# A Modular Structure to Explore the Interface Design and Interaction Testing Process of Teams

*Bahar Memarian[1*], Christos Koulas[2,] and Brian Fisher[3]*

*[1] University of Toronto, Canada*

*[2] MDA corporation, Canada*

*[3] Simon Fraser University, Canada*

## ABSTRACT

Interface design and interaction testing is not a completely robust or scientific process. Rather, it is an artful, iterative, social process regulated by inter- or multi-disciplinary design teams. Lamentably, the design trajectory and iterations are often left out or partially communicated in the description of a published design. We offer display design considerations considering AI and propose a modular structure for the interface design and interaction testing process of teams. The key feature of the structure is that it considers display design and display interaction testing and general experimental design and enables teams to transparently communicate how they start, traverse, and end their design cycles. The system can be accessed via an established Industrial Engineering Society on the world wide web. Such a structure would enable studying where innovation and failure happen through iterations of steps taken by different design teams. Subsequently, the information can be used to enrich future research.

**Keywords:** Display Design, Interaction Testing, Research Experiments, Teams, Human Factors

## INTRODUCTION

Display (also referred to as interface) design and interaction is an artful, iterative, and team-regulated process (Norman, 2013). Both the display and its developer or user function are based on the set of data and criteria that is communicated to and processed by them. This holds no matter if the display is situated in a real or virtual environment (Sherman & Craig, 2018; Stone et al., 2005). The display development is dependent on one or a combination of historical data and information requirements, rules and conditions, and additional smart or creative features proposed by humans and/or smart algorithms to process, configure, and present information (Hicks et al., 2002; Pahl & Beitz, 2013). Similarly, the user is dependent on the information communicated via the display and their information processing abilities and expertise to move a plan forward, problem-solve, and troubleshoot any rising issues in each environment with the aid of the display. Often teams design a display together to allow the user who is interacting with the display to achieve a set of goals in a socio-technical environment. Socio-technical environments contain humans and complex infrastructures working together or against each other in achieving a common or contrasting set of goals (Clegg, 2000). The motivation for display design is to aid the user of interest to take on a role and complete a set of tasks in a real or virtual environment. The design team may work together in parallel or sequentially to fabricate a final display design. Each specialized disciplinary group or team member may understand the other to some extent and only have the best knowledge about their contribution. Display design is hence also a communicative and socially constructed process and dependent on the design team's dynamics.

Modeling or interacting with a socio-technical environment through a new display design is not a completely robust or scientific process (Bennett & Flach, 2011). A challenge with complex socio-technical environments is that they involve many variables that change over time, posing an infinite number of unique scenarios that cannot be studied or trained with users using a display design in advance. To address this issue, researchers may resort to three broad approaches. One approach is that new displays are frequently tested with representative sample size. However, the instances recorded or recreated may be limited in terms of the number of cases or the user may still perform unexpectedly. A second approach is to adopt an ad-hoc approach and learn from errors and document them or restrict them in the system to prevent future happening. This approach, while seemingly efficient, can become most catastrophic and costly in the event an irreversible issue arises. An emerging third approach is to use smart algorithm features to learn and mimic the user's characteristics or environment. The emulated user then mines the problem space through a display design and potential sources of error are identified extensively in an entirely algorithmic and likely human-free way (i.e., with the aid of artificial intelligence or AI and automation). This approach, however, requires developing a digital model of an entire socio-technical environment and representative user group and may contain inaccuracies or over-simplifications. Due to our insufficient understanding of human cognition or resources to model socio-technical systems, we may continue to face challenges for years to come. Yet, the mentioned approaches and especially the use of AI may prevail for research studies in this domain.

In studies, researchers attempt to make the display design and interaction process characterized through metrics and adopt a methodical and reproducible approach as much as possible (Hicks et al., 2002; McFarlane & Cuthbert, 2012). Lamentably, however, the design trajectory and iterations are often left out or partially communicated in the description of a published design (Hornbæk, 2006; Roth et al., 2015; Vicente, 2002; Vincent & Blandford, 2015). We identify there is a lack of a central yet flexible system that can demonstrate and compare the roadmap of interface design and interaction processes made by design teams. Here our notion of the system covers the interface design, interaction testing, and general experimental design elements used and assumes there exist servers that can consistently process and structure large volumes of data provided by different design teams. Our goal, therefore, is to offer display design thoughts considering AI and a modular structure with some suggested set of steps that could be used by researchers when wanting to develop and test their interface.

## Design Considerations with AI

From a team's perspective the goal of utilizing smart algorithms in display design and testing is to advance usability and understanding to better solve a problem or maintain a resolved problem state in a context of interest (e.g., aviation, healthcare, etc.). This goal may be challenged if we see AI in a more societal light. Display design can take on different roadmaps depending on the size of the development team or user group and the format of their contributions or interactions with AI. This is because upon the interaction of either human developer or user with AI, their collective and/or individual intelligence enter a changed state. Each change may not necessarily lead to more human proficiency but may translate to more interaction time for the human and data collections for the AI. AI's intelligence may however surpass the humans' experiences gained through the time spent which can lead to AI overtaking display's goal without proper understanding of the humans about it. Not to forget, humans do not only interact with AI but also machinery and automation. AI may further optimize the intelligence of humans and the power of automation in ways that have been unintended for humans.

Display design can also take on a new form when AI is seen as a product versus a process. In a process view, AI may be seen intertwined with display design and part of every human's decision-making. In product view, however, AI may be seen as an individual aid that does not change or alter the design but provide recommendations as an entity (e.g., like a human team member or player). Display design can additionally lose its plural essence if AI is expected to fulfill various roles in the design process. In a conventional team, members compete with one another leading to innovation. If AI is expected to fulfill multiple personas, designs may begin to lose their human creativity and diversity for the cost of more precision and efficiency. On the upside, if AI embodies multiple roles in a team, it may be less susceptible to abuse its rank and have one member to overtake the design trajectory. Display design can be further impacted by the communications established between the human and AI roles. Collaborative communication can put human goals and safety on top of the priority list. A compromising or competitive communication, on the other hand, would sacrifice human objectives at the cost of other objectives such as efficiency or power. Overall, the fast growth of uncertain and ambiguous displays constructed by teams and AI can significantly affect humans and the environment. Accounting for design variabilities due to the different contributions of humans and AI is thus necessary.

## THE PROPOSED STRUCTURE

Our proposed structure does not follow a set methodological framework but rather presents common elements of display design and interaction testing for researchers to build from and specify who (i.e., human members and/or AI) contributed at each step, see Figure 1. The team would specify their framework on their own. For example, they may follow user or ecological interface design frameworks (Bennett & Flach, 2019; Stone et al., 2005).

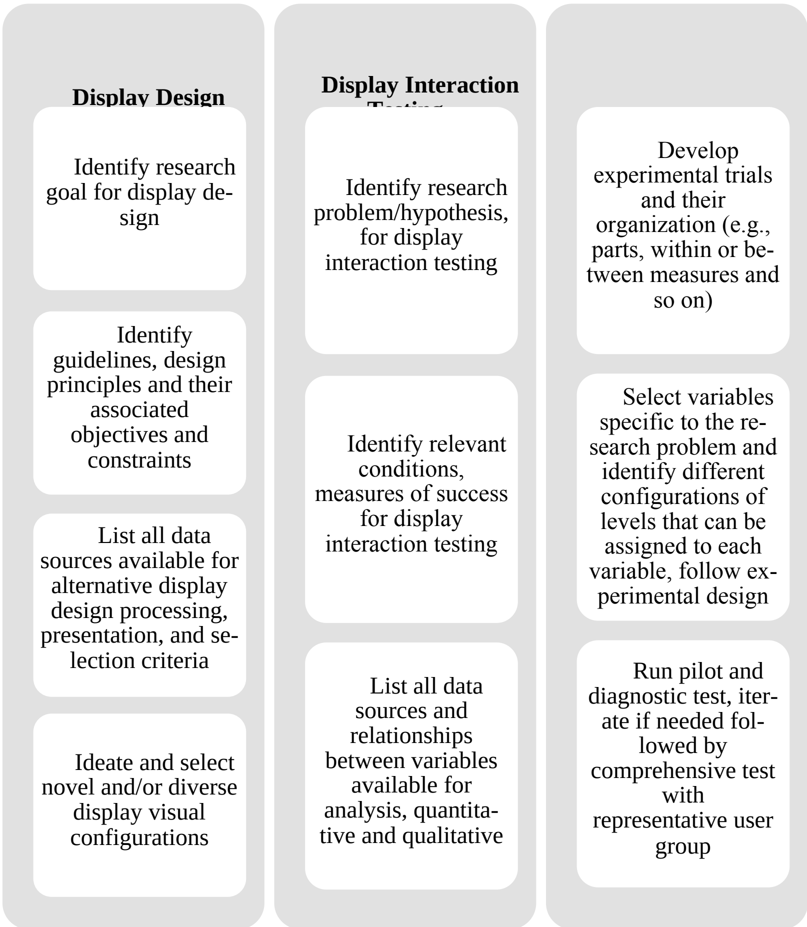


**Fig. 1.** Some proposed structure elements. Design teams may use resources at each element and traverse through the structure differently when designing iteratively.

The structure acknowledges that display design and testing tell a story only together and that different individuals or teams may take different steps or use different resources when trying to link display design with testing. Particularly, constraints presented by technologies such as augmented and virtual reality (AR/VR) may considerably impact the design trajectory (Sutcliffe et al., 2019). The structure allows the researchers to have a roadmap and consciously make decisions as to where to start, iterate and what to specify and select in their display design journey by accounting for the following elements:

Identify research goal and problem: Even if not specific at first, the interface design process would benefit from having the research goals at hand. Note that there are two goals intertwined with the interface: 1) goal the user achieves by using the interface and 2) goal the experimental plan achieves by having the user interact with the interface in a studied environment. While the two are often related, they may not be identical.

Identify guidelines and associated objectives and constraints: This step would acknowledge and bring in the underlying conceptual frameworks and principles the interface design is dependent on. Examples include design principles at a broad level, conditions, and physical and societal task-based laws at a very low level for a specific research problem under investigation. All such laws may be either already established or proposed as new ideas. If new, the researchers would add them as a category of unestablished rules to the structure.

List all data sources and variables available: Like the information requirements gathering of the design process, this step would require the researchers to identify all the available data sources used in their interface design and interaction process. Again, the variables may be established or not. Examples include but are not limited to: a) Quantitative: Such as quantitative and digitized data around the sensor-map layout, satellite data, library of locations that is fed to the display, or performance data collected by the display during or after completion of a display interaction, b) Qualitative: Such as communications verbalized by the user and inputted to the display or surveys, or think-aloud data collected by the display during or after completion of a display interaction, and c) Visual: Such as information visualizations that may be further situated in a certain interface design paradigm (e.g., user-centered or work-domain centered) or library of creative visuals (e.g., CAD sketches) that can be stored as a category of unestablished visuals.

Ideate and select display and develop experimental cases: The benefit of having all the available (established or not) design principles and visualizations in one place and shared is that a central system which may be equipped with smart algorithms can put forth display design configurations that would normally be missed if the researchers were working separately. In this step, the team could ideate and select or examine feasible design configurations based on the set of data input in the previous steps, then customize and select the top alternative designs for testing. A display design typically manipulates multiple variables and so when it comes to testing that display, it likely needs to be simplified and controlled for one or a few variables at a time. The researchers therefore would need to develop multiple experimental trials and associated conditions for a display and may therefore be investigating a slightly different research problem in each trial.

Select variables specific to the research problem and identify different configurations of levels that can be assigned to each variable: When the researchers try to scope down display testing to a research problem, they need to select relevant variables and specify the levels involved per variable. Technologies may dictate some variables and metrics, but they need more human instruction around defining performance and usability data which may be already established or not established. An example variable with different levels that can be defined in this step is: Capture performance after the onset of a condition in a) intervals, b) instances.

Note that each design team uses resources differently and has the flexibility to set the breadth and depth of levels per variable and set the experimental controls. Having a framework to capture what levels the researchers decide for their variable and the best practices they follow is another way to inform design validity to the research community and future studies.

Run pilot and diagnostic test, iterate if needed to be followed by a comprehensive test with representative user group: The representative user can then engage with experimental cases as instructed and the central system can provide diagnostic tests that are universal to any interface design. This allows the user to experiment with the display in pilot testing. The system can then learn the persona and performances of the user and deliver a high-level summary of which alternative design worked better for that representative user group to the design team. After necessary iteration and achieving an acceptable level for measures of success for testing, large-scale testing and analysis can then be conducted.

## CONCLUSION

We would like to emphasize the need for the research community to acknowledge the different order of steps and considerations taken by the design teams during the interface design and interaction testing process. Making this transparent for all can advance display design and interaction especially in worldwide domains such as healthcare and education. Teams can regularly contribute to a central system that can be hosted by an established Industrial engineering professional society on the world wide web. This would allow design teams to document their interface design and testing process as it truly proceeds and choose to share their process for learning by other design teams. Developing the modular structure proposed could shed light on areas where innovation or failure happens in the display design process. The structure can bring together design teams' crafts and lessons learned and may help make this process more systematic and reproducible. Within a structure with universal elements such as the one proposed, one could obtain a more realistic picture (e.g., flow chart) of the type, number, and order of steps taken by different design teams. Future work would require developing a small-scale version of the proposed structure with a few separate design teams focusing on an identical problem to examine how the proposed structure informs differences and similarities in the teams' display design and testing process.

## ACKNOWLEDGMENTS

We would like to acknowledge the corresponding author Dr. Bahar Memarian for the design and description of the structure and Dr, Brian Fisher for providing resources and guidance on this work. We would like to thank *Defence Research* *and Development Canada (DRDC)*'s *Innovation for Defence Excellence and Security (IDEaS)* program for supporting this work.

# REFERENCES

Bennett, K. B., & Flach, J. (2019). *Ecological Interface Design: Thirty-Plus Years of Refinement, Progress, and Potential. 61*(4), 513–525.

Bennett, K. B., & Flach, J. M. (2011). *Display and interface design: Subtle science, exact art*. CRC Press.

Clegg, C. W. (2000). Sociotechnical principles for system design. *Applied Ergonomics*, *31*(5), 463–477. https://doi.org/10.1016/s0003-6870(00)00009-0

Hicks, B. J., Culley, S. J., Allen, R. D., & Mullineux, G. (2002). A framework for the requirements of capturing, storing and reusing information and knowledge in engineering design. *International Journal of Information Management*, *22*(4), 263–280. https://doi.org/10.1016/S0268-4012(02)00012-9

Hornbæk, K. (2006). Current practice in measuring usability: Challenges to usability studies and research. *International Journal of Human-Computer Studies*, *64*(2), 79–102. https://doi.org/10.1016/j.ijhcs.2005.06.002

McFarlane, D., & Cuthbert, R. (2012). Modelling information requirements in complex engineering services. *Computers in Industry*, *63*(4), 349–360. https://doi.org/10.1016/j.compind.2012.02.014

Norman, D. (2013). *The design of everyday things: Revised and expanded edition*. Basic books.

Pahl, G., & Beitz, W. (2013). *Engineering design: a systematic approach*. Springer Science & Business Media.

Roth, R., Ross, K., & MacEachren, A. (2015). User-centered design for interactive maps: A case study in crime analysis. *ISPRS International Journal of Geo-Information*, *4*(1), 262–301. https://doi.org/10.3390/ijgi4010262

Sherman, W. R., & Craig, A. B. (2018). *Understanding virtual reality: Interface, application, and design*. Morgan Kaufmann.

Stone, D., Jarrett, C., Woodroffe, M., & Minocha, S. (2005). *User interface design and evaluation*. Elsevier.

Sutcliffe, A., Poullis, C., Gregoriades, A., Katsouri, I., Tzanavari, A., & Herakleous, K. (2019). Reflecting on the design process for virtual reality applications. *International Journal of Human–Computer Interaction*, *35*(2), 168–179. https://doi.org/10.1080/10447318.2018.1443898

Vicente, K. J. (2002). Ecological interface design: progress and challenges. *Human Factors*, *44*(1), 62–78. https://doi.org/10.1518/0018720024494829

Vincent, C. J., & Blandford, A. (2015). Usability standards meet scenario-based design: challenges and opportunities. *Journal of Biomedical Informatics*, *53*, 243–250. https://doi.org/10.1016/j.jbi.2014.11.008