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Title [Adopting Design-Based Research to Conduct a Doctoral Study as a Micro-Cycle of Design – A Practice Illustration](#)

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Abstract In this practice illustration, I elaborate on the methodological aspect of my doctoral research, developing a multilayered participatory approach to explore learning spaces drawing on Design-Based Research (DBR). Reflecting on my work, I explain “why” and “how” I adopted DBR in my doctoral research in Education. I argue that DBR is feasible to conduct doctoral research as a micro-cycle of design to develop *design methodology* and/or *domain theory*. I provide a rationale for choosing DBR as an underpinning methodology through which I designed the study and selected the data collection and analysis methods. I also describe how DBR was interrelated with the tenets of my study and the research questions. Providing an explanation of the relationship between DBR and participatory design, I explain how *design methodology* was developed in the context of my study. At the end, I briefly outline the findings and the contextual design principles that emerged from the findings.

Keywords DBR; Doctoral Research; *Design Methodology*, *Domain Theory*, Micro-Cycle of Design

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Adopting Design-Based Research to Conduct a Doctoral Study as a Micro-Cycle of Design – A Practice Illustration

Serveh Naghshbandi

1.0 Introduction

The underlying premise of DBR is to develop the design of artefacts, tools, curricula, and theories that can support more understanding of learning (Barab et al., 2007; Fishman et al., 2004) and effectively bridge the gap between research and practice (Anderson & Shattuck, 2012). DBR may appear to be a longitudinal and intensive approach to educational inquiry that doctoral students, most of whom expect to complete their degree within four to five years, cannot use this approach to conduct their doctoral dissertations. Encouraging doctoral students to adopt DBR in their doctoral research, Herrington et al. (2007) describe the components of a dissertation proposal that utilizes DBR methods in the context of educational technology research. Meanwhile, Kennedy-Clark (2013) and Bakker (2018) identify the characteristics of DBR that can be used in graduate level theses/dissertations; they include: recruiting expert groups and/or diverse participant groups, conducting micro-phases, and using a flexibly adaptive design, which enable researchers to refine the research design and their understanding of the problem.

Applying DBR in my doctoral research, I confirm the above findings and I argue that DBR is feasible for students to conduct their doctoral research to develop *design methodology* and/or *domain theories* within a micro-cycle of design(s). Edelson (2002) identifies a *design methodology* as a design procedure, which provides guidelines for the process rather than any product. Also, he clarifies that a *domain theory* is a descriptive analysis of the area of the problem, not necessarily design solution(s) or *design frameworks*.

In my doctoral research, I developed *design methodology* and *domain theory* to explore students' perceptions, experiences, and imaginations/ideals of their learning spaces. The *design methodology* included an integrated conceptual framework by incorporating related theories of Architecture and Education (Figure 1) plus the procedure for data gathering and knowledge creation about learning space design through a participatory approach. The aim was to identify the main conceptualizations of space from students' points of views and develop a participatory model to make students' multiple voices heard.

The notion of learning space simply expresses the idea that there are potential diverse forms of spaces in which learning can occur; however, there is a considerable complexity of interrelationships between learning and space (Boddington & Boys, 2011). To grapple with this

complexity and avoid over-simplifying the notion of a learning space, learning spaces should be seen from both architectural and educational angles through related theories and practices. In my research, I synthesized two different yet related perspectives to position learning spaces within the doctoral education context. Intersection of Lefebvre's (1991) *Production of Space* along with *situated learning theory* (Lave & Wenger, 1991) enabled me to build an integrated conceptual framework to explore doctoral students' perceptions, lived experiences, and imaginations of learning spaces in a Canadian research-intensive university campus.

I applied DBR to design and develop the multi-layered procedure of the study. DBR provided a process through which perceptions (*perceive space*, subjective aspect of space), experiences (*conceived space*, objective aspect), and imaginations (*lived space*, co-constructed aspect) of students in relation to their learning spaces were examined (see Figure 5); it also created an avenue where students could address the problems and formulate new visions for the future in a participatory manner, which can lead to more understanding and ultimately to change in future strategies in relation to those spaces.

Only the last part of this study was conducted during COVID-19 global pandemic and still so many uncertainties remain as educational institutions plan for the reopening of their buildings. Considering the radical changes that COVID-19 has brought in how we work, collaborate, study, and engage in social events, the timing is right for higher educational institutes to rethink their learning spaces for the post-COVID era to support students' learning and their meaningful engagement in learning communities. While further exploration on learning spaces in post-COVID time is beyond the scope of this study, it will certainly inform my subsequent work.

2.0 DBR and the Tenets of Study

I conducted my research within the framework of DBR. Wang and Hanafin (2005) outline the attributes of DBR, which I explain how they interrelated with the tenets of my study.

2.1 Having a Pragmatic Stand

Deriving from an integrated theoretical and methodological framework to link Education and Design, a participatory model for learning spaces was developed in my study. Development of the theory and practice has been on an ongoing pragmatic basis to explore how learning spaces are understood, experienced, and envisioned. The implicit epistemological assumption in this context draws on the view that one can know about the reality (in this case learning spaces), the problem(s), and the possible design solution(s) by experimenting in real settings.

2.2 Grounding in Theory and Real Practice

My study is grounded in lived experiences of students framed by interconnected theories, which are illustrated schematically in Figure 1. This integrated theoretical framework opened and synthesized two different yet related perspectives to view learning spaces. The integrated theory-driven perspective guided the study through a process/model, which was participatory, pragmatic, and learner-centered.

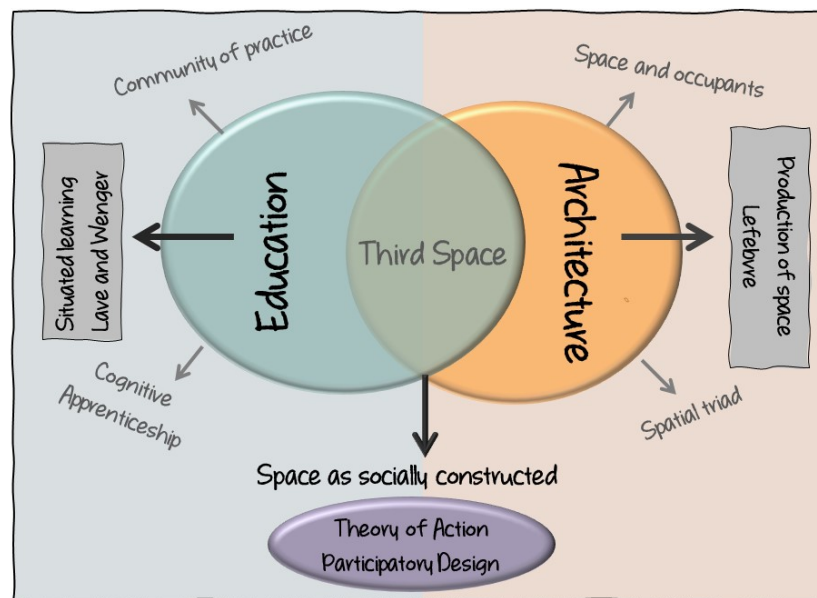


Figure 1: Conceptual framework to study learning spaces

2.3 Conducting Iterative and Flexible Processes

This study followed a flexible research strategy and multiple methods were used for collecting data as new needs emerged. The recursive movement that ensued within the design process allowed flexibility; moving from analysis-to-design-to-reflection-and-re-design created room for continual refinement.

2.4 Using Multiple Perspectives to Ensure Integration of Data Sources

I developed multi-phased research through three sequential phases, and accordingly, I used different methods of data collection and analysis for each phase (see Table1). The collected data addressed subjective, objective, and co-constructed aspects of learning space.

2.5 Connecting to the Context

Drawing from DBR, research findings and results relate to the research context, and with the design process through which findings are generated. This study was situated in a Canadian research-intensive university proceeding from the view that space is *socially constructed*. Findings identified areas for the future studies and actions to be taken by the university and implications for learning space studies for the U15 (Group of Canadian Research Universities) and U21 (the leading global network of research universities for the 21st century).

3.0 Research Questions

The research questions reflected both theoretical and practical aims (Table 1). To answer the questions, I developed multi-phased research through three sequential phases, and accordingly, I used different methods of data collection and analysis for each phase.

Table 1
Summary of research questions and methods of data collection and analysis

Phase	Research Question	Data Collection Method	Analysis Method	
			General Strategy	Complimentary Strategy
One	How do doctoral students perceive a “learning space” and its intended use(s)?	Questionnaire (Subjective aspect)	Reflexive TA (Inductive & deductive)	Reflexive iteration Axial coding
Two	What is the relationship, if any, between the university’s provided learning spaces and students’ identified spaces?	Photovoice Semi-structured interviews (Objective aspect)	Reflexive TA (Deductive, latent & inductive)	Reflexive iteration Axial coding Art-informed approach
Three	How might doctoral students envision the future of their learning spaces?	Participatory Prototyping Notes, Sketches, Prototypes (Co-constructed aspect)	Reflexive TA (Latent & inductive)	Reflexive iteration Art-informed approach

Table 1: Summary of research questions and methods of data collection and analysis

4.0 DBR and its Interrelationship to the Research Questions

Based on the DBR literature, Plomp (2007) concludes that DBR experiences comprise the following three stages:

Preliminary research: includes context analysis, literature review, and development of theoretical framework;

Prototyping phase: includes micro-cycles of research with formative evaluation; and,

Assessment phase: includes evaluation to conclude whether the intervention meets the pre-determined characteristics.

Exploring students’ perceptions and experiences along with the reviewing of the related literature fit in the *preliminary research* stage. Based on the findings from the first and second phases, the third research question explored the participatory prototyping; this phase of

the study corresponded to the *prototyping phase* and aimed at designing and developing a participatory design process to envision future learning spaces. The *assessment phase* was a (semi-)summative evaluation, which helped generate design principles for the future iterations (Figure 2).

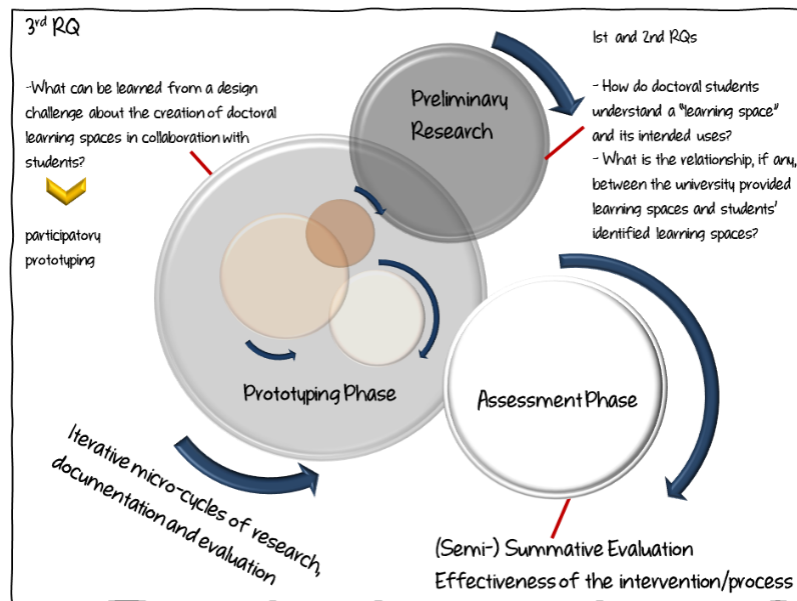


Figure 2: Plomp's stages and research questions

5.0 Research Design

Wang and Hannafin (2005) state that methods of data collection and analysis of the procedures in DBR are interdependent with the needs of research. Drawing on this approach, development of the design and selection of data collection methods as well as data analysis strategies for this research study were built upon the research questions and the theoretical framework. Multiple research methods were used systematically and purposefully based on the needs of design in three sequential phases.

The purpose was to reach areas connected to understandings, emotions, memories, experiences, and ideals of participants about learning spaces. With this purpose in mind, I drew from the concept of *different degrees of users' knowledge* (Figure 3). Dell'Era and Landoni (2014) explicate *what people do* underlines the actual situation, *what people say* reveals the past and the immediate future and *what people make* stimulates the researcher to investigate the remote past (memory) and the most distant future (dreams).

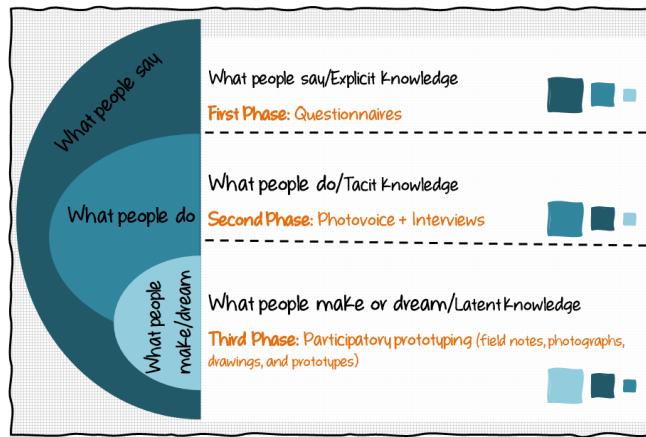


Figure 3: Sequential phases

The procedure of data collection and analysis drawing on the framework of DBR (Figure 4) was not as linear as illustrated; the procedure followed a flexible, recursive, and iterative flow allowing interaction and deliberation; each phase was overlapped with the next and/or previous phase. Following this iterative approach helped creating a more comprehensive picture of the situation of students' experiences, needs, and ideals in relation to their learning spaces.

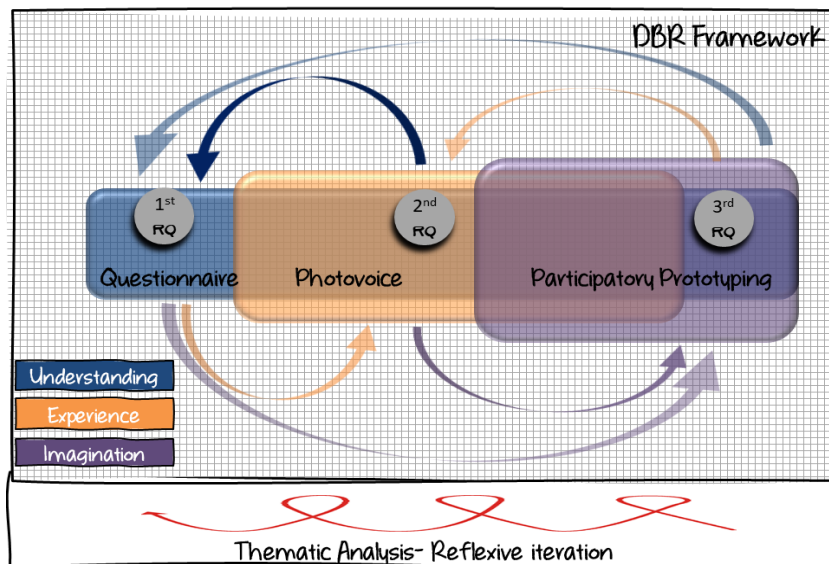


Figure 4: Sequential phases

6.0 DBR and Participatory Design to Develop Design Methodology and Domain Theory

My doctoral study supported the development of *design methodology* and *domain theory*. According to Edelson (2002), a *design methodology* is a design procedure, which provides guidelines for the process rather than the product. The procedure developed in my study aimed to address subjective, objective, and co-constructed aspects of learning spaces. The purpose was to reach areas connected to understandings, experiences, and imaginations of students about learning spaces.

The design procedure drew on the concept of *different degrees of users' knowledge* including *what people say, what people do, and what people make* (Sawhney, Prandelli & Verona, 2003), which correspond respectively to explicit, tacit (observable), and latent knowledge.

As Edelson (2002) clarifies, a *domain theory* might be about learning environments and how they influence teaching and learning. The aim of the first and second phase of my study was to address subjective and objective aspects of learning spaces through exploring how students have perceived, identified, and experienced the university's provided learning spaces.

The first phase corresponds with *perceived space* identified in Lefebvre's (1991) *spatial triad*, which includes the ordinary and unconsidered experiences of everyday lives within a space. On the other hand, the second question investigated the *conceived space* (Lefebvre, 1991), which is the conceptualized space by planners to pattern the social in space and the way people interact with the space (Figure 5).

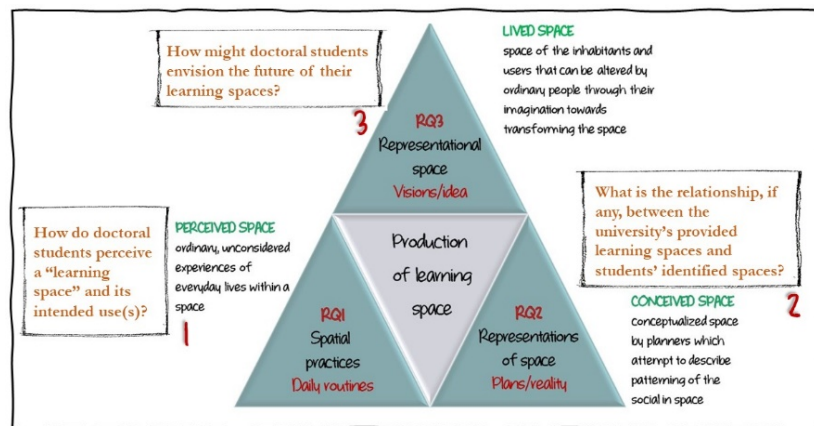


Figure 5: Adapting Lefebvre's (1991) production of space

Domain theory included a descriptive analysis of the area of the problem. The problem analysis must characterize not just the challenges, but also the process of implementing the design. Edelson (2002) emphasizes that developing a process that can make the design happen is essential. The aim of the third phase, prototyping, was to address the co-constructed aspect of learning spaces as the desired process of problem analysis.

Participatory prototyping was applied as the orienting theoretical framework in the study; developing a design process guided by the findings from the first and second phases supported the development of theoretical assertions about using a participatory approach in learning spaces design.

Within the discipline of design, participatory design offers promise for the learning sciences because of its aligned goals for engaging in the real-world situations as well as its democratic values (DiSalvo & DiSalvo, 2014). DBR ties to the diverse continuum of participatory research methodologies informed by a theory of knowledge, which holds the emerging meanings. Participatory design and inviting participants

to contribute to the designing and making process in educational setting is a concrete example of DBR within its diverse continuum, which was the focus of my study.

Figure 6 illustrates the development of design adapting a diagram by Reeves (2006), which demonstrates the iterative development of the process within DBR. These stages along with documentation, reflection, and evaluation of the process provided guidelines for the process of a participatory approach to learning space.

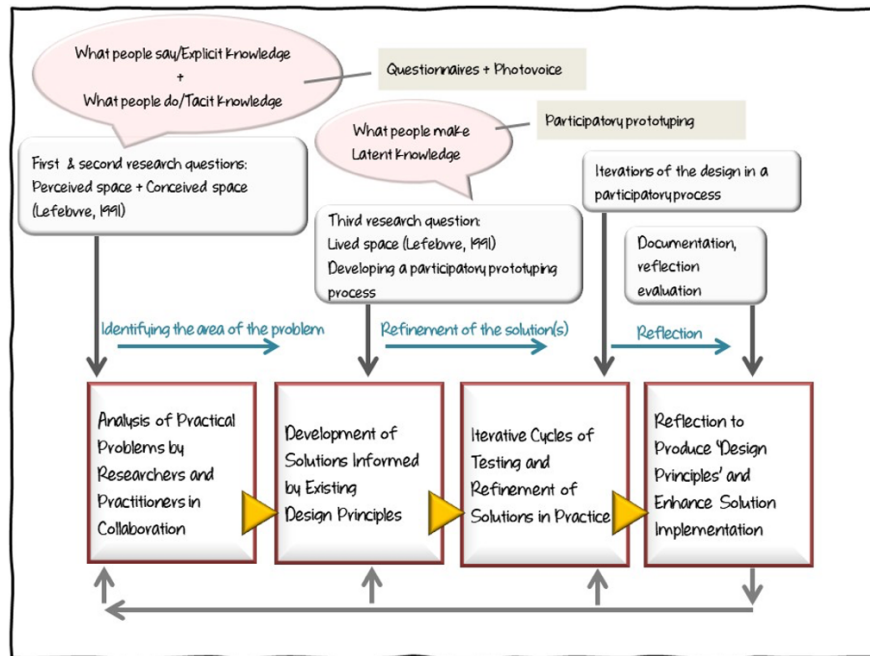


Figure 6: Iterative development of the process (Reeves, 2006)

7.0 Constructing an Eclectic Thematic-Analysis-Informed Approach for Data Analysis

DBR created an opportunity for an exploratory and retrospective process. The dialogic approach to data collection and analysis highlighted the complicated relationship between the literature and data.

Each data set required appropriate data analysis strategies. As a result, data in each phase was analyzed through an expedient method of analysis to respond to the specific need of the study and guide the study to the next step. This flexible approach was adopted from DBR and provided an opportunity to see areas in which I lacked needed data realizing that my data had gaps.

A combination of interconnected strategies for analyzing the data was applied in this study. While Thematic Analysis (TA), as the general method, informed the data analysis process at all stages, complimentary strategies were integrated to each phase when needed: reflexive iteration and axial coding in questionnaires analysis, reflexive iteration, axial coding, and art-informed approach in Photovoice, and reflexive iteration and art-informed approach in prototyping (Table 1).

The benefits of using such an eclectic approach included cross-disciplinary non-linear investigation, creating a complete picture of participants' knowledge obtained in different levels, enhancement of trustworthiness and rigor, and building a creative medium to interpret the data.

The qualitative analysis through TA did not proceed in a linear manner, but was instead recursive; the recursive movement allowed flexibility (DBR Collective, 2003) moving from analysis to design to reflection and re-design, which created room for continual refinement. Moreover, findings are not intended as generalizable to wider social groups, but rather convey a narrative of individual experiences and commonalities of participants that may reflect wider trends.

8.0 Coding the Data

The analytic process consisted of different iterative stages. Being informed by TA, data from each phase was analyzed through iterative cycles of coding, going back to the data and re-coding based on emerging codes, albeit Srivastava and Hopwood (2009) reminded us that codes and themes do not emerge on their own. They are driven by what we, as investigators, want to know and how we interpret the data based on theoretical framework, our ontological and epistemological assumptions, our subjective perspectives, and our intuitive understanding of the field.

To code, I followed Saldaña's (2009) "pragmatic eclecticism" (p. 47). I let the initial data collection and review occur before deciding on which coding method(s) to use. After the first cycle of coding in each phase, axial coding as a second cycle method was employed to find bigger picture of the concepts that link across the data sets (Strauss & Corbin, 1998). Through axial coding, I explored how the existing and emerging themes relate to each other within different phases of the study. Saldaña (2009) notes that axial coding is appropriate for studies that employ a wide variety of data forms, which was the case in this multi-phased study.

Reflexive iteration (Srivastava & Hopwood, 2009) was incorporated to TA as an applied strategy through visiting and re-visiting the data and connecting the emerged codes with the insights, thus leading to refined understanding.

Writing the results also led to reflective and iterative cycles. As the findings were written up, analysis continued with reflection on the results, returning to the analysis, writing up some of the findings, reflecting to the results, and so on. Braun and Clarke (2006) support this approach within TA and consider writing as an integral part of analysis, not something that takes place at the end.

In Table 2, I provide an example of the coding process; the initial codes emerged from iterative readings of each participant's transcript in the interviews along with the axial codes linking the codes across the data set, which are categorized into themes.

Table 2
Themes developed from codes: individual transcripts and cross-case coding/thematizing

Initial Codes	Axial Codes	Themes
Too many students in an office; Displacing students; Prioritizing students; Distracting office space	Lack of office spaces	Lack of office spaces
Not having the “own” space; Locked door no distraction; No longer concentrate when sb else at home; Lock my phone in a cupboard	No distraction	Having own space
Opportunity to multi-tasking; Cooking while working; Kitchen table with a nice natural view; Access to online resources	Work from home	Access to virtual spaces
No personalized space to feel belonged; Looking for a space; Stuff that aren’t mine; A poem on the wall; Making “my” space	Personalized space	Sense of belonging having own space
Natural light/window; Walking pedagogy; Lying down on lawn when read something	Close to nature	Promote well-being
Small conversations; Bringing appliances from home; No funding to buy microwave; Bringing tea/coffee for group; Indigenous thinking: things are shared in a circle	Sharing/making space	Sense of community
Doing different tasks; Alter the space to your needs; Furniture not conducive to moving around; Let me pick and choose	Potential for choice	Reconfigurability

Table 2: Themes developed from codes: individual transcripts and cross-case coding/thematizing

9.0 Methodological Issues

My doctoral study was conducted with a small number of voluntary participants in a research-intensive university, which therefore limits the types of generalizations that can be made. Moreover, any educational institution is part of a wider, dynamic web of cultural and social aspects which requires contextual investigation to unravel the complex relationship of space and learning in each context. The theoretical and methodological process of this study could be used as a guideline for other institutions’ explorations rather than the findings.

The assertions made in answering the study questions were limited to my interpretation of how and why the involved participants perceived and used the existing spaces and identify them as their learning spaces. If any of the students had not participated in the study, the findings would be different. From the same perspective, the inclusion of other participants from other universities would have changed the study findings as they have different perceptions and experiences in relation to their learning spaces. Luborsky and Rubinstein (1995) describe this issue as a common concern in qualitative research discovering the scope and nature of the universe to be sampled.

The theoretical aspect of participatory design involves issues regarding “the choice of user participants and the form of participation” (Kensing & Blomberg, 1998, p. 173). All doctoral students of the campus at the time of data collection were invited to complete the questionnaire. There was no chance to select a sample that represents the diversity of participants coming from different departments and fields of study, or cultural background, but students who chose to participate were from different departments and included domestic and international

students. However, there was still room to purposively select a diversity sample with the aim to cover all varieties, but time limitation and ethical consideration in recruiting participants did not allow to go further.

Another issue relates to coding and analyzing the data. There are guidelines for coding provided by qualitative researchers in the literature (e.g., Miles et al., 1994; Boyatzis, 1998), which are helpful technically. However, as Jansen (2010) declares, the quality of coding is not a technical issue; it involves theoretical sensibility and creativity, which is subjective to the researcher. The question that arises here is: At what point does the researcher's techniques and interpretations force instead of allow for emergence? This study and the research questions reflect my personal interests and motives; my worldview, values, and perspectives have influenced the interpretation of findings; my level of personal involvement in the research as a doctoral student filtered how I perceived, documented, and coded the data. So do the types of questions that I asked during the interviews and the types of responses that I received (Kvale & Brinkmann, 2009), the detail and structuring of my coded data (Emerson, Fretz, & Shaw, 2011), the gender, social class, and ethnicity of my participants and myself (Stanfield & Dennis, 1993).

Another limitation exists in most doctoral studies because of its nature; data were coded, and themes identified in the data by one person and the analysis then discussed with a supervisory committee. Although this process allows consistency in the method, it fails to provide multiple perspectives from a variety of people with differing expertise/perspectives.

10.0 Trustworthiness

Lincoln and Guba (1985) explain that trustworthiness is a way that researchers can persuade themselves and the readers that the procedure and findings of the conducted study are worthy of attention. Merriam (1988) suggests conducting early efforts in research design to establish validity and reliability; she recommends conducting strategies such as triangulating the data.

In developing and designing the study, I tried to establish a congruent methodological process connecting the research questions, the methodology, the data collection, and analysis based on DBR, which can offer support for the overall trustworthiness of the study (Bloomberg & Volpe, 2012). To ensure as much validity as possible and to gain as much insight as possible, triangulation (Gay, Mills, & Airasian, 2012, p. 393) was achieved by employing multiple research instruments and cross-checking different sets of data: semi-structured questionnaires in the first phase, photographs, and the scripts from interviews in the second phase as well as notes, photographs, sketches, and prototypes in the third phase.

Nowell et al. (2017) focus on data analysis in the TA procedure to ensure trustworthiness; they declare that the inquirer must demonstrate

that data analysis has been conducted in a precise, systematic and consistent manner through “disclosing the methods of analysis with enough detail to enable the reader to determine whether the process is credible” (p. 1). If readers are not clear about the underpinning assumptions of the researcher and the way that researchers analyzed the data, evaluating the trustworthiness of the research process will be difficult.

I conducted TA driven by Braun and Clarke’s (2006) six-phased approach as well as Lincoln and Guba’s (1985) criteria for trustworthiness during each phase (Table 3).

Findings from this study do not produce a complete account of learning space design, but it developed and tested a new framework and methodology for data gathering and knowledge creation about learning space design through a participatory approach. This is what Edelson (2002) calls a *design methodology*, among other potential outputs of DBR, which provides guidelines for the process rather than the product. The exploratory character of the study cannot allow generalizing the findings; what the outcome can offer is design principles (lessons learned) within a small-scale context.

Findings represent a vision, a beginning base to take action based on students’ experiences. Future research is needed to enlarge the sample and test the methodology. Drawing from DBR, findings can be examined and adapted to other contexts for their own purposes; generalization of the findings increases when they are tested and validated in more cycles of design in more contexts. It is also important to expand the information by including the perspectives of other involving stakeholders (undergraduate students, professors, staff, and graduate program providers) in future work.

Table 3
Establishing trustworthiness, adapted from Nowell et al. (2017)

Phases of TA	Means of Establishing Trustworthiness
Familiarizing with data	Extend engagement with data through transcription of the interviews, comments, and notes; Document my thoughts about potential codes/themes; Keep records of all data field notes, transcripts, and reflexive journal
Generating initial codes	Conduct pragmatic eclecticism allowing the initial data collection and review occur before deciding on which coding method(s) to use; Employ complementary strategies to coding; A combination of inductive, deductive, and latent coding; Audit trail of code generation
Searching for themes	Diagramming to make sense of theme connections; Keep detailed notes about development of themes
Reviewing themes	Recursive approach and cross-iteration comparisons
Defining and naming themes	Clearly describe the scope and content of each theme; Employ further refinement before moving on to the next phase
Producing the report	Describing process of coding and analysis in details; Thick descriptions of context; Explain theoretical, methodological, and analytical choices

Table 3: Establishing trustworthiness, adapted from Nowell et al. (2017)

11.0 Findings

My doctoral research took place at a campus of a research-intensive university in Canada as a *naturally occurring test bed* to address students’ perceptions, experiences, and imaginations about learning spaces and the space issues, which intimately portray the context.

Since design knowledge is contextual, social, and active, constant iterative exploration is required to refine the design process as well as the design principles.

Findings from the three phases generated some responses to the research questions which are summarized in Table 4 and briefly discussed below.

Table 4
Findings from three phased in relation to research questions

Space as Perceived: Subjective (First Question)	Space as Conceived: Objective (Second Question)	Space as Lived: Co-Constructed (Third Question)
Beyond physicality: multiplicity of spaces for multiple identities	Lack of personalized space	Physicality, individual and shared spaces
Social space, community as a missing vital layer of space	Lack of community and connection with peers	Liminality, in-between and on the margins
Individual space, a necessity in any PhD journey	Lack of spatial affordances	(Re)-Configurability
Virtual space, still an ill-defined space		

Table 4: Findings from three phases in relation to research questions

11.1 Space as Perceived

Students' perceptions in my study further confirm Lefebvre's (1991) *perceived space* in which space is subjected to the social practice, experiences and interpretations of the people who use the space. Participants perceived learning spaces beyond their physicality; a learning space was understood by participants both as a physical and a conceptual entity. For students "access to literature/publications", "new environments to get new perspectives", "a place to 'plant' one's self", "meeting with supervisor", or "computer screens" can all provide potential spaces for learning. Also, considering the complex interplay between individual, environment, and community, the relationship between the personal, social and material space tended to be a dynamic and unfolding interrelationship.

A major issue in thinking about learning spaces is to maximize the ease with which spaces can become psychologically available for large numbers of students; this is what Keppell, Souter, and Riddle (2011) call *spatial-dimensional multiplicities for identities*.

Research participants repeatedly mentioned the importance of being part of scholarly communities during a doctoral journey. What was perceived most was the social aspect of space where a conversation with peers and creating communities is possible. Participants felt that, however, they did not have enough opportunities to get involved in those communities as much as they should.

Doctoral students from different disciplines expressed a high level of need for individual spaces to support their long writing and reflection hours. As they get closer to the end of the doctoral program, the intensity of their writing hours increases, so too does their need for individual space. Despite the importance of such spaces in doctoral students' lives, participants expressed their dissatisfaction about not being provided a (quality) space.

11.2 Space as Conceived

Lefebvre (1991) refers to *conceived space* as the dominant “representations of space” that produce society’s spaces. He identifies *conceived space* as “the space of scientists, planners, urbanists, technocratic subdividers and social engineers” (p. 38). We can gain insight into the conceived spaces for learning in any context by investigating how learners experience such spaces and interact with them. Photovoice provided a process for students to amplify their voices, to influence and to shape future learning spaces of the campus. The qualitative data from this phase uncovered themes and patterns including lack of personalized space, lack of community and connection with peers and lack of spatial affordances.

11.3 Space as Lived

Prototyping helped participants to make their thinking visible and express their imaginations to shape future possibilities for learning spaces. The emerged themes included:

Physicality, individual and shared spaces. Regarding physicality of learning spaces, participants imagined comfort, quietness, privacy, living-learning spaces (home-like comfort), technology support as well as spaces that foster conversation. They envisioned the future spaces as a balance between individual and collaborative spaces. In fact, they imagined freedom and choice based on their learning styles and their needs to accomplish different tasks.

Liminality, in-between and on the margins. What students suggested was to re-use or re-purpose the unused existing spaces. They believed if spaces are flexible enough, they can arrange things in their own ways pushing the boundaries. There are liminal, unused spaces in all buildings, whether we are aware of them or not. Corridors and stairwells, for instance, as places of chance meetings, welcome and unwanted as well as places for learning.

(Re-)Configurability. Participants’ imaginations and ideals emphasized the flexibility and configurability of spaces to enable self-initiative. They felt that the ability to manipulate their spaces enables them to create the required spaces based on what they need in different situations. Rethinking learning spaces to prevent disease transmission and changes to the physical space will be necessary to allow for physical distancing; configurability will be an important quality of space more than ever during and after the Covid-19 pandemic.

12.0 Design Principles (Lessons Learned)

Design principles (Reeves, 2006) or simply lessons learned is a term to refer to the theoretical outputs of DBR. They offer situated guidelines based on contextual evidence derived from the findings including:

12.1 Learning Space Is a Layered Multi-faceted Phenomenon

Careful attention to the perceived, conceived, and lived spaces revealed multiple, layered, and dynamic components of learning spaces and the relationships through which learning and space intersect; it elucidated how learning space for doctoral education is produced. The resulting pattern may not result in design solutions in short term, but can illuminate university's decision-making in future.

Based on data, this study offers contextual recommendations (Figure 7) to improve learning spaces for doctoral students on campus including: creating reconfigurable spaces, providing home-like intimate spaces (individual and shared), using technological affordances to create communities, connecting learning spaces to the natural environment.

12.2 Learning Space Is an Indicator of Support

Space can be seen both as a site of learning and more as a site of power. Space thus serves as a tool of thought and of action; "in addition to being a means of production it is also a means of control, and hence domination, of power; yet that as such escapes in part from those who would make use of it" (Lefebvre, 1991, p. 26).

Participants of the study envisioned comfortable home-like spaces with flexible spatial affordances to accommodate different people. Students who were not provided with a space to work on campus were more likely to go home, which was not an ideal place for the less privileged students. They believed that providing quality space to graduate students to make it their "own space" is an indicator of support from the graduate programs and the supervisors.

12.3 Learning Space Has a Potential to Improve and Sustain Well-being

Participants implied that effective learning relates to their well-being, belonging, and engagement. Providing them with a space to make it their "own intimate space" helped them feel more belonging and reminded them of who they are; outdoor spaces, fresh air, natural light, and indoor plants can provide a space for solitude and reflection in order to "feel oneness with nature" and "plant one's self".

They also felt the need to gain a sense of belonging, stay motivated and inspired, and tackle the PhD lonely time through engaging in academic communities. What was missing in their PhD journey was engaging in a nested community of practice within and beyond departments to connect them to the peers across the campus.

Figure 7 summarizes contributions of this research to the literature.

13.0 Concluding Remarks

In my doctoral research, I proposed an integrated framework to explore learning spaces building upon Lefebvre's (1991) *Production of Space* and Lave and Wenger's (1991) *situated learning* and the concept of *communities of practice*. I also incorporated participatory design as a theory for action to bring those theories one step further into action. This blend of approaches helped to foreground the complexity of space as a socially constructed entity and to learn how to overcome binary thinking about learning spaces in higher educational setting.

In this paper, I articulated the process of my doctoral research, which was conducted drawing on DBR. I argued, although DBR may appear to be used in a longitudinal and more intensive approach to educational inquiry, that it could be also adopted to micro-cycles of design within doctoral dissertations.

I provided a rationale for choosing DBR as an underpinning methodology through which I designed my study and selected the data collection and analysis methods. I also described how DBR was interrelated with the tenets of my study as well as the research questions. To grapple with "how" to adopt DBR in a small-scale qualitative study in a PhD dissertation, I explicitly articulate the process of my data collection and analysis.

I explained that DBR provided me an opportunity to contribute to learning space research through developing *design methodology* (design procedure) and *domain theory* (design principles or simply lessons learned). They are not generalized principles for other contexts until they are tested as "working hypothesis" (Cronbach, 1975, p 125). Most importantly, they are not offered as "how to do" guides, but as a guide to help us think deeper about what learning spaces for doctoral education may look like and how we could possibly explore space in relation to learning through a participatory approach where multiple voices of the students are heard.

Contribution to the Learning Space Literature

Developing a multi-layer approach to participatory design of learning spaces in doctoral education

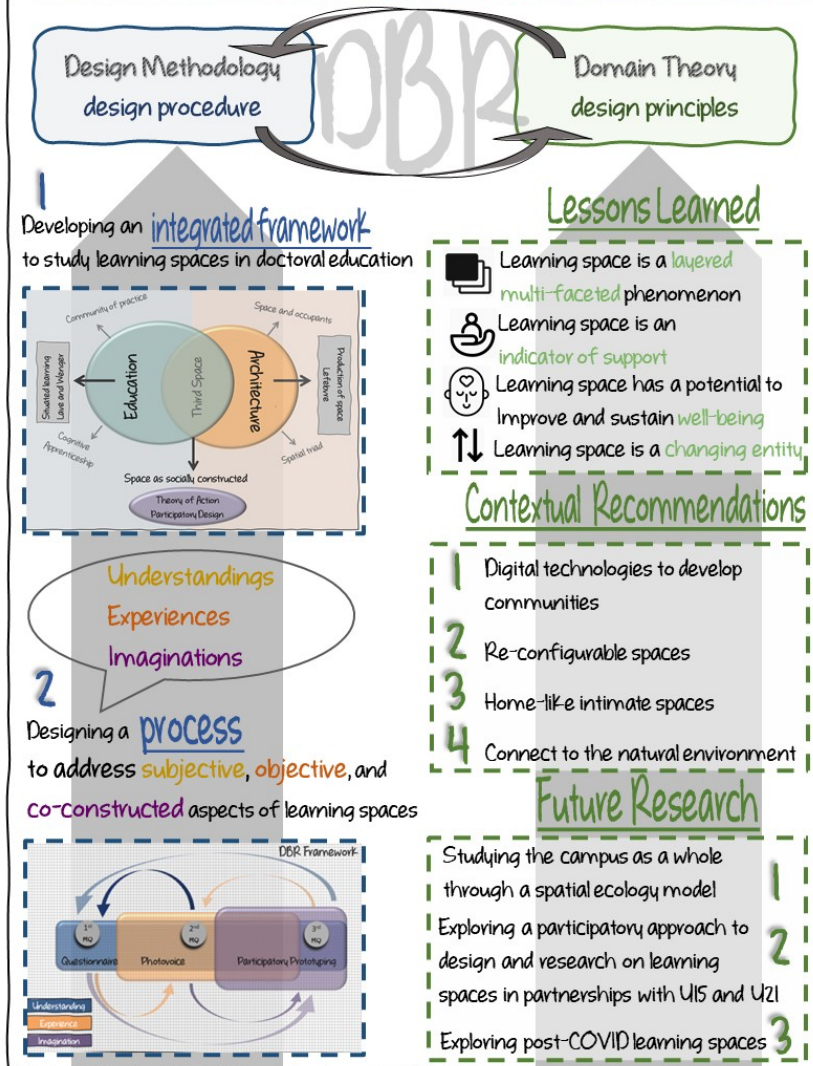


Figure 7: Summarizing contributions of this study to learning space literature

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