Paper ID #49707

WIP: Exploring the collaborative affordances of reconfigurable design spaces: Interview protocol development

Hadi Ali, Embry-Riddle Aeronautical University - Prescott

Hadi Ali is an Assistant Professor of Aerospace Engineering at Embry-Riddle Aeronautical University.

Trey Thomas Talko, Embry-Riddle Aeronautical University - Prescott
Eli Martin, Embry-Riddle Aeronautical University - Prescott
Angeline Liew Masongsong, Embry-Riddle Aeronautical University - Prescott

WIP: Exploring the collaborative affordances of reconfigurable design spaces: Interview protocol development

Abstract

In this work-in-progress, we develop an interview protocol to study collaborative behavior in design spaces and in relation to the affordances of the infrastructure of the design space. Although it may sound intuitive that design spaces exist to promote collaboration, this study is motivated by the observation that neither faculty nor students are efficacious in optimally reconfiguring design spaces. We seek to understand the relationship between self-efficacy in reconfiguring design spaces by students and faculty, as users of the space, and their perceived importance of reconfiguring the space to promote collaboration. The initial conditions of the collaboration space should never hinder the creativity in the design process. A design space configuration drives behavior, and conversely, the behavior of space users drives configuration. Yet, in an academic setting, as users transition between traditional classes and design spaces, the nuances of the collaborative affordances of reconfigurable design spaces seem to be missing. While it may be easy to simplistically assume the function of design space, our study aims to emphasize how design spaces should offer signals for users, especially in an academic setting, to augment the pedagogy of design education in subtle ways. We describe in this paper the research design to study participants behavior during designing and in relation to the design space. Semi-structured interviews are used with faculty and student participants in a cross-sectional study in design-based engineering courses. Specifically, we share here our developed interview protocol for data collection using the critical incident methods and artifact elicitation. We share preliminary findings from a pilot interview conducted with a senior engineering student in an early phase of their capstone design project.

1. Introduction

Can the movement of novice designers in a design space offer a profound learning opportunity in design? Exploring this question is vital to improving the design learning experiences to both students and design educators. In literature, the affordances of a physical space for learning, and as a pedagogical method, is often referred to as *active learning spaces* (ALS) [1]. In a comprehensive, meta-analysis study comparing traditional lecturing versus active learning in Science, Technology, Engineering and Mathematics (STEM) education, Freeman et al. found active learning to be the "the preferred, empirically validated teaching practice in regular classrooms" [2, p. 8410]. While there is no single agreed upon definition for ALS, these spaces have common features that make them recognizable for the affordances they provide to support pedagogy. Broadly, ALS can be traditional classrooms, deliberately designed rooms, "polycentric" or "acentric" with no clearly defined center, and spaces with easily accessible tools and devices to promote active learning [1]. Attention to ALS started to take shape in the 1990s with a study from the Rensselaer Polytechnic Institute on utilizing an active learning studio for teaching introductory physics [3, 4]. However, as more emphasis is being placed on the role of design in the engineering curriculum [5], the study of ALS to cultivate a design mindset is still lacking [6].

In this paper, we share the development of an interview protocol to understand the tacit aspects of design spaces and the behavior of users in those spaces. We share the preliminary findings from one student participant with the goal of collecting more data during the span of a year-long capstone courses in different engineering disciplines.

2. Conceptual framework

Design spaces link the *affective* (feelings, emotions, and preferences), the *cognitive* (beliefs, knowledge, and perceptions) with the *behavioral* (actions and intentions) dimensions of learning. Furthermore, design spaces have the unique attribute of staging *collaborative* behavior among novice designers in a learning setting [7]. In literature, "engagement" and "involvement" seem to be interchangeably used when referencing collaborative learning. However, to differentiate both terms, the definition for "engagement," in alignment with Talbert & Mor-Avi [1], will be defined as the "committed involvement" in the active learning space. In other words, engagement has the extra level of "commitment" to the activity, which is a unique attribute of the extended time and energy investment by participants in a design learning space. Furthermore, "involvement" indicates "the investment of physical and psychological energy in various objects" [8, p. 519]. This analysis of *engagement* and *involvement* in collaborative design spaces is necessary in conceptualization of behavior in our study as it guides the characterization of the interplay between emotions and attitudes on the one hand and learning and space on the other. Table 1 below provides an overview of other key concepts used in this study.

Table 1. Key concepts and their operationalization in data collection and analysis

Concept	Operationalization
Physical space	Refers to both physical space. This also could be any tool or situational aspect of the space (whiteboards, seating, room, etc.).
Social	Refers to the social structure of interaction during collaboration in space. This could be any form of communication, teamwork, or collaboration.
Technology	Refers to the digital infrastructure. This could be communication software, analysis/design software used for a project, or computer/testing equipment.
Design	Refers to both the design process and product.
Quality/feedback	Refers to the quality of design and work. This also involves feedback that students receive or provide; that educators provide or receive; or how feedback has been implemented.
Innovation/originality	Refers to aspects of design which are driven by uniqueness, or what has been sacrificed for efficient and otherwise common solutions.
Malleability	Refers to the reconfigurability of the space and its attributes.

3. Method

To understand how participants draw connections between their self-efficacy in the design process and their perceived importance of changing the space to promote collaboration, data is collected from both students and design educators through semi-structured interviews. Overall, the interview protocol inquires about participants' approach to the design process; how they interact with their space during the process; and characteristics of their space that they would change if they had the ability to during the design process. To elicit the relationship under study, interviews with the same individuals are conducted at two points: one during the preliminary (conceptual) design phase and one during the detail (hands-on building) phase of senior capstone projects. In addition, initial observations of how participants interact with their space, in the various engineering disciplines, are gathered. Observations are used to focus the data collection and to prime the participants into thinking more critically about their space during design projects. This deeper thinking is needed to elicit the implicit assumptions about the space, leading to more in-depth data. Our aim is to go beyond simply describing attributes of the design space (the *what*) to the affordances of the design space (the *how* and *why*) and the relationship between situations and behaviors.

Student participants

Student participants in this study are selected from senior design capstone projects where students are expected to build functional prototypes of their designs. These projects require engineering students to work in teams of 6-18 students while applying design and analysis principles to create a functional model, or product, after two semesters of development under the mentorship of a faculty member. The reason for choosing this course as a basis for this study is that the projects in this course take place in varying design spaces (studio and fabrication shops). Students work with the same team in the same collection of spaces for the longest period in the undergraduate curriculum of a small, private institution in the Southwest. Capstone courses are centered on engineering design and are usually supported by both internal and external funding from stakeholder that track the progress of projects over time.

Student participant recruitment

Student participants are recruited for interviews based on observations made by the research team of the design activities of different design teams. The research team initially requests access to the design spaces from the faculty mentor. After a period of observation and field notes, the researchers select student candidates for interviews. Participation is voluntary and with a request to be available for follow-up interviews. After their initial interviews, student participants are asked for follow-up interviews at the end of the project at a strategically selected point during the design process in order for the research team to elicit the relationships of interest.

Faculty participants and recruitment

Interviewing engineering faculty who are mentors for the senior design courses provides insights into students' interactions with the space and the importance of this as a pedagogical instrument. It is important for this study to consider the educators' observations of students due to a possible lack in students' self-awareness about how their space affects their processes. Faculty interviewees are recruited through in-person meetings and by email providing a description of the study.

4. Interview Protocol

Interview Protocol development

Data collection through the interview protocol with both faculty and students are mirrored in order to provide meaningful insights and comparisons between the learner and the educator. Each interview consists of five major parts: (1) critical incident review; (2) design process inquiry; (3) environmental blockers or enablers; (4) demographic questions; and (5) closing questions. The critical incident review asks participants to bring an artifact that represents an incident that happened during previous or recent design activity. The idea is to use the artifact to move from the *specifics* of the incident to *general* behavior questions about the design process and utilization of space [9]. The design questions elicit an understanding of how participants approach their design process and how they assess the quality of their design. The environmental blockers or enablers questions assess limiters and enablers to students' ability in working collaboratively together in a shared space. The demographic questions will allow correlation to demographic groups and social limiters to collaboration. Table 2 provides an overview of the structure of questions in the interview protocol. Both students and faculty are probed to further explain their responses.

Table 2. Interview protocol designed for this study.

	Student	*Faculty*
Critical Incident	[Ask the student to bring an artifact from the project that they are working on.]	[Ask the instructor to bring an artifact that may point to their approach to teaching design.]
	[If the student brought an object, ask the student to describe the artifact, her or his level of involvement in its conceptualization and creation, the steps taken to design and create the artifact, and the purpose of the artifact.]	[Alternatively: Can you describe a moment when you observed the physical layout of the design space or objects in the space facilitating/hindering students' ability to collaborate with their team on a design project?]
	[Alternatively: If the student did not bring an artifact, ask the following two questions]:	[Probe] How could design space be restructured to enable/avoid incidents like this in the future?
	(1) Can you describe a moment when you feel that the physical layout of the space or objects in the space enabled/hindered your ability to collaborate with a team on your design project?	
	(2) How could the design of the space be restructured to enable/avoid incidents like this in the future?	
Design	How would you describe your design process?	How would you introduce the design process to your students?
	[Probe] What are the steps in your design process?	
	What is your motivation for design?	How would you describe the motivation of your students around design?
	[Probe] If the student brought in an artifact, ask for an explanation on the motivation behind the artifact.	
	How do you assess the quality of your design?	How do you assess the quality of a student's design?
	How do you incorporate feedback on your design?	Do you see your students incorporate feedback into their designs? How? Why?
Environmental Blockers/Enablers	What aspects of your environment enable/hinder your ability to communicate or innovate?	What aspects of the design space have you observed enabling or hindering your students' ability to communicate or innovate?

	How do you expect changing your environment to affect your ability to innovate and collaborate?	How would you describe your teaching style during capstone?
	Describe a typical day in your capstone course.	
	How do you use your environment to enhance parts of your design process?	How do you use the design space to enhance the lecture portions of the capstone course?
	[For students that appear more aware of how their environment impacts their process, ask the following]: What do you see as necessities for your design process where changes to the space could help fulfill?	Do you use your environment when mentoring your students individually or in small groups? How? Why?
		[For instructors that appear more aware of how their environment impacts their process, ask the following]: What do you see as necessities for a student's design process that changes to the classroom could help fulfill?
Demographic	What is your major?	What area do you teach in?
	What is your academic standing at this institution?	What is your standing at this institution?
	[More demographics]	
Closing	What would your ideal environment be to work on a collaborative design project?	
	Do you have anything else you would like to add?	

5. Preliminary results

We share below the results of piloting the interview protocol with one participant to illustrate how this protocol elicits nuanced aspect of the phenomena under study. Caleb, a senior in an aircraft design course, shared his experience with us in our pilot implementation of the project. During the interview, Caleb regularly mentioned holding team meetings at a table in front of a large wall-mounted monitor where they could project sketches and design documents onto the screen to share with everyone. This idea of a focal point in the classroom being used for collaboration is a recurring theme during the interview. Caleb shared the following regarding creating focal points and the malleability of the infrastructure:

> *"… especially with the tables being aligned the way they are, it's like a massive switch. It's just like a lecture hall. The thing is, you just like wish you could float them around […] It is kind of nice the way it is set up because we have five sub-teams. We can put each of those sub-teams at*

one desk, but sometimes it does hinder the inner team communication and it kind of segregates some people too […] But it would be nice to be able to move them together so that we can have all team meetings together.”

Caleb understands the appeal of a malleable space. He also appreciates the benefits and drawbacks of different space layouts that have features that suit different parts of the design process. This is extremely important as most capstone teams commonly have to book spaces outside of their design assigned lecture room that have varying layouts that fit different needs. However, they are restricted by space availability, teammate availability, and the sizes of these various spaces on campus. This begs the question of how much the design process would be impacted by adaptable infrastructure that allows it to act as a central location for the project without having to rely on multiple spaces to serve different purposes. Relating more to the existing infrastructure in some of the spaces, Caleb shared the following regarding technology in the design space:

“It would be nice if the different TVs were easy to use. Half of the time, it seems like they don’t get an input they need. You can’t connect them to a computer really easily. It’s really useful to be able to share ideas […] We cannot figure out how to consistently get an image from one of the computers onto the TV, and there’s a switchboard down there, but there’s no instructions or anything for it.”

The TV’s do actually work; however, a simple thing like the lack of an operation guide, as a subtle pointer to how the room can be reconfigured was missing. In response to the question if the difficulty of projecting items to the screen affected their design process, Caleb responded:

“It just slowed it down. It became ‘hey, come over here to this computer’ that kind of thing.”

It is obvious that a simple thing, like operations instructions, is vitally important to any technology in the space no matter how simple the operation seems. There are ramifications for this situation: the inconvenience of connecting to the TV caused the team to avoid using it the further they got into their project, while admitting that projecting information was the most efficient way for sharing and communicating with the rest of the team. This caused infrastructure that would have been otherwise useful, and most likely expensive to install, to go completely unused.

Caleb characterized the team’s unique ability to produce and test prototypes during their preliminary design phase.

“*Most teams would be doing that next semester […] Most teams would probably just skip straight to the full scale […] To be completely candid with you, its because we have one member of the team who really loves 3D printing and already knows how to build an airplane. He wanted more to do. We said we can get some value out of it and we did […] Across the hall in the [Simulation Lab], there’s a ton of 3D printers set up in there.”*

This is a special case as very few students normally have access to the Simulation Lab, which limits teams’ ability to develop prototypes. Due to the importance of prototyping and testing to the design process, it would be interesting in future interviews to see the difference in the quality of deliverables produced between teams that do and do not have easy access to rapid prototyping equipment. This difference in quality may be a valid reason to explore the effects of providing access to rapid prototyping equipment in the primary space for capstone courses.

When asked if there was anything that Caleb would change about the space if given the choice, he provided a surprising answer that they would actually shrink the room and make it smaller:

“Early on, it might have been nice to have people closer. As people were still trying to figure out what questions to ask, it might have been nice to have everybody a little bit closer to each other

[…] It's just more difficult to talk to people or to get Systems and Structures [subgroups] who are sitting in opposite corners of the room to go talk to each other. Go ask the questions instead of just making an assumption. It seems so silly because you're all in the same room. But then that extends to being outside of the classrooms. I don't want to bother somebody or anything like that. Like a more intimate space would help not only facilitate that communication, but also so that you can see things that are going."

It is interesting to consider that a small change such as the size of the room might have a large effect on casual communication between sub-teams on a design project. It would also be interesting to observe if this is a reoccurring observation from student participants because Caleb's team was a unique team due to its larger size. This capstone space is also used by other, non-engineering classes that have multiple, smaller teams on different projects; the smaller size might cause interference between those projects and have a negative effect on their design process.

6. Future Work

There has long been a connection between people's space, cognition and communication. These connections can have major effects on a team's efficacy in communicating and collaborating. Enabling spaces, during different stages of design, can greatly improve the design process in each stage and lead to unique results of higher quality. This study aims to identify the relationship between specific space enablers (and barriers) to reveal elements of a design that should be present (or absent) at varying stages. A challenge in designing this study is the tacit aspect of the space that may not necessarily be obvious to participants, which in itself could be a unique finding. Our goal is to collect more data during the span of a year-long capstone courses in different engineering disciplines.

References

[1] Talbert, R., & Mor-Avi, A. (2019). A space for learning: An analysis of research on active learning spaces. *Heliyon, 5*(12).

[2] Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the national academy of sciences, 111*(23), 8410-8415.

[3] Wilson, J. M., & Jennings, W. C. (2000). Studio courses: How information technology is changing the way we teach, on campus and off. Proceedings of the *IEEE, 88*(1), 72-80.

[4] Wilson, J. M. (1994). The CUPLE physics studio. *The Physics Teacher, 32*(9), 518-523.

[5] Graham, R. (2018) *The global state of the art in engineering education*, Massachusetts Institute of Technology (MIT) Report, Massachusetts, USA.

[6] T. Talko, E. Martin, A. Masongsong, A. Richmond, H. Ali and J. Adams, "Exploration of Innovative Spaces that Enable Communication and Collaboration in Diverse Settings," *2023 IEEE Frontiers in Education Conference (FIE)*, College Station, TX, USA, 2023, pp. 1-6, doi: 10.1109/FIE58773.2023.10343259.

[7] Doorley, S. (2012). *Make Space: How to Set the Stage for Creative Collaboration*. Wiley.

[8] Astin, A. (1999). Student involvement: a developmental theory for higher education. *J. Coll. Student Dev. 40* (January), 518–529.

[9] Flanagan, J. C. (1954). The critical incident technique. *Psychological Bulletin, 51*(4), 327–358.

[10] H. Ali and M. Lande, "Why make it? Understanding undergraduate engineering students' conceptions for the purpose of prototyping in engineering design activities," *2018 IEEE Frontiers in Education Conference (FIE)*, San Jose, CA, USA, 2018, pp. 1-5, doi: 10.1109/FIE.2018.8658628.