WHAT DO AN ANAESTHESIOLOGIST, A NURSE, TWO DESIGNERS, AND A PROFESSOR IN ARCHITECTURAL TECHNOLOGY DO TOGETHER IN A ROOM? CRAFTING INTERDISCIPLINARITY

WHAT DO AN ANAESTHESIOLOGIST, A NURSE, TWO DESIGNERS, AND A PROFESSOR IN ARCHITECTURAL TECHNOLOGY DO TOGETHER IN A ROOM? CRAFTING INTERDISCIPLINARITY AS RESPONSE TO EMERGING INFECTIOUS DISEASES

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ABSTRACT

The health sector in the humanitarian context is currently experiencing great pressure in delivering adequate care, due to a number of increasing emerging diseases. The World Health Organization (2022) reports that: '…since 2011, there have been more than 1200 outbreaks of epidemic-prone diseases in 188 countries around the world, causing widespread death and suffering…'. A key factor that can contribute to ensure high quality care is the possibility to rely on adequate infrastructure and products. This paper presents the interdisciplinary methodology deployed to design and develop an innovative infectious diseases treatment module that could be deployed and utilised in the very first phases of health emergencies. The methodology proposed is organised around a three-level approach to ensure both core disciplinary solidity, and holistic understanding of the complexity of the challenge. The contribution of this work is the definition of key aspects in the proposed methodology that can help overcome difficulties in delivering high quality interdisciplinary research and work, as well as highlighting behavioural patterns that can ensure successful delivery of innovative products and facilities for the humanitarian health sector.

Keywords: Interdisciplinary Research, Design methodology, Innovation, Research methodologies and methods

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1 INTRODUCTION

Beside the COVID-19 pandemics, the world is currently facing an increasing number of emerging diseases. The World Health Organization (2022) reports that: '*...since 2011, there have been more than 1200 outbreaks of epidemic-prone diseases in 188 countries around the world, causing widespread death and suffering, disproportionately affecting the poorest and most vulnerable populations, and leading to social, economic and political disruption'*.

These emerging diseases set the premises of the critical real-world challenge of providing prompt infrastructural support to the medical sector in emergency contexts, able to: comply with adequate Infection Prevention Control (IPC) measures; respect environmental principles of resiliency and sustainability; and ensure dignity and respect of individuals and communities.

With the aim of answering to this challenge, many humanitarian organisations such as World Food Programme (WFP), World Health Organization (WHO), United Nation Humanitarian Response Depot (UNHRD), as well as many others are currently promoting initiatives to stimulate the development of effective products and processes in terms of preparedness and response.[1]

These initiatives called for high interdisciplinary collaboration between professionals of different disciplines - i.e. medical sector, architectural design, environmental engineering, and sociology - great degree of knowledge exchange and learning, and intensive activities of innovation development within short time frames.

Within this context, this paper presents the interdisciplinary methodology deployed to design and develop the process carried out by a number of International humanitarian organisations in conjunction with the Politecnico of Torino, Italy in developing an innovative infectious diseases treatment module that could be deployed and utilised in the very first phases of health emergencies.

2 SETTING THE PREMISES: OBJECTIVES, CHALLENGES AND RESEARCH QUESTION

In early 2021, the Politecnico of Turin was called by a group of humanitarian partners to provide scientific support and research for the development of an innovative infectious diseases treatment module that could respond to any sort of diseases, regardless of the modality of transmission. The module development looks at several aspects to ensure effective and high-level care for patients, comfortable conditions for both patients and staff while reducing the risk of nosocomial infection within the structure. As showed in Fig. 1, space functionality, looking at ergonomic factors, people movement and main flows, together with dimensions, location and energy consumption of bio-medical equipment and eventually the energy resources management of the overall module have been identified as key aspects which influence the design. These latter aspects set the premises for a unique challenge that would potentially introduce disruptive innovation on the market of existing products. Moreover, the COVID-19 pandemics in conjunction with a high number of other emerging diseases set high degree of time pressure in the schedule of the design and development process of such product; as well as the need for incorporating existing knowledge and experience from the field, scientific research, and the participation of a great variety of actors involved in the humanitarian sector.

[1] In June 2021, the World Food Programme (WFP) and WHO launched INITIATE², a 5-year initiative which brings together emergency response actors, as well as research and academic institutions, to develop innovative and standardised solutions and the related training in support of readiness and response capabilities in health emergencies.

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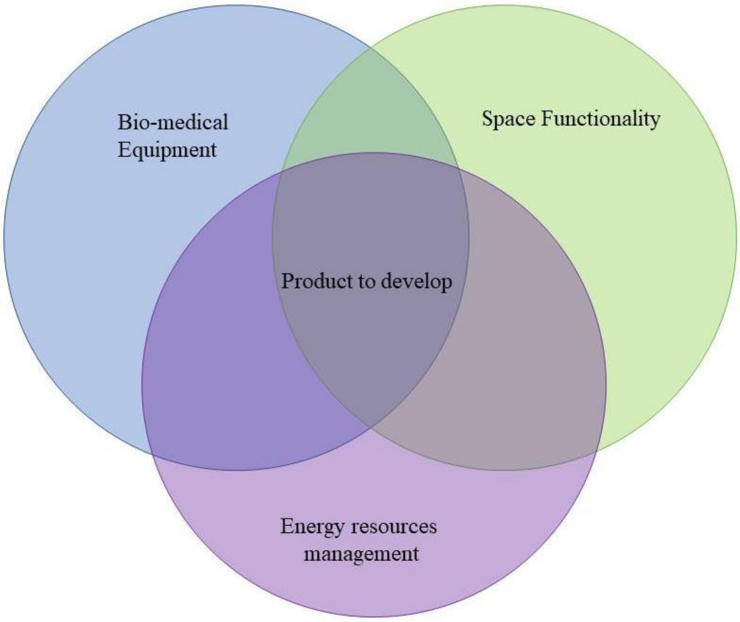

Figure 1: Main design principles for the product to be developed

The research group from the Politecnico of Torino in charge of this project in collaboration with the promoting humanitarian organisation soon understood the need for setting a highly interdisciplinary approach to the challenge. Interdisciplinary is crucial to analyse, study and find solutions to real-world problems, rather than problems framed in the core of a specific discipline (Repko, 2016), and this challenge was fitting into the definition of real-life problem, being generated by the current phenomenon of emerging diseases. Moreover, interdisciplinarity research approach rather than multidisciplinarity was required due to the need for knowledge integration between a number of disciplines (Repko 2016; MacLeod and Nagatsu 2018) and a comprehensive and holistic perspective understanding of a set phenomenon (Frickel and Jacobs 2009). The challenge called for expertise in the medical field, in the one of architectural and product design, as well as environmental engineering and logistic.

Yet, interdisciplinary research approach could face a number of limitations, such as: cognitive constraints; different evidential standards and epistemic values; different modelling and experimental practices; inconsistent concepts; opacity of practices due to their complexity and language/jargon barriers (MacLeod and Nagatsu 2016), institutional rigidity and constraints for the participants - i.e. peer reviews processes, tenure promotion based on disciplinary knowledge - (Jacob and Frickel 2009); as well as differences in framing problems within disciplines with specific methodologies and values (Brister 2016).

With these premises, the research question that served as backbone for the work was:
' How could we ensure Interdisciplinarity by setting a methodology able to ensure disciplinary solidity, while ensuring a holistic approach to deliver an innovative product for the humanitarian sector?'

The objectives of the work was to organise a flexible methodological approach able to:
1) set up an overall project management process that could ensure the inclusion of all the stakeholders involved in the initiative;
2) ensuring the scientific solidity of high quality research within the core of disciplines involved
3) ensure the quality of interdisciplinary approach to value the variety of knowledge involved and required.

2.1 Positioning the experience within engineering design

This work positions itself within design development studies in the context of engineering design. The development process focused on the development of product novelty that is realised by original designs incorporating new solution principles (Pahl and Beitz 2007). To do so, the approach utilised

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was the one of concurrent engineering, specifically forming an interdisciplinary team, setting goal-oriented, interdisciplinary and interdepartmental collaboration and parallel working throughout the development of the product (Pahl and Beitz 2007). Although authors such as Albers (2005) with the SPALTEN model or the VDI Guideline 2222 (and further developments) define precise approaches, individual methods, and working steps for the conceptual design of technical products, this work focuses on specific aspects of development process pertaining the challenges that Pahl and Beitz (2007) pointed out in relation to interdisciplinary work approach, rather than setting or applying specific guidelines for design activities. In particular, in line with Pahl and Beitz (2007), this paper focuses on exploring further aspects pertaining the challenge of interdisciplinary, such as: adaptation of common language and terminology; direct exchange of information through the early involvement of all the involved departments and disciplines; potential need for intermediary objects; need for a project management process systematically informed and structured; ability of taking individual responsibility for the assigned problems and tasks accepted in line with team decisions; and great suppliers and customers involvement from the beginning of the process.

3 CRAFTING INTERDISCIPLINARITY: A THREE-LEVEL METHODOLOGY

Interdisciplinarity is sought through the design of a three-level methodological approach, as showed in figure 2. Each level relies on mix-methods both quantitative and qualitative according to disciplines needs and requirements; as well as they are interconnected with a feedback loop system to ensure the satisfaction of all the partners involved. Level 1 is concerned with the management of the overall development process, which is organised in five phases, namely: pre-programming, hearing, designing, delivering, and sharing, and comprehended experts of different fields. Level 2 is concerned with core discipline-based activities, and focuses on the work carried out within a specific discipline by a selected number of experts. Level 3 is concerned with reviewing activities characterised by a high degree of interdisciplinarity and participation.

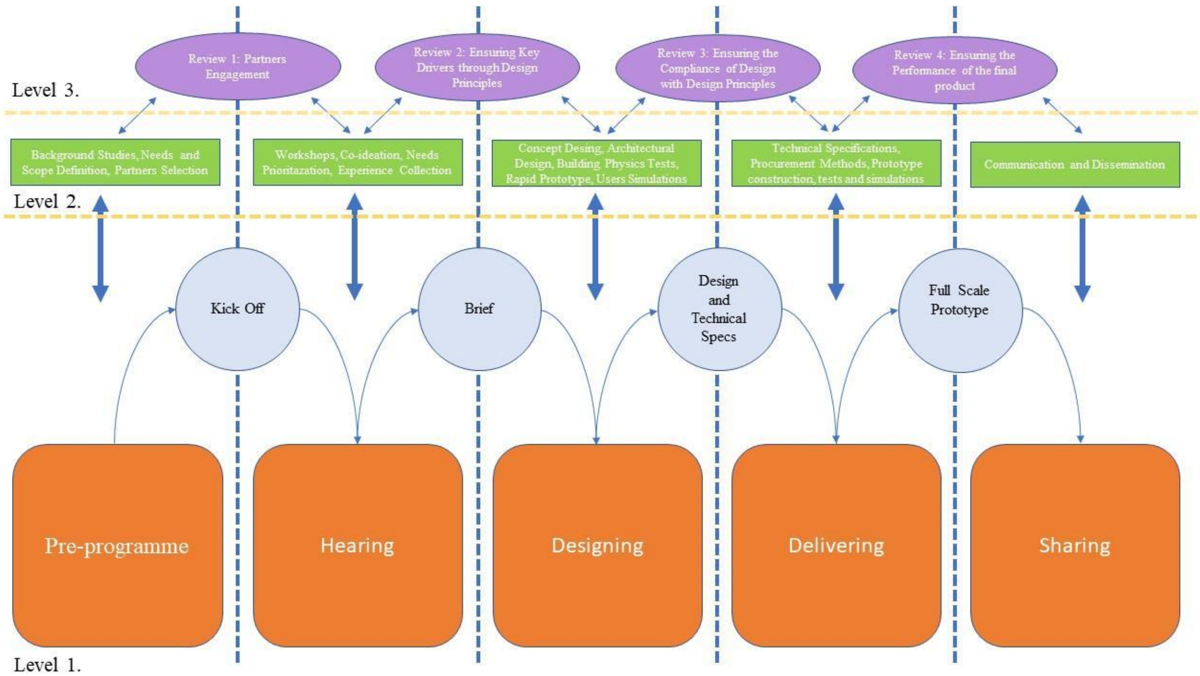

Figure 2: Overall organisation of the three-level methodology proposed to ensure interdisciplinarity

3.1 Level 1: Overall project management

The first level is envisioned as a linear process that moves from one phase to the following one, by carrying out activities to achieve milestones, and producing deliverables, which allows knowledge integration into technical documents to inform the next phase. Each phase is characterised as follow:

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- **Pre-programming phase**
  This phase is aimed at identifying priority challenges and objectives, as well as key actors to involve in the initiative. The technical document produced to inform the next phase is a report from a major kick off meeting carried out at the beginning of the initiative.

- **Hearing phase**
  The 'hearing' phase is aimed at setting a common language across disciplines, gaining in depth understanding and alignment on the challenges, visions, and target users. At the end of this phase, a design brief is produced to inform the following 'designing' phase.

- **Designing phase**
  The objective of the 'designing' phase is to deliver a complete design proposal that addresses all the requirements and needs addressed in the brief.

- **Delivering phase**
  The ‘deliver’ phase is aimed at completing and testing a full scale prototype. The milestone is to build a minimum viable product that is replicable, scalable, viable, reliable and impactful.

- **Sharing phase**
  The sharing phase is envisioned to disseminate knowledge and open both results and processes to a large audience with the aim of both advancing science and stimulating further innovations for the humanitarian health sector.

3.2 Level 2: Core discipline-based activities

The second level of the methodological approach proposed is characterised by discipline-based activities that tackle into the core of knowledge and relies on the expertise of the professionals of each field involved. The methods are mixed and both of quantitative and qualitative nature according to the specific requirements and characteristics of each disciple, and are organised as follow:

- **Pre-programming activities**
  Promoter's internal decision-making activities

- **Hearing activities**
  The hearing phase is organised around innovation-development workshops for ideas generation, ideas prioritisation, desk research, and empirical experience reports analysis. The milestones of this phase are the definition of key drivers, design principles, comparative analysis of existing products, innovation from the fields reported by the initiative participants, and desired key components definition.

- **Designing activities**
  The design activities is organised with weekly design meetings between a group composed of architects, product designers, ergonomists, environmental engineers, and academics, and medical professionals. Each week, an objective is defined, and the work organised between all the parties involved that are providing input with different degrees of technicality at different stages of the project development, by developing concept design, architectural design, building physics tests, and rapid prototype. Yet, every expert contributes since the preliminary phase of the idea generation of the 'designing' phase, to ensure an holistic approach that could address social and environmental aspects from the early stage. This is done by understanding and reviewing the output of the ‘Hearing phase’, discussing among design team, with round table sessions and charrette. Ideas and information are shared and agreed both via the use of technical reports, and MIRO platform, fed by ideas, technical drawings, 3d models, examples, and thoughts. Ideas are in this phase verified by undertaking environmental simulations that help refine design ideas throughout the project development. Therefore, the team works from the concepts to making mock-ups at Level 2 with a number of iterations, and then bring into technical and implementation requirements and made prototypes at Level 3 with further iterations with a larger interdisciplinary group, increasing the number of end users (the medical professionals).

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- **Delivering activities**
  The delivering activities are organised around the procurement methods based on Expression of Interest (EOI) to shortlist bidders for tender, and following gathering of proposals from bidding companies. Once awarded by one company, the prototype is built and reviewed through drill activities and simulations from the partners, as well as technical tests to ensure the building physicists characteristics of the product. After those tests and simulations, a phase for prototype adjustment is defined, before delivering a final full scale functioning prototype.

- **Sharing activities**
  The sharing activities will be organised both at the political level (countries ministers) and professional (users), also academic is important to open and increase the field of studies and its outputs.

3.3 Level 3: Interdisciplinary reviews and feedback loops

The third level of the methodology is characterised by interdisciplinary reviews and feedback loops, as showed in figure 3, concerning a larger number of experts involved in the project, to avoid methodological *crystallisation* (MacLeod and Nagatsu 2018).[2] All the partners involved in the initiative are called to undertake three main activities at each phase: 1) review draft of technical documents and reports produced within level 2 of activities; 2) build a rapid prototype (under given instructions by the technical teams operating at level 2) to simulate real-life scenario and verify that technical requirements and needs were met; and 3) comments on technical documents to ensure knowledge integration. This allows the design team to ensure the iteration between conceptual design and technical implementation, ensuring that needs and concepts pertaining to all the disciplines involved were taken into consideration.

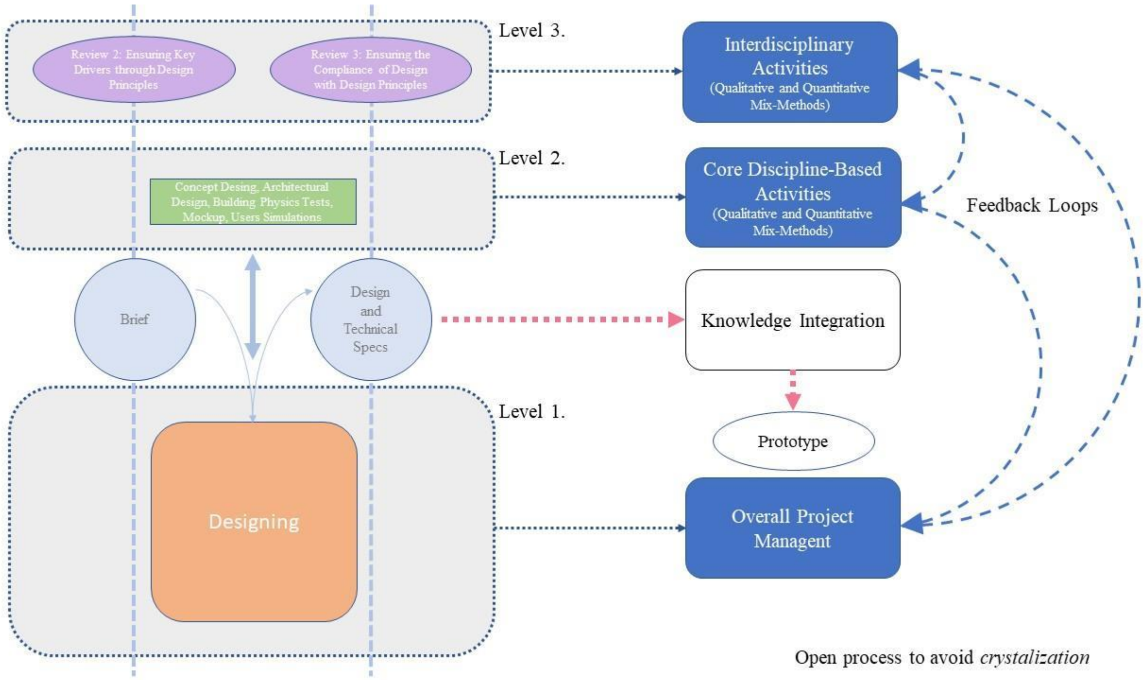

Figure 3: Feedback loop system and verification

4 RESULTS: A NEW PRODUCT AND A POSSIBLE PATENT

The result of the application of the methodology is the development of a full scale prototype of a highly innovative product for the medical sector in the context of emergency, which is ready to be produced and deployed on demand. The products consists in an inflatable module with four extendable

[2] MacLeod and Nagatsu (2018) define crystallisation as: …' *confining interdisciplinary interactions to a relatively small set of pre-existing modelling frameworks and strategies'*

connectors, one for each side, as showed in figure 4. The module presents a double layer of skin, installed in the internal and external side of the pneumatic structure to improve thermal control. Add-on internal partitions enable the module customisation according to the allocated function. A special transparent partition that include – equipped with gloves, holes for cable passage, and for small medical equipment movement – was designed to enable visual contact and emergency intervention on the patient from a staff-dedicated area. Thus, avoiding the direct contact between patient and staff, in order to avoid possible contamination.

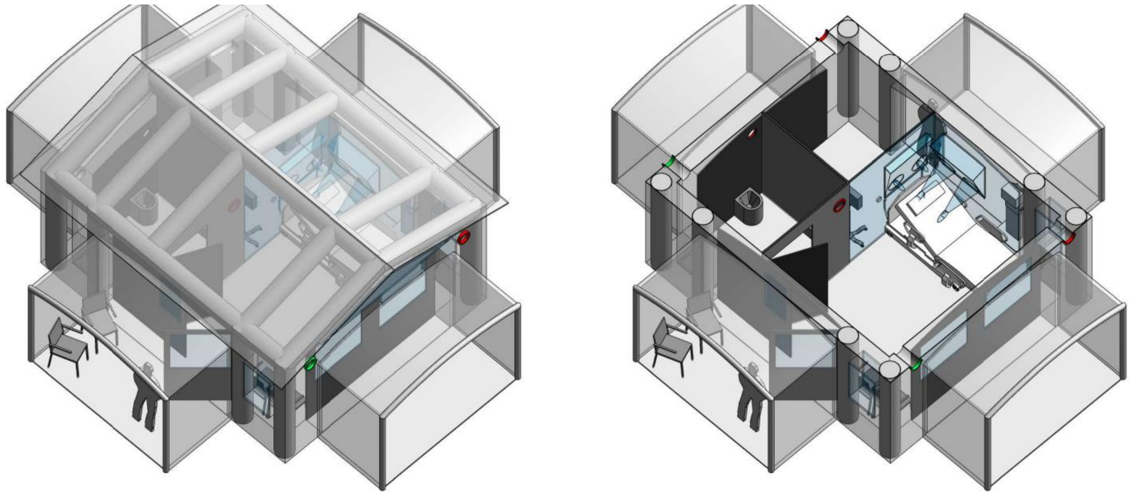

Figure 4: 3D Model of the developed product

The process was reported to be inspiring and exciting for the participants, who could acquire new knowledge, expand their professional network, support their professional development, and become familiar with interdisciplinary approach to research and problem-solving.
Moreover, one of the components of the final product is currently under the process to obtain a patent, as a demonstration of the degree of technological innovation that was obtained through the application of the methodology presented.

5 DISCUSSION

The key for the success of the initiative and the solidity of the methodological approach proposed resided in the review and feedback loop system put in place. Keeping an interdisciplinary team at every stage, and moving from the core of discipline to more interdisciplinary domains with constant feedback loops at various stages of the process ensured both specificity of disciplinary knowledge and holistic view and approach to the design challenge. Another crucial aspect to ensure the adequate flows of information, knowledge exchange and interdisciplinarity was the system of verification with rapid prototyping through the use of mockups used in level 3. Rapid prototyping is a crucial method to achieve interdisciplinarity because it allows all the stakeholders involved in projecting and testing the compliance with their own values on a shared product (MacLeod and Nagatsu 2018) with a unique tool that bridges and integrates all the disciplines involved. In line with Boujut and Blanco (2003), we supported the idea that intermediary objects play a crucial role in ensuring interdisciplinary understanding by acting on mediation, translation and representation. specifically, intermediary objects seemed to be particularly important in the communication between the management level and design team. The three-level methodology and its multiple reiterations loops enabled different types of empowerment (over, to, with and within) to all the project participants as suggested by Zamenopoulos et al (2021), who suggested such modality as a way to ensure equal relevant participation between all the actors involved in co-design experiences.

The limits of the work carried out were:
1) Semi-private/close engagement process based on participants' curricula, rather than open competitions, limiting in somewhat the degree of possible innovation.
2) Disproportionate between the number of staff in the management level 1, against a more restricted number of participants in the technical level 2.

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3) Difficulties in perceiving and understanding methodologies and methods pertaining to different disciplines.

6 CONCLUSION

Among many, the challenges that the health operators in the humanitarian sector are currently facing call for a great degree of scientific research. Yet, time restrictions and scientific complexity set the premises for the need of great interdisciplinary work. Although, since many years Interdisciplinarity has been largely discussed in the academic context, the implementation of agreed methodologies seem still to be an open field of discussion. The work carried out by the research group of the Politecnico of Torino, in conjunction with a number of humanitarian organisations has proven that pushing for Interdisciplinarity can lead to innovation, knowledge acquisition, market opening and patent registration, as well as to the provision of solutions for real-life problems. Yet, to achieve interdisciplinarity it is crucial to ensure both a solid review and feedback loop system based on rapid prototyping, as well as requiring and maintaining an open mind behaviour from all the project participants. Overcoming the limits of Interdisciplinarity highlighted in the literature (Repko, 2016; MacLeod and Nagatsu 2016 and 2018; Frickel and Jacobs 2009) is possible by being open to listen, learn, change mind and opinion, to the point the even the methodological approach set at the beginning of the process can be adjusted and improved if there is a need for. Moreover, to overcome some of the limitations encountered – namely: semi-private/close engagement design process; management overweight presence; difficulties in perceiving the value of interdisciplinary methods and methodologies – the authors propose to deepen Zamenopoulos et al (2021) approach on co-design to clarify the type of intervention and expectations from all the actors involved, with specific milestones and review at each feedback loop proposed in the three-level methodology.

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