skills. Matzembacher et al. (2019) studied the impacts of a practice-based learning methodology that involve the provision of community services on students' engagement and learning perception. Mann et al. (2021) presented a framework for practice-based education in engineering as an alternative approach that lifts learners out of traditional structures and repositions them within an authentic professional practice. In their study, students were challenged to solve real problems and offer service to the community as if they were experts. Their results revealed that practice-based methodology leads students to greater engagement. In summary, prior studies on practice-based learning which usually involve an instructor guiding students to proffer solutions to an identified scoped and/or designed projects that mimic or "streamline" the real problem into a manageable part have shown to be beneficial to learners. Although, reducing real complex problems into manageable parts is a practical way of exposing students to a practice-based learning environment. However, pressing global problems urgently demand a new approach to practice-based learning. The objective of this study is:

1. to determine the effectiveness of practice-based learning in transdisciplinary teams on students' success skills.
2. to study the differences in critical thinking level using practice-based learning between students in transdisciplinary teams compared to students in intradisciplinary teams.

2 Methodology

This study involved students in a food processing course (FDST 420 – Fruit and Vegetable Processing Technology). FDST 420 covers the fundamental of harvesting and postharvest handling (storage, processing, packaging) of fruit and vegetables and the necessary control strategies to mitigate safety and quality changes that can impede on storage life of the product and consequently result into postharvest losses. The course introduces students primarily to address the technical aspects of fruits and vegetables with specific reference to harvesting, storage, processing, packaging, and transportation. Students will be introduced to how to apply technologies learn in the course to increase storage life and consequently minimize postharvest loss.

Students from this course were immersed in a practice-based learning environment which begins with confronting the students with an open-ended, ill-structured, authentic (real-world) problem about sustainable tomato postharvest management. Currently, our world is unsustainable, we are facing global challenges that pertain to environmental, socio-political, and economic which include climate change, diminishing natural resources, poverty, and many more (Broman and Robert 2017). These challenges have been summarized through the United Nations' 17 Sustainable Development Goals (SDG). It is important for educators to adopt pedagogical approaches that support students to acquire the necessary skills that will be needed to address such global problems. To this effect, we presented the problem of postharvest loss in the tomato value chain in Nigeria to students at the start of the project as a class competition (Please see Appendix A for details about the project description). In addition to the project's description, students were presented with a virtual documentary of tomato production in Nigeria, highlighting challenges as they relate to sustainability and postharvest operations across the tomatoes' value chain in Nigeria.

Students were randomly assigned into groups to work collaboratively in proffering solution(s) to the problem (Interdisciplinary approach). However, two of the groups had students in a product design course to form the transdisciplinary teams. To further the understanding of the problem in the transdisciplinary teams, external stakeholders including practitioners from Nigeria and including government policy makers, practitioners were invited to introduce the problem and support students as they work through the process of problem framing and solving (Fig. 1).

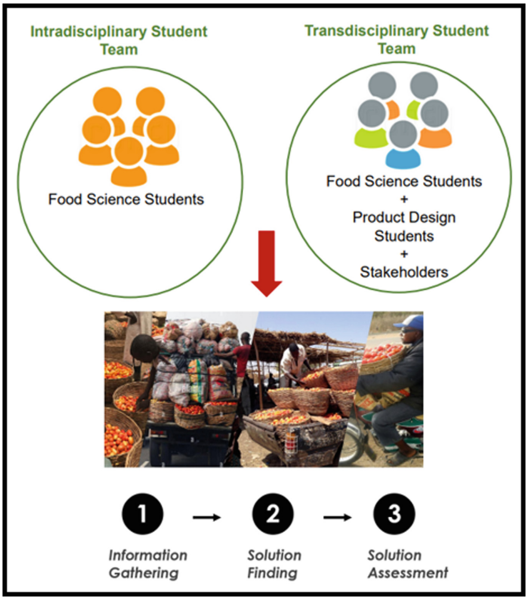

Fig. 1. Schematic Representation of the methodology

Generally, the students teams involved a total of twenty-three (23) upper-level undergraduate students and one (1) graduate student. Nineteen (19) students were enrolled in the food processing course (FDST 420 - Fruits and Vegetables Processing Technology), while four (4) students were enrolled in the product design course (IDES 491). Two (2) students in FDST 420 and all four (4) students in IDES 491 worked on the problem in two separate transdisciplinary teams, while seventeen (17) students in FDST 420 worked in intradisciplinary-based teams. Only the students that give their consent to participate in the study which had been approved by the human subjects institutional research board (IRB) at the University were involved. The students' teams (intradisciplinary and transdisciplinary teams) work collaboratively together in offering solution(s) to the problem. Students leveraged their prior knowledge to come up with suitable, sustainable solutions to the problem. The problem was presented in way to engage both the interdisciplinary and transdisciplinary approaches to practice-based learning. Students were tasked to produce an individual reports that analyze, synthesize, and evaluate solution(s) to the problem. By engaging in the individual report assignment, students were encouraged to review their own thinking about the problem, provide their own solution(s) regarding the tomato postharvest loss in Nigeria and justification for their solution(s) which could help to analyze and synthesize decisions made in their groups.

To examine the changes in student critical thinking we applied quantitative analyses. A data set that included students' individual reports scores during the project were analyzed based on critical thinking measurement rubrics shown in Appendix B. The critical thinking rubric included five sub-categories to evaluate students' ability in (1) Summarize the problem (2) Considers context and assumptions (3) Communicates own perspective, or position (4) Assesses conclusions, implications, and consequences and (5) Communicating effectively. For each sub-category, the rubric was further broken down into three levels of critical thinking that were termed "emerging," "developing," and "mastering." Also, questionnaire was designed to evaluate student perspectives about their experiences in both the transdisciplinary and interdisciplinary team approaches. To score the reports with the rubric, three reviewers including the instructors rated the students' reports. Each reviewer was trained in the use of the rubric before actual student report from the study were judged. Raters then worked independently scoring the reports. Average score from the three raters were then used in this study.

3 Results and Discussion

3.1 Some of the Solutions from the Student Teams

In general, all the students teams agreed that most of the post-harvest loss in tomatoes value-chain occurs during transportation from farm to market. Transportation of the tomatoes in Nigeria currently relies on unrefrigerated trucks which consequently leads to deterioration. Nigerian farmers and stakeholders need a more efficient and safer way for tomatoes to be transported to prevent post-harvest loss. Therefore, most of the students teams focus their solution on transportation. One of the students transdisciplinary teams came up with a solution to reduce tomato loss during transportation. They sought a solution that would be cost-effective, easy to produce, and easy to be adopted in Nigeria. They proposed a re-design of the traditional raffia baskets that would reduce bruises of the tomatoes by the raffia basket rough edges by laying the internal edges with cushion facilitates cooling through a simple evaporating layer at the bottom for cooling purposes during transportation as shown in Fig. 2.

Another fascinating solution that came up from the students in the trandisciplinary teams was the novel design of a rectangular-hexagonal transporting container with surrounding hinges that provide flexibility, structure, and vents holes for proper ventilation (Fig. 3). The container unit would be made up of a thin plastic material for easy recycling. And one the main reason for the designed is so that the tomatoes could be covered when transported, meaning that stacking of other containers would be easily carried out without causes overbearing pressure on the tomatoes which can easily leads to bruises.

However, one of the main problems of this design would be that the container will contain less quantity of tomatoes compared to the current raffia baskets being used in Nigeria. Also, another issue would be pricing, as many Nigerian farmers cannot

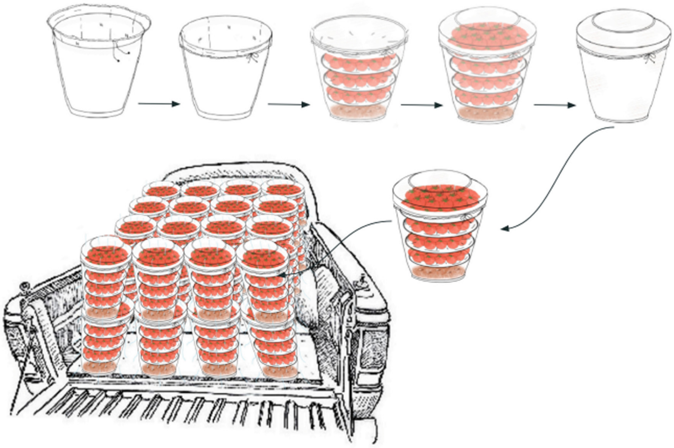

Fig. 2. Re-design raffia baskets with evaporative cooling layer

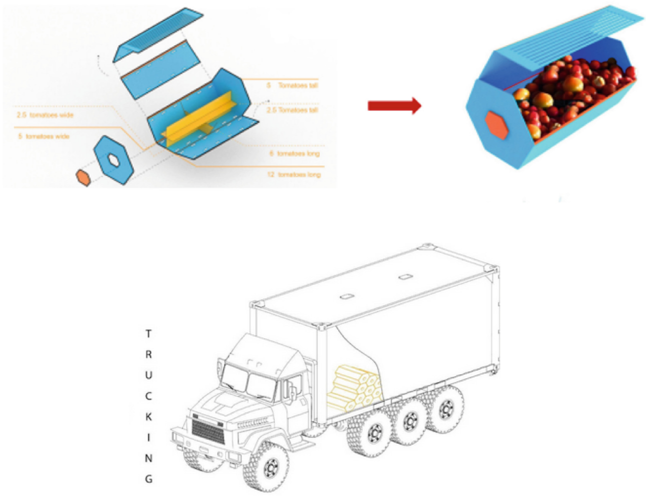

Fig. 3. Rectangular-Hexagonal tomatoes container

afford expensive containers. However, the solutions that came up from the students teams both the transdisciplinary team and interdisciplinary team all revealed the students understanding of the problem of post-harvest loss of tomatoes in Nigeria. And emphasize the importance of developing student competency to deal with complex problems in real-life contexts.

3.2 Differences Between Critical Thinking Level in Students Teams

Graded student reports were used to assess the student critical thinking level, data from the total 23 students which was the number of the students that agreed to participate in the study were collected and the mean score of performance on the individual reports for students in the interdisciplinary team was 12.3 out of a total of 25 and that for the transdisciplinary teams was 19.5 out of 25.

Table 1. Summary of Individual Report for Interdisciplinary Team

Individual Report - Subcategory (n=17)	Average Score	Standard Deviation (SD)	Range		% Average Score
			Low	High	
Summarize the problem	2.3	0.52	2.0	3.0	46
Consider context and assumption	2.5	0.54	2.0	3.0	50
Communicates own perspective	2.7	0.52	2.0	3.0	54
Assess conclusions and implications	3.2	0.41	2.0	4.0	64
Communicating effectively	2.4	0.66	2.0	3.5	48

This revealed that students' average critical thinking level in the interdisciplinary team fell majorly in the category of emerging and for transdisciplinary team, majority of the students critical thinking level was in developing stage. Mean scores for the five subcategories for students in the interdisciplinary and transdisciplinary teams are presented in Table 1 and Table 2. The subcategory "Assesses conclusions, implications, and consequences" was slightly rated higher (mean score – 3.2) compared to the other subcategories. This might be as a result that the students being "indigenous" food processing students were able to work collaboratively well to analyzes the food sustainable issue with a clear sense of scope and context, including an assessment of contextual topic. Comparing Table 1 and Table 2, for all the sub-categories, it can be observed that students from the transdisciplinary teams scored higher than students in the interdisciplinary teams.

As expected, higher number of students from the transdisciplinary teams exhibited both developing and mastering critical thinking levels. Figure 4 indicates that 66.7% and 16.7% of the students in the transdisciplinary team were at the level of developing and emerging critical thinking skills respectively compared to 41.2% and 0% for students in the interdisciplinary teams.

This might be as a result that the students in the transdisciplinary teams were provided with more explanations about the situation of tomatoes post-harvest loss in Nigeria by the involvement of the stakeholders. Also, the results further suggested that students in the transdisciplinary teams gained more profound interactions about problem solving by engaging students from different department with diverging perspectives and opinion about the issue of the post-harvest loss in tomato value chain in Nigeria.

Table 2. Summary of Individual Report for Transdisciplinary Team

Individual Report - Subcategory (n=6)	Average Score	Standard Deviation (SD)	Range		% Average Score
			Low	High	
Summarize the problem	4.3	1.03	3.0	5.0	86
Consider context and assumption	4.0	0.89	3.0	5.0	80
Communicates own perspective	4.0	0.89	3.0	5.0	80
Assess conclusions and implications	4.4	0.80	3.5	5.0	88
Communicating effectively	4.7	0.51	4.0	5.0	94

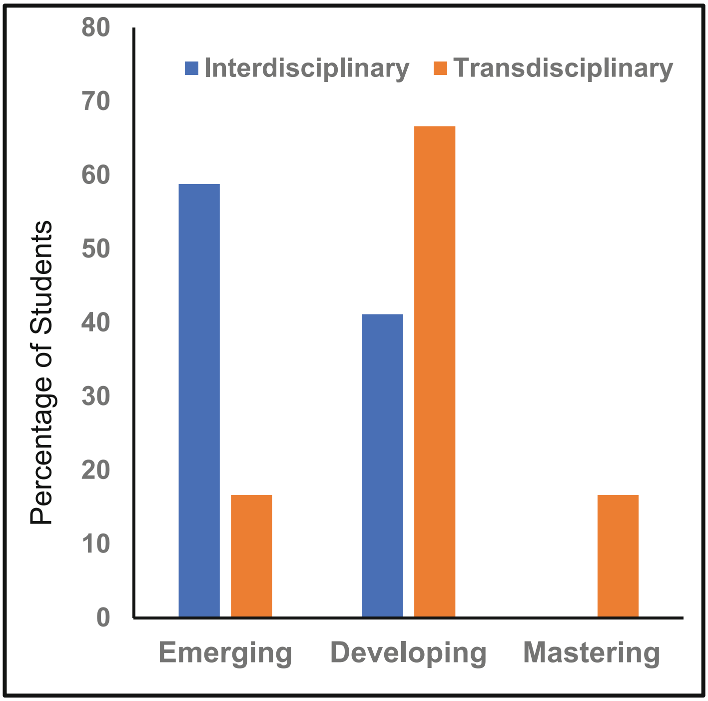

Fig. 4. Comparing students in the interdisciplinary and transdisciplinary teams

3.3 Effectiveness of Practice-Based Learning in Transdisciplinary Teams

An end-of-the-semester course survey was used to probe the feelings and thoughts of the students that participated in the transdisciplinary practice-based team regarding the effectiveness project. The following survey questions were used:

1. I was exposed to a real-life (global) challenge on food loss and food security issues.
2. I think the goals of the project stated in the course syllabus were met during the project duration.
3. I prefer to work in a team that involves multidisciplinary collaboration than working in teams with members from my discipline only.
4. I was able to adequately participate in my team's project decisions and conclusions
5. The project provided me with the opportunity to critically think on how to propose solution(s) to prevent and/or mitigate post-harvest loss of tomatoes.
6. The project provided me with the opportunity to improve my presentation and communication skills through the interactive sessions organized during the project.

The students were asked to choose between Strongly Disagree, Disagree, Agree, and Strongly Agree for each of the statements and the raw response results were presented in Fig. 5. The effects of transdisciplinary students' collaborative active learning approach on students performances were evaluated based on the survey results. The students reported that they felt the project helped them in developing success skills which was the main goal of the project implementation into the course. Based on the first and second questions, majority of the students agreed that the objectives of the project were met and then subscribed that they were exposed to real-life challenges that pertain to food sustainability. And the fourth, fifth and the sixth question indicated that majority of the students felt that the project was particularly beneficial to them as regards to success skills that involved critical thinking, collaboration, and communication skills.

However, about majority of the students felt slightly agree that the project provided opportunity to improve their presentation and communication skills through the interactive sessions organized during the project. This might be because most of the teaching and activities were completed online. The response results for the fifth question indicated that most of the students agreed that the project provided the opportunity for them to critically think on how to propose solution(s) to prevent and/or mitigate post-harvest loss of tomatoes.

4 Conclusions

In conclusion, our preliminary findings could inform instructors and instructional designers about how to use transdisciplinary team approach in practice-based learning to address global challenges and trigger higher level of critical thinking among undergraduate students. The results obtained indicates that 66.7% and 16.7% of the students in the transdisciplinary team were at the level of developing and emerging critical thinking skills respectively compared to 41.2% and 0% for students in the interdisciplinary teams. However, the result from the survey revealed that all the students in both teams agreed that they were exposed to a real-life global challenge on food loss and food security issues during the project. Furthermore, the study suggested that the transdisciplinary practiced-based learning employed in the study were useful to promote higher level of critical thinking.

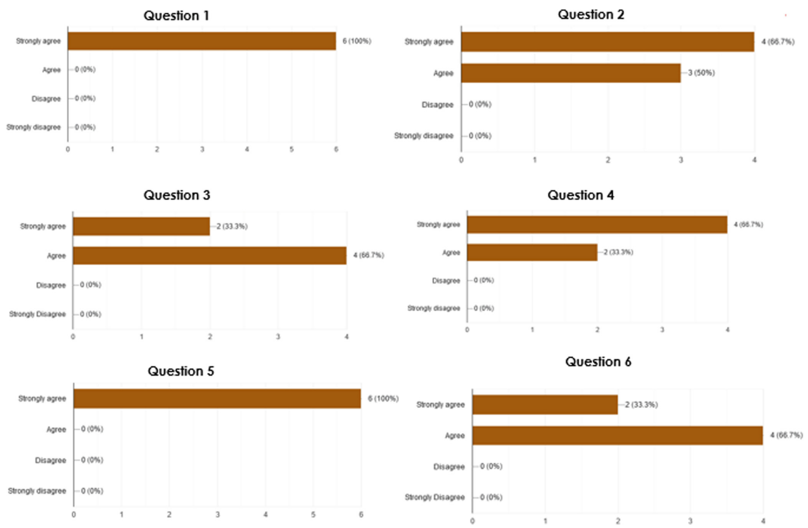

Fig. 5. Comparing students in the interdisciplinary and transdisciplinary teams

Appendix A

1 Project Background

Tomato Post-harvest Project Brief

About two billion people in the world face food insecurity, 820 million of this people which is about 8.9% of the total world population faces severe hunger (UN 2019). With continued population growth, more food production will be required with lower resource inputs such as labor, fertilizer, water, and land. This is a challenge that cannot be met by focusing exclusively on increasing food production. As a result, reducing post-harvest loss has been recognized as a vital tool for meeting global food and energy needs.

In this project, the primary focus will be on proposing solutions to mitigate tomato postharvest loss in Nigeria. Nigeria is currently the second largest producer of fresh tomatoes in Africa, producing 10.8% of fresh tomatoes in the region. Globally, the country is the 14th largest tomato producer. Over the last decade, the production of fresh tomatoes in Nigeria has grown by 25% from 1.8 million tons to an estimated 2.3 million tons.

Tomato postharvest loss is a major challenge in Nigeria. Tomatoes are prone to a high incidence of postharvest loss and waste, largely in part due to their high moisture content (often exceeding 80%), high respiration rate, and highly susceptibility to handling damage. In Nigeria, about 45% of fresh tomatoes produced annually were accounted to be wasted because of poor transportation systems. Tomato farmers in Nigeria lose a significant portion of their income because of this increase in tomato wastage and the country continues to depend on tomato importation to meet its demand.

How might we help farmers in Nigeria to reduce the loss of tomato yield after harvesting?

2 Project Objectives

1. To introduce to students the practices of ethical, social, and cultural innovation design.
2. To enhance student's collaboration within multidisciplinary teams and communication skills.
3. To stimulate a culture of critical thinking and inquiry based on sustainability in different regional contexts.

3 Recommended Reading and Deliverables

To support your research, two diagnostic research reports on Nigeria tomato value chain data have been provided. However, students are encouraged to use diverse source materials (library, internet, database etc.) in developing their research. All materials' used MUST be accurately cited and reference accordingly.

*** group presentation on demonstrating ownership of your own solution to the problem is required.

4 Project Steps

1. **Identify the problem** – The students will work collaboratively to identify the problem. For example, using this analogy, if a front wheel spindle breaks on a Ford pickup truck that had been lifted, what is the problem? Most students would say the problem is that the wheel fell of the truck when the problem is that I can't drive my truck!
2. **Define the problem** – Now, the students should define the problem – That is, based on our analogy - The spindle broke, and we will need to fix the truck and we will need a tow truck to transport the truck home.
3. **Develop the possible solutions** – This is the brainstorming part of the process where the student lists as many solutions as possible that they can think of to solve the problem. In the case of our analogy, there are two solutions: replace the spindle with a stock spindle or buy a new lifted spindle.
4. **Select the best solution** – The student should work individually to select the best solutions(s) from their own perceptive justifying with reasons. Using the above analogy, we have two options, and the most important factor is cost. An old spindle at home is available or buy a new lift spindle. Since the most important factor is cost, you select to put on the old stock spindles, at a cost $0.
5. **Communicate the solutions** – Write documented report about the project including all necessary steps during this project.

Appendix B

Criteria	Emerging (1–2)	Developing (3–4)	Mastering (5)
Summarizes problem, question, or issue	Does not attempt to or fails to identify and summarize the problem accurately.	Summarizes issues, though some aspects are incorrect or confused.	Clearly identifies the challenge and subsidiary, embedded, or implicit aspects of the issue. Identifies integral relationships essential to analyzing the issue.
Considers context and assumptions and communicates own perspective, or position	Approach to the issue is socio-centric and does not relate to other contexts. Does not recognize context and underlying ethical implications. Position is adopted with little consideration, failing to clarify the position relative to one's own	Presents and explores relevant contexts and assumptions, although in a limited way. Analysis includes some outside verification, but primarily relies on authorities. Presents own position, which includes some original thinking, though inconsistently	Analyzes the issue with a clear sense of scope and context, including an assessment of contextual topic. Identifies influence of context. Questions assumptions, addressing ethical dimensions underlying the issue. Position demonstrates ownership.
Analyzes supporting data and evidence	No evidence of selection or source evaluation skills. Evidence is simplistic, inappropriate, or not related to the topic.	Demonstrates adequate skill in selecting and evaluating sources to meet information needs. Use of evidence is selective, discerns fact from opinion and may recognize bias. Appropriate evidence is provided although exploration is routine.	Evidence of source evaluation skills. Examines evidence and questions accuracy and relevance. Recognizes bias. Sequence of presentation reflects clear organization of ideas, subordinating for importance and impact.

(*continued*)

(*continued*)

Criteria	Emerging (1–2)	Developing (3–4)	Mastering (5)
Assesses conclusions, implications, and consequences	Fails to identify conclusions, implications, and consequences, or conclusion is a simplistic summary. Conclusions are absolute and may attribute conclusions to external authority.	Conclusions consider evidence of consequences extending beyond a single issue. Presents implications that may impact other people or issues. Presents conclusions as only loosely related to consequences. Implications may include vague reference to conclusions.	Identifies and discusses conclusions, implications, and consequences. Consider context, assumptions, and evidence. Qualifies own assertions. Consequences are considered and integrated. Implications are developed and consider ambiguities.
Communicates effectively	Work is unfocused and poorly organized; lacks logical connection of ideas. Format is absent, inconsistent or distracting. Few sources are cited or used correctly.	Basic organization is apparent; transitions connect ideas, although they may be mechanical. Format is appropriate although at times inconsistent. Most sources are cited and used correctly.	Organization is clear; transitions between ideas enhance presentation. Consistent use of appropriate format. Few problems with other components of presentation. All sources are cited and used correctly.

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Relationships Between the Job Market and Multiple Intelligences

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Abstract. The purpose of this article is to observe and associate the activities developed in the predominant occupations in the job market with multiple intelligences, according to the characterization and classifications of each of the proposed intelligences. For that, it is necessary to map which types of intelligence are most demanded in the occupations and consolidate them by educational level. This process occurs by choosing representative occupations in the job market and identifying which intelligences are most demanded in each of them, through a proposed scale. The sum of the results obtained in each of the occupations expresses which intelligences are predominant at each level of education, and, in a broad perspective, reflects what happens in the brazilian labor market. The results show that the higher the educational level of each occupation, the greater the level of intelligence demand. Although the final result shows the predominance of some intelligences, such as linguistic, emotional and logical-mathematical, there is a balancing between all of them. Thus, an important contribution of this research is related to public policies, projects and learning processes that can be planned, considering the balance and the cross-cutting look of multiple intelligences.

Keywords: multiple intelligences · labor market · professional qualification

1 Introduction

This article presents a study on the mapping of the labor market in the Brazilian population, its characterization and its relationship with the types of intelligence according to the principles of Gardner (1983) and Goleman (1998). From this, it intends to map which intelligence profile is the most present in the job market through the analyzed occupations.

Several ways of assessing intelligence through psychometrics have been used in the population throughout history, as proposed by Spearman (1927). These tests, which valued logical-mathematical intelligence, were the basis for defining intelligence, shaping education in the world over the years.

Over time, intelligence received new studies and its conceptualization was complemented with different views. One such view is proposed by Gardner (1983) and called "multiple intelligences". Gardner (1983) divides intelligence into seven parts with the same degree of importance: logical-mathematical, linguistic, spatial, interpersonal, intrapersonal, bodily-kinesthetic and musical intelligence.

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Adding to Gardner's concept, a new intelligence emerges and gains great relevance: emotional intelligence described by Goleman (1998) brings a new perspective and makes use of this type of intelligence in different environments, such as the job market. According to Goleman (1998), with the advances of neuroscience, emotional intelligence proved to be responsible and stood out as the basis of the process for all other intelligences. More recent studies, such as the learning model developed by Gary and Low (2011), further reinforce the importance of the topic for health and individual and collective well-being, through which skills are explored, identified, understood., learned and applied in different contexts. Emotional intelligence is also present in intrapersonal and interpersonal intelligence, proposed by Gardner (1983). Thus, there is an intersection between them that will be used in this article as a guide for defining intelligence.

Still, it is necessary to understand if there are differences between the requirements of certain intelligences according to educational level, in order to more effectively direct training for each level. Thus, as a justification, this article becomes relevant to analyze whether there is a balance between all the proposed intelligences, thus tracing a more general and less specific view of the job market. This can help organizations to solve the problem in hiring talent, increasingly looking for generalist profiles and with a diversity of intelligences.

From the perspective of collective thinking and knowledge (Lévy 1998), which assumes that no one has all the knowledge and that everyone knows something, as well as from the perspective of collaborative intelligence proposed by González and Váttimo (2012), and from the use of empathy, proposed by Bradberry and Greaves (2016, p.31), as a social conscience and a basic skill it is possible to change the way in which teams and organizations relate to each other. In this way, this new collaborative action can even have social and global impacts on issues such as sustainability, education, poverty eradication and security. Initiatives have already been carried out through large organizations, applying, for example, the open innovation proposed by Chesbrough (2006). This vision brings a new perspective on the use of intelligence for innovation applied to the job market.

With this, the objective of this article is, through qualitative interviews and the consolidation of results by educational level, to map which types of intelligence predominate in occupations in Brazil and what is their relationship with the demand of the labor market. Another objective is to list which intelligences are required in each occupation and the level of demand for each one, thus identifying if there is a predominance of some intelligence in each educational level. In the next sections of this article, it will be presented the theoretical framework on the subject, the methodology used, the proposed scale of intelligence predominance, as well as the results found and the conclusions related to possible future discussions on the subject.

2 Definition of Intelligences

2.1 Multiple Intelligences Theory

Spearman (1927) is the author of the first theory of intelligence based on statistical analysis of test results. For him, each person tends to manifest the same degree of intelligence in all areas. In his studies, the author concludes that intelligence has as its main characteristic the existence of a general factor, the g factor, which is found in all types of intellectual activity and which is responsible for most of the variance found in the tests (Almeida 1994). Based on the concept of multiple intelligences created by Gardner (1983), seven types of intelligences are defined, and the individual can have all types of intelligences with different aptitudes. For Gardner (1983), intelligence is defined as "the ability to process information in order to solve problems or create products to be valued in a cultural environment". Gardner also suggests that multiple intelligences are separate types of intellect, and that there is no interdependence between them. In this way, each intelligence, by itself, is complete and has a complexity of its own.

The theory of multiple intelligences is anchored in biological factors, however, Gardner (1983) also considers environmental and cultural factors as major influencers in the development of a particular intelligence. Some cultures favor and privilege a certain type of intelligence. Other factors that can also favor certain types of intelligence are the environment to which the individual is exposed, the relationships he establishes, his cognitive stimuli and also his genetic background.

The seven types of intelligences proposed by Gardner are:

Logical-Mathematical Intelligence: Focused on the use of reason, solving abstract problems and quick calculations. It is the ability to identify logical and related patterns in numbers. It also features non-verbal language.

Linguistic Intelligence: Related to written communication, the creation of grammatical sentences and gestural modes. It is linked to the ease of expression and also language learning.

Space-Based Intelligence: Ability to have perceptive vision of the environment; ease of interpretation and creation of images, colors, shapes, spaces and the relationship between them.

Interpersonal Intelligence: Related to understanding and putting themselves in the shoes of others, noticing distinctions, contrasts in their moods, temperaments, motivations and intentions. It seeks constant relationships and connections between people.

Intrapersonal Intelligence: Knowledge of internal aspects and the way in which the inner self is dealt with; ability to discriminate emotions and feelings and use them to understand and guide one's own behavior.

Bodily-Kinesthetic Intelligence: Related to the use of one's own body to create a product or to solve problems. Mastery and control over the body, balance, movements, reflexes and motor coordination.

Musical Intelligence: Can interpret and recognize different types of sound and rhythms. Related to music composition. Also present in the use of musical instruments.

2.2 Emotional Intelligence

Recent studies and new perspectives on the subject of intelligence have been addressed. One of them is emotional intelligence. According to Goleman (1998), emotional intelligence is the ability to identify our own feelings and those of others, to motivate ourselves and to manage emotions well within ourselves and in our relationships.

Goleman (1998) assumes that emotional intelligence is the key success factor and that it is not associated with the genetic factor - that is, it can be trained in all individuals. For the author, emotional intelligence is most responsible for the success or failure of individuals. He also suggests that the emotional brain, as it retrieves past and present experiences, is directly involved in decision-making and reasoning, as is the thinking brain. In this way, Goleman (1998) indicates that we have rational and emotional intelligence, in such a way that rational intelligence cannot reach its fullness without emotional intelligence.

According to the author, emotional intelligence can be categorized into five skills. The first three are intrapersonal skills and the last two are interpersonal skills:

1. **Emotional self-awareness:** recognizing one's own emotions and feelings when they occur;
2. **Emotional control:** dealing with one's own feelings, adapting them to each situation experienced;
3. **Self-motivation:** directing emotions in the service of a personal goal or achievement;
4. **Recognition of emotions in other people:** recognizing emotions in others and empathizing feelings;
5. **Interpersonal relationship skills:** interaction with other individuals using social skills.

With more recent studies, Bradberry and Greaves (2016, p.7) also bring the importance of the limbic system of our brain, through which emotions are felt. Thus, strong communication between the rational and emotional sides of our brain becomes necessary. As Issah (2018) proposes, all these concepts can directly influence organizations and, especially, leadership - which plays an influential role in decision-making and organizational climate.

3 Methodology

To verify the existing relationships between the labor market and the theory of multiple intelligences (Gardner 1983), the path chosen was qualitative exploratory research (Appolinário 2006), which aims at familiarity and possible connections and interpretations with the themes presented here.

The reason for adopting the exploratory research methodology is due to this being a new situation and with few studies carried out so far. In this way, we can gather information on the subject, delimiting the field of work and mapping the conditions for the manifestation of this object (Severino 2000). This type of approach makes it possible to look for patterns, associations, ideas and hypotheses about the problem studied. In other words, it creates conditions to envision issues that need a detailed investigation of their sensitive points and their points of difficulty. From a practical point of view, this exploratory article involves the following steps: 1. Bibliographic survey on relevant topics; 2. Analysis of theories and concepts; 3. Data collection and qualitative interviews with professionals; 4. Data consolidation; 5. Consolidation of grades given for each intelligence; 6. Data analysis and cross-referencing.

3.1 Analysis Method of Research Occupations

Each of the occupations was characterized in order to extract the most central aspects of each one of them in relation to a standard working day. From the choice of the analyzed occupations, the categorization by educational level and the description of the main activities performed, we arrive at the scale of perception of predominance of intelligences. In this scale, each activity is classified by a certain intelligence according to the proposed intelligence level scale (where 0.0 the type of intelligence does not participate and 10.0 the type of intelligence fundamentally participates in that activity, considering intervals of 0.5 points). To identify the predominant intelligences in each occupation, five main activities were considered, according to the characterization. Thus, based on the grades of each of the activities, it is possible to arrive at the weighted average of grades of each intelligence for each occupation.

In order to propose more accuracy in the model and in the averages of the scores for each intelligence, a weight was considered for each of the five activities, according to how much each activity represents, in percentage, the time and relevance in a typical day of a given occupation. The sum of the percentages of the five activities represents 100% of the scope of action. Thus, the average score for each intelligence takes into account the weighted weight of each activity, as illustrated in Table 1.

Table 1. Example of activities of the occupation

Occupation	Weight	Logical-Mathematical	Linguistic	Space-based	Emotional	Bodily-kinesthetic	Musical
Ocuppation 1	100%	1,50	2,75	1,70	1,90	2,35	0,75
Activity 1	30%	2,0	1,0	2,0	1,0	3,0	1,0
Activity 2	25%	1,0	4,0	2,0	2,0	2,0	1,0
Activity 3	20%	2,0	3,0	1,0	2,0	2,0	0,0
Activity 4	20%	1,0	4,0	1,0	3,0	2,0	1,0
Activity 5	5%	1,0	1,0	4,0	2,0	3,0	0,0

Source: own authorship

In order to seek greater plurality, occupations of basic educational level (which are subdivided into children, elementary and high school) and higher education were chosen. In this way, it becomes possible to understand the required degree and the need for each intelligence, according to the level of education. Furthermore, the chosen occupations

Table 2. Consolidation of occupations.

Occupation	Logical-Mathematical	Linguistic	Space-based	Emotional	Bodily-kinesthetic	Musical	Educational Level
Doorman	1,50	2,75	1,70	1,90	2,35	0,75	Into children
Attendant	2,90	1,00	2,70	1,20	2,35	0,45	Into children
Motoboy	3,50	2,70	3,30	1,90	2,60	0,50	Into children
Popular singer musician	2,65	4,20	2,40	3,50	4,35	8,65	Into children
Domestic worker	2,50	0,60	3,60	1,20	3,40	0,50	Into children
Cashier	3,45	2,00	1,50	1,50	1,70	0,15	Elementary
Driver	3,60	2,35	4,65	3,10	3,80	0,65	Elementary
Seller	2,45	4,25	3,25	3,45	3,05	0,50	Elementary
Administrative Assistant	3,90	3,05	2,40	2,20	2,00	0,40	Elementary
Military police	2,75	4,70	5,00	7,20	5,45	0,85	Elementary
Teacher	4,40	6,80	2,30	4,25	1,90	0,40	High School
Lawyer	5,20	9,50	2,70	7,60	2,30	0,20	High School
Doctor	6,20	7,10	4,40	7,40	4,60	1,00	High School
Actor	2,35	7,85	3,30	7,30	5,70	3,60	High School
Engineer	8,00	5,60	8,00	4,40	3,10	0,60	High School

Source: own authorship

have large numbers of people developing them, in order to represent a significant sample of the Brazilian population.

The analyzes are carried out from the perspective of the occupations, not the individual - thus isolating the exceptions of a particular person who works in that occupation. In this sense, the standard activities, developed by most individuals who exercise that profession, are considered. In this way, it is also assumed that we can categorize occupations and that each of them requires specific skills and activities, which makes it possible to analyze which types of intelligence are required or predominant for a particular occupation.

The occupations listed in this article are: Professions that require a basic level of education: doorman, gas station attendant, domestic worker, motorcycle courier and popular singer. High school level: cashier, driver, salesperson, administrative assistant and military police. Higher education level: teacher, lawyer, doctor, engineer and actor.

To identify the activities that are necessary in each of these occupations, the CBO (Brazilian Classification of Occupations according to the Ministry of Labor) was used. The main activities carried out in the occupation in a typical working day were identified based on qualitative interviews with two professionals who have been working in the surveyed occupations for more than two years. The interviews were semi-structured and aimed at validating the five main activities, distributing the weight of each one of them and assigning a grade that assesses how much each type of intelligence participates in a given activity.

3.2 The Dominance Scale of Intelligences

Based on the proposed reasoning on intelligence, the scale will be adopted, as shown below, to classify the level of demand of each of the intelligences in the occupations, with the goal of enabling the contrast between the aspects of the intelligences. Based on already structured scales, such as the WAIS-III (Wechsler 2014), the scale presented only suggests a possible association of intelligence with occupations, according to the perception of the professionals who carry out the activities, not intending to determine each intelligence for the occupations. The scale goes from 0.0 to 10.0, with a range of 0.5 (Fig. 1):

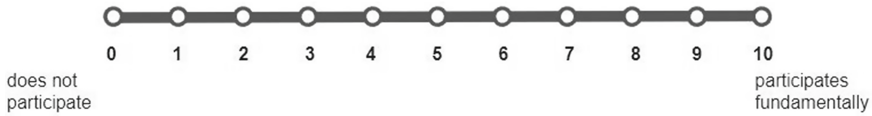


Fig. 1. Scale from 0 to 10 of intelligence levels, with an interval of 0.5. Source: own authorship

In this scenario, 0 (does not participate) means that the type of intelligence is not necessary to exercise that profession, and 10.0 (participates predominantly) means that the type of intelligence is indispensable for the execution of the activities of that occupation. The scale was applied to the five main activities of each occupation, based on qualitative interviews with professionals who have practiced the profession for at least two years. From the five activities, the weighted average for the level of intelligence in each occupation was reached.

The purpose of this scale, in addition to highlighting the contrasts between intelligences and occupations, is to help identify, through the intelligences listed, what level is required for the occupations chosen for this study, based on the analysis of job descriptions and activities performed in each occupation.

4 Results

Below is a table with the weighted average (based on the five activities) of each intelligence for the occupations analyzed in this article. The results presented in the table were found through the consolidation of data from qualitative interviews with professionals who practice each occupation (Table 2):

After the individual analysis of the occupations and their respective activities, it is noticeable the greater demand of all intelligences in the occupations of higher educational level. The difference in requirements between the secondary and higher education levels is substantially greater than the ratio between the basic and medium levels.

It is observable that, for the most diverse occupations, there is a balance of the required intelligences. An exception occurs in musical intelligence: extremes can be seen in it, since many occupations do not require this type of intelligence, and in others, such as musicians and popular singers, this type of intelligence is highly demanded.

5 Discussion

When observing what types of intelligences are present in a given occupation, first, more than one necessary intelligence is always identified, and not just a single source. It is clear that, in certain occupations, some skills and competences are more demanded and, consequently, there is a predominance of some intelligences.

The results show that no occupation carries with it the burden and requirement of just one type of intelligence, but a set of various intelligences on a greater or lesser scale. Therefore, a more horizontal and generalist look is necessary than a look focused on only one of the intelligences.

It is also observed that basic-level occupations require more bodily-kinesthetic and space-based intelligence than other intelligences. In the mid-level occupations, there is no prominence for any intelligence. And, at the higher level, linguistic, logical-mathematical and emotional intelligence are more in demand. With this, a relationship is concluded between basic level and bodily requirements, and higher level and intellectual intelligence.

The following premises are assumed, so that it is possible to arrive at these propositions and conclusions.

- A restricted number of 15 occupations were analyzed in the cut of this article, considering five of each educational level and occupations with a large representation of people. Occupations that have more specific characterizations and without great volatility and differentiations between regions of Brazil were also observed.
- According to the Laws of Directives and Bases of National Education (LDBEN), specifically based on Law number 9,394 of 1996 (BRASIL 1996), education in Brazil is divided between basic education (which is formed by early childhood education, elementary and secondary education) and higher education (which is formed by undergraduate higher education and postgraduate higher education, which is divided into two sub-levels: *latu sensu* and *strictu sensu*).

The premises lead to the formulation of some propositions, in order to reach the results presented in this article. In general, the following propositions are possible:

- **Proposition 1:** The selection of occupations used in the research covers a significant portion of the Brazilian population, so the results of the analysis of the predominance of intelligences bring great representation to the map of multiple intelligences in Brazil;
- **Proposition 2:** The educational levels required for each occupation are directly linked to which intelligences are most demanded and their level on the dominance scale.

Considering all the analyzed occupations, the intelligence that appeared as the most necessary to the occupations was linguistic intelligence. In second place is emotional intelligence, in third place is logical-mathematical intelligence, in fourth place is spatial intelligence, in fifth place is bodily-kinesthetic intelligence and in sixth place is musical intelligence. This result is suitable only under proposition 1, for which the distribution of occupations corresponds to those used in the article, and that it does not keep a certain distance from society.

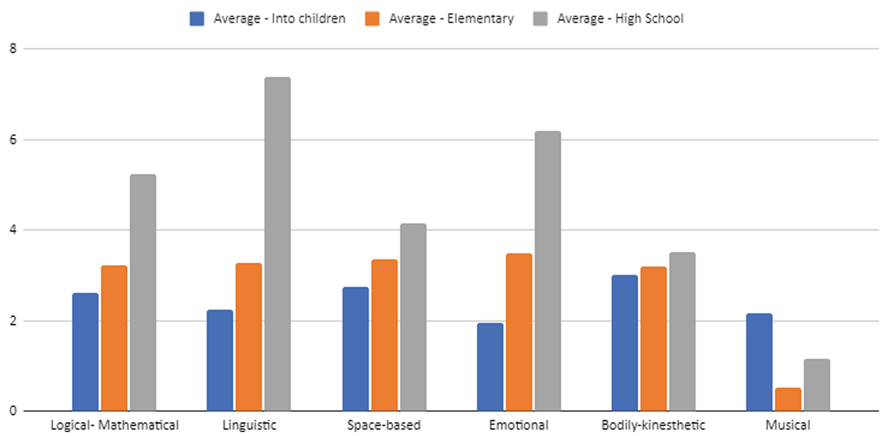
Proposition 2 starts from the premise that five occupations of each educational level were analyzed. Thus, it was possible to obtain the differences in the intelligences required at each level, as shown in Table 3.

Table 3. Consolidated grades by type of educational level

Occupation	Logical-Mathematical	Linguistic	Space-based	Emotional	Bodily-kinesthetic	Musical
Average - Into children	2,6	2,3	2,7	1,9	3,0	2,2
Average - Elementary	3,2	3,3	3,4	3,5	3,2	0,5
Average - High School	5,2	7,4	4,1	6,2	3,5	1,2
Total Average	3,7	4,3	3,4	3,9	3,2	1,3

Source: own authorship

It is also observed that there is a significant gap between grades at all educational levels for linguistic, logical-mathematical and emotional intelligence. On the other hand, for space-based and bodily-kinesthetic intelligences, the difference is not so substantial between the levels. Only musical intelligence has variations, as it is fundamentally required in some specific occupations.



Graph 1. Intelligences by educational level

6 Conclusions

A more horizontal and generalist look is necessary than a look focused on only one of the intelligences. Despite having identified the balance of intelligences at all educational levels, when looking at the educational scenario in Brazil, little is thought about it. Rare public educational policies are created with the aim of stimulating a transversal and diverse view of the multiple intelligences, so present and so necessary in the Brazilian population.

In the job market, by mapping each individual's intelligence, it is possible to direct activities according to each one's abilities and, thus, increase productivity and innovation in collective projects. As Cooper (1997) proposes, today's increasingly open, fluid and constantly changing work style rewards a combination of intellect and emotional intelligence, especially when it comes to trusting other people and collaborating with them to solve problems and seize opportunities.

The school also plays an important role in the development of multiple intelligences, adopting multidisciplinary learning processes that encourage intellectual capacities and apply the diversity of intelligences. Antunes (1997) also exemplifies Goleman's studies on professional competences, which says that every person is born with at least nine intelligences, but ends UP entering a school that charges only two, being as if walled in by these values.

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Generation Z and Intrapreneurship: Perceptions of Employed Workers of Large Companies, Start-Ups and Unemployed Workers

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Abstract. This study is based on a survey directed at Generation Z members (for the purposes of this study: people between 16 and 25 years old) segmented into three groups; people who work in large companies, those who work in start-ups, and those who are not currently working. The objective was to identify the intrapreneur profile in these three groups. This study is important because companies are increasingly looking for employees with this profile, giving more value to professionals with intrapreneurial skills, in order to become more competitive organizations. The results indicate that the employed members of Generation Z have traits of the intrapreneur profile, and they are bothered with traditional work models. Those who work in start-ups perceive that this type of organization, unlike conventional companies, tends to attract Gen Zers with intrapreneur characteristics. Although the study is limited by its sample size (91 respondents), it can be inferred that more dynamic environments (start-ups) attract and release the intrapreneurial spirits of Generation Z. Thus, we suggest more comprehensive studies whose results can lead to generalizations and that large companies should adopt actions aimed at retaining the Generation Z talents.

Keywords: Generation Z · Innovation · Intrapreneurship

1 Introduction

Nowadays, with the Fourth Industrial Revolution, adaptation is not only essential for companies to survive in the market, but also for people because they are a key part when executing operational/administrative tasks, making decisions, and defining goals and strategies (Schwab, 2020). In this scenario, people continue to be very important to keep companies in operation, always seeking to innovate and improve their products.

Due to companies' adaptation in the face of new market requirements, new businesses, products, or services are emerging ever more quickly. This is accelerated by the entrepreneurial movement of professionals seeking new solutions to meet an existing demand or a demand that will come into existence with a new product that can make people's lives easier. These entrepreneurs have different characteristics and profiles and can either be entrepreneurs in an existing company, or entrepreneurs creating new businesses and companies. People with an entrepreneurial profile have a particular way of

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doing new businesses and ease the environment they are immersed in (Barros Neto, 2018).

In this context, the main objective of this study was to analyze the intrapreneur profile of Generation Z members entering the job market, comparing the perceptions of this generation about the atmosphere of each organization, as well as to evaluate the expectations of those unemployed regarding their future employer. That is, the perceptions of people belonging to generation Z were collected in three different contexts: unemployed, workers in start-ups and employed in traditional organizations.

2 Theoretical Background

The great challenge of human resources administration today is the management of at least four generations that coexist and work together: the Baby-boomers (born between 1945 and 1965), Generation X (born between the 1960s and the late 1970s), Generation Y or Millennials (born between the 1980s and the mid-1990s), and Generation Z (born as of the mid-1990s), which was born at the time of transition from off-line to online and has a markedly different profile in the labor market (Barros Neto, 2022).

It is important to remember that dividing people based on generations does not mean that all its members have homogeneous behaviors (Oliveira; Barros Neto, 2022), however it is a way of, roughly speaking, obtaining common characteristics and perceptions.

2.1 Generation Z, Large Enterprises and Start-Ups

Gen Zers are fully conversant with the latest digital technologies and would not have difficulty in learning to deal with the new features that come out almost every day, unlike members of preceding generations. The “Z” comes from “zapping”, that is, changing channels on the TV quickly and constantly with a remote control searching for something interesting to watch or listen to, or even out of habit. “Zap” means “to do something very quickly” and “energy” or “enthusiasm” (Kampf, 2011).

The concept of “Z to Z” company brings the idea of digital companies created in this new era of start-ups, whose essential activity is to transform ideas into products and evaluate the reaction of customers. A Start-up is an organization dedicated to creating something new under uncertain conditions, which includes both the young entrepreneur working from home and the experienced professional in a large organization. They have in common the mission of moving through the uncertainty of business towards innovative and sustainable organizations (Ries, 2019).

Thus, employees of those organizations need to be fast and agile to create products and deliver the best customer experience, and those companies must offer them mechanisms and incentives to change and transform (Tucci, 2022).

2.2 Intrapreneurship

In large companies, we can find the so-called corporate entrepreneurs, also known as intrapreneurs. Despite the lack of convergence on the term, the literature on corporate entrepreneurship reveals two main trends. The first is focused on the individual who implements innovations in the company, presenting corporate entrepreneurship as a set of psychological characteristics, personal attributes, and also the roles or functions of entrepreneurs acting within the organization. The second trend seeks to demonstrate the intrapreneurial process, the factors that lead to its emergence and required conditions, outlining corporate entrepreneurship as an organizational mode. It is characterized by factors such as freedom and autonomy, allowing its employees to always be in search of innovations (Henrique et al., 2012). Fumagalli (2008) points out that the word "intrapreneur" was created by Pinchot in 1985 to combine the term "intra-corporate entrepreneur", that is, a person within the organization who is responsible for transforming an idea into a profitable product by assuming the risk of innovation.

Pinchot (1989) states in his pioneering work that there are ten practices adopted by successful intrapreneurs, which are as follows: a) Be true to your goals, but realistic about the ways to achieve them; b) Build a team of enthusiastic volunteers by selecting only the best professionals; c) Network with people who are able to provide help and assistance whenever needed; d) Be humble and work quietly so as not to generate the organization's resistance mechanisms to change; e) Be loyal and honest with your supporters and sponsors in the company; f) Circumvent any rule that might hinder the realization of a good idea; g) Do the impossible to turn ideas into reality; h) Ask for forgiveness instead of permission, but respect the limits set by the organization; i) Go to work each day willing to be fired; j) Always stay focused.

Klofsten et al. (2021, p. 6) conclude their research by stating that "intrapreneurial capabilities are the organization's ability to react quickly and innovatively to internal/environmental changes and have a significant implication for achieving an organization's survival and success, especially during uncertain and turbulent environments" and thus ratify the importance of intrapreneurs for the success of organizations.

2.3 Intrapreneurship and Generation Z

It is quite evident that Generation Z has intrapreneur traits. That is why, Fig. 1 was drawn to compare both profiles.

	Generation Z Members	Intrapreneurs
Technology	Born in the digital era.	They use technology to innovate.
Leadership	Lead people towards a common goal.	They use leadership for team development.
Responsibility	They are responsible due to love for the cause.	They are responsible with the business due to the feeling of ownership.
Celerity	Due to the need for change to improve daily life.	They perform tasks quickly to improve customer insight.
Adaptability	To deliver value to the cause.	According to market needs.
Agility	In ideas.	In deliverables.
Innovation	Used to improve their everyday life.	Used to make profits for the company.

Fig. 1. Comparison between Generation Z members and intrapreneurs. Source: Based on Uriarte (2000); Said and Said (2013).

It can be said that this generation shows greater aptitude for intrapreneurial values according to Monteiro, Ribeiro, Azary, Marques (2016). Thus, investing in intrapreneurial talents to achieve better work performance has been increasingly common in companies (Kuenne and Danner, 2018).

For corporate entrepreneurs, the feeling of ownership is essential to work, and professionals who have this personality trait end up having more opportunities for career growth, after all, those who dedicate themselves to business with the commitment of an entrepreneur, in the medium and long term, end up becoming the top management leaders of the company (Dolabela and Bodian, 2018). This spirit increases the desire and willingness to lead companies to stand out because it is understood that as this happens, entrepreneurs will have new chances and tasks, being able to raise their pay and improve customers quality of life (Sefton and Gallini, 2020).

2.4 Innovation

According to Mascarenhas Bisneto and Lins (2016) the need for organizations to innovate is constantly demanded by society, and thus we see that innovation is linked to new combinations of factors that break the existing equilibrium, such as changes in the environment (Schumpeter, 2022).

It can be said that innovation is the introduction of novelty or improvement in the productive or social environment that results in new products, processes, or services. Moreover, invention is the emergence of a new product, process, or incremental improvement; it is related to obtaining sustainable competitive advantages, competitive positioning, core competence concepts, innovation capability, and organizational learning (Horn, 2021).

Innovation is divided into three different types, namely incremental, radical, and disruptive: each one with different characteristics. Incremental innovation is based on the creation of new ways of working internally to gain productivity and reduce costs with a long-term gain. Radical innovation is a process in which a company undergoes a structural change or key business change pursuing the market trend. Disruptive innovation, on the other hand, seeks to solve societal problems and monetize by bringing financial return and high impact (Waengertner, 2018).

All forms of innovation are important to keep companies alive in the face of new trends because in this way they become competitive. However, in the 21st century, companies with disruptive innovation have been gaining market share due to their focus on customers and on gaining scale in an accelerated way. In this model, the amount spent is higher because leverage is needed in the market to create a demand for a new product (Christensen, 2018).

2.5 Intrapreneurship and Disruptive Innovation

The corporate entrepreneur profile has been gaining ground in organizations when it comes to making innovations or changes in companies' operation format, for this is the main agent of organizational and economic change.

Regardless of the size of the company, whether small, medium, or large, employees with this profile pursue competitive advantages, act with co-workers who seek new ways of thinking, and make changes totally out of the ordinary (Orofino, 2021).

To identify this profile, innovation is a fundamental tool because it sets the intrapreneur apart from other employees, as the intrapreneur is an individual or a group of individuals who creates new corporate business, either inside or outside the organization, or puts in motion the strategic renewal of the organization (Thomke, 2021). Thus, corporate entrepreneurs who master this technique will certainly stand out among their peers and will be agents of transformation and innovation in the company, turning it competitive in the market.

3 Methodology

The present study is a cross-sectional survey. Its main characteristic is the collection of data at a single point in time (Babbie, 1999). As questionnaires and interviews are the typical data collection methods of surveys (Bryman, 1992), an electronic form was created in Google Forms and sent to the participants.

To select the participants, the link of the form with its proper instructions was forwarded to people who were part of the researchers' WhatsApp (instant messaging application) groups.

These people could answer the questionnaire (or not) and forward it to other contacts they considered fit, according to a technique called snowball sampling (Goodman, 1961). This technique is a form of non-probability sampling, often used in social research, in which the initial participants in a study appoint new participants, who in turn appoint other new participants, and so on. The process should continue until the saturation point is reached, that is, the moment in which new respondents start repeating the content already obtained in previous answers without adding new information relevant to the research (Vinuto, 2014). In the present study, data collection was concluded after receiving 91 valid responses because the time limit of the schedule made it impossible to extend the collection period.

The Survey is more suitable when you want to answer questions that express opinions, customs, or characteristics of a particular target audience and, for this, it is common to use objective questions (Gil, 2019). The research questions were prepared based on the theoretical framework on the characteristics of Generation Z and the startup environment. It is important to point out that this is not a study with statistical sampling, therefore, the risk of having some bias is recognized, however, as it is an exploratory study (Matias-Pereira, 2016), this does not invalidate the results, for this is exploratory research.

4 Analysis and Discussion of the Results

To analyze the data obtained quantitatively, Microsoft Excel© was used, which generates graphs, tables, and several statistics. The respondents were also separated into three distinct groups according to the research objectives. The Likert scale was used and there were five response options available (1. Strongly disagree, 2. Disagree, 3. Indifferent, 4. Agree and 5. Strongly agree). In the following tables we show and analyze what we call favorability, that is, the sum of grade 4 and 5 answers in percentages related to the total number of respondents.

4.1 Generation Z Members Already Working in Companies

The sample included 49 Generation Z professionals employed by companies. As the answers in Table 1 show, these young people are already starting to occupy leadership roles and functions, although most of them do not feel prepared to take on these positions yet. Nevertheless, almost half of the organizations of the respondents usually hire people from Generation Z to occupy leadership and management positions, indicating the need for young people to seek, as soon as possible, management training and preparation to lead.

Table 1. Answers of Generation Z members working in large companies.

Question	% (4 and 5)	N.
The company I work for encourages innovation	61.22	30
The company I work for encourages personal initiatives	59.18	29
The company I work for encourages teamwork	85.71	42
The company I work for hires young people (from 20 to 26 years old) for leadership/management positions	46.94	23
The company I work for promotes people for their quality of work	75.51	37
I feel that I am ready to take on a leadership position	28.57	14
People who deliver results get promoted quickly	30.61	15
People with good relationships get promotions faster	51.02	25
In the company I work for there are many young people (from 20 to 26 years old) in leadership/management positions	18.37	9

Most large companies, in the view of Generation Z, do not promote people who deliver results (technically competent) quickly, but promote those employees who can establish good relationships (possess social skills).

On the other hand, this generation perceives that large organizations promote people for the quality of their work and, quality being a broader concept that encompasses both the deliveries and the way these deliveries are made, it can be inferred that such companies value employees that achieve results and deliver them consistently.

Also, Generation Z members consider that most of the large companies they work for promote individual initiative, teamwork, and innovation. This is an important result since these are intrapreneurial characteristics and fundamental requirements for organizations to remain competitive in the current market context.

4.2 Generation Z Members Working in Start-Ups

The total number in the sample of Generation Z participants employed or interning in start-ups was 14 (from 16 to 25 years old). After carefully analyzing Table 2, it can be seen, as a pattern or average, that the Generation Z respondents who work in start-ups have the perception that most people who work in this type of company are from their own generation (Z). They perceive themselves as people who are well prepared to perform leadership positions and see themselves as problem solvers. The respondents also believe that they are encouraged to achieve personal development and to take initiatives in their jobs.

Although there is a significant difference between the number of participants from Generation Z working in large companies (forty-nine respondents) and those working in start-ups, it is possible to ascertain that there is a substantial difference between the environments of these two types of companies. It seems that the atmosphere in start-ups is indeed more dynamic and open to the potential of Gen Zers and has more to do with the characteristics and expectations of these newcomers to the job market.

Table 2. Answers of Generation Z members working in start-ups.

Questions	% (4 and 5)	N.
The people in the company I work for are mostly from Generation Z	85.71	12
The people in the company I work for seek to solve problems	85.71	12
The people in the company I work for are encouraged to innovate	92.86	13
The company I work for encourages personal development	92.86	13
The company where I work encourages personal initiatives	78.57	11
The people in the company I work for are promoted by results	85.71	12
The people in the company I work for who are in leadership/management positions are unprepared	21.43	3

As more and more start-ups emerge and compete for talent in the human resources market, it is to be expected that this type of organization will attract and retain more employees than large organizations. In this sense, the human resources management teams of large organizations will have to develop other mechanisms to attract and retain Generation Z employees, at the risk of not being able to add new competencies to their companies.

4.3 Generation Z Members not Working in Companies

The total number of Generation Z members included in the sample who were not working in organizations during the research period was thirty-one (31). When analyzing closely the content of Table 3, it can be seen that Generation Z members that have not yet entered the job market prefer companies that are similar to the answers of start-up employees than to large companies' employees.

This makes sense because those who are working in large companies do not see young professionals taking on leadership positions, unlike the start-ups participating in the study, which offer incentives to develop their younger employees to take on these positions, making them to feel more prepared to take on leadership roles.

Table 3. Generation Z Members not working in companies.

Questions	% (4 and 5)	N.
I want to work on something that I believe in	100.00	31
I want to work in something that gives me more freedom	87.10	27
I want to work in an innovative environment	80.65	25
I want to work in an uncertain environment	6.45	20
I want to perform multiple tasks at one time	45.16	14
I want to grow fast in my career	77.42	24
I do not like receiving too many orders	35.48	11
I like to work on my own time	64.52	20
I like the idea of earning a good salary	93.55	29
I develop my own skills; I do not expect it from the company	54.84	17

5 Concluding Remarks

Generation Z members who are already active in the labor market have traces of the intrapreneur profile (described in the theoretical background) that seeks innovation and accelerated growth in companies and are bothered by traditional organizational models.

Start-ups employees perceive that leadership in this type of company differs from leadership in traditional companies, because in start-ups, intrapreneurs and Generation Z members have already been assuming leadership positions.

It was observed that Generation Z respondents who have not yet entered the job market would like to earn well but work on their own time. Nevertheless, they want to grow fast in their career, work in something that has purpose and be free to make decisions. This confirms, as seen in the theoretical background, the fact that start-ups differ from traditional large companies, and they are closer to the expectations of Gen Zers who are yet to enter the job market.

Generation Z members showed in this research a more innovative profile, focused on intrapreneurship, and seeking their own development. They want to move up the career ladder quickly, seek innovation, deliver results, higher salaries, management of their time and autonomy. However, large companies are not yet aligned with the profile and expectations of this new generation.

This may lead these young people to feel frustrated and willing to employ their skills and ideas outside the companies, seeking entrepreneurship and increasing the resignation of these employees, who will undertake entrepreneurship in the market or look for new companies that are in tune with their ideals of autonomy, growth, better salaries, causes, and purposes.

This work raised even more questions and doubts about how prepared Generation Z members would be to take on leadership positions in such a complex world, and whether large companies will adapt quickly enough to welcome these young people into their workforces. We also wonder if start-ups would be the organizational model to prevail from now on by attracting Generation Z talents and condemning large traditional companies to face employees' shortage very soon. These questions make the limitations of this study explicit, mainly because of its small sample of respondents and indicate paths for future research.

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Inclusion as the Next Frontier of Innovation

Fuzzy Front End and Design Thinking Integrated Frugal Innovation Framework for Feature Concept Generation in a Product: Portrayal for a Wheelchair

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Abstract. This article primarily aims to develop a hybrid framework for frugal innovation-oriented feature concept generation, by combining the fuzzy front end and design thinking paradigms, which is scantily available in the extant literature, adducing a scope to explore and development of the same of a certain kind. This concept generation process adopts empathy mapping and follows the first three steps of design thinking approach, namely, 'empathize', 'define' and 'ideate', while setting aside 'prototype and test' phases for development only after concept validation is undertaken, aligned with the fuzzy front end focus with affordability consideration based on frugal engineering paradigm. Frugal innovation and engineering succor sustainability: socially, as it addresses the issues of the base of the pyramid market and customer; economically, as it brings in affordability; and ecologically, since frugal design restricts features to only essentials or core, discarding the supererogatory ones, ensuing lesser consumption of material and other resources that in turn slashes energy requirement and thereby limits emission. The suitability of the model or rather the framework is tested by validating through the feedback of relevant experts by deploying Delphi modality for consensus opinion and convergence on the feature concept design for a product, to be developed frugally, that is with the perspective of affordability engineering. The feature considered in this study is the step-climbing capability, enabled by augmenting with double-acting load-bearing hydraulic cylinder attachment to a product that is a wheelchair in this case. The concept schematic is presented as a CAD model for judgment which is captured through a questionnaire that is also developed here. According to the observation of the experts, participating in the Delphi based study, a positive response is indicated, converging after the first round itself, establishing the efficacy of the proposed framework in product feature concept generation and proffering benefits to companies and especially in design and manufacturing oriented entrepreneurship, generally impeded with resource constraints.

Keywords: Frugal Innovation · Fuzzy Front End · Design Thinking · Hybrid Framework · Wheelchair Design

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1 Introduction

An overview of the topic at the beginning would be expedient for cognizing the perspectives in designing a product, particularly counting the front-end part, before product development and major investment for commercialization, bearing noteworthy impact in the course of innovation. In the front-end part, the variables are of diverse nature and involve significant degrees of uncertainty and hence the phase is called fuzzy. The decisions are to be driven through the earlier stages of development, namely, opportunity and scope identification, defining the problem, ideation, and conceptualization, that is prior to committing for actual physical development. The front end decisions are responsible for a larger part of cost commitment, while the actual spend during that phase is low. Another salient aspect of product innovation is concerned with the value sensitive market where affordability becomes a significant issue and is considered as design constraints and seeks to realize the development and innovation with a cost-economic frugal engineering approach. In the recent past, since the global financial crisis more than a decade ago, the economic meltdown led to a rather speedy adoption of the concept of frugality with respect to innovation and its engineering. Frugal engineering as a practice in the industry is quite evident from its adoption by the globally known companies like Siemens, General Electric, Samsung, Phillips and several others over the last decade and is intensifying during and in post-Covid era. Frugal innovation is a resource-scarce solution, designed and implemented despite resource constraints, whereby the outcome is significantly competitive offerings that are good enough to meet the basic needs of customers who would otherwise remain un(der)served. Predominantly, three paradigms namely, design thinking, fuzzy front end and frugal engineering have been considered to address these requirements but with a standalone methodical approach.

For frugal engineering, ideation, conceptualization and design specification constitute the front end before development, i.e., before major investment for commercialization. Cost commitment is done at this stage but actual expenses are not made. This front end, however, is called fuzzy because of the uncertainty of the aspects involved in this phase. Fuzzy front end (FFE) at the pre-development stage helps to determine the technology and the functionalities of the product and the cost associated with the same. Idea generation is also known as problem-solution fit and concept generation is known as product-market fit. Need-based ideation is now aligned in the frugal engineering paradigm and value proposition to have frugal innovation as the outcome. Feedback is taken till Frugal Innovation is satisfied. We need to assimilate fuzzy front end with frugal engineering (FE) to reduce the risk or uncertainty (fuzziness) of frugal innovation leading to affordable commercialization. A hybridized framework would supplement the deficits of exclusive and single paradigm and proffer a comprehensive solution approach which is the need of the present time.

The literature review on prior research reveals the nature of work undertaken in the subject area and is indicative that it has exceedingly become important to consider the affordability aspects in product creation, as the emerging economy markets are becoming the drivers of the economy, due to the huge consumer populace, that is about two-third of world population, with lower purchasing capability. It is needed to offer value-sensitive products and eventually conceptualize for the same based on the tenets of frugal engineering. Frugal design and innovation supports sustainability factors; economic, social and environmental. Substantial cost reduction, concentration on core functionalities and optimized performance level are considered as three primary criteria to define frugal innovation [24]. Frugal innovation is the most disruptive type of all resource-constrained innovations as it enables unprecedented applications specifically developed for resource-constrained environments in emerging markets [25]. The no-frill, cost-cutting, and resource-saving nature of frugal engineering has enabled many firms to create successful, affordable products [26]. The core characteristic of frugal engineering (FE) is engineering simplicity as the use of raw materials and other resources need to be minimized, which results in lower manufacturing cost [27]. Other important features of frugal technologies are robustness and durability, especially in products that are used in remote areas [28]. The association or rather support of another emerging practice methodology 'Design Thinking'(DT) can be found for frugal innovation as has been dealt with by [29, 30, 36]. The goal of design thinking is to coalesce heterogeneous and varied perspectives and ideas and navigate the assimilation towards innovative solutions. This sounds similar to the New Product Development (NPD) process adopted and followed in many enterprises and the Fuzzy Front End (FFE) stage, in particular, in NPD exhibits significant equivalence with the design thinking process. Substantial similarities can be noticed in some articles on design thinking (DT) [21, 29, 30] and on Fuzzy Front End (FFE) [22, 32] and show the potential of capability transfer between them and it can improve the application due to symbiotic and synergistic effect. Design thinking essentially does not include the two aspects adequately enough: first is the affordability aspect considering the frugal engineering and innovation paradigm requiring the need to bring this perspective in the framework, and the second, the design thinking begins with a discovery or empathy phase and ends with test and delivery consideration of product or system, any special attention in the pre-development or pre-prototyping stage has not been markedly empathized [40]. These two precepts are crucial and hence have been hybridized in the framework where design thinking alone would rather be insufficient to some degree.Idea and concept generation is a front-end activity in product development. For front-end activity that involves a high degree of uncertainty due to the presence of several factors which are diverse in nature, decision-making has to be done in a fuzzy situation. The aim is to de-fuzzify the decision-making associated with multiple factors or variables. While the purpose of defuzzification regarding bringing clarity has been discussed in the literature, the methods and means to do such exploration and investigation for efficacy and determination are scantily available though approaches like design thinking have enormous potential in such application. Another important dimension is affordability which exclusively becomes crucial in planning and strategizing product development, with due consideration of the market size [29, 38]. For determining the production volume and economy of scale, a major factor is an emerging economy, which has become the driving force due to its enormous consumer population which is nearly two-third of the world population. In spite of the fact that the market size is quite large, the affordability is limited since the consumers or users range from middle- and low-income countries broadly known as developing countries.

This work therefore aims to address the need or rationale, based on the above aspects and conducts study on the interfaces and interdependencies of the three paradigms, namely, frugal innovation and engineering, fuzzy front end and design thinking according to extant literature. The features of the paradigms are considered together to discern operational and functional relationships, since a comprehensive framework is effective for designing and realizing the goal of developing affordable products of copacetic quality. However, any framework combining the above three paradigms is hardly available in the extant literature and it reveals a gap in the study, undertaken so far and throws up an opportunity and scope for work on this aspect. Moreover, consequently, validation of product idea and design feature concept generation based on a formulated framework is practically unavailable and addressing that want is a highlight of the present study.

The present work aims to address the above two aspects: developing a suitable framework and validation of concept generation suitability. Now, while it is the question of selecting a product, the authors felt that it would be ideal to consider one that has a social impact as many people in emerging economies like India, Brazil and other Latin American countries, several other countries in Africa and Asia. It is equally important for the bottom of the pyramid people in the developed economies as well. Wheelchair and assistive technology products are considered for this purpose. From the literature review [31] and the exploratory survey, it is found that the step-climbing feature for a wheelchair is a sought-after one but is available only as very expensive models, unaffordable for a large population globally. It may be noted here that a more needed feature is step-climbing and not exactly the stair-climbing type since often the need is to climb on the pavement (footpath) or to enter a hall or a shop which is just a few inches above the traversing surface and practically in the workplace there will be elevators and stair-climbing may not be much needed as would be for the step-climbing locations where usually there will be no elevator service.

The methodology adopted in this study, to begin with, involves identification of the limitations of the three notable aforementioned paradigms, namely, design thinning, fuzzy front end and frugal engineering, in the event of application in isolation and discerning the sparsities and mismatches. Then to create an interface among these paradigms design thinking, fuzzy front-end and frugal engineering and complement abridgements by conceptualizing for a common framework cross-supplementing the deficiencies particularly in the front end of innovation, focused on ideation and conceptualization stages in product development. The methodology involves analyzing the constituent parts in the paradigmatic blocks and discerning with their interactive pathways or connections within the block elements. Ideation and conceptualization of a product which is a step-climbing wheelchair have been undertaken and the graphic design of the same has been created and checked for its suitability or acceptability based on expert opinion. The detailed methodology is presented under the ‘Methodology’ section below.

An explication in the form of a thesis statement brings out the modalities of creating a comprehensive integrated hybrid framework to address the design conceptualization of a product with affordability engineering for value sensitive market embodying essential features, which have been exemplified here with a step-climbing wheelchair for testing the efficacy of the developed framework and for the purpose of its validation.

An elaboration of the constituents of the paradigms is aimed to provide better clarification and the organization of the paper is presented in the section wherein the objectives and research questions have also been delineated.

Frugal innovation is also referred to as ‘affordable excellence’ because of its Unique Value Proposition (UVP) which is reduced cost of ownership, robustness, user-friendliness and economies of scale. Affordable products with pertinently good quality, developed with frugal innovations and engineering are becoming vital for maintaining long-term competitiveness in both the emerging and industrialized economies. Literature indicates that frugal innovation has three primary dimensions: i) Product: characteristic pertaining to its functionality, simplicity, robustness and problem-solving capability, user-driven ii) Process: Bottom-up creative process to respond to challenges, localized research and development and scaling options and, iii) Context: Affordability, resourcefulness (doing/ performing or achieving more with less), radical transformative implications.

Frugal refers to what truly is the most vital from the user or buyer’s point of view or rather something that is extremely critical or essential, i.e., those features in a product without which the product will not be acceptable. By extending it a little further it may be expedient to use the word VITAL as an acronym conceived and presented in this work, as it appropriately reflects the true essence of frugal: V - Value sensitive, I – Impressive (attractive), T - Trustworthy (including performance quality, robustness and reliability aspects), A - Affordable and L – Lift and Lean. Value sensitiveness signifies a judicious selection of core features, that a customer is willing to pay for if the same is amalgamated into the product. ‘Impressive’ is a more generic term than attractiveness to include attributes such as user experience. By ‘trustworthy’, it means that a product or service needs to earn the trust by virtue of quality, performance, reliability and durability. Affordability is the basis of frugality focusing on the core functionalities. Lift and lean refer to lifting bits and pieces of different technologies and assimilating the same (bricolage), waste elimination and reducing the cost through local production.’Lift’ basically refers to picking up proven and performing technologies in bits and pieces from available sources that do not necessitate high cost of new technology development for an affordability-engineered product for incremental or not so substantive improvement.

The copacetic region is our target region for Frugal Engineering where cost is almost halved but quality features (Q2) are about 90 to 95% of the standard product (Extant) with the current design. 5 to 10% compromise on Quality from standard products is allowed in frugal. On the other hand, bog-standard goods are those ordinary cheap products with low cost and high compromise on quality. With reference to Fig. 1,

$$Q_1 = \text{minimum acceptable quality (say, for bog} - \text{standard products)};$$
$$Q_2 = Q_1 + Q'_2;\ Q_3 = Q_2 + Q'_3 = Q_1 + Q'_2 + Q'_3;\ Q'_2 = k_1 Q_1 Q'_3 = k_2 Q_2;$$

where k_1 and k_2 are multipliers as coefficients

Similarly, for Cost, we have:

$$C_2 = C_1 + C'_2;\ C_3 = C_2 + C'_3 = C_1 + C'_2 + C'_3;\ C'_2 = l_1 C_1;\ C'_3 = l_2 C_2;$$

where l_1 and l_2 are multipliers as coefficients

As per the World Health Organization (WHO) (2021), around 15% of the worldwide population have disabilities of various levels, and around 75 million people need affordable assistive mobility devices like wheelchair and only 5% of those who has

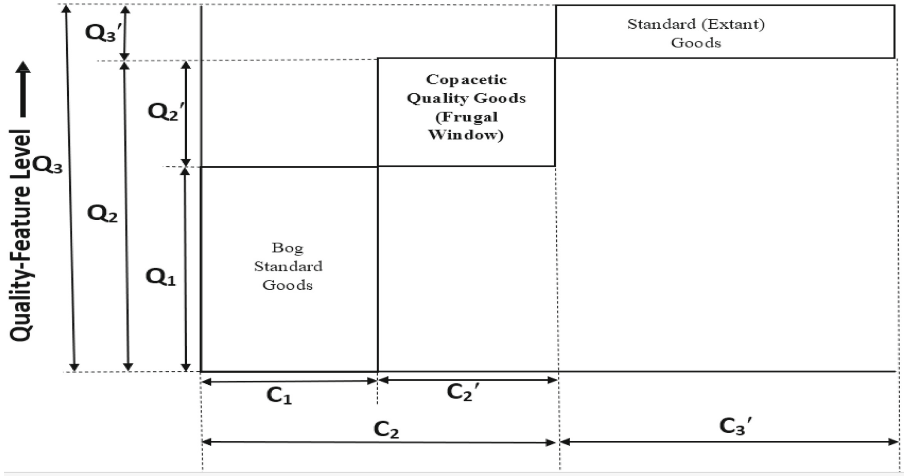

Fig. 1. Frugal engineering space: a pictorial analytical illustration

need to access to one rest of people can't afford it [45]. A manual wheelchair, which is our principal worry in this review, is the most restoratively assistive gadget used in less-resourced settings by individuals who experience issues in versatility, and is self-impelled or pushed with the guide of someone else. According to the past information available, there is no systematic framework or classification of activities and choice seems to be based on the assumption of what type of fundamental activities disabled people might experience a problem with. The wheelchair assistive technology model with a fuzzy front end and design thinking-based frugal design has some specifications to cover all major human activity areas with minimizing the overlap between categories. The various kinds of wheelchairs available in the market are manual wheelchair, electric-powered wheelchair, sports wheelchair, child/junior wheelchair, specialty wheelchair and Institutional/nursing home/depot wheelchair. According to the survey, the step-climbing wheelchair is the most demanded feature for the frugal product design aspect with affordability consideration.

According to the survey, there was not any concept to design a step-climbing wheelchair on the basis of alignment in design thinking and fuzzy front end of innovation. Alignment of design thinking steps like Empathies, Define and Ideate with the fuzzy front of innovation build a new concept generation for the new product development. According to this new concept, the most demanded feature of the wheelchair has to be designed (step-climbing). The first phase has empathized in which observation takes place and identifies problems with the users, second phase is 'define' in which user feedback from empathize phase has to be taken and a design brief of context and opportunity will be carried out with valid reason. The third is 'ideate' in which brainstorming and CAD drawing of a model has to be taken and a valid idea of concept evaluation in new product development will be carried out. This alignment helps us to identify the effective concept generation for the development of new features in frugal design products.

The review of the conceptualization of different features of wheelchairs with affordability consideration and to design the new concept of most needed step climbing wheelchair with a frugal product design approach of affordability. In conceptualizing the design consideration of step climbing wheelchair, fuzzy front-end innovation plays an important role.

The key features of the fuzzy front end of innovation are: preliminary market assessment, opportunity identification, idea generation and screening, idea selection and concept testing, product strategy formulation, product definition and project planning. According to these features we conceptualize the final feature of frugal design-based affordable wheelchairs that have great impact on product quality, costs and time.

The special product portfolio for this important and large market segment is regularly being created by large firms, including multinational companies and simultaneously the same has become the pursuit of many business start-ups. However, this affordability or frugal innovation approach is rarely addressed in the extant literature when the difference variable particularly the front-end of product creation is being targeted. Finding this as a huge gap a couple of objectives have been attempted to be framed here. These objectives are to examine the matching interfaces of these affirmation paradigms - fuzzy front-end, design thinking and frugal innovation, and most saliently to create a comprehensive framework involving this paradigm in order to obtain a guided pathway for successful product development or rather specifically for guidance in ideation and conceptualization phases, which greatly determine the success and failure of the project. Based on these objectives, the research questions ensue as i) How do we integrate fuzzy front end and design thinking into a frugal innovation framework? ii) How are these three paradigms namely, fuzzy front end, design thinking, and frugal innovation helpful for the concept generation of, new product development? iii) What kind of approach is to be taken with the frugal innovation concept for the development of a step climbing wheelchair? iv) How will the frugal innovation hybrid framework be validated to develop product features?

2 Methodology

The salient aspect of the methodology has been to first explore the literature to check the availability of a combined and hybrid model as assessed as the gap in the study on the framework combining the three paradigms, namely, Frugal Engineering, Fuzzy Front End and Design Thinking in new product concept generation and innovation. As such a model is scantily available, the need has been to develop a conceptual framework ascertaining the interrelationship of these three paradigms for this and is conjured up here, which is depicted in schematic form in Fig. 2.

It may be delineated here that the 'value proposition', referred to within the right-lower block in the above figure, includes the determinants; reduced total cost of ownership, robustness, user-friendliness and economies of scale as suggested by Tiwari and Herstatt as well as product appearance and getup or attractiveness/ aesthetics [33, 34], which the authors have accommodated in the model as the fifth value proposition metric. This essentially means that the frugal product may be priced low but should not appear as low- end. The emotional engineering design aspect (*kansei*) makes aesthetics important

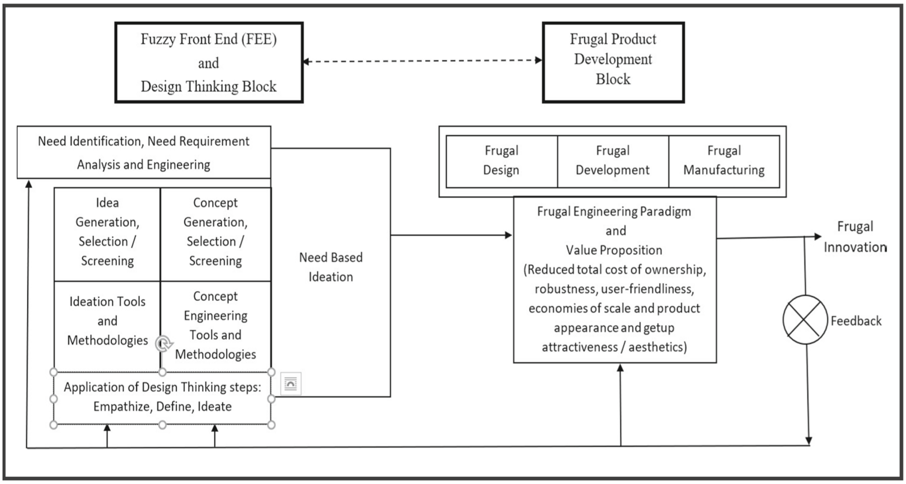

Fig. 2. Hybrid product feature generation model Inter.connecting FE, FFE and DT.

for a customer and the appearance, in most cases, does not involve large costs but needs creativity and attention. The methodology includes judging the proposed wheelchair against the above-mentioned compliance metrics and if the outcome is not meeting the cost and market targets based on feedback, iterations will continue till the satisfactory concept is realized.

The afore-stated framework for concept generation needs validation and an actual feature of a product has had to be identified for verification, in this case, is considered based on the step-climbing capability feature of the wheelchair product. For this intent, a method for validation of the conceptual outcome is devised and parameters are identified for such, as presented in the 'Questionnaire' developed for this purpose and presented below in Table 2. The consideration of affordability issues is necessary alongside the technical, operational and ergonomic suitability for subsequent approval for prototype development. The extant designs associated with the step- climbing feature considering affordability have been explored before embarking on freezing the functional and operational concept for the feature. An empathy map is prepared, based on the user feedback, as the foregoer of the design thinking approach-based concept development process to create the scheme effectively. However, prototyping and product testing stages are set aside for physical development and the 'Empathize', 'Define' and 'Ideate' routeway is tracked. The relevant tools and what is opted is presented in Table 1.

The empathy map is to be developed to ascertain users' need in particular aspects of proposed usability of product. Empathy maps are an excellent starting point for developing this understanding of users behaviors, visually communicating and uniting the team of the users. The empathy mapping can point out the gap in user research and highlight what further needs to be discovered about users' needs. The empathy map is a square shape divided into four quadrants with users in the middle and four quadrants look like what users think, feel, say and do. After dividing user need into these four quadrants, the pain and gain should be obtained according to the user's perspective in the empathy

Table 1. Aligning Design thinking and Fuzzy front end of innovation

Design Thinking Phase	Tools Used	What is opted
Empathize	Interview checklist Observation checklist	Personas and empathy map User Feedback Problem identified
Define	User feedback from empathizing phase Sketching drawing and CAD	Design Brief Context and opportunity analysis and assessment
Ideate	Brainstorming and use of 'post-it' slips Drawing CAD and whiteboard Design brief in the 'define' phase	Ideas, concepts, and sketches Ideas/Concept evaluation

map. The empathy mapping is a cost-effective technique and easy transmittable way to analyze users' needs. The Empathy mapping of the most essential feature of wheelchair i.e. step-climbing should be developed and incorporated on the basis of fundamentals tools according to the consideration of actual empathy map.

To obtain feedback from the experts for concept validation, the graphic design of a wheelchair with step-climbing feature, along with a functional sequence diagram is to be created, as is needed to verify if the contrived conceptual design, prepped in accordance with the developed framework, is primely acceptable, and if so only then the proposed hybridized product concept development framework can be considered as validated. The functional sequence diagrams or the schematic design of step-climbing wheelchair are depicted below at different climbing stages which will be in reverse sequence for climbing down, and also the operational and technical descriptions for the same are explicated hereinafter.

Multiple concept alternatives have been generated by the authors' team, with mechanical arrangements namely, cam-based, mechanical jack based and hydraulic-mechanical based considering the affordability or frugal factor. However, the hydraulic cylinder operated system is elected, considering all the related aspects, that also requires minimal effort in the event of a self-driven wheelchair. Following the 'define' phase of DT, a 2-D concept functional sketch incorporating two double-acting hydraulic cylinders in the wheelchair and its operational and step-climbing schematic is prepared through SolidWorks CAD software for comprehension of the expert respondents for a Delphi based convergence. The schematic is presented in Fig. 3 (Stage 0 through Stage 4). The development of a step-climbing wheelchair contains 4-wheels (2 drive wheels and 2 caster wheels) and 2-hydraulics double acting cylinder one at the back with two wheels for stability and auxiliary in nature, for operation and the other on any of the sides placed between the drive wheel and caster wheel that is purposed to lift the wheels from the ground surface to any elevated surface or pavement or hall or shop entry. The above 2-D CAD model shows the stages of the concept feature of the step-climbing wheelchair. Stage-0 consists of the stationary position of the wheelchair with 2-double-acting cylinder hydraulics on the front and back sides of the wheelchair. Stage-01 shows the lifting

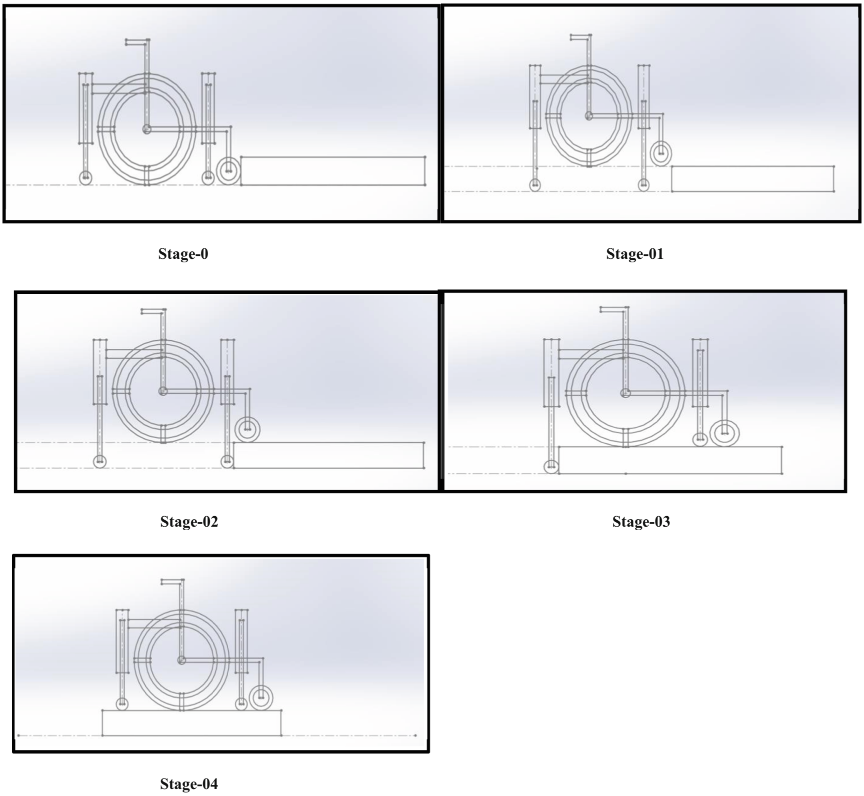

Fig. 3. Schematic design of step.climbing wheelchair

of both the drive wheels and caster wheels by two double-acting cylinder hydraulics. Stage-02 shows that the caster wheel is on the step or pavement and moving forward. Stage-03 shows the front hydraulic is lifted and the whole system of the wheelchair is moving forward with the help of belt-pulley arrangement up to when the rear-drive wheel is on the step or pavement. Stage-04 shows when the rear hydraulics wheel is lifted and the whole system of the step-climbing wheelchair is on the step or pavement.

Now, a questionnaire, as needed to capture the expert feedback is prepared and is presented in Table 2, from which the verification and validation of the design concept is to be conducted. To have a convergence on the observations and feedback the consensus-making Delphi approach is considered. The Delphi method has been used as a research tool for expert problem-solving as for complex issues it requires knowledge from people who understand the different technical and other related aspects. Delphi technique is a group method that does not require the concerned experts to meet face-to-face with the benefit of confidentiality and freedom from peer pressure, but enables them to reach a consensus through an iterative process. In the event of relatively fewer experts with knowledge about the issues in context, the requirement for the Delphi panel size is modest. The Delphi exercise was executed with five physical therapists who are technically and functionally closely involved and who are considered appropriate for this study for their experience and expertise in the context of patients in wheelchairs.

Table 2. Questionnaire for step-climbing wheelchair

Sr. No.	Questions	Options				
Que.1	How is the effectiveness of this (in sketch) step-climbing wheelchair?	Highly suitable	Suitable	Indifferent	Unsuitable	Very unsuitable
Que.2	What is the user-friendliness of this wheelchair?	Highly suitable	Suitable	Indifferent	Unsuitable	Very unsuitable
Que.3	What is sophisticated and advanced or a getup/aesthetic look?	Very good	Good	Simple	Bad	Very bad
Que.4	What is your opinion on the performance and robustness of this wheelchair?	Very good	Good	Simple	Bad	Very bad
Que.5	How is the usefulness of this affordable step-climbing wheelchair?	Highly useful	Useful	Indifferent	Not useful	Highly unusual
Que.6	What is comfort-ness of the patient while moving in a wheelchair?	Highly comfortable	Comfortable	Indifferent	Uncomfortable	Very uncomfortable
Que.7	How is the value for money for a price range of 450\$–500\$?	Highly suitable	Suitable	Indifferent	Unsuitable	Very unsuitable
Que.8	How is the value for money for a price range of 500\$–700\$?	Highly suitable	Suitable	Indifferent	Unsuitable	Very unsuitable

The methodology as proposed and elucidated hereinbefore for information capture, analysis and evaluation can be used for similar application situations, since it is primed on a logical flow of operational interaction among interrelated contextual factors.

3 Results and Discussion

According to the hybrid framework which mentioned in methodology section and graphic design of wheelchair with step-climbing feature the empathy map have to make which consider personas of multiple users in the form of Think, Feel, Do, Say of this kind of feature of wheelchair and obtained what kind of pain and gain for primly acceptable this step-climbing wheelchair.

The empathy map, which is self-explanatory, is presented in Fig. 4. The pain aspect in existing wheelchairs is due to affordability issues, expelling a major limitation in step-climbing. The gain is accommodating this feature with a relatively simpler mechanism, not requiring sensors or electrical etc., making it maintenance-free and user-friendly. It benefits all stakeholders; users, patients, and caregivers along with the developers and suppliers of such equipment.

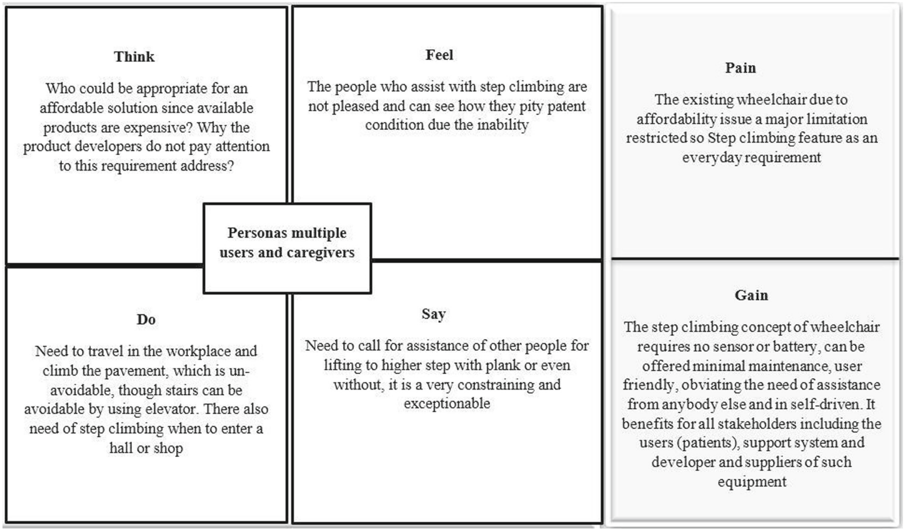

Fig. 4. Empathy Map

Expert feedback from five physical therapists along with their evaluation rating is presented in Table 3 in response to the queries listed in the questionnaire presented in the Methodology section under Table 2.

The validation of the hybrid framework on the Step climbing feature of wheelchair is feasible and provide best output from the experts opinion. The suitability of product feature concept generation using the FE-FFE-DT hybrid framework can be ascertained from

Table 3. Response by the Expert

Sr. No.	Questions	Expert Assessment					Remarks
		Experts					
		E-01	E-02	E-03	E-04	E-05	Average Ratings
1	Question.1	HS	HS	HS	HS	HS	HS
2	Question.2	HS	HS	HS	HS	HS	HS
3	Question.3	VG	VG	VG	VG	VG	VG
4	Question.4	VG	VG	VG	VG	VG	VG
5	Question.5	HU	HU	HU	HU	HU	HU
6	Question.6	HC	HC	HC	HC	HC	HC
7	Question.7	HS	HS	HS	HS	HS	HS
8	Question.8	HS	HS	HS	HS	S	(4HS + 1S)/5 Which is close to HS

E – Expert, HS - Highly Suitable, VG - Very Good, HU - Highly Useful, HC - Highly Comfortable, S – Suitable.

the responses captured through the developed questionnaire, where five physical therapists opined favorably and reached a consensus after the first round itself. The response of all the experts based on the conceptual schematic of the proposed design select the options in the left-most column in the questionnaire, with a very minor exception of one expert who feels that the cost aspect (in the range of 500$–700$) would ‘suitable’ and may not be categorized as ‘highly suitable’. Overall, the observations perfectly support the framework including inherent assumptions as evidenced by the results. The Delphi process yielded a consensus in the responses after the first round itself.

4 Conclusion

A hybrid concept generation framework for product design has been devised integrating design thinking, fuzzy front end and frugal engineering paradigms seamlessly as it is enabled to support such purpose involving the initial or front end phase namely, discovery or empathy, problem defining and ideation rather successfully and efficaciously, while also including the affordability factor on the tenets of frugal engineering.The framework has provided guidance in concept development for the target product, exempli gratia, step-climbing wheelchair, an assistive mobility device, quite systematically. This product design concept has been able to secure favourable evaluation by the experts in the capacity of physical therapists. Fairly high ratings by the experts through a prompt consensus regarding the suitability of the design concept establish its acceptability and thereby confirm the validity of the product concept generation framework. Use of the framework may be extended for evaluating concepts for other features of the wheelchair product or for another feature of a different product under resource-constrained design conditions, that is the scenario in any company, especially the resource-starved startups.

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Fostering Social Innovation and Entrepreneurship with Action Research: The Design of Face Masks for the Brazilian Deaf Community

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Abstract. The aim of this paper is to present the design of an accessible face mask as an applied framework to promote the principles of social innovation. During the pandemic, the Brazilian Deaf Community had not been properly considered as part of the emergency policies, which demanded the use of face masks, increasing communication barriers for a high-risk, underserved, and vulnerable population group. We approached this challenge proposing the use of the research action as problem solving method. As a result, a social organization brought together a group of local seamstresses, residents of a nearby slum, and the university together in a collaborative way to create the masks.

Keywords: Social Innovation · Action Research · Inclusion · Entrepreneurship · COVID-19

1 Introduction

The COVID-19 Pandemic impacted public health and work, causing economic and social problems for different people. Close to 690 million people were at risk of failing into extreme poverty. The workers in informal economy have been highly impacted due to lost access to productive assets [1]. People with Disability are disproportionately affected during the COVID-19 Pandemic [2]. The World Health Organization (WHO) reported that 1 billion of people live with a disability, which means that 15% (ten percent) of the world population has at least a disease [3].

Those people usually have specific needs for living, education, health, leisure, safety, and others to promote their wellbeing. In addition, this matter is justified through the 2030 Agenda for Sustainable Development, adopted by all United Nations Members States, which reinforces the need for inclusion and development of solutions to those people [4].

As a mitigant for the needs argued by COVID-19 Pandemic, the social innovation appears as proper solution. Although this term has been discussed since the begging of this century for different agents and authors, there is no consensus about its definition.

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As a result, this concept suffers from lake of approaches, methodologies and frameworks [5]. One of the pillars of social innovation refers to the social inclusion and capacitation process [6] for people with disability [7].

Then, this paper aims not only to develop the social innovation as a solution for new and existing needs of people with disability argued by COVID-19 pandemic, but also aims provide an applied framework to help the scientific community.

The content of this paper is organized as follows. In Sect. 2 we presented the definition of social innovation used in this paper. Section 3 explained how we selected collect, analyzed, and provided the data used in the paper. Section 4, we reported our results, while in Sect. 5 we present the main conclusions.

2 Societal Transformation Through Social Innovation

In the Schumpeterian tradition, innovation takes place through the form of a product or service (new or enhanced), a process (production, delivery, techniques, equipment, and software), marketing (design, packaging, placement, promoting and pricing) or an organization (business methodologies, workplace or in external relations). It involves the design as part of an innovation process as per Oslo Manual published by The Organization for Economic Cooperation and Development (OECD) [8]. Despite of its importance, there is the critic that this connect of innovation is to focus on economic development.

On the other hand, recent decades have seen the emergence of the concept of Social Innovation (SI) as an alternative the purely economic view of innovation. Social Innovation primarily address social change, where the value created accrues to society rather than private individuals. [10]. Social innovation is the key to transform the society through a piece of legislation, a social movement, an intervention, or some combination of them [5].

The novelty about social innovation concept is that it has been guided more by behavioral change than technological or market change, generally appearing through organizational processes bottom-up than top-down due to the changes in the way individuals or communities work to solve their problems or to create new opportunities [11]. As per involved agents in the process, the SI is not limited to the social economy, but is also present in the private and public sectors as well as on new technologies, research institutions and other actors and institutions of society [12].

3 Research Design

Action Research is a methodology developed in the social sciences field in the last century. It is an iterative methodology of research to provide more scientific knowledge based on the actions taken to solve an existing problem of an organization, community, or group.

The main goals of this methodology split in two pillars: research (understanding) and action (act on the environment). It is also highly typified by the participation of the researcher as an insider (an individual working or living in the environment) or outsider (a person working or living outside, strongly involved in the research environment).

In both cases, the researcher turns from a spectator to a coadjutant, helping and advising on the changing. The research is applied iteratively with all stakeholders to refine the solution and be more assertive [13]. The Action Research cycle is defined as below Fig. 1:

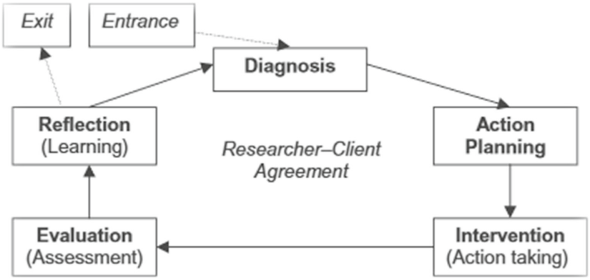

Fig. 1. Action Research Process [13]

The diagnosis phase, also known as entrance stage, aims to identify and analyze the problem or root causes that should be changed. It is not a simple work and requires an overview about the context. The Action Planning phase, the next step, aims to define the data and agents responsible for gathering information based on their knowledge and skills. The Researcher, as an insider, should record his own perception or, as an outsider, record the feedback and perceptions of all involved people in a detailed way.

The intervention phase is mainly characterized by the actions taken individually, simultaneously, in group or experimentally, at same time that records the capture of qualitative and quantitative data from different sources, based on surveys with open-ended or close-ended questions, feedback, voting. The follow stage, evaluation, consists on the validation of the intervention and its results.

On the reflecting phase, a review of the activities and obtained results is done to decide if a new cycle should be started due to an unsuccessful criterion or looking for more improvements, or decide for the closure, that might be motivated by the successful changing, timing out, budget or interest [14]. All detailed actions taken on each stage are described in the next states:

3.1 Participants

The Action Research methodology was applied to develop the Social Innovation through Digital Plural, a Social Innovation Platform organized by Professors and Students of UFABC (Federal University of ABC), authorized by the committee of support actions against coronavirus of the Federal University of ABC, located in Santo André, a city of greater São Paulo area, in Brazil [15].

As per this platform, a deaf leader of a NGO in São Bernardo do Campo, a city of greater São Paulo, was invited to take in part in the development of the solution and a craftsperson who leads Projeto Costurando o Futuro in a Favela of São Paulo was invited in the development led by Fundação Volkswagen jointly with Federal University of ABC.

3.2 Data Collection

At the end of the development, a virtual survey via Google Forms, was applied to the relevant stakeholders: craftspeople and people who bought the face masks. In the survey there were key-questions for qualification of all surveyed, with semi-structured questions regarding the perception about the face masks and an open question for feedback.

3.3 Data Organization and Analysis

The data collected via virtual survey were exported to excel for analyses and data organization.

3.4 Validation

The validation of the face mask was done through videocalls. The feedback of the end state solution was collected via virtual survey.

3.5 Ethics Consideration

The virtual survey was pre-aproved by the Brazilian Ethics Commitee for Research under number 34838620.2.0000.559.

4 The Process of Co-creating the Face Masks for the Deaf Community

4.1 Diagnosis

Researches pointed to the difficulties suffered by people with disability on the COVID-19 pandemic figured in a report in a famous American business and economic magazine, regarding an accessible face mask - with a transparent protection for laughs - created and designed by Ashley Laurence, an American student, who creates it to help the communication of the deaf, through lipreading, during the pandemics [16]. This news was the inspiration to the implementation of a new and innovative solution.

On other hand, many craftspeople and dressmakers have been economically affected for not having the opportunity to sell their handmade products in open-markets, shopping or exhibitions due to lockdown restrictions set in the region. At that time, too many people and small companies were producing and selling face masks. Then, the researcher leader proposed that the production of accessible face masks should be by groups economically impacted by the Pandemic, especially the craftspeople' part of solidary economic groups. The proposal was to have a solution that helped more than one affected group during the pandemic.

4.2 Action Planning

The initial scope was the development of handmade face masks with lips display made by plastic material. The handmade material should be aligned with guidelines provided by the Brazilian Health Agency.

A Car Industry, based on the metropolis of São Paulo, handles "Costurando o Futuro" (the "solidarity economy"), a social project of entrepreneurship for people living in favelas to make money through the learning of new skills and production of craft products based on the materials donated by them [17]. Thus, this solidarity-based economy group of craftspeople was chosen to have a partnership with the University on the development of the face mask, establishing a public-private partnership.

4.3 Intervention

At the first stage of development, a prototype was made, and the initial tests pointed out an issue - how to ensure the plastic display would be unblurred? This was one of the pain points listed by two deaf who took part on the usability tests. After this point argued by the main-users, new research was initiated to solve this issue.

The solidarity economy invited a new partner: a relevant chemistry industry to take part in the design process, and some chemical solutions have been applied on the plastic until it met the customer requirements. Thus, a solution was found and applied on the accessible face mask, resulting in an innovative mask: an auto-unblurred clear face mask, based on a sustainable process which converts the final price to the producers - the craftspeople economically affected by COVID-19 Pandemic (Fig. 2).

Fig. 2. Accessible face mask prototype [2022].

4.4 Evaluation (Assessment)

The first tests with deaf required a solution to have the face mask unblurred, then the process returned to the diagnosis phase to investigate a better solution to fit their pain points. At the second time, it was duly approved by the users.

An online survey applied to those agents who took part in the process or the consumers which bought the face mask showed different and important impacts of a Social Innovation when answered the question "how the face mask helps you" as described below Table 1:

Table 1. Feedbacks provided by involved people.

Group	Interviewer	Feedback
Deaf	#1	Helps on the communication process
	#2	Helps on the lipreading
	#3	Sometimes we may not be close to lipread, then the accessible face mask helps ourselves
Craftspeople	#1	Help on the home expenses
	#2	Help to make money
	#3	We had no perspective of labor. The project came to help (economically) our business
Other users	#1	Help on the communication Process
	#2	It might be useful for Signal Language Interpreter
	#3	It helped myself because I could wear a lipstick again and could see the mouth of my friends. The face masks helped me to better understanding what people were talking about

Considering that the project was implemented in June 2020, it had a highly positive impacts for craftspeople as per report and all feedbacks provided online, resulting in new labor perspectives to make money. At the end of 2020, Costurando o Futuro reported the production of over 16,000 units of accessible face masks [17]. The project was successfully implemented, and the local magazines reported the innovative face mask created [18] (Fig. 3):

Fig. 3. A Woman wearing the accessible face mask [18]

Additionally, the developed solution comes from a private-public partnership between the Academy and the Solidarity Economy, handled by a Car Industry to solve existing and social problems, and the design process delivers a smart, sustainable and cheaper product to the Market.

4.5 Reflection (Learning)

At the first assessment stage, the process returned to the diagnosis phase to establish a real innovative product, once similar products were appearing on the market at that time.

At the second time, when an auto-unblurred face mask was designed, prototyped and tested, the cycle was ended in order to roll out the solution to the market (Table 2).

Table 2. Summary of actions taken during the Action Research and its results

Stage	Cycle	Action	Results
Diagnosis	1st	Research on the web and sharing in a collaborative social innovation platform	Deaf people were suffering difficult to wear the masks due to be a barrier for orofacial communication [19; 20]. The transparent masks helped on communication process however were highly expensive [21]. As a potential solution, an accessible home mask developed in the USA was found [16]
	2nd	Research for a product that cleared the face masks	A plastic cleaner was identified as a possible solution to apply on the mask
Action Planning	1st	Definition of scope, suppliers, productors and end user testers	The relevant participants composed by me as researcher in social innovation, a doctor, a lead of craftspeople and the lead of the social business who handles the "Costurando o Futuro" project decided to move on with materials guided by the Brazilian Health Agency The scope was to produce an accessible mask with a lipread display. This production should be done by groups economic affected during the pandemic. The mask was produced based on cotton fabric and sewing thread as well

(*continued*)

Table 2. (*continued*)

Stage	Cycle	Action	Results
	2nd	Definition of materials and test period	Multilayer plastic film composed of polyolefins, with interleaved layers of polyamide for greater mechanical resistance, especially in sewing, with anti-unblurred additive
Intervention	1st	Design and prototype of the solution	Design and protype of the face mask by the craftspeople' lead
	2nd	Enhancement of the solution	Appliance of the founded solutions on the prototype
Evaluation	1st	User acceptance test of the prototype	The usability tests involving the by a deaf person pointed out to a face mask that would be unblurred
	2nd	User acceptance test of the prototype auto-cleared	The chemist applied the plastic cleaner and the mask became auto-unblurred. A deaf person tested it and approved as auto-unblurred solution
Reflection	1st	Restart of the cycle	The prototype did not full attend the user and enhancements were needed
	2nd	Close of the cycle	The prototype attended the user needs so the cycle was closed and the solution launched in the market

5 Conclusion

As per main aim, the experiment proved that Action Research may be applicable as framework for development of social innovation. It reinforces the need claimed by Bignetti regarding the absence of methodologies, since the concept is under development in the Academy yet. The methodology is useful, reproducible, clear and not only fit on the development of social innovation, but also produced and contributed with scientific knowledge, especially for social innovation field which requires an academical consensus about the concept as well as methodologies and frameworks.

The novel solution connected minority groups affected during the pandemic to help each other and provided a cheaper face mask when compared to professional transparent masks. It not only met the social innovation definition presented by Stanford Centre for Social Innovation, but also went beyond the minority groups, reaching out to people that originally had not demanded this solution. As per Manzini definition, the solution itself attended – the academy, as public agent, established a partnership with private organizations on the treatment of social and existing problems.

As per methodological view, the Action Research would fit very well for development of social innovation, once requires the interaction and participating with the demanding people on the research and development of the solutions.

Although communication has been the key need pointed by deaf, other needs such as social inclusion and sense of being safe should also be considered as important aspects for the human needs, especially in a crisis environment. For Craftspeople, the project has not only become a source of income, but also fitted as social equality for those people economically impacted by lockdown. On both cases, their social needs were attended in a creative way that connected the "hidden people" in an innovative solution to the producers which were looking for labor demands, and consequently make money.

Finally, it not only may help to support the social needs, but also might be a strong approach to develop innovative and creative solutions when different agents work and contribute to a same goal. The appliance of Action Research as a framework for social innovation is replicable, and a possible way that may be used in new studies and initiatives.

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Designing Digital Services to Connect Deaf People to Public Health Care System

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Abstract. In recent years, digital health innovations have proliferated rapidly. Therefore, we must establish innovation processes that address the specificities faced by groups that represent the population's diversity within a health context that employs technological tools that promote equity. Remembering than on a telemedicine platform the protocols used for a hearing user should not be the same for a Deaf user. To achieve the paper's goal, we used an ethno-graphic action research method, with the participation of two Deaf researchers who documented their experiences and observed how healthcare is currently provided at the Institute of Hebiatrics. In development, a brief summary of the context of Service Design with TechQuity was presented. The method is based on Ethnography, being a type of scientific research that aims to know the culture of a specific group or environment, based on participant observation and may include other qualitative and quantitative methods. The analysis of the collected data was carried out through the meetings with the objective of tracing the context of the reality that Deaf users encounter during their health journey. It is concluded that it is important to place the Deaf user at the center of the solution design process, as he has his own ruler to measure con-strained feelings in relation to the lack of accessibility and autonomy in accessing health care, which is why inclusive designers identified the problems reported by Deaf researchers when designing a proposed solution.

Keywords: Digital Health · Inclusive Design · TechQuity · Deaf

1 Introduction

In recent years, digital health innovations have proliferated rapidly. However, it has also been observed that a solution sometimes can only serve a subset of users. As a result, we confront the fact that technology can function as a component of the structure that reinforces health disparities [1–3]. Therefore, we must establish innovation processes that address the specificities faced by groups that represent the population's diversity - that is, people of different races, ethnicities, with disabilities, socioeconomic conditions, and cultural origins, as well as people with diverse lifestyles, experiences, and interests - within a health context that employs technological tools that promote equity.

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In other words, studies that allow us to understand the journey of "atypical" users within a digital health service are required. For example, on a telemedicine platform, the protocols used for a hearing user should not be the same as those used for a Deaf user. To provide a service that does not intensify inequalities, designers and developers of health services/equipment/experiences, policymakers, businesses, and service providers must understand and incorporate the concept of TechQuity [4, 5]. The term TechQuity is formed by combining the words technology and equity. This concept arose from the realization that the pandemic aggravated the systemic marginalization of certain groups in society from access to health care services due to a lack of access to some digital tools [4, 5].

Therefore, the objective of this article is to prospect opportunities that promote equity from the experience report of deaf patients. It has been observed that digital health professionals, in collaboration with health care service designers, play an important role in the process of social innovation, as their decisions can help to eliminate barriers to health access for social groups that have historically been excluded for social, economic, demographic, or geographic reasons [6–8].

To achieve the paper's goal, we used an ethnographic action research method that included the participation of two Deaf researchers who documented their experiences and observed how healthcare is currently provided at the Institute of Hebiatrics [9]. The researchers have a diverse background (biomedical engineering, sign language linguistics, bilingual phonoaudiology, hebiatric medicine, sociology of youth, computational semiotics, and production engineering). As a result of the research, we proposed some simple actions that use a smart phone to innovate appointment scheduling so that Deaf users can access it autonomously.

The remaining sections of this article are organized as follows: The conceptual framework is introduced in Sect. 2. The Sect. 3 describes the methodology used in the re-search design. The Sect. 4 presents the current situation and our proposed solution describing the benefits that will accrue when the desired result is achieved. Finally, the Sect. 5 presents the conclusion.

2 Service Design with TechQuity

By aligning an organization's operations to maximize user experience, service design strengthens both user and service provider interactions. TechQuity outlines the significance of technology in the development of social gradients in health in the age of digital culture. As a result, greater commitment to eliminating structural inequalities is required [4, 5].

As such, the types of questions that inclusive designers asks and the requirements that are prioritized will result throughout innovation in health care services; and for health strategies that generate social, environmental, public policy, and business impacts [10, 11]. Therefore, an inclusive designer is someone who identifies and tries to fix misaligned connections between users' experiences when interacting with a product/service/system [13, 14] As a result, inclusive designers are teams made up of people who have navigated exclusionary designs.

As digital health becomes more permeable, health-care systems must consider the impact on user access universality [10–12]. You must ensure that every touchpoint in the deaf user's journey is considered, and you must collaborate closely with the deaf person to design and develop solutions to determine where and when interpreter or translation services are most needed [13].

2.1 Why is TechQuity Critical to Service Design?

TechQuity emphasizes the role of technology in the creation of social gradients in health [4]. As a result, greater commitment to eliminating structural inequalities is required [5]. Thus, the notion that true innovation occurs when the transformation process is social rather than just technological is embedded.

As a result, the types of questions that a researcher asks and the problems that are prioritized in scientific research that will result in innovation in health informatics; for the practice of medicine and public health; and for health business strategies generate impacts, social, environmental, and business governance.

Digital health is no longer merely a supplement to face-to-face care; it is now an alternative. Several auxiliary features and services can improve the interaction between the provider and users with specialized needs [15–17]. However, while digital health's rapid adoption has opened many doors, it still poses significant challenges for Deaf users.

3 Research Design

3.1 Participants

3.1.1 Deaf Researchers

Ethnography is a type of scientific research that aims to learn about the culture of a specific group or environment. It frequently relies on participant observation and may include other qualitative and quantitative methods. The researcher establishes ongoing relationships with research participants in order to observe and record conversations and behaviors [9].

3.1.2 The Institute of Adolescent at ABC Medical School

The Institute of Hebiatry is a center for qualified assistance to adolescent health through Hebiatricians (from Hebe, the Greek goddess of youth). It also has educational programs, group experiences and professional training workshops.

Adolescence is a time of individualization - children are slowly discovering their identity as adults, separated from their parents and other adult influences. Such a critical time of psychological development, complicated by cultural influences that shape their expectations of adulthood and define how they relate to other people [18].

In medicine, pediatrics is the expertise that involves the medical care of infants, children, adolescents, and young adults. In the case of Brazil, the Brazilian Medical Association (AMB) and the Brazilian Society of Pediatrics recognizes the hebiatric doctor as a specialty of pediatric medicine concerned with physical, mental, functional and social conditions in adolescent patients. The chronological limits of adolescence are defined by the World Health Organization (WHO) between 10 and 19 years old (adolescents) and by the United Nations (UN) between 15 and 24 years old (youth), The term young adults are also used to encompass the age 20 to 24 years old (young adults) [18].

Thus, the hebiatricians doctors task is to guide adolescents to navigate this journey that is made more complex by hormonal changes, helping adolescents to understand the physical and emotional changes from childhood to the reality of their imminent adulthood, offering them in addition to corrective care, preventive and health-promoting experiences and well-being, which can also support them in their adult journey.

Therefore, according to the World Health Organization, universal health coverage, in the Brazilian case, the Unified Health System, provides an opportunity for renewed attention to meet the health needs of adolescents through the strengthening of health systems.

3.2 Data Collection

Ethnography is especially useful for understanding the impact of social and cultural norms on the efficacy of health interventions [19]. In this paper, the researchers are also Deaf so their participation as action research is important to determine what and how data should be collected and analyzed. The researchers seek to contextualize specific events by focusing on the culture and social interaction of the people or groups observed.

Observational data refer to the raw materials an observer collects from observations, interviews, and materials, such as reports that others have created. Data may be recorded in several ways: written notes, sketches, tape recordings, photographs, and videotapes. The purpose for observing a system being used is to obtain in a limited amount of time relevant data needed to change and/or improve the system.

Field notes refer to transcribed notes or the written account derived from data collected during observations and interviews. There are many styles of field notes, but all field notes generally consist of two parts: descriptive in which the observer attempts to capture a word-picture of the setting, actions and conversations; and reflective in which the observer records thoughts, ideas, questions and concerns based on the observations and interviews.

3.3 Data Analysis

As a result of our discussions at the Institute, which spilled over into our remote meetings, we conducted data analysis. Thus, the meetings aim to trace the context of the reality that Deaf users encounter during their healthcare journey. Communication barrier caused by health professionals' lack of understanding of sign language and Deaf cultures. Simultaneously, there are numerous ways to broaden communication by utilizing visual resources such as video in sign language, drawings with nonverbal language, illustrations, and so on.

Explanatory leaflets in cartoon format are a good example of Deaf culture that catches their attention. These documents' communication processes put an emphasis on facial expressions and body language. Despite having written speeches, it can also communicate with the deaf.

3.4 Research Ethics

This research follows the ethics committee recommendations 43353721.5.0000.5594.

4 An Inclusive Design to Support the Deaf Journey in the Healthcare

Digital information in medical care is becoming more prevalent because it saves users' and caregivers' time while also providing a better user experience. This is the case with pre-consultation registration, in which a patient can provide relevant information about their case to the doctor. The patient can now pass on to the doctor what will be discussed in the consultation, such as pain, and other symptoms without having to visit the clinic. Here, we proposed innovative solutions based on readily available digital technology that can significantly increase Deaf's inclusion in the healthcare system.

4.1 The Report of Deaf Participants and Their Experience Using a Basic Health Unit in Person

4.1.1 The Problem: An Emergency Medical Appointment

Bruna Tavares Leite and Lucas Ferreira da Silva, two of the paper's co-authors who are also Deaf, experienced symptoms such as intestinal disorder, headache, and fever on January 7, 2022. They were concerned that they could be contaminated with the virus of Covid-19 after having contact with a family who had tested positive for the virus. They have stayed at the family's house from the first day of symptoms on December 27th 2021 until their return trip from Passos - MG to São Paulo – SP on January 3rd 2022.

4.1.2 Filling Out a Patient Registration Form to Receive Health Care

Their journey on the Public Health System started on January 07 at 8 am, when Bruna and Lucas had decided to go to the Basic Health Unit to be tested for Covid-19. Arriving there, they wrote to the door person asking where the place was to make an appointment request was. The door person pointed out toward the reception area. There they realized there was a short queue to get a paper with a number for the service order. However, there was no display to check the number of the service desk. They realized they had to write to the clinic attendant that they could not follow the "sound" call because they were Deaf. The attendant proposed to wave to them as a solution for the lack of a visuospatial display.

Once called, information such as names, addresses, and ID numbers were requested. Following that, details about the reason for the appointment, such as symptoms, had to be shared. All this communication had been reported in writing language. It was unclear what the next referrals were, and another number for a different type of service was provided.

A wave was used once more to reach the Deaf users, who had asked urgent attention because they were not feeling well. Meanwhile, they required assistance to use the restroom because they could not identify any direction based on visual information.

They then received their appointment. Because it was their first time using the public Unified Health System, they first had to register with the Family's Health Program, which is why there were two procedures.

As can be seen, the entire service process is still quite manual - and even simple tasks like filling out a form or registering for a program required the assistance of two different attendants. The registration was done by hand rather than using digital procedures.

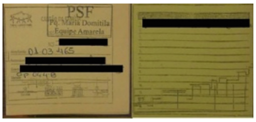

Fig. 1. Example of the Family's Health Program Identification card. Source: Authors

4.2 An Inclusive Design to Support the Deaf Journey in the Healthcare

A healthcare provider cannot impose barriers on its users when they require healthcare, regardless of whether access is remote or physical. As a result, the integration of various environments must be considered in the service design. An inclusive experience should give users with disabilities, for example, the ability to access it independently.

4.2.1 Diagnosing the Barrier for Deaf's Users

Most healthcare scheduling occurs, at the healthcare provider's office, over the phone or online through a third-party scheduling platform. Scheduling becomes a barrier for Deaf's users if the service lacks accessibility resources.

We were able to map the pre-consultation process as it is currently carried out after visiting the Institute of Hebiatrics with a group of interdisciplinary researchers, one of whom was Deaf. This was the first source of frustration for Deaf users, as the instructions were written in a language in which they were illiterate (Fig. 1). They must also fill out written forms in a language they do not understand.

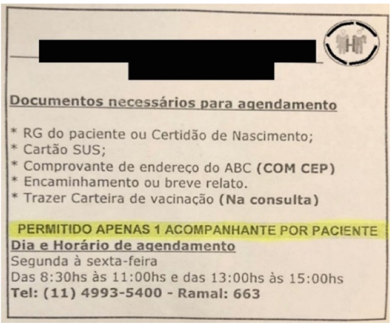

Fig. 2. Explanatory leaflet for scheduling an appointment. Source: Authors

4.2.2 Eliminating the Barrier for Deaf's Users

During Pre-Consultation, patients are usually required to fill out several detailed forms about their current health, medical history, and medications in order to be admitted. If the patient is unable to read and comprehend the content of the form, he/she will be unable to complete it correctly. Instead, provide translation services at the entrance so that patients can communicate important health information in Sign Language (Fig. 2).

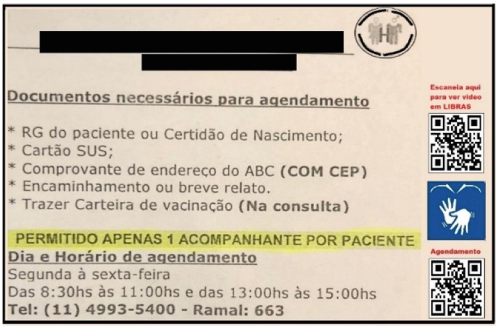

Fig. 3. Explanatory leaflet with sign language accessibility for scheduling an appointment. Source: Authors

As a solution, we have proposed an alternative scheduling method for Deaf users. In this case, the use of QR codes allows that Deaf can access videos with explanations in Sign Language. The QR Code is read using the camera on mobile devices that have a Code scanner, also known as a QR Code scanner. When scanned, the QR code generates information in the form of a URL.

A URL (Universal Resource Locator), which is a virtual address, can be stored in a QR Code. It can generate a link from a video as long as the video is available on any website. Soon, the videos will be able to be uploaded to a website and accessed via QR Code, allowing them to be accessed at any time. The benefit of this is that it increases usability, agility, autonomy, and performance.

To make the service more inclusive, we have included a QR code in the regular form, which follows the steps below (Fig. 3):

1. QR code 1 to access a video in signal language describing the necessary documentation.
2. QR code 2 to fill out the digital form.
   When scanning QR code 2, it opens the scheduling form, allowing an appointment to be scheduled (Fig. 4).

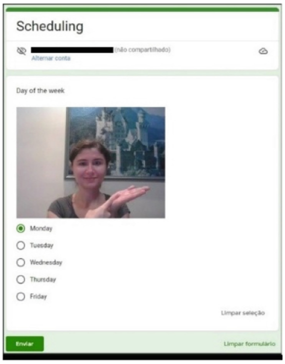

Fig. 4. Form with information in Sign Language

3. Video with the process
   With available digital technologies, the Deaf person will be able schedule his/her appointment. At the same, the designer has applied the concept of TechQuity, allowing integrality to be achieved as a means of realizing health as a matter of citizenship.

The link shows the sequence of events that occurred between the use of the QR Code application and the appearance of the Scheduling form. The QR Code application scans the QR Code illustration and opens another screen where the form is displayed.

It is available at https://youtube.com/shorts/aHBP7tsYo2s?feature=share.

5 Conclusion

This paper provided an opportunity for reflection on how technological devices can be used to help Deaf users overcome language barriers in accessing healthcare. Admission to the health service is one of the journey's points of contact. Scheduling and pre-consultation processes can cause delays (taking longer to receive services), impairment (incorrect information provided), or exclusion (withdrawal from the service). This requires putting the Deaf user at the center of the solution-design process, because he or she has his or her own ruler for measuring constrained feelings in relation to a lack of accessibility and autonomy in accessing health care.

The inclusive designers identified the problems reported by Deaf researchers in accessing the Basic Health Unit during the design of a solution proposal. Based on this experience, they attempted to correct nonconformities in the development of an effective tool to communicate between health professionals and Deaf patients, enabling the creation of connections and ensuring access to health care for them in an equitable manner, given that it is an example of TechQuity. Future research will focus on removing communication barriers between Deaf patients and healthcare providers at other stages of the journey, such as consultation and follow-up.

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Correction to: Encouraging Data Literacy via an Open Academic Digital Platform

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In the original version of the book, the author "Alessandra Cristina Santos Akkari Munhoz" was included erroneously as co-author, which has now been removed and replaced by "Andrea Paula S. O. Kamensky" and also the corresponding author's last name was incorrect, which has been corrected from "Marina F. da Costa" to "Mariana F. da Costa". The chapter and book have been updated with the changes.

The updated original version of this chapter can be found at https://doi.org/10.1007/978-3-031-29129-6_6

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