OBSERVED SOCIAL LIFE OF PHYSICAL ARTIFACTS: AN ETHNOGRAPHIC APPROACH TO STUDYING TEAM SHARED OWNERSHIP IN AN INTERDISCIPLINARY DESIGN STUDIO

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RESEARCH PROBLEM

Design is a social process (Bucciarelli 1994). As building system design necessitates collaboration through more interrelated systems (Orr 2006), there is a move away from cooperative approaches where the design work is divided into independent parts to more collaborative ones with shared decision-making (Smith et al. 2005). Collaborative interdisciplinary design includes unstructured processes, negotiated goals, the need to define shared problems, develop procedures, and produce socially constructed knowledge (Goldsmith & Johnson 1990, Dorsey et al. 1999). Team shared understanding is needed in building design teams to support interdisciplinary decision-making (Langan-Fox et al., 2000). From shared understanding, shared ownership emerges in which no one person or discipline feels possessive of the design. The question we take up in this paper is to understand how visualizations, particularly representations produced from emerging computer modeling tools, support the development of shared ownership in collaborative design teams.

Physical Artifacts, such as design visualizations and shared lists, can assist team member interaction and problem-solving (Suwa et al., 2000; Whyte et al., 2008). However, the presence of physical artifacts alone may not always yield effective team collaboration (Troise, 2022). Misinterpretation, confusion, and delay of design progress are a few of the potential disadvantages of physical artifacts when absent clear intent (Bresciani & Eppler, 2008). In building design, confusion and delays can be costly for stakeholders and reduce the performance of the final building, therefore, articulate, visual tools are imperative to achieving effective designs (Beynon-Davies & Lederman, 2017; Steenkamp et al., 2017). In addition, the production of more physical artifacts has been shown to support team problem identification, but not necessarily generate more solutions (Dossick & Neff, 2014; Dossick & Pena, 2010). Identifying what techniques reinforce team ownership when used with physical artifacts may help in fostering advantageous team collaboration. We observe the in-situ methods used that support or detract from the development of team shared ownership.

METHODS AND APPROACH

A summary of reoccurring techniques observed from eight student design teams is presented. The observations were collected from a university in the Northwestern US during two semesters of a multi-disciplinary building studio class in 2017 and 2018. The teams included architecture, engineering, and construction students. We focus on the data collected during weekly group meetings and we use mind-mapping practices to identify reoccurring techniques that support the development of team shared ownership. While many methods are available to measure team shared understanding (Mathieu et al., 2000), this research uses the qualitative method of observation to document and map the design teams' interactions, specifically their behaviors in relation to the physical artifacts they produced. While this method is subjective to researchers' interpretations when developing the structure of team interaction and analysis (Mohammed et al., 2000), it is an established method for gathering and analyzing data that can be investigated further (Mirhosseini, 2020). In addition, qualitative observation methods have been used in previous building design team research to examine differences in the mental models of architects and engineers (Casakin & Badke-Schaub, 2015).

In this research, a trained ethnographer observed the teams' interactions during class work sessions and recorded their observations in daily reports. A second researcher, who was not present for the initial data collection, interpreted the observations. Although an additional perspective is introduced with the second researcher which may further obscure the subjective accuracy of observations, it also allows for the interpretation of events only listed in the observations. Through this approach, observations that were not recorded by the ethnographer do not influence the summary of key findings presented in this paper. The observed events were organized by the second researcher following mind mapping techniques. Inductive thematic content analysis was used to identify reoccurring behaviors from the teams that supported communication with their physical artifacts.

KEY FINDINGS

The physical artifacts prompted social interactions and acted as live, mutually accessible documents throughout the teams' collaboration. From the ethnographer's notes, physical artifacts, such as handwritten design goals, printed floor plans and sections, and material samples with associated costs, allowed teams to gather around a common focal element. Any team member could see, comment, and draw on the physical artifact, prompting more cohesive team engagement and ownership. The ethnographer summarized in their notes:

> *The drawings [that the students] make leave artifacts of their thought processes, their possible solutions, and decision-making, the most important often kept near the top of a pile of papers or taped on a wall. These mediated representations and abstractions are therefore never closed, but always open and ready to change with another trace, line, or more detailed drawing. They are always ready for interactivity, including the digitized images on the laptop, that may not change in as an immediate way as the paper materials they can directly draw on, but can also be changed through the software programs that allow their ideas to be made manifest, and documented when the idea has materialized enough and become formalized enough to be brought to another stage of the design. In this way, the space with which all these media formats are located is important as it allows the full range of communicative possibilities to take place: 2D drawing, tracing, doodling; digital searching, photo sharing, the last formalized digital design; gestural representation, using tools as extensions of the body, the ability to make physical connections between mediated images of different perspectives. All these things allow the team to translate their ideas, share concepts, and even become through movement the very natural elements that would move through a building space, such as sunlight and air.*

Alternatively, while digital tools were beneficial in allowing the disciplines to revise details with precision, they were not as approachable for team discussions in the context of this studio. In instances where teams discussed items on a computer screen or tablet, only 2-3 people could see the screen at a time, and since the visualization was on an individual's computer, there was a sense of individual ownership of the model. One team's construction and engineering students were observed saying "your model" and "our estimates" to the architect. In another team, a construction student said that his team saw him “as the numbers guy” and that it felt more like a “cooperative” relationship than a “collaborative” one. Alternatively, a different team, who wrote a list of their design goals on a large sheet of paper and left it pinned to a wall, referred to “their” design collectively when discussing goals and options. They mentioned that physical artifacts – work posted by the team on the walls - were useful in collecting and documenting everyone’s ideas in one, common location that could be referenced in later meetings. From the observations, we conclude that to achieve interdisciplinary collaboration there is a need to establish a sense of shared ownership of design. From this research, we have found that there are three interrelated elements that lead to team members’ sense of shared ownership: shared record-keeping, interactive gestures, and structured cross-disciplinary (figure 1).

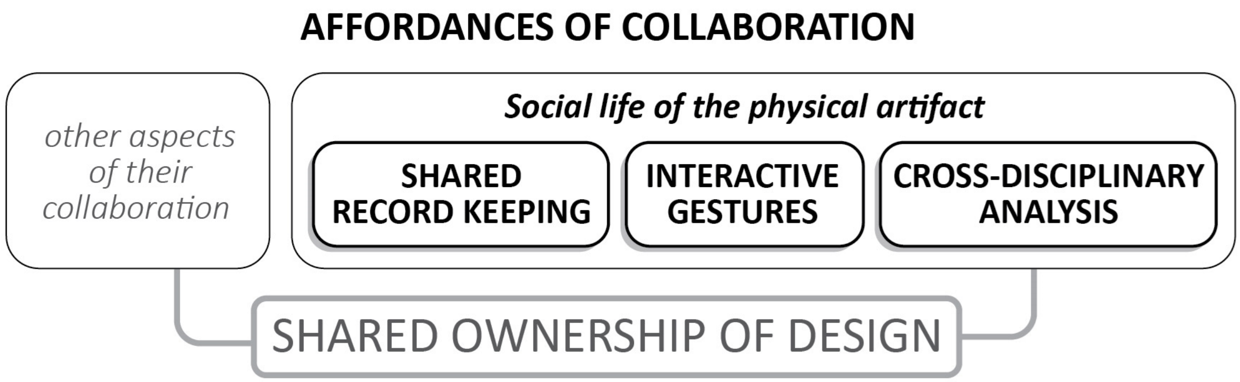

Figure 1. Diagram of the reoccurring methods for supporting shared ownership of design

Shared Record Keeping

Physical artifacts provided a record for decision-making. While some ideas were rapidly produced on sketch or transparency paper and set aside, teams were also observed marking team decisions as well, such as drawing a smiley face to confirm a courtyard scheme or a big X to indicate a portion of the plan will be deleted. The teams pinned these important decisions up for future reference. In another less productive instance, a team used a digital tablet to discuss options and sketch ideas, but since the screen was small, they cleared the sketches after making decisions, leaving no tangible record of the decisions made. In listening to discussions between students and instructors, the ethnographer noted that some teams reported that they tried to make decisions only through digital messenger platforms, but they felt uncertain what conclusions were made and who was up to date on current decisions. Alternatively, in-person discussions around physical artifacts seemed to help foster team cohesion with a shared display that recorded the team decision that was often co-created, thus supporting shared ownership.

Interactive *Gestures*

The physical artifacts used during in-person meetings also supported physical forms of communication. Recurringly, the students used hand gestures to illustrate a spatial idea related to an aspect of a physical drawing and they often pointed to parts of a drawing to be explicit about what they were discussing. Although the teams developed digital 3D models, when discussing the status of their design or presenting new ideas, the use of printed material combined with hand gestures provided spatial communication for all team members, not just the people with the 3D model. Expression of daylight was shown through open palm, swooping motions as light entered the building. Often, body language from teammates, such as head nods, affirmed their understanding across the team. In addition, daylight effects were often discussed with hand motions that expressed the daylight penetrating a window and spreading around a space. Gestures played a significant role in supporting the communication of ideas across the team where different members had different levels of technical knowledge about daylight. All members were able to express their ideas and contribute through gestures.

Cross-disciplinary Analysis for Shared Understanding

An additional technique that overcame barriers in cross-disciplinary ownership was the use of options paired with visualizations of ideas. In all cases, the teams began with endless possibilities for their design, which was difficult to comprehend and challenging to divide responsibilities. However, in many instances, the teams used comparative schemes to explain a complex disciplinary idea and to help facilitate design decisions. For example, cost impacts from structural and finishing materials were challenging for one team to comprehend, but when presented with a few printed material samples with associated costs, the estimator was able to explain alternative solutions that still met the team's design goals. In another instance, a team collectively wrote the pros and cons of two different designs next to axonometric drawings pinned to a wall to cohesively discuss concerns and advantages across disciplinary expertise. As a result, the team was able to continue developing their design without revisiting established decisions made as a team.

IMPLICATIONS

While many approaches may lead to effective team knowledge sharing, the techniques observed in this research can be useful for future integrated design team interactions and shared ownership. From the observations in these interdisciplinary studios, in-person meetings and the production of physical artifacts is advised in multi-disciplinary teams. However, we acknowledge that digital tools are not inherently problematic and that when digital spaces are accessible by all team members, collaboration can occur. It has been established that where there is a shared environment, diversity in teams can lead to more creative solutions (Lee et al., 2020). Student groups in this interdisciplinary studio who relied on digital forms of communication, rather than in-person meetings, reported challenges in finding a digital platform that they all could use effectively. This limited the team's observed communication compared to groups who met in person in front of physical artifacts. These observations align with research that found remote collaboration can have adverse impacts on cohesive actions such as co-ideation, collectiveness, interaction, and design activity (Lee & Ostwald, 2022). It can also have a negative effect on novice designers compared to experts (Kiernan et al., 2020). Since online meetings have become common in response to the 2020 pandemic, future research may consider we may be able to translate the aspects of shared physical artifacts into shared digital spaces.

Team shared understanding is cultivated in the social interaction between disciplinary work where physical artifacts, such as visualizations, support team interaction as shared objects. Not only does the work environment (physical or digital) need to support the exchange of information, but it must also display co-created decisions. In this research, we extend team shared understanding to include shared ownership through observations that the social process of interdisciplinary collaboration necessitates shared ownership as well as shared understanding. The relationship between collaboration, shared ownership and shared understanding should be further explored.

RESOURCES

Beynon-Davies, P. and Lederman, R. (2017), “Making sense of visual management through affordance theory”, Production Planning & Control, Vol. 28 No. 2, pp. 142-157.

Bresciani, S., & Eppler, M. J. (2008). *The Risks of Visualization: A Classification of Disadvantages Associated with Graphic Representations of Information* (1).

Bucciarelli, Louis L. (1994) *Designing Engineers*. MIT press.

Casakin, H., & Badke-Schaub, P. (2015). Mental Models and Creativity in Engineering and Architectural Design Teams. In *Design Computing and Cognition ’14* (pp. 155–171). Springer International Publishing. https://doi.org/10.1007/978-3-319-14956-1_9

Dossick, C. S., & Neff, G. (2014). Interpretive Flexibility and the Price of Documentation. *Working Paper Series, Proceedings of the Engineering Project Organization Conference.*

Dossick, C. S., & Pena, R. B. (2010). Bringing Together ‘A’,‘E’and ‘C’in a Problem- based Collaborative Studio. *National Institute of Building Sciences Annual Meeting, Ecobuild America*.

Dorsey, D. W., Campbell, G. E., Foster L. L., & Miles, D. E. (1999). “Assessing knowledge structures: relations with experience and post-training performance”. Human Performance, 12, 31–57.

Goldsmith, T. E., & Johnson, P. J. (1990). ”A structural assessment of classroom learning.” In R. W. Schvaneveldt (Ed.), Pathfinder associative networks: Studies in knowledge organization (pp. 241–254). Norwood, NJ: Ablex.

Kiernan, L., Ledwith, A., & Lynch, R. (2020). Comparing the dialogue of experts and novices in interdisciplinary teams to inform design education. *International Journal of Technology and Design Education*, *30*(1), 187–206. https://doi.org/10.1007/s10798-019-09495-8

Langan-Fox, J., Code, S., & Langfield-Smith, K. (2000). Team Mental Models: Techniques, Methods, and Analytic Approaches. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *42*(2), 242–271. https://doi.org/10.1518/001872000779656534

Lee, J. H., Ostwald, M. J., & Gu, N. (2020). Introduction: Exploring Design Thinking. *Design Thinking: Creativity, Collaboration and Culture*, 1-32. Springer EBooks.

Lee, J. H., & Ostwald, M. J. (2022). The impacts of digital design platforms on design cognition during remote collaboration: A systematic review of protocol studies. *Heliyon*, *8*(11), e11247. https://doi.org/10.1016/j.heliyon.2022.e11247

Mathieu, J. E., Heffner, T. S., Goodwin, G. F., Salas, E., & Cannon-Bowers, J. A. (2000). The influence of shared mental models on team process and performance. *Journal of Applied Psychology*, *85*(2), 273–283. https://doi.org/10.1037/0021-9010.85.2.273

Mirhosseini, S. A. (2020). Collecting Data Through Observation. In: Doing Qualitative Research in Language Education. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-56492-6_4

Mohammed, S., Klimoski, R., & Rentsch, J. R. (2000). The Measurement of Team Mental Models: We Have No Shared Schema. *Organizational Research Methods*, *3*(2), 123–165. https://doi.org/10.1177/109442810032001

Orr, D. (2006) Design on the Edge, The Making of a High Performance Building, Cambridge Massachusetts: MIT Press.

Smith, K. A., S.D. Shepard, D. W. Johnson, and R. T. Johnson. (2005). "Pedagogies of Engagement: Classroom–Based Practices." Journal of Engineering Education 94(1): 87–101.

Steenkamp, L.P., Hagedorn-Hansen, D. and Oosthuizen, G.A. (2017), "Visual management system to manage manufacturing resources", Procedia Manufacturing, Vol. 8, pp. 455-462.

Suwa, M., Gero, J., & Purcell, T. (2000). Unexpected discoveries and S-invention of design requirements: important vehicles for a design process. *Design Studies*, *21*(6), 539–567. https://doi.org/10.1016/S0142-694X(99)00034-4

Troise, C. (2022). Exploring knowledge visualization in the digital age: an analysis of benefits and risks. *Management Decision*, *60*(4), 1116–1131. https://doi.org/10.1108/MD-01-2021-0086

Whyte, J., Ewenstein, B., Hales, M., & Tidd, J. (2008). Visualizing Knowledge in Project-Based Work. *Long Range Planning*, *41*(1), 74–92. https://doi.org/10.1016/j.lrp.2007.10.006