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Learning Theory Expertise in the Design of Learning Spaces: Who Needs a Seat at the Table?

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This study highlights the impact of including stakeholders with expertise in learning theory in a learning space design process. We present the decision-making process during the design of the Krause Innovation Studio on the campus of the Pennsylvania State University to draw a distinction between the architect and faculty member's decision-making process. Often, the architect relied on guiding principles such as flexibility, while the faculty member drew from learning theory such as the sociocultural theory of learning (Vygotsky, 1978). This study demonstrates the value of learning theory expertise and includes suggestions and possible implications for future designs of learning spaces.

Introduction

We begin this paper by describing what it is not. This paper is neither a learning space design case study, nor a critique of individual design stakeholders' levels of expertise with learning theory. Rather, this paper introduces and presents the stakeholders' decisions during the design of a new learning space to understand where learning theory expertise resides on a design team and how learning theory expertise informed decisions made during a design process. We provide an example of how multiple learning theories influenced the design of a learning space, the Krause Innovation Studio at the Pennsylvania State University. We also conduct an analysis of stakeholder expertise during the design of the Krause Innovation Studio to answer our research question: *where does learning theory expertise reside in the design team during the design of a learning space?* It is our hope that upon reading this paper, the reader will have evidence for the inclusion of a learning theory expert on future learning space design teams.

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Why Learning Theory Expertise?

One of the factors often overlooked in the teaching and learning process is the impact of space (i.e. the affordances of spaces and tools) on learning (Van Note Chism & Bickford, 2002). In other words, the design of a learning space has an effect on the learning process. Thus, it is important to design a learning space with the learning process in mind. Monahan (2002) suggests any design of a learning space includes an "architectural embodiment" of learning theory, which he describes as *built pedagogy* (p. 4). Learning theories have much to offer the field of learning spaces. Learning theories provide notions of how people learn and how pedagogy impacts the learning process.

Learning spaces often promote a specific type of teaching and learning. For example, rows of desks facing a podium with a projection system suggest a built pedagogy that is instructive in nature, facilitating a space for lectures and individualized learning. Can we hypothesize that the architects and designers involved in the layout and design of rows and individualized desks made decisions to enable a call and response conditioning to learning, involving the transmission of content from teacher to student? If we were to interview the hypothetical design stakeholders, would anyone on the design team describe the rationale for space design in a way that was informed by either behavioral (e.g., Skinner, 1938) or social (e.g., Bandura, 1977) learning theories?

Built pedagogy often leaves tacit and unexplored the underlying theories of learning that inform design decisions. When people design a learning space, they should understand the learning theories that inform the design of the space. However, we would venture to guess that often

decisions are not made based on specific notions of learning theory. In a review of literature, we continue this conversation by discussing how learning space design decisions are made.

Review of Literature

Design stakeholders' rationales for decisions during the design of learning spaces have a long history in both proxemics (Hall, 1959) and environmental-behavior design (Scott-Webber, 2004). Proxemics (Hall, 1959), the theory of how a person uses a space in relation to the culture, explains differences in distance between intimate space (0-18 inches), personal space (1.5-4 feet), social space (4-12 feet), and public space (12-25 feet). Environmental-behavior design (Scott-Webber, 2004), the theory of how spaces relate to patterns of behavior, includes factors that affect blood pressure, behavior, and performance including room organization, noise, lighting, colors, and air quality (Martin, 2006). While both proxemics and environmental-behavior design offer important considerations, these approaches are lacking the in-depth perspective of learning theories and best practices that inform pedagogy, the study of teaching and learning.

Design stakeholders also rely on previous case studies and design principles, as well as student and faculty feedback (regarding current spaces), to make decisions in the design of new learning spaces. For example, at the Pennsylvania State University, classroom designers rely on a design document (see University Committee of Instructional Facilities, 2011) that provides guidelines and specifications for learning spaces. The document includes recommendations on room dimension ratios, codes, visual requirements, glare, classroom equipment, storage, furniture, doors, windows, walls, ceilings, chalk boards, room signs, projection screens, seating, pipes, heating, ventilation, air conditioning and air movement, lights and lighting control, telephones, wireless systems, video conferencing, and sound systems (University Committee of Instructional Facilities, 2011).

Student and faculty feedback is used primarily to choose color schemes, technological affordances (e.g., projection system(s), devices, tools), and pedagogical affordances (e.g., the layout/arrangement) of the learning space (Bickford, 2002; Hughes, 2002). In cases where students and faculty are included as stakeholders on the design team, and/or pedagogical affordances are discussed in depth, learning theory expertise may still be missing. Adding faculty members to a design stakeholder team does not mean that learning expertise is added to the team. Learning theory expertise does not require, but often resides in faculty members that engage in a study of learning theory.

An analysis of recent (learning space) design case studies (Barber, 2006; Holtham, 2006; Lombardi & Wall, 2006; Oblinger, 2006; Siddall, 2006) demonstrates commonalities that guide the design of learning spaces. From the perspective of these five case studies, innovative learning spaces should be:

- Open (Barber, 2006)
- Accessible (Barber, 2006; Siddall, 2006)
- Flexible & Versatile (Lombardi & Wall, 2006; Siddall, 2006)
- Technologically Rich & High-Tech (Siddall, 2006; Holtham, 2006)
- Comfortable & Aesthetically Pleasing (Siddall, 2006)
- Fluid (Lombardi & Wall, 2006)
- Sustainable & Maintained (Barber, 2006; Siddall, 2006)
- Used Effectively (Siddall, 2006)

The principles of design listed above emphasize the focus in learning spaces research on proxemics, environmental-behavior design, and/or student/faculty feedback. The principles are important in the design of learning spaces, yet it is still unclear how these principles directly tie to learning theories. The individual principles do not suggest the learning outcome of the space, but rather fragments/pieces of what general innovative space could look like. Without understanding the stakeholders' frame of reference behind the design principles, it is hard to prove that the design decisions had resulted in or had impacted certain learning outcomes or learning experiences of users. Furthermore, a lack of literature around stakeholders' knowledge of and use of learning theory may occur because a learning expert who understands rigorous learning theories is not included in the design process or has a limited to small role.

While there is an attempt by learning space design stakeholders to understand concepts directly associated with learning (e.g., collaboration, active learning, flipped classroom), any discussion involves surface-level descriptions of these concepts in relation to learning theory. We do not suggest that learning spaces design case studies are either superficial or surface-level forms of scholarship. Rather, we suggest that the discussion of these concepts of learning leaves the reader in need of more information about the authors' frame of reference. In other words, we suggest that any discussion of learning in the context of learning spaces should also make reference to the learning theories upon which the concepts are defined and operationalized. Current learning theories such as the sociocultural theory of learning (e.g., Vygotsky, 1978), situated cognition (e.g., Brown et al., 1989), and situated learning (e.g., Lave & Wenger, 1991) could provide designers with explicit guidance to ensure that the affordances of the space contribute to the learning it is designed to support. In Table

1 (see Appendix), we provide an example of how learning theories could inform the designs of learning spaces.

The examples in Table 1 offer suggestions for how specific learning theories could inform the layout, furniture, and affordances of learning space design. Multiple learning theories could be combined to inform the design of learning spaces as well. Depending on which theories/perspectives designers draw from, the affordances of learning spaces will vary significantly, and the affordances will inform the pedagogical activities that teachers and students enact in the space.

Context of the Study

The Krause Innovation Studio in the College of Education at the Pennsylvania State University represents a sophisticated example of spatial design practices in higher education. Informed by situated cognition, situated learning, and sociocultural theories of learning, the Krause Innovation Studio affords many kinds of tools and social interactions. The design of the space facilitates discussions with differing viewpoints and opportunities for individuals to learn through participation. Any person in the Krause Innovation Studio can connect a device to a monitor and/or projection system to participate in a conversation, share a visual aid, or offer a differing viewpoint. The Krause Innovation Studio can be divided into two areas: (1) the main Studio space and (2) the Learn Lab.

Main Studio Space

The main Studio space (displayed in Figure 2) features a welcome area and working bar with individual seating, five semi-private collaborative pods in the middle of the space, one open room/space, one staff office, and four private rooms. The welcome area and working bar serve as a parking area while students or staff members wait for other areas in the space to open. The five semi-private pods feature Steelcase's media:scape®[1] tables and a large 42" display. The media:scape® design includes a console in the center of the table, which offers 6 electrical outlets and 4-6 video graphics array (VGA) connections to the local display. The students can connect individual devices to the system and toggle between display devices using one-touch control pucks. Two of the four private rooms offer media:scape® connections to a set of two 32" displays. In these rooms, two students can display individual devices simultaneously side-by-side.

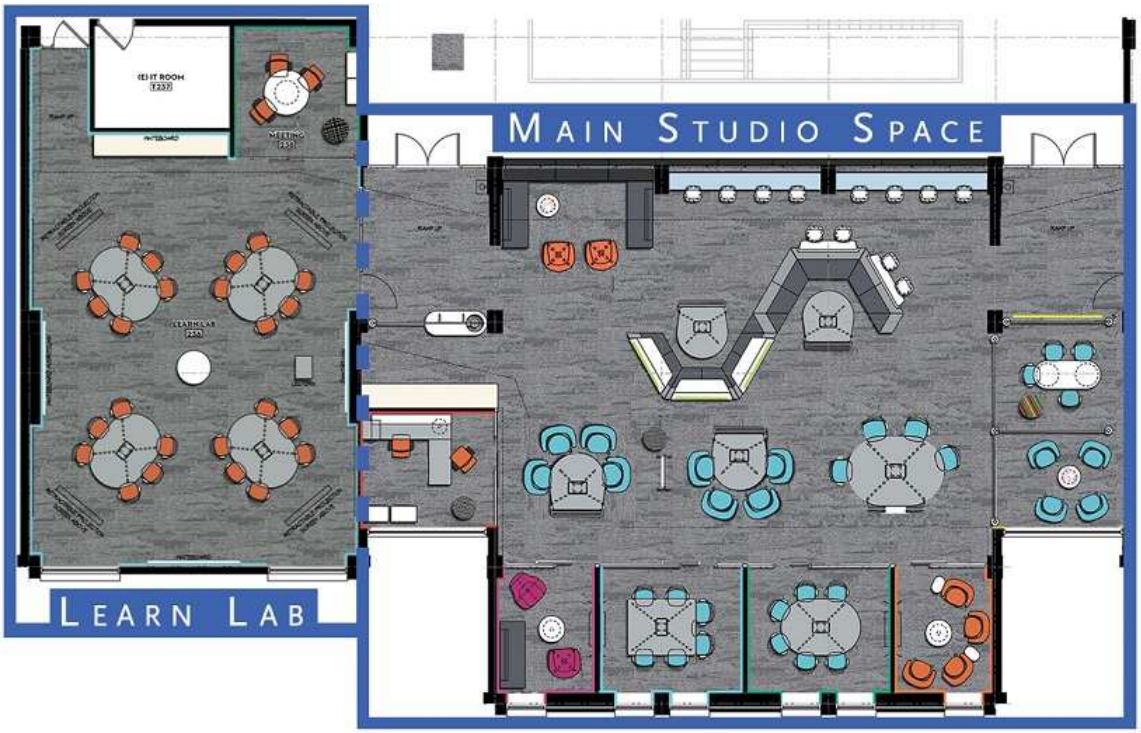

Figure 1. The two Krause Innovation Studio spaces: the Learn Lab and the main Studio space.

[1] More information about Steelcase's media:scape® technology can be retrieved from: http://www.steelcase.com/products/collaboration/mediascape/

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Figure 2. The Main Studio Space in the Krause Innovation Studio.

The Learn Lab

The Learn Lab (displayed in Figure 3) is a College of Education classroom that seats 24 students and includes a break out green room with seating for 3-4 in the back, right corner of the space. The tables are arranged in a way that every seat in the classroom has maximum access to sightlines to all parts of the room. The four tables also feature media:scape® technology, allowing each student to connect a device to the display system in the room, which includes five LCD projectors. The instructor controls the display system by deciding which table's output is displayed to which projector through a Crestron®[2] switching system. The display system facilitates a tremendous variety of student-led and small- or large-group activities. The output from a table can be displayed to a projector screen at the end of the table, or to any other projector screens in the room allowing students to share work with their local group or with any or all groups in the space. The space is decentralized with no set front of the room and no specific spot for a podium. There are whiteboards on all four walls, one of which is an interactive whiteboard. In addition, there are moveable huddle boards on carts that can be hung on railings on the walls. The Learn Lab, as the name implies, is a space for research and development around teaching and learning. The space was designed to encourage open, collaborative and interactive forms of pedagogy.

Method

Using a case study approach (Stake, 2005), we seek to understand and answer the research question: *where does learning theory expertise reside in the design team during the design of a learning space?* Key design stakeholders of the project were interviewed to provide an understanding of learning theory expertise within the design team and design process. The design stakeholders included the Dean of the College of Education (COE), the COE Human Resources Manager, the Director of the Krause Innovation Studio, an Architect, the Director and Assistant Director of Media Technologies, and the Construction Service Representative. The design stakeholders were interviewed between April and July 2012, just after the completion of the construction of the Krause Innovation Studio. The design stakeholders that were not interviewed included the Facilities Project Coordinator and the Sales Representative from the furniture company. The rationale for removing these two stakeholders from the study was based on their perceived importance to the study. In other words, the Facilities Project Coordinator

[2] More information about Crestron® can be retrieved from: http://www.crestron.com

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Figure 3. The Learn Lab classroom.

and the Sales Representative did not make any decisions, only recommendations, during the design of the Krause Innovation Studio so the decision to exclude them from participation was made.

Interviews were recorded and transcribed between May and August 2012. While the interview protocol varied little, the time of each interview varied greatly. The interviews ranged from approximately 8-45 minutes, with an average of 21 minutes in length. The reason for the variance was based on the stakeholders' perceived contribution to the design process. In other words, the design stakeholders who had significant contributions during the design process, also had more to say during the interviews. For example, the two primary stakeholders and decision makers during the design process, the Director of the Krause Innovation Studio and the Architect, also had the longest interviews.

The authors analyzed the transcripts with an interpretivist case study lens, using coding schemes from grounded theory (Charmaz, 2005) to find themes within the data. Design documents and design meeting documents were reviewed and analyzed to triangulate the results from the interviews. The interview questions were divided into three sub-categories: role during the design, design decisions, and rationale for decisions.

Results

The results from interviews produced four categories of data: (1) an overview of the design process; (2) design stakeholders' roles in relation to the design process; (3) design stakeholders' self-reported understanding/view of learning theory; and (4) the rationale for why decisions were made.

Overview of the Design Process

Phase 1: Strategic planning. The design of the Krause Innovation Studio began with a strategic plan. Early in the process, the Dean of the College of Education (COE) tasked a sub-committee of the strategic planning team to think about technology in teaching and learning. The sub-committee, comprised of faculty members and the manager

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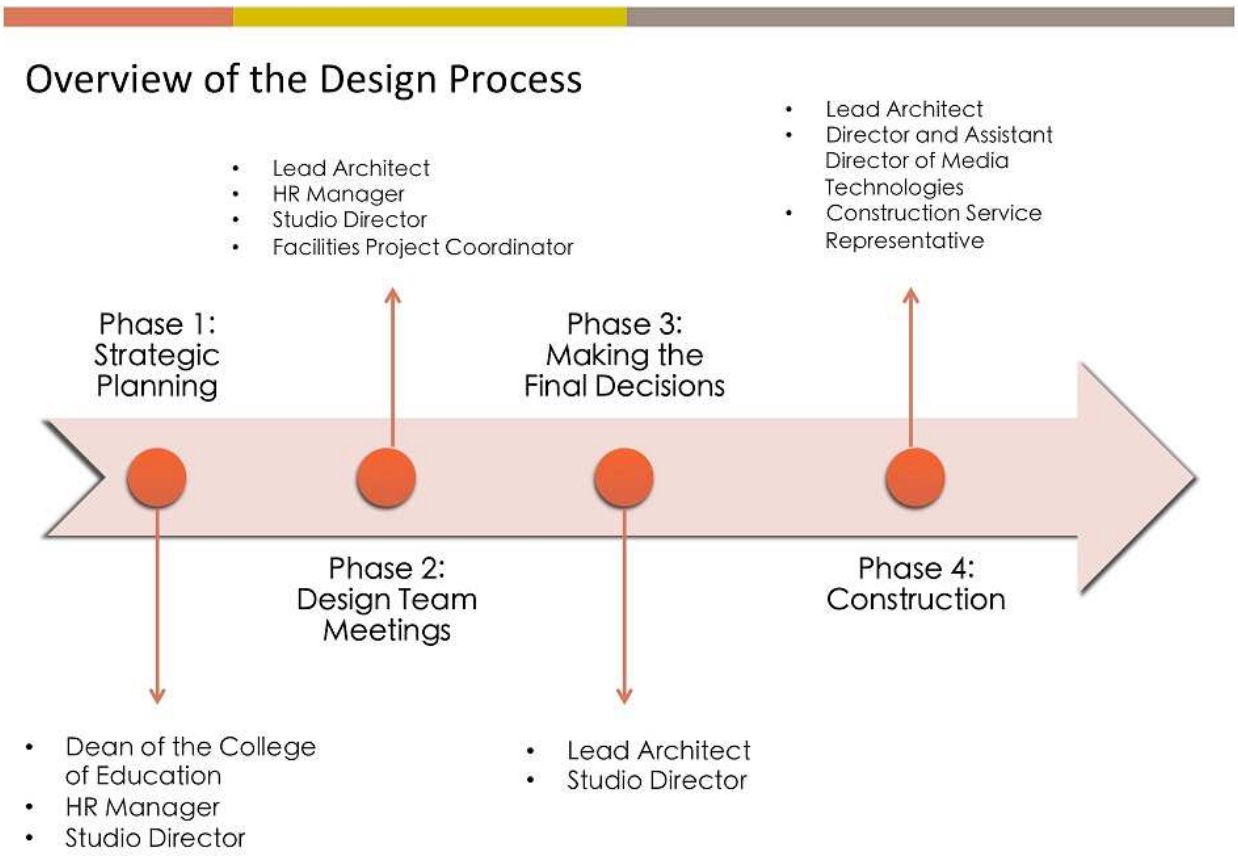
Figure 4. Phases of the Design Process with Design Stakeholders' Involvement



of educational technology, proposed an initiative around supporting pedagogy, higher education, and resident instruction with technology. The focus was on teaching first, and then technology second.

The sub-committee recommended to establish a physical space to support the initiative. At this point in the process, the Dean appointed the Krause Innovation Studio Director based on an understanding of the Director's research interests and shared vision for the Krause Innovation Studio. Together with the Director and the Human Resources (HR) Manager, the Dean provided direction for the vision of the Krause Innovation Studio. During this time, discussions began with the donors, Gay and Bill Krause, about the initiative and the possibility of endowing the Krause Innovation Studio.

Phase 2: Design team meetings. The HR Manager recommended to hire an off-campus Architecture firm as lead architects on the project. This decision was based on a previous working relationship that the local firm had established in the COE, and with an understanding that the outside firm did creative and innovative work. The Architect took the vision and created initial renderings of what the space would look like. The renderings were shown to the donors, Gay and Bill Krause, and that led to multiple discussions about endowing the Krause Innovation Studio and what that the Krause Innovation Studio would look like.

The initial design meeting occurred on January 27, 2009, involving the Architect, Director, HR Manager, and Facilities Project Coordinator. During the meeting, the Architect reviewed the goals for the space based on the Director's sociocultural notions of how people learn. The space was meant to facilitate social interaction at group-based tables. The Architect also outlined design specifications including aesthetics, space requirements, structural constraints, and preliminary layouts. Aesthetic designs were made to reflect a clean, high-tech feel with bold accents of color and a digital age look.

The Architect invited the design team to tour Steelcase University.[3] The design team made two trips to Steelcase over the course of the design process to look at the Learn Lab, as well as other collaborative spaces. At the time, Steelcase University had an active project with Dean Deborah Ball from the University of Michigan. At Steelcase University, the design team observed Dean Ball teaching a class in a classroom with cameras and microphones set up to observe how teaching methods worked in the Learn Lab classroom. Steelcase's media:scape® and Learn Lab concepts were based on environmental-behavior design research that suggests that 4-6 people make a good small group size. The Learn Lab at the Krause Innovation Studio builds upon Steelcase's model with the potential to move seamlessly from the ideal small group size of 6 to a whole classroom-sized group.

Phase 3: Making final design decisions. Although the design of the Krause Innovation Studio was a collaborative effort among many stakeholders, two stakeholders made a majority of the final design decisions, the Architect and the Director. The Director had the vision and the Architect realized that vision.

Phase 4: Construction. It was at this point in the design process that the initial design team invited the Media Directors to join the conversation to provide audio and visual component recommendations for the Krause Innovation Studio. The Media Directors provided recommendations for the classroom projectors and displays to meet the demands of the Krause Innovation Studio.

After the design documents were signed off and the construction budget was approved, the Office of Physical Plant put out the project for bid. The Construction Services Representative served as the point person between the construction company with the winning bid and the Architect and Director during the construction process. The Construction Rep. ensured that the construction was following the design and vision outlined by the Architect. The official design process concluded when the Krause Innovation Studio opened for operation on March 12, 2012.

Design Stakeholders' Roles

The Dean of the College of Education (COE). The Dean was tasked with planning and developing a vision and a sense of direction for the COE. The Dean appointed a strategic planning sub-committee on technology that in turn recommended a College-wide initiative that became the inspiration for the Krause Innovation Studio. During the design of the Krause Innovation Studio, the Dean facilitated the planning of the Krause Innovation Studio, communicating with the donors regarding the concept and construction. The Dean relied on other stakeholders to help articulate and enact the specific goals and aspirations of the project.

The COE Human Resources (HR) Manager. The HR Manager is the manager of human resources, administrative services, and facilities management in the COE. The HR Manager was tasked with designs and repairs of rooms on the insides of buildings in the COE. During the design of the Krause Innovation Studio, the HR Manager recommended an off-campus architect to lead the project and represented the COE's interests in the design and construction of the Krause Innovation Studio.

The Director of the Krause Innovation Studio. The Director (third author) also serves as an Associate Professor of Science Education in the COE. The Director was tasked with high-level administrative tasks, annual reporting, strategic tasks, the intellectual direction of the Krause Innovation Studio, setting policies, and making decisions about how the Krause Innovation Studio and its resources were used. The Director was appointed by the Dean to create a research focus and build upon the suggestions from the sub-committee on technology. During the design process, the Director provided overall conceptualization of the Krause Innovation Studio, explaining the larger vision for what the Krause Innovation Studio would look like and how it would be used.

The Architect. The Architect is an architectural and interior designer at a local design firm. The Architect was involved in all phases of the design process, from the project's feasibility study through construction. The Architect's firm was recommended by the HR Manager and hired by the Office of Physical Plant. During the design of the Krause Innovation Studio, the Architect organized meetings with the client (the other design stakeholders), conducted a feasibility study, created sketch-ups and 3D models of the Krause Innovation Studio, developed design documents, construction documents, and specifications for finishes, and worked with the construction contractor.

Director and Assistant Director of Media Technologies. The Media Directors are responsible for the installation and maintenance of the technological, audio and visual equipment in university classrooms. During the design of the Krause Innovation Studio, the Media Directors were brought in to provide suggestions for media components that would meet the needs of the project. Also, the Media Directors were responsible for providing directions to the service technicians that would complete the wiring and

[3] More information about the spaces at Steelcase University in Michigan can be retrieved from: http://www.steelcase.com/discover/information/education/

programming for the audio and visual equipment in the Krause Innovation Studio.

Construction Service Representative. The Construction Service Representative watches over the day-to-day construction of spaces across campus. The Construction Service Representative was involved in all phases of the construction of the Krause Innovation Studio, ensuring that goals described in design drawings were met.

Design Stakeholders' Understanding/View of Learning Theory

The majority of design stakeholders (e.g., Dean of the COE, HR Manager, Media Director, Construction Rep.) quickly established during the interviews that it was neither their role nor expertise to bring understandings of learning theory to the design of new learning spaces. However, most were experienced with aspects of learning space design. For example, the Dean of the COE and the HR Manager were experienced in gathering feedback from COE faculty and students, and the HR Manager was experienced in managing classroom projects. Additionally, the Media Directors were experienced with classroom technology and specifications, having spent more than 10 years in their respective positions.

The Architect acknowledged her limited background in learning theory but expressed how she borrows from understandings of human interaction, environmental-behavior design, sociology, and psychology when she designs. We argue that the Architect is not an expert in learning theory in the way we present learning theory expertise in this paper. An example of both her limitation in learning theory, yet experience in understanding of design and interaction, is expressed in the following excerpt about the public-to-private transition of spaces in the Krause Innovation Studio (see Figure 5):

> I drew from studies of how people interact in different sorts of restaurants and bars, with notions of public space versus private space. So, I can speak to that (as opposed to learning theory). Public space is more exposed, and I thought of the Krause Innovation Studio as a progression of public to semi-private to private. In private rooms, you begin to feel more comfortable with your group interaction and get a little noisier. Whereas in public space (e.g., the laptop bar along the front), you spend less time there, but that works for different types of functions that we want to have. For somebody to be able to come in here between classes and work and leave and feel comfortable that they're not committing too much to being deep into the space. Kind of stop and go. (Architect, 4/10/2012).

The final design stakeholder is the Director. As mentioned previously, the Director serves as a faculty member in the COE. During the interview, the Director demonstrated not only a level of expertise in learning theory, but also an awareness of how learning theory contributed to the decisions made during the design process. The next sections include numerous excerpts from the Director's interview that offer evidence of learning theory expertise.

Figure 5. The progression of privacy at the Krause Innovation Studio.

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Learning Design Principles

The decisions made during the design of the Krause Innovation Studio can be split into two categories: 1) decisions guided by architectural design principles (e.g., open, flexible, aesthetically pleasing); and 2) decisions guided by learning design principles (e.g., diversity of spaces, bring-your-own-device). We focus here on the decisions guided by learning theory identified in our analysis: diversity of the Krause Innovation Studio(s), bring-your-own-device, and furniture to support social practice. For each of these decisions, we unpack how learning theory informed the design process. This is not to say that these decisions do not occur in design processes that are less well-informed by learning theory, only that in a case where learning theory had a clear influence these decisions will be justified in different ways and supported with different rationales.

Diversity of spaces. The organization of the Krause Innovation Studio is a privacy progression from public spaces in the front to private spaces towards the outside windows. The Architect and the Director combined to make decisions about the arrangement of the Krause Innovation Studio spaces. Figure 5 provides a visual representation of the progression of privacy in the Krause Innovation Studio. There is a significant distinction between the rationale the Architect provided for this choice versus the Director. The Architect focused on environmental-behavior design, "you begin to feel more comfortable with your group interaction and get a little noisier" (Architect, 4/10/2012), while the Director focused on the social affordances of public and privacy based on sociocultural theories of learning, "you have to have spaces designed for people to easily communicate and share with each other because that's the fastest way to build culture and community" (Director, 5/2/2012).

The focus on talking and social practice more broadly draws from notions of community and identity in sociocultural learning theory. Gee (2014) suggests that "people build identities… not just through language, but by using language together with other 'stuff' that isn't language" (p. 45). Specifically, Gee suggests that all talk is part of a larger set of social practice that involves gesture, patterns of behavior over time, objects in the local environment, and numerous other 'stuff' that is used in constructing a social interaction. The Krause Innovation Studio's organization draws on this idea to provide people with a variety of different spaces designed to support different kinds of social interactions. This recognizes that social practice in learning spaces will be diverse and require different local spaces to support those differences in practice. Some learning spaces research focuses on making spaces flexible (Lombardi & Wall, 2006; Siddall, 2006) as a way to create variety, while the Krause Innovation Studio design did this through diversity of fixed spaces. Either way, the goal, from a learning design perspective, is the creation of spaces that support diverse social practices.

This diversity of spaces principle is addressed differently in the Learn Lab classroom, whose initial design was influenced by Steelcase's Learn Lab classroom, but with a rationale grounded in learning theory:

> From my point of view learning, teaching and learning is about establishing a culture and a culture can only be established through communication (between) multiple members of the community; it can't be unidirectional from one person to everybody else. So if that's the case then you have to have spaces designed for people to easily communicate and share with each other because that's the fastest way to build culture and community. The more open the communication lines, the more active everybody in the group is, the faster you develop a cohesive set of norms and practices. (Director, 5/2/2012).

Culture, as mentioned here, is another way to characterize the patterns of social practice described by Gee in terms of identity and discourse. The notion that learning (and culture) happens as a result of talk between peers and more knowledgeable others is guided by Vygotsky's (1978) notion that "every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological), and then inside the child (intrapsychological)" (p. 57). Everything you learn, you learn through people, and to improve learning you need to support interactions between learners. In this way, complex interactions between many participants provide richer learning environments, and more opportunities to learn. While you can learn from listening to someone speak, it is the least rich kind of interaction, and barely qualifies as an interaction.

Spaces that are grounded in sociocultural theories of learning recognize the value of rich, interactive (in the sense of multiple people) environments for learning. The other two learning design principles we describe are related to specific decisions made about tools and affordances within the context of diverse spaces to support social practices.

Bring-Your-Own-Device (BYOD). The decision to not have computers in the Krause Innovation Studio was a decision made by the Director to support the Krause Innovation Studio's goal of creating a teaching and learning space, not a technology space for faculty and students:

> Putting a lot of technology into the Krause Innovation Studio would pull the direction of the

> way people thought about this space away from where I wanted it to be… which was about teaching. And if there were lots of computers in here then people would think of this as a computer place. But, if there are no computers in here, it gets harder to think about it as a computer place… (Director, 5/2/2012).

The thinking about BYOD, however, is justified beyond a focus on teaching and explicitly draws on concepts from learning theory as a way of thinking about why faculty and students should bring their own devices to the space:

> And one of the challenges I think we had to deal with that I really wanted this space to reflect, a positive view of that is, I would much rather have people learn how to use the devices they regularly use to accomplish the tasks they want to accomplish as opposed to giving them tools they only have access to in certain places. So, I want them to have ubiquitous access to tools they're going to use to solve their problems… I want them to be able to come here and hopefully get support in solving problems with tools they already have and know how to use. (Director, 5/2/2012).

The rationale here is drawing on notions of distributed intelligence/cognition (Pea, 1993), where learners are using tools in the environment to support their thinking. If people in the space are distributing some of their cognition onto the devices and objects in the environment as they are learning, then it would be important to have as many of these tools as possible stay with the learner. By bringing devices and tools inside and outside the Krause Innovation Studio, this allows people to support their own thinking outside of the Krause Innovation Studio (i.e. BYOD context).

The Krause Innovation Studio was designed as a space where people could come and use their own tools to support their learning, and the staff would be available to facilitate people using their own tools to share their thinking. This is a learning design principle in action. In addition to drawing specifically on distributed intelligence, it pulls more broadly from situated cognition where Brown et al. (1989) suggest that the process of acting with the aid of tools and the learning that occurs through that acting are inseparable:

> People who use tools actively rather than just acquire them, by contrast, build an increasingly rich implicit understanding of the world in which they use the tools and of the tools themselves. The understanding, both of the world and of the tool, continually changes as a result of their interaction. Learning and acting are interestingly indistinct, learning being a continuous, life-long process resulting from acting in situations. (p. 33).

Furniture to support social practices. The decision to use Steelcase media:scape® tables was made by the design team based on the kinds of interactions they hoped to support in the space. The media:scape® tables served as a conduit for students' own tools, allowing students to display work on a larger display. From the Architect's perspective, the furniture selection was made based on two design principles: futuristic feel and longevity. The furniture needed to convey a high-tech and futuristic look in the Krause Innovation Studio. Also, the furniture was constructed with solid steel improving durability and longevity.

From the Director's perspective, the furniture selection was grounded in supporting specific kinds of social practice for students and faculty, specifically to support and facilitate group discussion and provide affordances for many kinds of tools and social interactions, so individuals could learn through social interactions. Lave and Wenger (1991) describe "social practice (as) the primary, generative phenomenon, and learning (as) one of its characteristics" (p. 34). Social practice is not just useful for supporting learning, it is the primary phenomenon. Social interaction must proceed learning. Thus, any choice about furniture must take into account the fact that social interactions are primary.

Although both the Architect and Director agreed on the choice of furniture, the rationale and justification by each was different, one being informed by theories of social practice and the other by principles of futuristic feel and longevity. We are not suggesting design decisions in the Krause Innovation Studio would have been radically different without the Director's input, and specifically without his background in learning theory. However, we are suggesting that richer expertise at the table during the design of the Krause Innovation Studio likely provided new ways of thinking about design decisions and provided a new foundation for existing decisions. What we can say is that if an entire category of design principles are not part of the decision making process, then the possible range of designs will be limited. In particular, for a learning space, not having learning expertise at the table limits the degree to which design decisions can be informed by learning theory. While this may seem obvious, it is a critical realization as educational institutions begin to take the design of their learning spaces seriously.

Discussion

The design of learning spaces should involve a variety of stakeholders with diverse expertise including architecture, construction, and human resources, among other fields. The notion of learning theory as residing in the design team is often taken for granted or implicitly ignored as irrelevant. The design of a learning space is typically influenced by tried

and true design principles from established learning spaces case studies, without drawing on learning design principles informed by learning theories.

The context investigated in this paper, the design of the Krause Innovation Studio on the campus of the Pennsylvania State University, involved an Architect, the Dean of the College of Education, a Human Resources Manager, a Construction Representative, and the Director of the Krause Innovation Studio (also an Associate Professor of Science Education). Although the design of the Krause Innovation Studio was a collaborative effort among many stakeholders, two stakeholders collaborated on the majority of the design decisions, the Architect and the Director. The Director had the vision and the Architect supported the realization of that vision. While there was consensus on the decisions made in the Krause Innovation Studio, the rationales for the decisions differed between stakeholders. The Architect was led by guiding principles such as openness, flexibility, futuristic feel, longevity, and notions of public vs. private space. The Director was drawing on learning theories and his decisions were grounded in notions of how people learn including sociocultural theory (Vygotsky, 1978), situated cognition (Brown et al., 1989), and situated learning (Lave & Wenger, 1991).

The results in this study demonstrate that the learning theory expertise, provided by the Director of the Krause Innovation Studio, inserted implicit learning design principles into the process. While other stakeholders may have had some experiences with and understandings of learning theory, they did not have the deep understanding needed to draw on learning design principles to inform design decisions (as presented in Table 1).

Implications

Earlier in this paper, we presented a framework around learning theories and suggested they could provide designers with explicit guidance to ensure that the affordances of a space contribute to and support the learning it is designed to support. While attending to the learning affordances of a space is possible with design stakeholders who do not have learning theory expertise, the example presented in this paper demonstrates the impact a learning theory expert has on a design process, not only in thinking about the learning space, but also when informing specific design decisions. We recommend that learning space design teams include a faculty member (either in a school/college of Education, or one that is recognized as having a deep understanding of learning theory, and preferably both) and also make this faculty member a key contributor to design decisions. This recommendation is in addition to any user data from faculty or students a design team gathers during the design process of a new learning space.

The role of the Director presented in this paper was enabled by the early nomination (i.e. involvement from the strategic planning stage), which could be considered different from other design processes. That is, in the design of the Krause Innovation Studio, the Director was invited to participate and lead the design process which justified and empowered the Director to contribute to conceptualizing the Krause Innovation Studio and communicating notions of learning theory with the Architect, the Dean, and other stakeholders. On the other hand, in other design cases, the nomination of a director of a learning space may be decided after the space has been designed and constructed, which gives little room for a director to contribute to the design process (especially if the assigned director is a learning theory expert). Thus, it also is important to include a learning theory expert early in a design process and provide him/her with the authority to make design decisions.

We conclude with a final note (from the Dean of the COE) about considering the addition of a faculty member to a learning spaces design team:

> And then one thing you have to guard against or be sensitive to is with (facilities operations) and learning spaces... What is convenient for the construction people can sometimes drive what is happening. You have to know when to push back. They might face something on the construction side of things that is difficult and inconvenient, as opposed to impossible. They might talk about it as though it is impossible because they just as soon not deal with it. And it is hard for someone like (a learning theory expert) to know the difference. When is it really impossible and when is it just (construction workers) not wanting to deal with it? (An Architect) is closer to the nitty-gritty of the construction and probably in a better position to know if, is it just that they don't want to be bothered or is it really a difficulty that is quite decisive? (Dean of the COE, 4/19/2012).

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Appendix

Table 1. An Example of How Learning Theory informs the Design of Learning Spaces.

Learning Theory	How Theory is Practiced	Informing Design Decisions
Behavioral Theory of Learning (Skinner, 1938)	Learning involves conditioning behaviors based on stimuli.	The design of the space enables a call and response conditioning to learning, involving the transmission of content from teacher to student. The design also could allow students to interact one-on--one with machines.
Information Processing / Social Learning Theory (Bandura, 1977)	Learning is an individual process that can be accomplished through observation.	The design of the space enables direct observation of a practice, often with the teacher modeling the correct behaviors.
Constructivism (Piaget, 1977)	Learning is both an individual and social process where an individual goes through stages of development and constructs his/her understanding of the world based on discovery.	The design of the space involves furniture and layouts to allow for discovery, including a more decentralized teacher role and greater emphasis on tools.
Sociocultural Theory of Learning (Vygotsky, 1978)	Learning is a social process between individuals and mediated by tools (both physical and conceptual). The teacher and peers (more knowledgeable others) assist in an individual's learning through social interaction.	The design of the space involves furniture and layouts for group discussion and affordances for many kinds of tools and social interactions.
Situated Cognition (Brown et al., 1989)	Learning is a culturally relevant practice where individual cognition is rooted in the context(s) of culturally specific notions and tasks.	The design of the space involves affordances based on culturally specific norms and practices. Also, the design of the space facilitates discussion of differing viewpoints.
Situated Learning (Lave & Wenger, 1991)	Learning involves increasingly sophisticated participation in a community through the learning of norms and practices while engaging in authentic activity.	The design of the space involves modeling the layout after professional practice with opportunities for individuals to learn through participation.
Cognitive Apprenticeships (Collins et al., 1991)	Learning involves an individual engaging in tasks that are the same or analogous to those of an expert in the area being learned. Also, learning includes an understanding of how experts think about tasks while performing tasks.	The design of the space involves modeling the layout after professional environments where individuals get authentic practice by observing and talking to experts. Tools are available for understanding experts' cognitive processes.