Enabling Better User Experiences across Domains: Challenges and Opportunities Facing a Human Factors Professional

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Abstract. *Human Factors* is a multidisciplinary field studying the design of systems and equipment that fit the human physical and cognitive abilities. *Human factors* professionals are in a unique position to practice their trade within a variety of domains including government, industry, and military. Regardless of the domain, good *user experience*, as provided by a human factors practitioner, affords more effective human systems interaction. In this paper, we offer insights into the value of a good user experience and the consequences of not providing it; we discuss organizational and practical challenges that may lead to neglecting user experience; and finally, we offer ideas on how to bring human factors into projects and provide better user experience.

Keywords: user experience, human factors, domains, challenges, opportunities.

1 Introduction

ISO 9241-210 defines *user experience* as "a person's perceptions and responses that result from the use or anticipated use of a product, system or service" [1]. Good user experience, as provided by human factors practitioner, affords more effective human systems interaction where the user is an important part of the system (Fig. 1). Regardless of the domain, when humans are required to use technology to perform their daily tasks, their interaction and experience with the system or product will be the determining factor for overall efficiency, safety, and acceptance.

A host of people – e.g., cellphone users, on-line shoppers [2], drivers, healthcare professionals, gas & electric operators, oilfield engineers, mining operators [3], satellite operators, flight controllers [4], pilots [5], and soldiers – all interact with products and systems, and they all suffer if their experience is not pleasant, simple, efficient, or safe. As *human factors* practitioners, we are uniquely positioned to apply scientific principles to bring the best possible user experience to our users.

In this paper, our objective is to inform the reader on potential challenges and opportunities when designing a better user experience across a variety of domains. First, we explain the importance of providing a good user experience and how different

domains emphasize different aspects of a user's experience. Next, we discuss the reasons why user experience may be neglected and the consequences of not providing a good user experience. Finally, we offer ideas on how to bring human factors into projects and provide better user experience.

Fig. 1. In a variety of domains the human operator is the key element for success. A good user experience is essential to a successful product or system.

2   Background

2.1   The Importance of User Experience

The value of user experience is that it emphasizes all aspects of a user's interaction with the product, from beginning to end. This may include shopping, purchasing, unboxing, setup, learning, technical support, and usage of a particular product. A major goal of the *human factors* practitioner is to design and enable the best experience in all stages of product acquisition and use.

Fig. 2 shows the famous tree swing cartoon depicting a tire and rope swing in various states of dysfunction [6]. This cartoon, which has existed in many variations since the late 1960s [7], illustrates some of the pitfalls faced when working on a project. The cartoon has a simple premise: a customer needs a way to swing from a tree. There are many ways to design a tree swing, but a customer's explanation of their needs may not always be interpreted correctly. In his excitement, the customer may fail to provide key details or over-specify, leading the project leader to develop their own interpretation of the customer's needs. The project leader provides a simplified version of the design – a single bench connected to the tree. However, he misses the most important fact about the swing, which is that it should not swing across the tree trunk. The analyst, perceptively, fixes that problem by cutting the tree trunk and adding support so that the tree doesn't fall down. The programmer ignores both trunk cutting and supports, focusing instead on implementing his understanding of project requirements (a bench, some rope, and some relationship between rope and tree). From there

things go spectacularly downhill. The business consultant promises a comfy padded armchair, yet the product that is installed lacks any resemblance to the customer's initial explanation. The customer is billed for a whole amusement park and is left with little to no documentation or support for how the product is to be used. In the end we see that all along what the customer really needed was the simplest solution of all: a tire swing. We laugh because, as users, we have seen products that function that way, and as product creators, we have experienced any or all of the misunderstandings implied.

A project may fail because of poor product design, poor customer service, or because of a failure to understand the user's needs. A failure in one step can ruin the whole experience. User experience emphasizes all aspects of user involvement and input. A well-designed user experience should help avoid many of the problems highlighted in this cartoon.
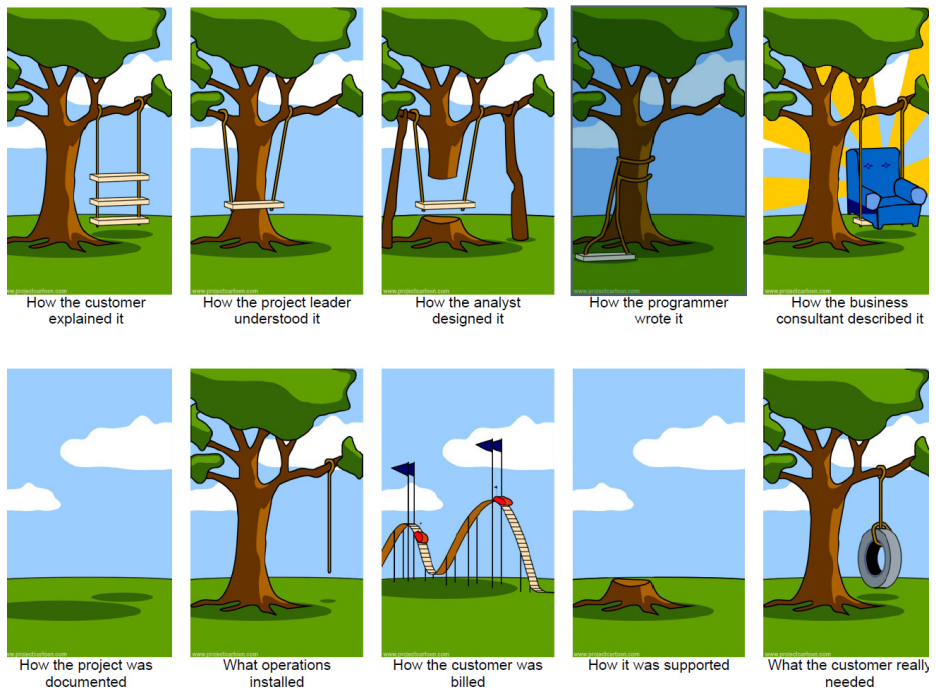

Fig. 2. The famous "tree swing cartoon". A well-designed user experience should help avoid many of the problems highlighted in this cartoon. *Creative Commons Attribution 3.0 Unported License,* http://www.projectcartoon.com/about [6].

2.2 Use and Emphasis across Domains

User experience can be seen as a component of the human factors (or *ergonomics*) discipline. The International Ergonomics Association defines human factors as "…the

scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance." [8] The term *user experience* was introduced by Donald Norman in the mid-1990s with the intention to emphasize all aspects of the person's experience with a system, including design, graphics, the interface, the physical interaction, and the manual. [9]

Different domains often emphasize different aspects of a user's experience. For example, the term user experience is more often used in consumer-oriented industries because of its strong emphasis on the user (who is making the purchase decision). Industries with an emphasis on computer systems, especially complex ones, tend to refer to human-computer interaction (HCI) or computer-human interaction (CHI) as an alternative term. HCI focuses more on users working specifically with computers, rather than products or machines. References to man-machine interfaces (MMIs) or human-machine interfaces (HMIs) are more common in the military since soldiers tend to work with a combination of software and hardware, including mechanical systems. In general, the use of the term human factors signals an emphasis on performance and safety aspects of a system.

Nevertheless, good user experience can make a significant difference in all domains where humans are at the center of interaction and decision-making, as good user experience can make things safer, more efficient, and enjoyable. After all, it is difficult to imagine a situation where users will not appreciate a well-designed user experience.

3   Missing User Experience

3.1   Reasons for Missing User Experience

Still, bad user experiences abound as there are many challenges to building good user experiences. There are several reasons for this.

First, management support may be lacking. While human factors is not a new field and user experience is a fairly well-known term, there are managers and decision makers who are not familiar with human factors and its benefits, or at least not familiar enough to incorporate it into their projects. They may not have experience working with human factors practitioners or may not understand the value they provide to the product development lifecycle. Plain old resistance to change is hard to overcome.

Second, incorporating human factors into a project requires using a user-centric design and development process, which includes human factors practitioners in all stages of design and development, from requirements gathering to validation and deployment. This in turn requires rethinking existing design and development processes. Project planning has to be done with upfront human factors focus, and the project timeline has to incorporate regular evaluations and usability testing. When budget and time are limited, the additional focus on human factors might be seen as merely an unnecessary increase to project duration and cost.

Third, human factors may be seen as an optional component, while software and hardware development are essential to shipping a product.

Fourth, some systems may be too complex to be redesigned from scratch. For example, improving the user experience in mining operations may require fundamental changes to a variety of hardware and software that were designed perhaps independently by different contractors or vendors [3].

Finally, management may not understand that creating a product without human factors is akin to building a house with only a hammer and saw. The final product may look fine, but on closer inspection is barely useful or completely unusable.

These issues are less common in consumer-facing industries where a lack of usability or good experience directly translates into lost revenue. For example, one cannot imagine a successful website without good design and usability. In other industries, however, it is harder to persuade managers or decision makers of the value in providing a good user experience unless it clearly translates into fewer accidents, increased productivity, or some other clearly quantifiable factor. It took airplane crashes to bring the usability of flight systems to public attention [10].

3.2   Consequences of Missing User Experience

While there are many aspects of user experience that can be neglected, this paper will address one specific, common failure – that of technology-centic design, where pieces of technology are cobbled together to perform a variety of functions, resulting in disarray from the user's perspective. This technology-driven approach can result in a collection of systems that gather and present their own data sources, with each new system being added alongside existing ones. The data are not integrated or transformed to take into account the user's needs. This causes significant challenges for the user experience, as they must gather disparate pieces of information from multiple systems or displays, then integrate these bits together mentally to develop an understanding of system functioning [11].

For example, Fig. 3 is a picture of the inside of an electric shovel cab used in mining operations. In addition to communication controls, mechanical controls, and a control panel, there are six computer monitors interfacing a variety of systems. This example is by no means atypical, especially in domains with complex systems (such as the military). Such systems may be built by multiple contractors or provided by multiple vendors, where each one delivers an isolated function that, at best, integrates loosely with the rest of the system. Each vendor usually understands a small part of the puzzle and may not be aware of the big picture.

Another example is in oil well drilling, where multiple systems are employed and each system has its own alarms. Since the multiple systems don't communicate with each other, alarms can go off during steps in the drilling process where they are not relevant (e.g., a "low flow" alarm goes off during breakout because the system that monitors flow doesn't know they have turned off the pumps to add new pipe).

Fig. 3. Example of a technology-centric design in an electric shovel cab. Six computer monitors, communication systems, mechanical shovel controls, and a control panel clutter the cab. Clearly, this is not a user-centric design.

Users are flexible, but they can adapt only so much. Information overload and increased workload brought by each additional system can quickly overwhelm and surpass human cognitive capabilities. This may result in more accidents, reduced safety, reduced customer acceptance, reduced productivity, and decreased performance. The science of human factors, particularly situation awareness and decision making research, is ideal for improving the user experience in this area.

4   Bringing Better User Experience

So, what can we do to bring good user experience to projects? Measuring and quantifying benefits of good user experience are good starting points for convincing decision-makers.

4.1   Measure Benefits

First, we need to demonstrate value – how user experience and human factors benefit the projects. We need to measure benefits such as increased system performance and usability, user acceptance and performance, and decreased workload and error rates. These are all parameters that will help management make informed decisions. If a product or system is not properly tested for usability pitfalls there will be significant uncertainty about the success of that product.

4.2   Quantify Benefits

It is even better to quantify those benefits in terms that directly affect decision-makers – potential profits or, equivalently, losses the project can suffer due to user experience issues. Translating what usability really means for a project's bottom line can help decision-makers understand the necessity of creating good user experiences. Clearly, poor safety and poor performance, driven by bad system design or integration, can cost money and lives. Below are some examples from the mining domain.

1. A large haul truck fully loaded with high-grade gold ore can be worth hundreds of thousands of dollars. Poor system integration (between shovels, dump trucks, and dispatch), poor visibility into system behavior, and poor UI feedback can (and does) result in haul trucks accidentally dumping valuable ore into waste areas.
2. At peak capacity, a crusher can grind thousands of metric tons of copper ore per hour, potentially worth hundreds of thousands of dollars. A lost bucket tooth, if undetected (either due to lack of alerts or to too many alerts that are ignored), can jam crushers and require dangerous repairs along with hours of downtime.
3. Mines operate on large scales: large volumes of material, mega-shovels, mega-trucks. Small incremental improvements can result in large profits. According to a study [12] a small increase in haul truck efficiency can translate into millions of dollars in yearly increased revenue.

4.3   Convince Decision-Makers

It is critical to be aware of what is important to decision-makers. In some situations, there is a special group of end users whose need for user-friendliness is paramount because their time is especially valuable. An example of this is the highly competitive field of e-commerce, where user experience can directly affect a user's decision or ability to purchase a product. Another example of this is manufacturing, where small improvements in usability for highly repetitive actions can translate to large increases in productivity. In other situations, the software must be completely error-proof because the cost of human error is very high; an example is cockpit software for airline pilots. Demonstrating added value in high visibility circumstances can inform and often influence decision-makers.

4.4   Improve Communication between Human Factors and Development

Another key to successfully completing a project that provides good user experience is effective communication and collaboration between human factors and development teams. While the human factors team focuses on the user, the development team focuses on the technical aspects of the project. These are clearly complementary functions with strong interdependencies. Both teams have the same goal: delivering a successful product. At the same time, there is an inherent conflict of interest because of the different focus areas of these teams. There is a clear tradeoff between the value certain features provide to the user versus the time and effort required to develop them, and effective communication makes yes / no decisions (whether to develop a feature) easier. Table 1 shows a simplified decision matrix for feature implementation.

Table 1. A simplified decision matrix showing the value of a feature to the user versus its development cost. 'Yes' indicates that it is probably worthwhile implementing the feature; 'No' indicates features with a high cost/benefit ratio; and 'Depends' is for those in-between cases.

		Development Cost		
		High	**Medium**	**Low**
Value to User	**High**	Yes	Yes	Yes
	Medium	Depends	Yes	Yes
	Low	No	Depends	Yes
	None	No	No	No

Good management facilitates communication between different areas of expertise and finds the right balance for the success of the project, especially when facing tight deadlines and limited budgets that inevitably impact most projects. Also, both teams need to understand how the other team operates rather than working independently. Human factors teams may not fully understand the intricacies of development, and development teams may not fully understand how incorporating the user's perspective leads to a better product. Good user experience is not easy to provide, and good development takes time and effort. If the teams are aware of each other's challenges,

they will be more amenable to their differences. Obviously, there are many other teams involved in a project (business analysis, software testing, documentation, etc.), and good communication between all teams is important.

5   Conclusion and Future Work

To summarize, there are many reasons why user experience may be neglected; however, we propose a number of approaches to counteract this neglect.

- Clearly explain and quantify the benefits of human factors, preferably translating them to the bottom line (e.g., more satisfied users, more revenue, better sales, percent increase in performance or efficiency, reduced number of errors, etc.)
- Facilitate communication between teams to understand how each team works and understand the rationale behind their responses.
- Good management who appreciates all teams and their value, and who understands that good user experience is essential.

References

1. International Organization for Standardization: Ergonomics of human system interaction - Part 210: Human-centered design for interactive systems. ISO/FDIS 9241-210:2009. Geneva, Switzerland (2009)
2. McCarthy, J., Wright, P.: Technology as experience. Interactions 11(5), 42–43 (2004)
3. Onal, E., Craddock, C., Endsley, M.R., Chapman, A.: From theory to practice: Designing for situation awareness to transform shovel operator interfaces, reduce costs, and increase safety. Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Journal 4(4) (2013)
4. Wickens, C.D., Mavor, A.S., McGee, J.P. (eds.): Flight to the future: Human factors in air traffic control. National Academies Press (1997)
5. Endsley, M.R., Garland, D.J., Shook, R.W., Coello, J., Bandiero, M.: Situation Awareness in General Aviation Pilots. In: Annual Report Prepared for NASA-Ames Research Center Under Contract #NAS2-99073 (2000)
6. The Project Cartoon, `http://www.projectcartoon.com`
7. Businessballs, `http://www.businessballs.com/treeswing.htm`
8. International Ergonomics Association, `http://www.iea.cc/whats/index.html`
9. Norman, D., Miller, J., Henderson, A.: What you see, some of what's in the future, and how we go about doing it: HI at Apple Computer. In: Conference Companion on Human Factors in Computing Systems, p. 155. ACM (1995)
10. Wiegmann, D.A., Shappell, S.A.: A Human Error Analysis of Commercial Aviation Accidents Using the Human Factors Analysis and Classification System (HFACS). In: Federal Aviation Administration Oklahoma City OK Civil Aeromedical Inst. (2001)
11. Endsley, M.R., Jones, D.G.: Designing for situation awareness: An approach to human-centered design. Taylor & Francis, London (2012)
12. Chapman, A.: Field Study on Haul Time Variability in Open Pit Mines. Thesis submitted to the Department of Mining Engineering. Queen's University, Kingston, Ontario, Canada (2012)