Bridging Disciplines with Visualization: Fostering Interdisciplinary Collaboration in Computer Science and Beyond with Design Studies

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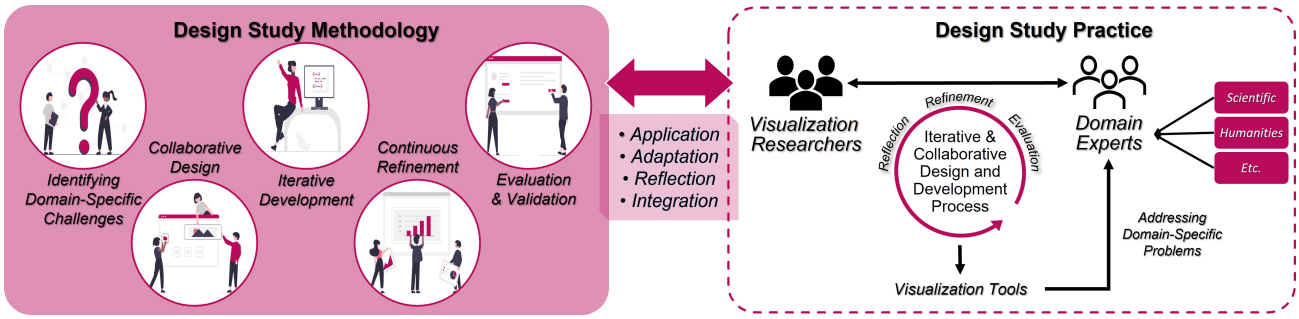

Figure 1: Key components of design study (left) and the illustration of how it bridges disciplines with visualization (right).

ABSTRACT

This paper highlights the role of design studies in promoting interdisciplinary collaboration and innovation in visualization research. As demand for visualization and analysis of large data volumes across various disciplines and domains grows, design study has gained attention for its iterative approach to addressing real-world challenges in specific domains. We share our experience in applying and adapting existing design study methodologies to conduct collaborative visualization projects with diverse domain experts, with valuable visualization tools as the output. We also summarize commonalities and differences encountered during collaborations with experts in various domains. By integrating our findings into design study frameworks, we hope to contribute to the development of a more comprehensive methodology system. Our work underscores the importance of using computer science and visualization technologies to address real-world challenges across multiple disciplines. The insights and lessons learned from our practice can serve as guidelines to facilitate the execution of visualization projects in collaboration with experts from different backgrounds and domains.

CCS CONCEPTS

• **Human-centered computing** → **Visualization application domains**; **Visualization design and evaluation methods**.

KEYWORDS

design study, visualization, application

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1 INTRODUCTION

As data become increasingly integral to our daily lives, visualization has captured the attention of various fields, including academia and industry, leading to an increased demand for effective methods to visualize, understand, and analyze data. Consequently, the application of visualization tools has emerged as a central theme within the visualization (VIS) domain. Design studies have become vital in this context, providing guidance on conducting VIS projects in collaboration with domain experts and creating tools to tackle domain-specific challenges. Developing effective and practical VIS tools is based on a systematic, iterative, and collaborative process. Design study methodologies provide structured approaches to guide the design, development, and evaluation of VIS tools, which guide VIS researchers in collecting and refining domain requirements, defining VIS tasks, collaborating efficiently with domain experts, and evaluating both the development process and the final output. Adhering to design study methodologies enables researchers from different backgrounds to co-design customized VIS tools that address domain-specific challenges, ensuring that the tools are functional and user-friendly. Therefore, design studies, encompassing both methodologies and practices, play a pivotal role not only in advancing the visualization domain but also in fostering interdisciplinary collaboration across multiple disciplines. As visualization

design studies are application-oriented and built on the foundation of in-depth communication with domain experts, the increasing number of such projects contributes to the continuous improvement and development of design study methodologies. Simultaneously, they facilitate the exchange of knowledge and expertise between different domains, ultimately contributing to the growth and development of each discipline involved.

2 BACKGROUND AND RELATED WORK

Design studies within the VIS domain involve collaboration between visualization researchers and domain experts to address real-world challenges using visualization techniques (Figure 1 right). This process encompasses the development and retrospective evaluation of problem-solving solutions. The design study literature can be broadly categorized into two groups: works that summarize methodologies for guiding design study execution [3, 6] and works that document design study practices, featuring iterative design processes with domain experts and visualization solutions addressing domain-specific issues [1, 4]. An extensive body of literature exists on the methodologies side, offering general and structured approaches to conduct design studies, e.g., the Nine-Stage Framework [6] and the Nested Model [3]. In addition, significant efforts have been made to develop methodologies tailored to specific contexts, such as collaborations with artists [2], and design studies in educational settings [7].

By applying and adapting existing methodologies, we have undertaken design studies in collaboration with experts from various domain backgrounds. Drawing on our own experiences, we believe these methodologies can be further refined and adjusted to better suit design studies under different domains and disciplines.

3 DESIGN STUDIES IN DIFFERENT DOMAINS

We have broadly classified the application domain into two large groups: humanities-focused and science-based. In the humanities, we have collaborated with researchers in humanities and history, concentrating on visualizing constitutional convention data and historical book trade data [8]. It should be noted that we have developed the *BookTracker* platform [9] with three novel and practical visualization toolsets for the book trade project to address different challenges in the domain. Some toolsets are already in use, and collaboration is ongoing. In scientific domains, we have collaborated with experts on the visual analysis and prediction of COVID-19 data [5]. Drawing from existing methodologies and our own practices, we identified commonalities and differences during different stages of design studies across various domain collaborations. We present five key components for conducting a design study in Figure 1 (left). All of these components are highly dependent on intensive close collaboration between VIS researchers and domain experts.

Similarities in conducting successful design studies include: ***Problem identification***: It is crucial to understand and identify domain experts' specific problems and challenges to create effective visualization tools. ***Two-way communication***: To ensure successful outcomes in the iterative design, development, and validation process, it is essential to establish cooperative communication between visualization researchers and domain experts. This will enable the identification of problems and establish a common language and an understanding of domain-specific terminology. ***Visualization principles***: Fundamental principles, such as clarity, simplicity, and user-centered design, apply to all projects.

We also reflected on the ***differences*** encountered in design studies with collaborators from different domains: ***Nature of data***: Scientific projects often handle quantitative data, while humanities projects involve more qualitative data or a mix of both, influencing visualization techniques and design. ***Research objectives***: Scientific projects focus more on identifying patterns and correlations, while humanities projects prioritize storytelling and interpretation. ***Evaluation criteria***: Criteria for evaluating effectiveness may differ, with scientific projects emphasizing accuracy, efficiency, and reproducibility, and humanities projects prioritizing user engagement, interpretability, and contextual understanding. ***Domain-specific constraints***: The constraints and requirements of each domain can vary, necessitating different design considerations.

By recognizing and addressing these similarities and differences, we intend to contribute to the refinement of design study methodologies, which in turn can aid in conducting effective visualization design studies with collaborators from diverse backgrounds.

4 CONCLUSION

In this paper, we highlight the importance of design studies in promoting interdisciplinary collaboration and fostering innovation in visualization research. Our work underscores the vital role design studies play in tackling real-world challenges across various disciplines. We share our findings on the similarities and differences encountered while conducting design studies with collaborators from diverse domain backgrounds and seek to tailor methodologies to better fit each project. It is essential to note that these conclusions regarding humanities and scientific visualization projects should not be generalized or stereotyped, as they can vary depending on individual participants and specific projects undertaken.

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