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| Author | Family Name | **Psyché** |
| | Particle | |
| | Given Name | **Valéry** |
| | Prefix | |
| | Suffix | |
| | Role | |
| | Division | |
| | Organization | TÉLUQ University |
| | Address | 5800 rue Saint-Denis, Montréal, QC, H2S 3L5, Canada |
| | Email | valery.psyche@teluq.ca |
| Corresponding Author | Family Name | **Daniel** |
| | Particle | |
| | Given Name | **Ben** |
| | Prefix | |
| | Suffix | |
| | Role | |
| | Division | |
| | Organization | Otago University |
| | Address | Dunedin, New Zealand |
| | Email | ben.daniel@otago.ac.nz |
| Author | Family Name | **Bourdeau** |
| | Particle | |
| | Given Name | **Jacqueline** |
| | Prefix | |
| | Suffix | |
| | Role | |
| | Division | |
| | Organization | TÉLUQ University |
| | Address | 5800 rue Saint-Denis, Montréal, QC, H2S 3L5, Canada |
| | Email | jacqueline.bourdeau@teluq.ca |


Abstract

This paper introduces the concept of learning space in the digital age and considers the various contexts in which learning occurs. In addition, the paper discusses issues about the modelling of a context-aware learning space ontology. The paper is based on an ongoing collaborative research, which focuses on the interface of learning space and context-aware learning. The long-term goal of this project is to introduce the notion of learning space and explore the role of the design of learning space context-aware ontologies

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| Keywords (separated by '-') | Learning space - Learning context - Ontology - Context awareness - ITS |

# Adaptive Learning Spaces with Context-Awareness

Valéry Psyché[1], Ben Daniel[2(✉)], and Jacqueline Bourdeau[1]

[1] TÉLUQ University, 5800 rue Saint-Denis, Montréal, QC H2S 3L5, Canada
{valery.psyche, jacqueline.bourdeau}@teluq.ca
[2] Otago University, Dunedin, New Zealand
ben.daniel@otago.ac.nz

**Abstract.** This paper introduces the concept of learning space in the digital age and considers the various contexts in which learning occurs. In addition, the paper discusses issues about the modelling of a context-aware learning space ontology. The paper is based on an ongoing collaborative research, which focuses on the interface of learning space and context-aware learning. The long-term goal of this project is to introduce the notion of learning space and explore the role of the design of learning space context-aware ontologies with the ultimate aim of constructing a transformative theory of context-aware learning spaces such as personal learning networks, virtual learning spaces, social learning spaces, and cognitive learning spaces.

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**Keywords:** Learning space · Learning context · Ontology · Context awareness · ITS

## 1 Introduction

Learning spaces are often depicted as classrooms with students seating in rows, listening and taking notes, with a teacher or lecturer standing in front of them, delivering knowledge or information. This model of learning space assumes that the student's progress toward a programme of study is determined by the time spent in classrooms, his place in the classroom and his interactions with teachers and other students. As such, the physical design and organisation of the classroom and the seating position of the student in the classroom can affect performance [1]. However, the changing landscape of learning environments and students (i.e. diversity in students and learning needs, and the permeation of digital technologies into learning), suggest that the conventional understanding of learning space, be it the formal lecture room, the seminar room or tutorial room, is untenable for all types of learning modalities of the 21st century.

The 21st-century students are social, team-oriented, multi-taskers who have a positive outlook on life. They are hands-on with a "let us build it" approach that places increasing value on network devices [2]. Further, learning for this generation has now become a lifelong pursuit, which takes within technological frontiers, supporting physical, online and blended [3, 4].


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The modern teacher is likely to be using various pedagogical approaches such as case-based, problem-based learning, community-oriented pedagogues; where the teacher assumes the role of a facilitator, and students work in groups and teams. [5] stated that the impact of digital technologies since the mid 1990s has implications for where and how learning might happen, whether it is online or offline, situated or distributed. It is also worth noting that while classrooms are formal learning spaces, distributed, and networked learning environments can take forms of informal and non-formal learning spaces.

In this paper, we first introduce the concept of learning space in the digital age, and the various contexts in which learning occurs. We then provide various dimensions of the concept of learning space, taking into account the context in which each dimension can support learning. We present our ideas for modelling learning spaces based on the work of [6]. Further, we discuss the issues of context and learning space in the light of a context-aware learning space framework. This framework will support various experiments on instructional design in order to improve adaptive and personal learning within the networked educational paradigm.

## 2 Related Research

Discussions of learning space within many higher education institutions largely remain constrained to three areas, namely the classroom (where almost all learning occurs), the library and the faculty offices—where programs are designed and student work graded [7]. Today, learning environments, as we know it, transcend physical spaces to virtual, cognitive and social spaces.

A growing body of research has called for the rethinking of learning spaces needed for the 21st century [7–9]. It is generally noted that research into learning space provides an opportunity to inform the development of adaptive and personalised technologies to enrich the student individual is learning need. Beyond that perspective, it is possible to open the learning space in order to support the establishment of a social network for exchanges between students across the planet, leading to new educational experiences that might otherwise not be possible to achieve. As [10] noted that social networking technology supplement face-to-face courses and can enhance students' sense of community.

Optimisation learning space requires the development of new learning paradigms that can adequately meet the needs of current generations of learners, the Net Generation (1982–1990s) and Gen Z (born 1995–2010) [2]. We take a holistic view of learning space, conceptualising it along fundamental dimensions (physical, virtual, social, and cognitive, see Fig. 1).

Virtual learning spaces comprise learning mediated both synchronous and asynchronous. In these environments, students learn to multitask and continually work outside of the classroom in spaces that promote social learning. Learning in the context of social networks is highly self-motivated, autonomous and informal and forms an integral part of the higher education experience [11]. Besides, social networks are considered useful in developing essential skills like selecting relevant information, critically interpreting and analysing the sociocultural context, working collaboratively

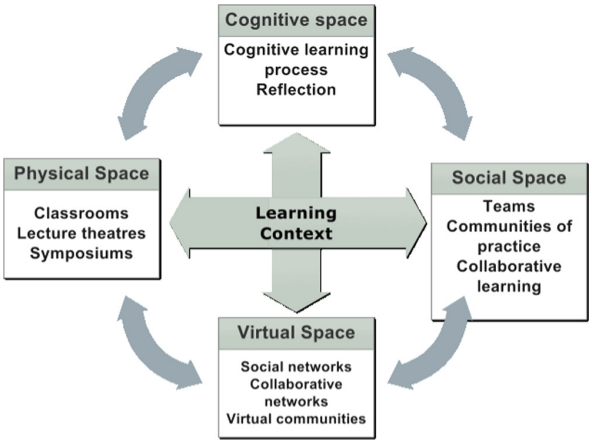


**Fig. 1.** Defining learning space.

and sharing knowledge [12]. In the social aspects of learning spaces, the concepts of learning ecology [4] and learning communities [13] are critical because they emphasise learning in a social context, recognising that learners are simultaneously involved in multiple learning settings.

A learning ecology is a collection of contexts—physical and virtual—that provides opportunities for learning [4]. In higher education, this usually includes multiple courses, formal and informal contexts across the institution, and settings at work, community and home. Social learning spaces are instrumental in setting conditions for learning because they create a supportive environment to engage students in critical thinking and promotes interactions that are richer, more gratifying and intrinsically rewarding [12].

Physical learning spaces are also valuable learning environments, and they are considered part of the aesthetic view, one of identity and symbolic of power and prestige. Beyond the classroom, physical learning spaces are quiet spaces or individual pods for individual or small groups; break out spaces that could be large or small and widened corridors allowing the gathering of students away from the formal learning environments.

## 3 Modelling Learning Space Inside Learning Context

In artificial intelligence, the notion of context appeared in the 1990s [14], but it was not until the early 2000s where this area of research gained interests among researchers in ubiquitous computing, mainly focusing on geolocalization technologies, where the spatial and temporal dimension of the context became traceable. [15] have analysed one hundred and fifty definitions of the context. From this study results the most cited model of context among research. It represents the components of a situation and the relations between them. According to Bazire and Brezillon “A situation could be

defined by a user, an item in a particular environment, and eventually an observer." In their model in context, context and environment are separate but related.

According to [16], "space is an important context in many context-aware applications, and most context definitions mention space as a vital factor". [17] described "context as any information that can be used to characterise the situation of an entity, where an entity is a person, place or object that is considered relevant to the interaction between a user and an application". The notion of learning context in education describes the various circumstances in which learning might occur, where the learning context consists of students, culture, teachers, lesson plans, etc. In addition, learning context refers to the set of learning activities, including the space in which learning itself occurs, and students' perceptions of the ability of a particular space in providing rich learning experiences.

Knowledge of learning context enables both teachers and students to rethink about the design of teaching and learning, and the constraints of the learning spaces [18]. The affordances of a context must be perceived by an individual who must also have the abilities to interact with these attributes. Openness disrupts teaching conventions; however, it is the social activity of the inhabitants that define the possibilities of a learning space [19]. Moreover, learning context consists of students, culture teachers, lesson plans, etc.

The emergence of Massive Online Open Courses (MOOC) in 2008 and the subsequent possibility of accessing large data about student interactions in online learning situations triggered more interests in understanding context and learning. Recently, studies have emerged in teaching in context [6, 20]. [21] stressed the importance of the external context in networked collaborative learning. According to these authors, the external context of a learning situation is influenced by environmental factors that have subsequent impacts on the learning process.

## 4 Development of the Approach

In order to investigate the linkage between learning space and context, we will adopt the Design-Based Research (DBR) methodology, which considers the process of design as important as the product, and where, each iteration is considered a sub-result leading to the next one [22]. The methodology would involve the conception and modelling of the context model of different learning spaces. The model draws from [15], which considers various forms of the environment (physical, virtual, social and cognitive). In this model, we take into account the "spatiotemporal location" component of the context, where the "items" represents any learning systems (e.g. in intelligent tutoring, computer-supported collaborative learning systems or massive open online courses).

The second phase of the methodology will involve the construction of an ontology of learning spaces. This ontology will be built from a reflexion on the relationship between learning space and learning situation (see Table 1). The ontology will inform the development of use case scenarios demonstrating various forms of learning spaces.

**Table 1.** Examples of learning situation

| Type of space | Learners | Learning | Teacher |
|---|---|---|---|
| Classroom | Group[a] | Individual | Human Tutor |
| Classroom | Team inside a group | Collaborative | Human Tutor and Facilitator |
| CSCL[b] System | Team or Group | Collaborative | Facilitator |
| ITS[c] | Learner | Individual | Intelligent Tutor |
| MOOC[d] | Learner inside a Massive Virtual Group | Individual | No Tutor/Facilitator |

[a]A Group = around 30 learners; a Team = 3 to 6 learners, and Individual Learning = 1 to 3 learners.
[b]Computer Support for Collaborative Learning.
[c]Intelligent Tutoring System.
[d]Massive Online Open Course.

The third phase of the methodology would involve running user experiments, where learners will engage in learning activities, and their overall learning experiences will be evaluated.

The experimental design will take into account the possible factors they attribute to enhance learning outcomes or experiences, and space and context in which this occurs. Besides, the design of the learning activities will be informed by an instructional design model, which involves analysis, design, development, implementation and evaluation (ADDIE) [23]. We will also collect learning analytics and learners' profiles to build a knowledge base (activity trace templates) [24]. The knowledge base analysis will help validate the ontology of the learning spaces and the discovery of contextual knowledge.

## 5 Summary and Future Work

Digital learning technologies have transformed the way students engage and interact off and online, yet the physical learning spaces in which learning occurs has not changed much. In this paper, we introduce the concept of learning space and the various contexts in which learning might occur. This is work in progress; future work involves the development of context-aware ontologies and conducting a series of experiments to construct a transformative learning theory that takes into account the various contexts of learning spaces (physical, virtual, social, and cognitive).

We are aware that it is unlikely that providing support to all forms of learning spaces can necessarily enable students to transition from one space to another without facing any challenges. Therefore, there is a need to address out of class physical and virtual learning spaces to encourage learning is critical as [25] noted that students tend to spend more time in informal learning spaces rather than formal learning environments.

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