Communication Between Human Factors Psychologists and Engineers: Challenges and Solutions

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Human factors psychology has evolved as a field to include research that reaches across many disciplines, including engineering, medicine, and education. This interdisciplinary work can be accompanied by barriers to communication between human factors psychologists and other professionals. This paper addresses challenges in communication between human factors psychologists and engineers as they work together on interdisciplinary projects. The primary purpose of this paper is therefore to examine these challenges and propose possible solutions that may aid in communication. This paper secondarily serves as a call for dialogue and research examining interdisciplinary communication in human factors.

INTRODUCTION

The field of human factors psychology has become increasingly diverse over the years, with professionals today being involved in several domains including education, healthcare, aviation, and military operation. Given the diversification of domains being explored in the field of human factors, it is commonplace to find human factors psychologists working in teams alongside engineers, computer programmers, doctors, or teachers. Such interdisciplinary teams can face many challenges, especially when work demands smooth execution at all levels. For example, one case study indicated that two common disadvantages to multidisciplinary work in human-computer interaction are (1) lack of a unified view and (2) loss of focus (de Paula & Barbosa, 2004). It may be that the underlying cause of such "disadvantages" lies in issues with communication. After all, it has been found that certain types of interdisciplinary teams may have trouble with communication between members from different professional backgrounds (Bunderson & Sutcliffe, 2002).

Of particular interest today are interdisciplinary teams involving human factors psychologists and engineers who often work together to win the never-ending race to technological perfection. Human factors psychologists and engineers may work together on a variety of problems, including the creation of intelligent agents, interfaces, and performance standards. Many of these problems may involve safety-critical aspects, making it imperative for human factors psychologists and engineers to succeed in their efforts to perform well as a team to attain high technological safety and performance. However, as stated above, communication issues could impede this process. The primary purpose of this paper is to explore key challenges that may arise in communication between these two types of functionally diverse professionals – human factors psychologists and engineers – and propose solutions that may aid in their communication. The secondary purpose of this paper is to initiate dialogue and research concerning interdisciplinary communication as it relates to human factors.

In meeting these objectives, I will discuss four challenges that can be found in interdisciplinary projects involving engineers and psychologists. For each of these challenges, I will portray examples of how they may arise, and propose multiple solutions that may be considered for each. I will conclude with a discussion of practical implications and next steps involving the research of interdisciplinary communication in human factors and related fields. It should be noted that this paper is not exhaustive in its suggestions, and is meant to be a first step in identifying challenges in the interdisciplinary communication specific to human factors psychologists and engineers.

CHALLENGES AND SOLUTIONS

Challenge 1: Getting on the Same Page

One challenge that may arise in multidisciplinary projects involving human factors psychologists, engineers, and other professionals is a lack of a unified view of the project (de Paula & Barbosa, 2004). Human factors psychologists and engineers generally focus on different aspects of the same project, which may impede their abilities to understand how each individual piece fits into the larger picture.

As an example, consider a scenario in which a group of human factors psychologists and engineers work together to design a robot. The engineers may be in charge of creating the robot and making sure it functions according to plan, while the psychologists may be in charge of choosing the characteristics of the robot that are necessary to achieve a certain level of performance. In this scenario, the engineers may not be aware that, for example, the psychologists are also concerned with the *safety* of the robot, leading the engineers to instead focus on optimizing performance at the cost of safety. However, if the engineers share a unified view of the project with the psychologists, they will be aware that there are safety concerns and will consider this in their own project tasks. To ensure that psychologists and engineers in this scenario share a unified view of project goals, they may (1) create scenarios, (2) use visual aids in brainstorming.

Solution: Create scenarios. A common approach to project planning in multidisciplinary teams in human-computer interaction involves creating scenarios (Norman & Draper, 1986). Scenarios can be useful in that they allow a team to consider possible situations and outcomes involving a system being designed (Rosson & Carroll, 2001). In a human-robot interaction project, the creation of scenarios can allow team members to agree upon the goals of the robot's interaction with humans. This, in turn, will inform the team's understanding of what considerations will make the robot design a success. For example, if the team wants a robot to be partially autonomous, building a scenario that shows exactly what the robot can do may help in determining how best to control the level of autonomy of the robot.

Solution: Use visual aids in brainstorming. While scenario creation is great for generating conversation on project goals and ideas, it may be limited in its ability to speak for the project as a whole. Another solution to supplement this is the use of visual aids in brainstorming. This has been proposed by people in the field of human-computer interaction (de Paula & Barbosa, 2004) and is a worthwhile consideration for any multidisciplinary project involving engineers and human factors psychologists. Visual aids may include simple diagrams dictating the goals of the project and the steps to reach those goals, or more elaborate interaction models conveying the system being developed in a detailed form (de Paula & Barbosa, 2004). The use of elaborate visual aids can allow team members to understand all aspects of the project, especially those not under their immediate purview.

Challenge 2: Conflicting Terminology

Human factors psychologists and engineers have at least one thing in common: they both use terminology (commonly understood as terms specific to a subject) to describe the phenomena they work with. In fact, this can be said for just about any specialized field. The use of terminology is useful in that it allows someone to combine a wealth of information into one word (Perelman, Barrett, & Paradis, 1996). The downside to using terminology is not everyone knows the same terminology. Indeed, people *in the same field of study* may have conflicting understanding of terminology. This has been cited as a complaint in the field of engineering, for example (Gilb, 2007). Furthermore, terminology is often thrown around in conversation or writing with the expectation that others know what the speaker means. This can be particularly problematic when interdisciplinary conversations arise because the likelihood of an expert in one field knowing the terminology being used by an expert in another field is slim.

As an example, consider the same scenario discussed above in which a group of human factors psychologists and engineers work together to design a robot. The first thing they may agree to do is build a *model* of human-robot interaction. What is a *model*? The engineering experts may mean to build a model consisting of mathematical relationships (Law, 2015) or a diagram showing exactly what happens in the interaction. The psychologists may agree with one of these definitions, or they may define a model as something different, such as a theory that hypothesizes what affects the human-robot interaction (see "psychological model" in Psychology Dictionary). These two definitions of *model* are equally valid to their respective fields, and without clarification of what the term means to all of the experts on the team, the psychologists and engineers may find themselves working toward two different goals. Given this type of scenario, what can be done to ensure that all members are on the same page? Two solutions may be: (1) avoid using terminology or (2) define key terminology.

Solution: Avoid using terminology. One option for making sure everyone on the team understands what is being said in a conversation is to avoid using terminology. For example, if an engineer is suggesting to the team to build a model, s/he might replace the term *model* with its definition (E.g. "Let's build a mathematical representation of how this works."). On the other hand, a psychologist on the team could take the same approach (e.g. "I think we need to form hypotheses predicting how this may work."). By eliminating the term *model*, members on the team can minimize the possibility of misunderstanding each other.

Solution: Define key terminology. Another, perhaps better, approach to making sure everyone on the team understands what is being said is defining key terminology. Providing clear definitions of technical terms has been offered as a key principle for their use (Perelman, Barrett, & Paradis, 1996). Doing this, as opposed to avoiding terminology altogether, has the added perk of educating others on terminology of the field in question. For example, an engineer could suggest "Let's build a model. By model, I mean a mathematical representation of how this works." By including both the term and the definition in this statement, the engineer not only clarifies, but also allows any psychologists in the conversation an opportunity to understand what the term *model* means to the engineer, which may come in handy in future conversation.

Challenge 3: Concrete Versus Soft Answers

One difference that can be found between many human factors psychologists and engineers lies in the types of solutions being sought. Engineers are, by profession, driven to find concrete solutions. After all, an engineer can't build a fully-functioning system by just approximating how the pieces work together. They generally need mathematics to quantify and specify solutions. On the other hand, human factors psychologists may seek either concrete solutions or softer ones, depending on the nature of the question at hand. This can be expected because human behavior is not a simple puzzle to solve and it isn't easy to define precisely (e.g. with mathematics). While the field of psychology has grown to include more precise solutions, including mathematical models, some questions remain hard to answer with concrete solutions, and some may have more than one answer. This can make it difficult for human factors psychologists to give engineers the answers they need to complete their jobs.

As an example, consider the team of human factors psychologists and engineers building a robot above. The engineers may want to know exactly how autonomous the robot should be during its interaction with a human in order to optimize safety and performance. They leave it up to the psychologists to figure this out. However, the psychologists realize several constraints when they set out to find this information: (1) the appropriate level of autonomy (LOA) changes with the situation (Parasuraman, Sheridan, & Wickens, 2000); (2) autonomy isn't an "exact science" (p. 294); and (3) there is a safety-performance tradeoff (Bicchi & Tonietti, 2004). This example – as is often the case in psychology – yields many possible answers that may not be "exact" in nature. There are multiple approaches the team can take to seeking, finding, and implementing these answers to best help the engineers: (1) Create "if-then" statements from guidelines, and (2) Aim for relative instead of absolute answers.

Solution: Create "if-then" statements from guidelines. In a case where numerous guidelines exist to answer a single question, it makes sense to collect these guidelines into one place by performing an extensive review that collects all of the relevant information. However, compared to the exact information engineers seek, guidelines can appear muddy. One way to clarify guidelines might be to create "if-then" statements out of them. This allows an engineer reading such guidelines to link several scenarios (*ifs*) to solutions (*thens*) quickly. For example, if a human factors psychologist has a guideline stating that LOA should vary with the type of function being performed, the details of this guideline can be parsed out to several "if-then" statements of the form: "If function X is being performed, then LOA should equal Y."

Solution: Aim for relative instead of absolute answers. Even with guidelines and experimentation, there may not always be one exact answer to a question. In the current example, it is stated that automation isn't an "exact science" (Parasuraman, Sheridan, & Wickens, 2000, p. 294). The same can be said for many other concepts in human factors psychology. This can be a point of conflict between human factors psychologists and engineers when the latter is expecting explicit information from the former. In such a situation, one possible compromise between both parties might lie in seeking relative answers. Relative answers may include probability (e.g. "There is X% chance of Y happening"), or ranges (e.g. "Aim for a workload score between X and Y"). Taking this approach has the advantage of giving engineers information they can use mathematically while keeping psychologists from having to provide definitive answers where there are none.

Challenge 4: Communicating Too Late

Human factors psychologists often help in developing interfaces, including playing a role in usability inspection for engineers (Nielsen, 1994). However, human factors psychologists may not be called in to help until late in the engineering life cycle. This can cause delays and expenses if it turns out that a product must be redesigned due to usability issues. This is particularly problematic later in the life cycle, as it leaves more work which must be redone.

As an example, consider a scenario in which a group of engineers are building an elaborate tablet-based controller for the robot designed above. Due to time constraints, they quickly jump into designing and building the controller interface based on functional requirements alone. Once they have the controller nearly finalized, they call in a human factors psychologist to perform a usability study. The usability study results indicate that several changes need to be made to the controller so that it is easier to use. This results in more time and money being invested in the redesign of the controller. Is there a more efficient way to make use of human factors psychologists in such a situation? In light of the topic of this paper, the obvious solution lies in communication. Communication can be improved in two ways: (1) Communicate earlier in development, and (2) Consult before project kick-off.

Solution: Communicate earlier in development. Reaching out to human factors psychologists earlier in the engineering lifecycle can expedite testing and implementation later on. For example, Nielsen (1992) outlines a model whereby usability can be addressed throughout the engineering life cycle. In the case of the example presented above, usability could have been assessed by human factors psychologists during the designing and building of the controller interface. Doing so could have saved a great deal of time and money (Nielsen, 1992). Similarly, safety and performance can be assessed as well as other aspects of human-machine interaction. A good guideline for deciding when to incorporate a human factors psychologist in the engineering lifecycle is immediately after determining the task involves humans using machines.

Solution: Consult before project kick-off. Taking the above guideline to the next level, one way to get the most out of communicating with human factors psychologists is consulting with them in depth before project kick-off. This can benefit both the human factors psychologists and the engineers who may be involved in the project, as it allows an opportunity to delineate roles among each player on the team, as well as take into account any insight which human factors psychologists may have for engineers before the full project plan is laid out. It also allows an opportunity for any concerns to be raised, whether it be concerns over usability, safety, or performance. Discussing these concerns ahead of time can help engineers see where in the project they should be sure to include human factors psychologists.

DISCUSSION

This paper aimed to initiate a discussion of challenges and solutions that can be found in interdisciplinary work involving human factors psychologists and engineers. As a first step, I provided four challenges addressing such work, as well as possible solutions to each challenge. Many of the solutions presented here are already in use, but not always consistently so. In cases where interdisciplinary teams of human factors psychologists and engineers are having trouble fulfilling project goals or feel that they are not always on the same page, the ideas presented here may be of benefit.

Several questions remain regarding the improvement of interdisciplinary work in human factors psychology. First, are there other challenges that need to be addressed? If so, what are some solutions to those challenges? Future research, including case studies, SME interviews, and experiments, may help identify weak and strong points in such interdisciplinary projects. While others have researched these same questions (e.g. de Paula & Barbosa, 2004; Norman & Draper, 1986), there is still much work to be done.

A second question that arises out of this paper is whether the solutions I have presented can be applied to other contexts. As stated previously, human factors psychologists find themselves working alongside professionals from many different fields, including doctors and teachers. Can the solutions that aid in communication between human factors psychologists and engineers also aid in communication between human factors psychologists and doctors? Some of the solutions presented here can be applied universally (e.g. defining terminology), but others may not be relevant to other fields such as medicine (e.g. using visual aids). Furthermore, there are likely still more potential solutions that can be implemented to improve communication in other contexts including medicine.

One limitation of this paper is that it is written from the perspective of a human factors psychologist, and thus geared mainly toward colleagues in the same field. A critical next step in addressing challenges to interdisciplinary work between human factors psychologists and experts from other fields involves taking a joint approach to identifying challenges and possible solutions. A panel of experts from both human factors psychology and engineering may be able to reach solutions that I was unable to reach on my own. It is my hope that this paper can generate discussion for improving interdisciplinary work in the field of human factors.

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