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RIVISTA DELLA SOCIETÀ ITALIANA DI ANTROPOLOGIA MEDICA
FONDATA DA TULLIO SEPPILLI

Fondazione Alessandro e Tullio Seppilli (già Fondazione Angelo Celli per una cultura della salute) - Perugia

In copertina: gli street artist di tutto il mondo hanno interpretato la pandemia da Covid-19 a modo loro. Monna Lisa, cioè la *Gioconda*, e l'interpretazione di TVBoy, al secolo Salvatore Benintende, che a Barcellona ha raffigurato il capolavoro di Leonardo nell'atto di proteggersi dal Coronavirus indossando la mascherina.

Il logo della Società italiana di antropologia medica, qui riprodotto, costituisce la elaborazione grafica di un ideogramma cinese molto antico che ha via via assunto il significato di "longevità", risultato di una vita consapevolmente condotta lungo una ininterrotta via di armonia e di equilibrio.

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Editoriale di AM 59: etnografie mediche

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In questo numero 59 ci sono due etnografie del Covid: una in Val di Fiemme, di Nicola Martellozzo, e una di Domenico M. Sparaco, a Codogno e comuni vicini. Il primo studia la doppia pandemia, *vegetale*, con il coleottero Bostrico dell'abete rosso, seguito alla tempesta Vaia avvenuta nell'autunno del 2018 con il forte vento di scirocco e le piogge, che ha interessato la fascia che va dalla Francia alla Croazia passando per l'Italia, l'Austria e la Svizzera, e *animale* con il Covid-19. Il secondo studia il cerimoniale del lutto nel primo Covid italiano nel Lodigiano. Se il primo ritiene che il concetto di salute sia interspecie, il secondo rinnova, per quello che può, *Morte e pianto rituale* di Ernesto de Martino.

La ricerca di Giacomo Pasini sui meteorologi popolari messicani rivela che non ci sono soluzioni di continuità fra *tiemperos* e *curanderos*. E che la religione fa da sfondo comune per quanto riguarda la correlazione clima-salute.

C'è poi l'esito della ricerca sui farmaci e la migrazione di Chiara Moretti, condotta in U.S.A.; la ricerca di Elisa Rondini sulla psichiatria territoriale condotta in Umbria; lo scritto di Elena Sischarenco che dà conto di una ricerca etnografica italo-slovena che fa della "consilienza", cioè della interdisciplinarità avanzata, il perno centrale del discorso.

Chiude Lorenzo Urbano con uno scritto dedicato ai metodi che usano la *mindfulness* come riabilitazione per le dipendenze nei servizi toscani, che qui sono esplorati etnograficamente.

L'etnografia è ciò che accomuna questi scritti, un'etnografia consapevole del fatto che essa è una prassi e non un mero metodo, che si cala nei mondi di esperienza del malessere in tutte le sue forme.

Si prosegue con *Riflessioni e Racconti* che stavolta consiste in uno scritto dedicato al tema della felicità in rapporto alla malattia: si direbbe “ammalarsi fa bene”.

Infine, come sempre, si termina con le recensioni.

E speriamo che questo assortimento sia accolto bene. Come sempre.

AM
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Innovating through Transdisciplinary Knowledge

Bridging Engineering and Medicine through 3D Printing Technology

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Riassunto

Innovare tramite la conoscenza interdisciplinare: collegamenti tra ingegneria e medicina nella tecnologia di stampa 3D

Il presente articolo esplora come la collaborazione interdisciplinare tra medici e ingegneri possa promuovere l'innovazione nella produzione di tecnologie mediche, come impianti e protesi realizzati tramite stampa 3D. Attraverso un lavoro di campo condotto in Slovenia, Austria e Italia, sostengo che un'innovazione efficace richiede la traduzione tra conoscenze cliniche e ingegneristiche, anche se questo processo è spesso ostacolato da barriere comunicative, vincoli istituzionali ed epistemologie disciplinari consolidate. Analizzando esempi etnografici nel campo della manifattura additiva nei trattamenti oncologici e negli interventi di revisione dell'anca, questo lavoro mette in evidenza le sfide culturali e pratiche nel superare le divisioni disciplinari.

Parole chiave: interdisciplinarità, conoscenza, tecnologia, innovazione, collaborazione tra medici e ingegneri

Introduction: On Epistemological Frictions

Doctors and engineers have very different types of knowledge and ways of knowing. They often speak distinct professional languages and sometimes assume that their concepts and ways of thinking are universally understood when, in fact, they are not. During my fieldwork research, I observed that the integration of these different forms of expertise was crucial to develop solutions that neither discipline could conceive alone.

Doctors have direct experience with the human body, but they often lack technical expertise. In contrast, engineers design based on models and simulations but frequently need practical problems to apply their theoretical frameworks to technologies. For example, as we will see, 3D printing can enable the creation of personalised prosthetics or anatomical models – but only if doctors and engineers collaborate throughout all phases of the process, including the idea creation and the design process.

My ethnographic vignettes illustrate tensions and moments of mutual learning during this process. A device may not be useful if it is impractical in the operating room or does not address the real needs of the patient. Effective collaboration is therefore essential. As medical anthropologists have shown (Lock, Nguyen 2018; Guerzoni 2020; Raffaetà 2023), technologies are never neutral; rather, they emerge from situated practices and are shaped by specific social, cultural, and professional contexts, as we will see here in the negotiation between engineers' technical skills and doctors' embodied expertise. Knowledge itself is embodied through experience (Stoller 2007: 158-181) and has a situated and relational character, which the fieldwork vignettes will illustrate. As Harris states, «any knowledge is inevitably situated in a particular place and moment; that it is inhabited by individual knowers» (Harris 2007: 4). Furthermore, Mol and colleagues (Mol *et al.* 2010: 14) remind us that care and technology are not separate domains but are intricately intertwined in practice: technologies «do not work or fail in and of themselves. Rather, they depend on care work».

This perspective resonates with wider discussions on the relationship between different forms of knowledge. It points to a broader epistemological divide: the long-standing distinction between the so-called hard sciences, which prioritise numerical data, and the social and human sciences, which rely on qualitative methods. This divide between forms of knowing is also reflected in how different disciplines define and handle knowledge (Sischarenco 2023). In the field of artificial intelligence, for example, Diana Forsythe (2001) observes that engineers tend to prioritise formal, rule-based, and explicit knowledge – that which can be easily extracted, categorised, and encoded. This inclination towards abstraction contrasts sharply with how knowledge emerges in collaborative, real-world settings, such as hospitals.

However, as Attilia Ruzzene (2023) discusses, these scientific different paradigms are not necessarily in opposition. She specifically reflects on the intersection, or *consilienza*, between these two ways of knowing. She addresses the complementarity of "big data", which is numerical and characteristic of the hard sciences, and "thick data," which is typical of the human and social sciences. The term "thick data" (Wang 2013) draws from Geertz's notion of "thick description" (Geertz 1973), where data emerges from the researcher's field immersion, which allows for a rich and detailed description of the context. The immersive context from which thick data arises is key to situated knowledge. Thick data introduces complexity and depth (Ruzzene 2023) to the understanding of reality by offering insights that go beyond mere quantification. The integration of these types of data is a dialogical, experiential, and embodied process that creates a more comprehensive and situated form of knowledge. While technology is often thought to rely solely on well-defined numerical empirical data, its refinement and successful application in human environments also depend on qualitative empirical data, as the following examples will show.

In this article, I first describe my methodology before delving into my specific fieldwork observations of the creation of personalised artificial implants. I discuss the challenges that arise when knowledge is lacking on either the engineering or medical side – for instance, when reading computed tomography scans. I also investigate how interactions and collaborations begin with a focus on doctors' availability and willingness to engage with innovative technologies to find new solutions as well as some engineers' surprising depth of medical knowledge. Through my analysis of ethnographic vignettes on, for example, the development of 3D-printed medical devices, I explain how transdisciplinary knowledge emerges not only from shared goals but also from the friction between embodied medical expertise and engineers' technical knowledge.

Fieldwork, 3D Printing, and the Making of Biomedical Innovation

My data comes primarily from fieldwork conducted during a 2020 Horizon project on Responsible Research and Innovation in Additive Manufacturing, commonly known as 3D printing, with case studies in both the automotive and medical sectors. My research in the project lasted approximately two years (July 2019 - October 2021) and involved numerous partners from both academia and industry. One of the project objectives was to conduct case studies for the development of innovative products in the medical field and their subsequent industrial applications. I was fully involved in these case studies not only in the ways an anthropologist would hope (*i.e.* carrying out participant observation, closely following interactions among project partners, attending their meetings, and observing their innovation work) but also, at times, by actively facilitating and managing these encounters myself.

Many of the project collaborators were materials or mechanical engineers working in the 3D printing sector. However, in this context, I also had opportunities to interact with doctors who, although often external to the project, influenced industrial and design requirements – and, consequently, our research. In particular, while collaborating with an academic and industrial engineer in Slovenia, I had the chance to meet various doctors, communicate with them, and observe their interdisciplinary interactions. I also engaged with doctors and engineers while carrying out participant observation in a ceramic 3D printing company based in Vienna.

Beyond this project, I further enriched the data in October 2024 by conducting additional observations and interviews with colleagues from the engineering department of the University of Bergamo. Their perspectives and expertise helped me validate some of my findings and deepen my understanding of the interactions between doctors and engineers.

In the following sections, I will draw attention to my ethnographic observations of such interdisciplinary encounters to explore how they unfold and how collaborative dynamics are shaped.

Innovating through Transdisciplinary Knowledge

«Do you need to know all this?» I ask Dragan with surprise as he explains cervical cancer to me – how it develops, its different types, and how it is treated. He exclaims, «You need to get the idea; otherwise, you cannot help!» Dragan is a university professor and mechanical engineer specialised in 3D printing applications for the medical sector. His work involves frequent interactions with doctors at the local hospital. He explains that having some understanding of the medical issue is essential in order to come up with a good idea together.

Ideas are drawn in collaboration. They result from discussions about possible solutions and a wealth of shared knowledge among doctors and engineers. For an idea to be produced, Dragan needs some understanding of the medical issue and what is happening. He describes to me the typical interaction: «Usually, the doctor comes with a problem to solve or a rough idea of what he needs, and we talk and try to find the best solutions together». In other words, the doctor presents the problem to the engineer, who translates it into a technical challenge and considers possible solutions to design. The problem should be detailed and include the current methods and their limitations.

In the case Dragan explains to me, which I take here as an example, it is important to know that an instrument called the Stockholm applicator is used to irradiate cancer cells in this specific type and stage of cancer. A wire with a radioactive head is inserted into the holes of the applicator to target the tumoral cells while protecting the healthy ones from radiation exposure. The standard applicator is already in use, but a customised version allows for patient-specific irradiation based on the exact location of their tumoral cells. Additive manufacturing has made this level of customisation possible.

Many of my informants talk about customisation as the future of the medical sector, though some remain sceptical due to the high costs still associated with this kind of medicine. They point out that while 3D printing enables patient-specific solutions, widespread adoption depends on reducing production expenses and ensuring regulatory approval. Despite these challenges, the medical field shows a growing interest in exploring how additive manufacturing can make personalised treatments more accessible and efficient.

Thinking outside the frameworks of the usual technology can be challenging for anyone, not only for the doctors, as Daniel, a medical field specialist and salesperson at the company in Vienna, tells me, «It's about what you're used to. You don't naturally consider that a different solution could also work because it has always been done the same way». He highlights the challenges of introducing innovation, particularly in the medical sector, where established practices make it difficult to imagine that problems could be tackled in other ways with possibly better results. Overcoming this resistance often requires knowledge as the first step as well as a shift in mindset and trust in new technologies.

Daniel adds, «They really need to understand the potential of the technology, how to use it effectively, and what they can achieve with it». Without this knowledge, established practices remain unchanged – even when better alternatives exist – and certain problems remain unsolved.

In Dragan's example, ideas take shape through direct conversation, where understanding the medical issue is seen as a necessary starting point. However, not all collaborations follow this model. At the company in Vienna, I witnessed how the absence of shared knowledge can lead to confusion or missed opportunities. In the following vignette, I describe one such moment, when a lack of context around a printed object reveals the limits of communication, the challenges of interdisciplinary work, and the difficulty of innovating.

We are seated in the dining hall at a long table. Alfred, an expert 3D printing technician, and another engineer from the company examine a small cylinder, rolling it between their fingers. I approach them, and they explain that there is an extremely small hole inside, which is designed for a liquid to pass through. I continue asking questions. The client is one of their regular service providers, but they usually don't know what the objects are actually used for.

I immediately realise that this is a major problem. How can you optimise an object if you don't know its function or final application? Alfred agrees, adding that certain components are cylindrical simply because traditional manufacturing methods require them to be that shape. However, with additive manufacturing, these objects could be designed differently if more engineers had a deeper understanding of the possibilities. Many engineers still lack sufficient knowledge of additive manufacturing, which limits their ability to rethink designs beyond conventional constraints. This can be easily translated to the medical field. If engineers could design more effectively with more knowledge of technological innovations, we can imagine that such knowledge could also greatly impact doctors by enhancing their understanding of how new technologies can be applied to their field and improving their efforts to tackle medical problems.

Notably, innovation does not depend solely on doctors' knowledge and willingness but also on the broader social system that funds and enables it. Dragan explains, «It depends on where you live, how insurance works, and what is covered by public funding – essentially, what doctors are allowed to do». He continues, «If you have a system where insurance companies and lawyers are just waiting to make things difficult, it can completely stall any development». Dragan's words highlight how financial and legal structures can facilitate or hinder medical innovation, thus shaping what is ultimately possible in practice. However, this topic is beyond the scope of my discussion, which focuses on the exchange of knowledge between engineers and doctors and the consequences of such encounters.

Acquiring Medical Knowledge and Engaging with Technologies

The knowledge of medicine that Dragan possesses is astonishing. He is an engineer, not a doctor, but he explains procedures and illnesses to me with precision and accuracy. After getting to know his work better and spending some time with him, I understand where much of his knowledge comes from.

We are sitting in the car of a doctor named Matteas, whom Dragan works with. We are travelling to the coast of Slovenia for a conference on medicine, where Dragan and Matteas will give a presentation. By presenting at medical conferences, Dragan explains, they attract interest in their work, which is a good starting point for launching new collaborations. After such presentations, doctors often approach him with many questions, as I witness firsthand when attending the conference. After Dragan speaks, there is a great deal of interest and attention from the audience, and many doctors are eager to engage in discussion. This exchange may or may not lead to future collaboration, but sharing knowledge remains essential.

In the car, we laugh about Dragan's vast medical knowledge. He recalls a cancer diagnosis he recently made when studying for a hip revision. As for procedure, he started to analyse the computed tomography (CT) scan of a patient and discovered that a huge ball was covering part of the scan. He immediately ran to the doctor's office and showed the scan image to the doctor, asking, «What is this?!» Matteas laughs as he remembers this accident.

Dragan and Matteas recently worked on hip revisions. If for any reason a defect to the bone is detected after some years of using the artificial implant, a revision operation to the hip should be carried out. Matteas explains, «Often, big defects have been developed because there was no follow up after the operation, for instance». He says, «a bacterial infection can occur that caused an inflammatory response of the body and subsequent bone loss». In such cases, the implant moves from the original position, and a revision is very much needed.

I ask, «Why did you think about additive?». Matteas recounts,

> My first experience with additive was ten years ago, when I saw the personalised instruments to implant an artificial knee. We first thought about the instruments in order to pass from conventional surgery to personalised one, but we did not find great advantages… the precision is not so significant, but the cost is much higher. Therefore, we stopped, and we are doing it only for special cases where it is not possible to use the standard instruments – in

> the case of femoral deformity, for instance, in which you cannot drill into the canal. We just ordered two from the manufacturer, who also offers the customised tools.

Matteas realised that using additive manufacturing to produce surgical instruments is too expensive and does not offer significant advantages. However, he envisions a promising role for additive manufacturing in the production of implants, particularly in complex cases requiring revision surgeries. For instance, he recognises the great potential of customised implants designed to achieve better kinematic alignment, when the goal is to restore the patient's pre-arthritic condition rather than to simply ensure a mechanical alignment, as was commonly the case in the past.

According to Matteas, patients tend to be more satisfied when their natural previous condition is restored, even with its imperfections and defects, than when they are fitted with a standardised implant. In contrast to the standardisation of implants, which reflects broader biomedical logics, kinematic alignment challenges the "one-size-fits-all" approach that is critiqued by other anthropologists (Dumit 2012). By prioritising patients' pre-arthritic anatomy, customised implants resist the biomedical push for standardisation – a tension that engineers like Dragan's colleague Slavo navigate when translating CT scans into customised designs. Matteas states,

> After some years of using the artificial implant, there are some defects, bone defect, and with the customised implant we try to fill the defect and restore the anatomy. With the conventional technology, it is very difficult to achieve stability and restore the anatomy.

The hip operation is a well-established and relatively easy procedure. It does not require expensive customised implants unless there is a need for revision and specific bone loss which makes the usual implant impossible to use. In such special cases, the doctor would use the expertise of Dragan and his team of engineers to find a personalised solution. They even created a specific protocol to follow for the CT scan they use for the evaluation of cases. Dragan says,

> We got to know the person who works with the CT scan there at the hospital, so if we need to study a case, we phone and ask to use the particular protocol that we have already tested. We need a volume to do the segmentation and take out the non-interesting parts. This volume can be processed with different algorithms, but we need to use the same protocol for all cases.

The interpretation of the CT scan is the most difficult part. Dragan and his colleague Slavo, who specialises in the additive manufacturing design, sit together with the doctor to discuss. These discussions can be lengthy.

Slavo says, «We need to be sure that what they get will be useful. The drawing (of the customised hip) in itself can take a week, but we need to be sure that we do what is needed and expected, so the meetings and talks with the doctors take much more time». The difficulty of reading the scanner is often due to free electrons that orbit around the metal creating confusion and obscuring the borders between metal and bones. There are parts, they say, that act as bones but are not bones. Extensive discussions and changes are made, usually while sitting at the same table as the doctors. By comparison, the case of a skull implant can be handled much more easily and precisely because there is nothing around to cause confusion. In such cases, «We need to interpret stuff», they tell me, «and sometimes also the doctors cannot. They are experts, but sometimes they do not know».

Slavo says, «After the meeting, we draw some conclusions and then proceed with the drawing so that when we bring the piece, it is not something new to the doctor». He adds, «Doctors are very disorganised. They prefer to open and see and rely on their experience. They do not like to plan in advance, but then there might be problems». This is why, in the case of customised hips, Dragan and Slavo plan everything ahead of time and accompany the doctor into the surgery. They say to me, «It is so new that you need to be there to explain and help the doctor with the implant».

It is only through the exchange of knowledge between engineers and doctors that such solutions can be developed and this kind of surgery can be performed. Like in the case of the Stockholm applicator, where the engineer needs to grasp the medical context to contribute effectively, the process of working on hip revisions unfolds through moments of hands-on learning – misreadings, sudden insights, and shared attempts to make sense of complex images and situations. These are not linear processes; knowledge is built collaboratively, often in unexpected ways, and it is in these moments – between a CT scan and a shared laugh, between confusion and clarity – that innovation becomes possible.

When Engineers Meet Doctors: Challenges and Opportunities in Communication

The exchange between engineers and doctors sometimes begins with unexpected ways of sharing and acquiring knowledge, such as through the media. Dragan recalls how a surgeon was motivated to contact him after reading an interview he had done with a local newspaper on a new procedure for skull implants using additive manufacturing. Dragan himself was still new to the employment of this technology for skull implants, but he knew people working with it and understood that it was very feasible. Dragan and the doctor started to collaborate, and the procedure has already become routine.

As we have seen, some collaborations arise spontaneously through media exposure or from the curiosity of a doctor engaged in research. These collaborations can lead to successful outcomes. However, not all doctors are as open or attentive, and daily interactions between engineers and doctors can tell a more complex story. Cases of immediate and easy connection are rare, and communication between the two fields is often far from smooth.

As I spend time in the engineering office, I often find myself having lunch with engineers who are working in medical research and development. These informal moments provide a chance to enquire about their experiences, so I take the opportunity to ask a question that is on my mind as I write this article: How is communication between you and the doctors?

Diego, a postdoctoral researcher, immediately answers: «Honestly? Usually, it does not work very well. Doctors are always incredibly busy. They often reply late, if they reply at all. Just getting a hold of them is a challenge».

Engineers and doctors operate within distinct cognitive and institutional frameworks. Often, their ways of reasoning, priorities, and timelines do not align, which generates friction in interdisciplinary work. Diego's frustration with unresponsive doctors underlines a cognitive asymmetry: clinicians prioritise urgent patient care, while engineers operate on iterative research and development timelines. This dissonance can sometimes stall collaboration.

Recently, I served as a human model to help my colleagues engineers with a programme. They took pictures of me in specific positions which would be used to train their programme. They are developing an application that can recognise and count different types of physical exercises. This idea stemmed from discussions with doctors. As they explained, the pre- and post-operative periods are among the most critical phases for heart surgery patients, as patients often feel lonely and lack continuous support. A major issue is that they are required to perform specific daily exercises to prepare for and recover from surgery. These exercises are crucial for a good result; however, without supervision, patients often skip them, claiming that they weren't sure if they were doing them correctly or that they were simply feeling unmotivated. Diego is part of a group of engineers devising a programme to help with daily motivation. To clarify the programme concept for me, Diego compares it to the language learning application Duolingo.

Diego tells me that the female cardiologist they often communicate with has a PhD and has a different mentality because of her research background. He adds, «She is always available. If we have doubts, we can contact her anytime, and the communication is fast and smooth». He explains that they often collaborate with her because, as he puts it, «You need someone who is available, who is willing to sit down and explain things in detail for us to understand the needs and come up with ideas». He concludes, «You need to talk».

Sometimes, collaborations begin with individual doctors who are particularly curious about new treatment opportunities or who have a strong connection to the world of scientific research. Their familiarity with research allows them to recognise the potential benefits of working with engineers and other specialists. These collaborations are not simply about applying existing technologies but about adapting and refining them to fit medical needs.

Knowledge is not something that can be simply transferred from one expert to another; it must be actively discussed, negotiated, and shaped through interaction. Solutions are co-constructed through these exchanges, where different perspectives come together to refine and transform medical technologies. In *The Body Multiple* (2002), Annemarie Mol describes how medical realities are not singular or fixed but are co-constructed by various actors in different settings. Using the example of atherosclerosis, she shows how the disease is enacted differently in pathology labs, clinics, and other medical spaces depending on the practices and perspectives at play. Similarly, in the case of 3D-printed heart models, engineers and doctors work together, each contributing their own knowledge and expertise, and constantly engage in dialogue to shape both the technology and the medical practice surrounding it.

This ongoing exchange does more than just refine existing tools – it actively builds a shared way of working and thinking. As researchers Jean Lave and Etienne Wenger (1991) capture with the concept of a "community of practice", professionals who engage in sustained collaboration develop common understandings and approaches even if they come from different disciplines. In the present case, the engineers and doctors are not simply exchanging information; they are shaping the medical reality itself and determining how 3D printing can be integrated into medical work. Their discussions are not just technical but conceptual, as they influence how medical interventions are imagined, prepared for, and carried out. Lave and Wenger (1991) also underline the social and situated nature of learning and describe communities of practice as groups who «collaborate regularly to share information, improve their skills, and actively work on advancing the general knowledge of the domain». These communities thrive on professional networking, personal relationships, and shared knowledge. In this context, engineers and doctors are not only refining technologies but also co-developing new ways of understanding and approaching medical challenges.

Combining Knowledge: The Role of Engineers in Medical Innovation

It is Tuesday, and I am at the department of engineering. At lunch, I find out that Rita, a postdoctoral medical engineer, is supposed to accompany Luca, her supervisor, to a meeting that afternoon at the main hospital in Bergamo, where they will be shown a programme doctors use for surgical training. I try to persuade Luca to let me join, but I am unsuccessful. However, he agrees to take me along to a meeting tomorrow at another clinic with a doctor they will be seeing for the first time. The goal is to present a new 3D-printed heart model created with a specialised machine and a new material. The materials used are not common plastics; they were specifically designed with biomechanical properties similar to those of heart tissue.

The next day, Luca and I meet another senior professor at the clinic. We patiently wait for the doctor to finish her visit with a patient. The doctor is specialised in radiology, particularly angioradiology. Together with her and a young female engineer who is interning there, we head to a private office for the meeting. It is a shared space used by different doctors, and it features two monitors on a circular desk and some chairs. We sit in a circle, facing each other, with the desk behind us. The doctor brings an additional chair. After a brief introduction, we begin our discussion. The 3D model is incredibly delicate; we pass it around carefully, as if we are holding an actual heart. Luca accurately explains the model and the technology employed, expressing the desire of understanding whether this material is not only marketed as having properties similar to heart tissue but also if doctors can validate this characterisation. The doctor asks about previous uses of such models for other medical applications. Luca explains that they are designed to assist in surgical procedures and help cardiologists prepare for interventions, but he also highlights the significant costs associated with this particular type of model. The doctor replies, «Of course, this isn't done for all patients, but only in specific cases». She adds, «Just last week, I acquired the CT scan of a patient who needs a left atrial appendage closure», referring to a small sac-like structure in the heart. The senior engineer looks at the doctor and points to the exact position on the model where the prosthesis should be placed. He says, «It needs to be placed here».

The doctor explains that this type of prosthesis comes in standard sizes, and cardiologists need to know the precise dimensions of the appendage, including its structure, shape, length, and various diameters. She clarifies that the left atrial appendage is typically categorised into four main shapes, but its anatomical variations are endless. Giving an example, she describes a recent CT scan of a patient with an exceptionally small appendage. «In such cases», she explains, «the prosthesis would undoubtedly need to be custom-made». She concludes, «What's really interesting is precisely this niche of patients who fall outside the standard».

The doctor also states the reasons for closing the left atrial appendage. She explains that the procedure is necessary in patients with atrial fibrillation to prevent the formation of blood clots. The senior engineer nods in agreement, and the doctor adds, «Of course, the challenge is the ability to create a custom-made prosthesis… But what's really interesting is precisely this niche of patients who fall outside the standard». She continues, «If the surgeon has a model of the patient's heart in hand, they can make more precise evaluations – assessing the exact size, shape, and fit of the prosthesis before the actual procedure».

Bringing in more examples and case studies from her colleagues, she says, «Perhaps a custom-made prosthesis isn't necessary, but rather a modification of the existing ones». She notes that she needs to speak with the cardiologist who refers these patients to them and propose a collaboration with the university. She got the idea of working with them after attending a conference of orthopaedic specialists, who deal with similar problems but obviously require less precision. Addressing the engineers' questions, she mentions that, in the discipline, these procedures were originally carried out using pig hearts, for example. She adds, «We need to find the right approach». The engineer asks, «Do you think these models could be useful for testing before performing the procedure on a patient, especially in very specific cases?» She explains that they currently test on a model based on two dimensions, but it's not the same as physically entering in the model with your hands. Luca then describes the various scenarios in which such a 3D print could be used, stating, «It's necessary for the cardiologist to see it and to understand if this operation test with the 3D model could be useful for them». The senior engineer holds the simplest 3D plastic model they brought along. He points to it, looks at the doctor, and says, «I imagine the cardiologist will enter from the right side of the heart». The doctor explains how the procedure works and then turns to the screen to provide a more detailed explanation of the operation.

I could continue detailing exchanges of knowledge between doctors and engineers that I have witnessed, but I will pause here for some reflection. I have described this exchange because it highlights the crucial role engineers play in developing medical technologies, and it demonstrates how such advancements emerge from shared reflections and an ongoing back-and-forth exchange of knowledge. Collaborations develop over time, especially fruitful ones, and require a deep understanding of clinicians' work to adapt existing possibilities and technologies into something that truly serves medicine.

We often assume that only doctors possess certain knowledge. Yet, in reality, engineering plays a fundamental role in hospitals. Since doctors now rely heavily on technology, they need to understand it well. Likewise, engineers are deeply involved in the world of medicine, and they need to understand doctors in order to develop everything from medical equipment to prosthetics and beyond.

I express my surprise to Luca about how well they followed the doctor's explanations, which were completely unintelligible to me. The senior engineering professor in particular asked highly specific questions, which demonstrated a thorough understanding of not only anatomy but also surgical procedures and the functional issues of the heart. Luca responds without much surprise. He simply says, «Of course, he's a biomedical engineer», as if it were completely normal.

I learn from Rita that engineers in their medical engineering specialisation (*ingegneria biochimica*) take exams on various areas of medicine, such as general medicine, cardiology, and neurology. Moreover, in their bachelor's programme, they have courses on subjects such as anatomy and biology in the industrial health engineering curriculum. She makes sure to specify that their exams are much lighter than those taken by doctors, but they still ensure that they have enough knowledge to understand part of the language of the medical field.

The senior engineering professor's specific questions show how engineers need to understand anatomy and surgical procedures in order to create effective medical tools. This understanding comes not only from technical expertise but also from specialised training in subjects like cardiology and anatomy. Engineers in the medical field, as Rita explains, take medical courses to communicate with doctors and understand their needs, even if their exams are less demanding than those of medical doctors. Additionally, the practical experience of these kinds of meetings teaches them a great deal. They explained to me that the senior engineer I saw is a reference point in their field and, after years of working with hospitals and doctors, has accumulated a vast amount of knowledge and experience that is tacit and comprised of skills and insights gained through experience rather than formal training. Knowledge comes from experience on the ground and is embodied and interiorised through an active learning process (Coy 1989; Herzfeld 2004; Ingold, Lucas 2007).

As stated in the previous part, knowledge is then co-constructed. Through the process of sharing information and experiences with a community of practice, members learn from each other and have opportunities to develop personally and professionally (Lave, Wenger 1991). Cicourel (1990) emphasises that medical diagnosis is not a solitary act, but a collective process shaped by distributed knowledge. In the case of medical innovation, engineers bring technological expertise, while doctors contribute clinical experience and knowledge of medical procedures. Their discussions, like those surrounding the 3D-printed heart model, require constant negotiation, interpretation, and adaptation to align technological possibilities with clinical needs.

The interaction between doctors and engineers observed in my ethnographic work closely resonates with the concept of co-design as a process of "joint inquiry and imagination", as proposed by Rizzo (2009). In this kind of collaboration, solutions are not simply transferred from one domain to another but emerge from situated interactions in which actors with different backgrounds bring together their skills, languages, and worldviews. Innovation takes shape through shared practice, where meanings are negotiated, and possible futures are co-constructed. As in co-design, in the case of innovation in the medical-technological field, knowledge integration occurs through discussions supported by tacit knowledge, accumulated experience, and operational intuition. Engineers such as Dragan or the senior professor from the last example are key mediating figures who are capable of translating clinical needs into technical possibilities, and vice versa, thus contributing to the co-production of knowledge.

Professional expertise is not static but emerges through interaction. Engineers and doctors must navigate different forms of knowledge, tacit understandings, and institutional constraints to arrive at workable co-produced solutions. The way they handle the 3D model, question its properties, and imagine its application in surgical planning mirrors the way medical realities are enacted in practice. This reinforces the idea that technological advancements in medicine are not purely technical but are socially and institutionally embedded and shaped by interdisciplinary collaboration.

Conclusion

As Forsythe (2001) notes in her ethnography of AI researchers, knowledge engineers often privilege explicit, technical knowledge that can be formalised into rule-based systems while frequently overlooking more contextual, tacit forms of understanding. This reflects a broader tendency to "delete the social" (Star 1991), stripping knowledge of its relational and experiential dimensions.

In contrast, the interactions I observed between engineers and medical professionals reveal a very different mode of knowledge-making that is dynamic, negotiated, and embedded in specific practices. Rather than extracting expertise into abstract representations, knowledge is co-produced through dialogue, material experimentation and ongoing negotiation. This highlights the limitations of treating technical knowledge as static or universal and reinforces that innovation, particularly in interdisciplinary settings, is as much a social and epistemic process as it is a technical one.

The study also demonstrates that the process of innovation is relational rather than purely technical. As Haraway (1988) suggests, "situated knowledges" are crucial for understanding the complexities of medical and engineering work. Both engineers and doctors must engage in dialogue, translating and adapting their respective forms of knowledge to ensure that technological solutions are grounded in real-world clinical needs. This iterative exchange fosters creativity and generates friction between disciplines that becomes a catalyst for innovation.

Ultimately, this research shows that transdisciplinary innovation is not a linear process but a recursive one, where 3D-printed prototypes become sites of negotiation, reshaping both clinical practices and engineering assumptions. For technology to succeed, it must be technically sound and meaningfully embedded in human contexts to enhance the lived experience of both patients and practitioners.

This case of co-production and co-design involves two expert communities – engineers and medical professionals – each with specialised knowledge, practices, and institutional constraints. Their collaboration reveals a specific form of interdisciplinary negotiation in which mutual learning and adaptation are crucial to creating workable solutions.

In conclusion, this article emphasises the importance of transdisciplinary collaboration in medical innovation. It shows how the combined expertise of doctors and engineers leads to more personalised and effective treatments for patients. Engineers must engage not only with numerical data but also with "thick data" – the lived, contextual insights of doctors – which enriches their understanding of clinical needs. Doctors should be able to stay open and understand technology and its use in order to foresee solutions to their daily clinical work. The integration of big and thick data (Ruzzene 2023) and the ability to overcome epistemological and ontological disciplinary divides through mutual learning, time, and dialogue (Sischarenco 2023) prove to be essential. As my field research demonstrates, this kind of collaboration, when successful, fosters innovation and technological development that can genuinely address and meet real-world clinical needs.

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Scheda sull'Autrice

Elena Sischarenco, nata il 4 settembre 1982 a Bergamo, ha conseguito un dottorato in Antropologia Sociale presso l'Università di St Andrews (Regno Unito) nel 2017. Attualmente è assegnista di ricerca in antropologia culturale presso il dipartimento di Lingue e Culture Moderne dell'Università degli Studi di Bergamo, dopo aver lavorato in diverse università internazionali, tra cui l'Università di Lancaster (2019-2021) e l'Università di Friburgo in Svizzera (2022-2024).

La sua ricerca si concentra sull'antropologia economica e d'impresa, l'economia circolare, la sostenibilità, l'innovazione, la conoscenza, l'imprenditorialità, l'etica e la ricerca responsabile. Nel corso della sua carriera ha svolto studi etnografici in diversi settori, tra cui la stampa 3D, la manifattura industriale e le industrie automobilistica, medicale e edile. È autrice del volume: *Encountering Entrepreneurs: An Ethnography of the Construction Business in the North of Italy* e ha pubblicato su numerose riviste internazionali.

Abstract

Innovating Through Transdisciplinary Knowledge: Bridging Engineering and Medicine through 3D Printing Technology

This article explores how transdisciplinary collaboration between doctors and engineers drives innovation in the production of medical technologies such as 3D-printed prosthetics and implants. Drawing on ethnographic fieldwork in Slovenia, Austria, and Italy, I argue that effective innovation requires mutual translation of clinical and engineering knowledge, yet it is sometimes hindered by communication barriers, institutional constraints, and entrenched professional epistemologies. By analysing ethnographic examples in the fields of additive manufacturing in cancer treatment and of hip revision surgeries, this work highlights the cultural and practical challenges of bridging disciplinary divides.

Keywords: Interdisciplinarity, Knowledge, Additive Manufacturing Technology, Innovation, Doctor-Engineer Collaboration

Resumen

Innovar a través del conocimiento interdisciplinar: conexiones entre ingeniería y medicina mediante la tecnología de impresión 3D

El presente artículo explora cómo la colaboración interdisciplinar entre doctores e ingenieros impulsa la innovación en la producción de tecnologías médicas, como los implantes y las prótesis impresas en 3D. A través de un trabajo de campo etnográfico llevado a cabo en Eslovenia, Austria e Italia, argumento que una innovación efectiva requiere la traducción entre conocimientos clínicos y de ingeniería, aunque a menudo este proceso se ve dificultado por barreras comunicativas, limitaciones institucionales y epistemologías disciplinares consolidadas. Mediante el análisis de ejemplos etnográficos en los campos de la fabricación aditiva en tratamientos oncológicos y las cirugías de revisión de cadera, este trabajo resalta los desafíos culturales y prácticos implicados en la superación de las divisiones disciplinares.

Palabras clave: interdisciplinariedad, conocimiento, tecnología, innovación, colaboración entre doctores e ingenieros

Résumé

Innover par la connaissance interdisciplinaire: relier ingénierie et médecine grâce à la technologie d'impression 3D

Cet article explore comment la collaboration interdisciplinaire entre médecins et ingénieurs favorise l'innovation dans la production de technologies médicales, telles que les implants et les prothèses fabriqués par impression 3D. À partir d'un travail de terrain ethnographique mené en Slovénie, en Autriche et en Italie, je soutiens qu'une innovation efficace nécessite une traduction entre les savoirs cliniques et ceux de l'ingénierie, bien que ce processus soit souvent entravé par des barrières de communication, des contraintes institutionnelles et des épistémologies disciplinaires consolidées. En analysant des exemples ethnographiques dans le domaine de la fabrication additive appliquée aux traitements oncologiques et aux chirurgies de révision de la hanche, cet article met en lumière les défis culturels et pratiques liés au dépassement des divisions disciplinaires.

Mots-clés: interdisciplinarité, connaissance, technologie, innovation, collaboration entre médecins et ingénieurs