Factors that Influence the Disconnect Between Physicians and Engineers

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

There are an estimated 2 million different kinds of medical devices on the world market, with an annual increase of 177 to 303 filing of new medical device patents in the United States between 2008 to 2015 (*The Value Of Medical Device Patents | Medical Product Outsourcing*, n.d.). With all these devices to choose from, physicians often stick to brands and devices they are familiar with (Gendia & Shamma, 2022). This makes it difficult for new devices to be adopted in the medical space, especially with the growing number of devices. This can create a problem when some new devices introduce improvements that can greatly benefit healthcare.

My team is working to redesign a tibial guide used for ACL reconstruction surgery in order to improve clinical stability outcomes from the procedure. We work with an orthopedic surgeon to get feedback on our designs. In one of our first meetings, my team presented our initial design. We received a lot of feedback about how the different components and mechanisms we described would not be feasible for use in the operating room. This made me wonder how we could be so wrong in our design. We believed that we created a good design that addresses the problem we want to fix but it was so different from what the physician was envisioning. There was a disconnect between our points of view which caused differing opinions on designing the device.

The field of healthcare is rapidly changing through technological development, from new drugs and treatments to new devices (Thimbleby, 2013). These innovations have lessened some of the burdens on physicians as well as allowing the automation of certain procedures which grants other healthcare workers the opportunity to perform more meaningful tasks. Additionally, medical technology has greatly increased life expectancy and saved many lives through new therapies. According to the National Bureau of Economic Research (NBER), therapies accounted

for 45 percent of the increase in life expectancy in the late 1990s and 73 percent in the early 2000s (*The Value of Medical Innovation*, n.d.). The adoption of more technology in healthcare will improve the quality of treatment and help address more serious conditions.

Even with all the benefits of incorporating technological development into medical practice, there are situations where practitioners are still reluctant to utilize it. Not all physicians will agree on the use of every innovation and the adoption of new technology can come down to individual preferences. Engineers may not understand all the factors that doctors are looking for in their devices which comes down to the differences in training for the two professions. However, understanding these differences can greatly impact the innovation of medical devices and failure to reach a common ground can lead to a reduction in healthcare development. It is a necessary skill for an engineer to understand their user, especially when it comes to medicine.

By dissecting the literature about physicians and engineers, I will discover why a disconnect occurs between these professions. Through the lens of configuring the user, defined by Steve Woolgar, I will determine the main factors that differ and define the thought process for orthopedists. Through content analysis of studies about physicians' decision-making and discourse analysis on user manuals created by engineers for various orthopedic devices, I will identify the disconnect between orthopedists and engineers. Configuring the user will help show how engineers are limiting the actions of physicians in their medical devices due to assumptions made about the user. The way engineers think a device should be used is different from how surgeons are trained to operate during a procedure. This misunderstanding can lead to reluctance by the surgeon to use the new technology. There is a disconnect between orthopedic surgeons and engineers that primarily stems from the differences in their thought processes, causing a reduction in the adoption of new, lifesaving medical devices.

Literature Review

It is important that physicians are utilizing new life-saving technologies in their practice. However, the medical profession is generally a conservative group that does not accept new technologies readily. This isn't necessarily a bad thing since medical journals often produce weekly reports introducing new technology, tests, and other advances in medicine, but physicians cannot keep changing the way they practice medicine at that rate (Thier & Ekelman, 1988). Nonetheless, we need a way for engineers that make beneficial, medical technology to catch the eye of doctors and design it in a way that targets the needs of the physician in the device. Medical devices are fundamental components of health systems that are crucial in preventing, diagnosing, treating, and rehabilitating illnesses and diseases (*Medical Devices - PAHO/WHO | Pan American Health Organization*, n.d.).

Orthopedic surgeons, like other doctors, must consider many factors when making decisions on how they want to treat their patients. There is never one correct form of treatment, physicians must rely on their experience and training to determine the problem and solution. It might seem that there are too many individual factors that may influence the decision-making of physicians but a study at Allegheny General Hospital in Pittsburgh, PA showed that doctors' diagnostic and thinking abilities can be taught and improved (Reilly et al., 2013). In a professional field, the training you received greatly impacts the way you think about a situation, especially in medical practice. Even with this understanding, there are limited studies that investigate which factors most influence this way of thinking. It is clear that orthopedic physicians have a huge say in what devices get adopted in their hospitals (Gendia & Shamma, 2022). Therefore, engineers must understand what doctors want if they want their devices to be used. There have been some studies that try to predict and measure physicians' motivation to

adopt medical devices (Felgner et al., 2018; Hatz et al., 2017). However, they do not further investigate the engineer's role in the dynamic of medical device adoption.

Engineers are trained to think in an analytical way in order to optimally solve a problem which will influence the way they work and the design decisions they make. Engineers seek optimal solutions to problems and they must make judgments and provide explanations to justify their choices when looking to find the best trade-offs (Robinson, 1998). Graduating engineers are taught design thinking, which is a complex topic that can be thought of as a form of solution-based thinking (Dym et al., 2005; Pusca & Northwood, 2018). Solution-based thinking is linked to creativity while problem-oriented thinking is closely linked to critical thinking. This way of looking at a problem is taught to engineers and gives them the ability to think outside the box. Thus, they are able to design innovative technologies and think of new ways to optimally solve a problem in order to produce quantitively better results. The issue is that the designs may not always be practical or address the entire needs of the user. Moreover, engineers might not always present their devices in a way that resonates with the user. A study identified five important features of speaking in engineering: simplicity, persuasiveness, results-oriented, numerically rich, and visually sophisticated-all of which invoke the skill of translation (Dannels, 2002). Although these features can provide numerical justification for the benefit of their devices, it does not convey other factors the users may be looking for and addresses other concerns, such as the usability of the device. Additionally, the focus on these features might present the design in a way that seems to limit the doctor's movements in the operating room.

The differences in the training and thought processes of doctors and engineers create a disconnect between them. This is common across all disciplines as it is difficult to maintain effective interdisciplinary communication due to challenges that arise when communicating

among people with different backgrounds (Hassani, 2019). This is an overlooked issue as people primarily focus on communications within a discipline. Thus, addressing this problem among physicians and engineers can result in the designing of effective medical devices that improves patient safety. There can be an impedance mismatch inhibiting the flow of information between engineers and clinicians. Differences in what an engineer wants to develop and what physicians need to be improved can become detrimental to the physician's workflow (Nelson, 2017). The engineers' way of thinking creates devices that limit the doctors' actions in ways that go against their ideal way of thinking.

To better understand this gap between the user's and non-user's way of thinking, I will rely on the framework of "configuring the user" as explained by Steve Woolgar (Woolgar, 1991). In this chapter, Woolgar explains how there is a distribution of knowledge and expertise between the users and the developers. By conducting a case study on users trying a new device, he was able to identify assumptions that engineers make about the users as they are developing the technology. He discovered that the various developers involved in the device's creation had different ideas about the user's way of thinking, which affected the way they viewed how the product should be made. As seen from the study, this results in a disconnect as the user is unable to utilize the tool at all. Woolgar argues that user configuration is necessary by looking at the user's character, capacity, and possible future actions with the device. In the context of medical technology, physicians are the users that the engineers need to configure. By making assumptions instead of trying to understand the practitioners, the engineers are creating devices that the user is unable to utilize. The engineer must not only focus on a singular aspect of improvement, even if it is supported by research. They must also incorporate the physicians' viewpoints. Therefore, engineers need to understand how to configure the physician in order to

create medical technology that will be easily adopted and utilized to improve healthcare. This is especially important in the medical field as the engineers do not want to create a device that sets strict parameters for the physicians' actions. The device should predict the future actions of the physician and complement these actions. I will utilize this framework to identify how engineers are configuring physicians in their devices and how it differs from what doctors are looking for from their tools.

Methods

Primary sources of user manuals of prevalent medical tools used by orthopedists and studies that look at physicians' decision-making were gathered. Additionally, secondary sources of journal articles and studies that highlight the main factors physicians look at when deciding which medical technology to use and adopt were also collected. A discourse analysis was conducted on the user manuals to investigate how engineers present medical devices to the world. The discourse analysis helped me find patterns in the way engineers anticipate their work to be used by looking directly at the way they are presenting their technology, not the actual information itself (Tannen, n.d.). This technique identifies how the engineers are configuring the users of these devices. Content analysis of the articles and research studies was used to establish the recurring factors that influence physician decision-making. This informs me of what the physician deems most important when using medical devices and treating patients. The literature analysis allows me to take apart a text and understand what the author is trying to argue (*Literature Analysis | Writing Center*, n.d.). This information is used in comparison to the results of the discourse analysis to see if the engineers are considering these factors as they are configuring the user.

Results & Analysis

The Engineer's Point of View

Engineers are establishing parameters for the users' actions through the way they explain their products in the device's manuals. I was able to find ways where the engineers seem to limit the actions of the surgeons when examining the user manual of three orthopedic devices: the Arthrex Tibial Guide, the Manman Bone Drill, and the Gratloch Wire Bender.

The engineers at Arthrex create technical guide manuals for a lot of their products that are used to assist and teach medical professionals how to use the tool. However, these manuals dictate specific step-by-step uses of the device with options that describe what to do if different conditions are spotted at different steps (*Transtibial ACL Reconstruction for BTB Grafts*, n.d.). Although there is a disclaimer at the end that states medical professionals must use their professional judgment, it is not easily seen. Moreover, there is a note in the manual that goes against the disclaimer by warning the user to not deviate from the described technique. This form of discourse sets parameters for the user's actions and gives the user little freedom in how they would like to approach using the device. The engineer makes assumptions about how the surgeon should be performing the procedure and their background training in this technique. This effectively attempts to configure the user as described by Woolgar. The engineers are constraining how the surgeons will be able to perform the operation.

The engineers of the Manman Bone Drill and Gratloch Wire Bender created manuals with a similar format that describes the functions of their respective devices (*Manman Bone Drill Manual*, n.d.; *OrthoMed Wire & Pin Management Manual*, n.d.). However, their discourse differed from the Arthrex guide by not defining strict guidelines on how the tools can be used.

These two manuals focused on just outlining the unique mechanisms of the tool without setting parameters on the actions the users must take. This allows the surgeon to have a bit more freedom on how they want to approach utilizing the tool, but the manual does not give further information about the tool that may be important to the doctor.

Although these user manuals highlight how the engineers want the physicians to utilize their devices, they mainly focus on one specific function and expect the physicians to perform their procedures in this way. However, there are many parts to surgery and each tool serves to deal with one aspect. The tool must work with many other factors, such as other devices, possible surgical complications, etc. The failure to highlight this creates limitations on the device and what the surgeons can do. Moreover, the manuals do not address other factors that may be important to physicians when they are making their decision on whether they want to adopt a tool. The engineers define their users and set up parameters on what they can do without addressing other important issues.

The Physician's Point of View

There are determinants that influence medical practitioners' thought processes which will drive whether they decide to adopt a medical device. A few different studies have investigated the defining factors that determine if a physician will decide to adopt a medical device. The first study utilized exploratory factor analysis to look over 457 questionnaires completed by medical personnel, which was used to inform the development of the physician-motivation-adoption (PMA) scale (Hatz et al., 2017). This study resulted in defining 6 main factors that influence the decision: functional, conformity, power, hedonic, patient benefit, and cognitive. Another study conducted interviews with 23 senior physicians to "identify factors and generate thematic categories utilizing qualitative content analysis" (Felgner et al., 2018). The researchers

categorized 52 factors into eight categories: evidence base, hospital, technology, state of medical care, regulation, patient, manufacturer, and individual. A third study utilized a System Utility Score (SUS) questionnaire to assess the usability of an application among 13 orthopedists and 13 orthopedic residents (Macedo et al., 2021). The SUS questionnaire focused on assessing three main categories: effectiveness, efficiency, and satisfaction. All these studies approached looking into physicians' decision-making of adopting medical technologies in different ways and derived some classifications of what the influencing factors are.

Although there were many different categories of factors described in each study, the most important and common factors related to functionality, patient benefit, and personal satisfaction (i.e., comfort, and ease of use). When deciding if they want to adopt a medical technology, physicians will mainly look at these factors. Engineers need to address these factors in their consideration of who the user is in order to prevent limiting the user in these categories. While it is difficult to not set any parameters on the users' actions, engineers must do their best to properly configure the user in a way that does not limit how they want to operate, especially when it comes to medical practitioners. By learning how the users want these factors to be satisfied in the device will help increase the likelihood the device gets adopted into medical practice.

Physicians are unable to easily locate concerns about their issues in relation to these factors. As seen from the analysis of the user manuals, patient benefit and personal satisfaction were rarely addressed. Although functionality was heavily discussed, that is only one portion of what physicians look for in medical device adoption. The other factors need to be included in the engineer's communication of the device in order for physicians to understand the benefit of the

tool. Doctors need all their concerns to be addressed before making the decision to learn the new technology.

Conclusion

Engineers and surgeons have been trained in completely different ways to excel within their professions which makes engineers think about optimizing results through their creation while surgeons use what they know to perform procedures. This creates differing perspectives on what each party is looking for in the creation of medical devices. We now know that understanding and confronting these differences can help bridge the disconnect and lead to the development of tools that can benefit patients and are adopted for use by physicians. Engineers need to address the concerns surrounding functionality, patient benefit, and personal satisfaction when designing medical devices. Engineers should not assume but understand how the users interact with the tool in relation to these factors and ensure the tool does not limit the users' actions. By identifying what is most important to physician decision-making, specifically in adopting medical devices, engineers can better reevaluate and configure their users in a way that does not rely on inherent biases and assumptions.

Patients might prefer their doctors to be comfortable with the device they're used to instead of trying new things but that will hinder the development of the medical field and reduce our ability to address new health concerns. Moreover, some might think that just having the doctors talk to engineers during the design process will solve the problem, but it is not that simple. Engineers and doctors are trained very differently so they will have different viewpoints. We need to establish and understand these differences so they can be addressed. Moreover, there will always be inherent biases, as described by configuring the user, that can hinder the working

relationship if we cannot appreciate each other's thinking and preferences. The issue is not merely about getting the two sides to talk but understanding ways they can effectively communicate with each other through learning more about the other's background and points of view.

The results of this paper can help engineers, namely, biomedical engineers, have a new perspective when developing medical tools that will help their devices be easily adopted by medical personnel. The factors outlined can give engineers a place to start when communicating with physicians and give them more elements to think about when creating their designs. Moreover, these results should influence the training of biomedical engineers to include understanding the perspective of physicians. However, this paper relied solely on studies and did not conduct interviews and other research methods to see if the findings correlate to real-world scenarios for the two professions. Thus, future researchers can build off this project by performing studies that confirm my findings and factors. For example, different groups of engineers can be gathered, some informed about/utilizing my findings and some not. They can all be given the same task to develop a certain medical device with the same prompt. Then doctors can test all the devices to see which they believe will be most effective in practice. The results of this study will hopefully support the claim that understanding and considering the identified factors influencing doctors' decision-making will create devices that are more easily adopted. Moreover, future research should find ways to best implement these findings into the engineering design process.

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