Understanding Teaching-Learning Practice

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Christian Köppe *Editors*

Hybrid Learning Spaces

Springer

Understanding Teaching-Learning Practice

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Yishay Mor, Ph.D. Dr Yishay Mor is a multi-faceted researcher, entrepreneur, and consultant in educational technology and innovation. He is the CTO of EXPEditions, a vibrant start-up on a mission to make the knowledge of the world's leading experts on critical issues available and accessible to all. He works with educational institutions, NGOs and organizations to lead technology-supported innovation. Dr Mor founded and led the centre for innovation and excellence in teaching at the Levinsky college of education, and was one of the leaders of the open education challenge – the first pan-European EdTech Startup accelerator. He was a senior lecturer at the British Open University's Institute of Educational Technology, where, among other things, he led one of the OU's first MOOCs. Dr Mor has published over 60 papers (with nearly 3000 citations) and is frequently invited to give keynotes and seminars. He was the editor of eLearning Papers. He has co-organized numerous international workshops and conferences, including EduPLoP.dk and the HLS workshop at ECTEL 2019, which contributed to the work presented in this volume.

Yannis Dimitriadis, Ph.D. Dr Yannis Dimitriadis is Full Professor of Telematics Engineering and former dean of the Doctoral School, Universidad de Valladolid, Spain. He is also the coordinator of the GSIC/EMIC research group, an interdisciplinary group, integrating over 20 researchers and practitioners from the field of information and communications technologies (ICT) and pedagogy. He has contributed more than 25 years in understanding the phenomena, and supporting educational practitioners and technology designers in carrying out innovations within hybrid modes of learning (e.g. collaborative and inquiry), contexts (e.g., formal and informal) and spaces (e.g., face-to-face, web-based and 3D worlds). His recent research work has focused on learning analytics and smart learning environments, alignment of learning design and learning analytics, design patterns, conceptual and technological support to the orchestration of computer-supported collaborative learning processes, active pedagogies at scale, and across-spaces (Web, 3D worlds and augmented reality) learning. He has participated in more than 50 competitive research projects on technology-enhanced learning, co-authored more than 100 journal papers and 215 conference papers, and organized several workshops and symposia, at ECTEL, CSCL and ISLS. Dr Dimitriadis is also a senior member of IEEE and a member of ISLS, and has spent his most recent sabbatical year (2017–2018) at Berkeley, University of Edinburgh and EPFL.

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Introduction

Einat Gil, Yishay Mor, Yannis Dimitriadis, and Christian Köppe

Into the Hybrid

Recall your favorite sci-fi books or movies. Most of these are very imaginative when it comes to transportation (hoverboards, teleportation and time traveling DeLorean), weapons and even sexual recreation (see Woody Allan's Sleeper). However, when it comes to education – almost always students physically congregate in a dedicated space, where they are taught to by a master, even if that master is an alien or AI.

Now, compare this image with present day reality. We have all witnessed situations where some or all of the students are at home, in a cafe, on the beach or in the woods – while others are participating in the same experience from a classroom. Even the teachers may be anywhere. As we allow technology to intermix our physical spaces – inadvertently it intermixes our social circles. No college student would ever think of bringing their mother to school, and yet we are no

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longer surprised when a family member, friend or pet enters the frame in a video session.

The blurring of boundaries goes beyond physical and social spaces. High school students are taking university MOOCs, alongside university graduates who want to upskill themselves without re-enrolling in a formal degree program. Students in formal academic programs will fill gaps in their department's curriculum through online courses from other universities, congregating in study groups that bring together local and remote peers alongside "informal" learners. They will conduct independent research in remote laboratories and collaborate in hackathons and competitions.

Such rich and complex technology-mediated modalities of learning, formal, informal and non-formal; individual and collaborative; face-to-face and online, have been growing intensively during the last decade, and have become part of everyday life for young students or lifelong learners. Their common element refers to the hybridity of different dimensions of learning.

Fast forward or back in time, we reach the Covid19 pandemic, raising hybridity into our educational circumstance in multiple ways, and bringing the topic of this book from the fringes to the mainstream. Yet our work on this topic did not start in the Covid19 lockdown. In 2016, some of us were involved in EduPLoP.dk, a design patterns workshop focused on hybrid pedagogy. In 2019, we organised a workshop on Hybrid Learning Spaces at the European Conference on Technology Enhanced Learning (EC-TEL 2019) in Delft. This one-day workshop that explored hybridity in content and in practice brought together 35 participants from across Europe. It continued with a collation of papers contributed to BJET special section on HLS, published in the July 2020 issue (Volume 51, Issue 4). Another small step consisted in a small hybrid conference carried on in February 2020 across three geographical locations in Israel with a live contribution from Denmark.

This book offers a broad approach to Hybrid Learning Spaces, a term that has recently moved from the periphery to the center of educational practice. It adopts an interdisciplinary perspective, which combines pedagogy, technology and space design (including both physical and virtual space). The transversal inquiry-oriented approach looks at considering and connecting values, theory, design and practice. The book brings together different takes on hybridity from leading researchers and practitioners and thus presents the reader with new insights of how hybridity unfolds in different permeating planes – formal-informal, digital-analogue, online-f2f etc. We interleave voices from the learning sciences, architectural pedagogy, anthropology etc. Looking at the way hybridity manifests not only in one dimension. This book is unique in bringing together these diverse perspectives which do not often intermix.

What Do We Mean by Hybrid Learning Spaces?

The term hybrid originates in biology, where it denotes offspring resulting from combining the qualities of two organisms of different breeds, varieties, species or genera. In education, this term (often confused with blended learning) refers to arrangements which intermix distinct modes of learning and teaching. This notion, which seemed radical or esoteric not long ago, has now come to dominate our lives. Due to lockdowns imposed by Covid19, we all interleave our work and our family lives, our leisure and our teaching and learning. As Cohen et al. (2020) phrase it, "our life has been hybridized. We share co-working spaces with our families, we bring our classes into our homes, and ourselves into our students' homes". All aspects of our life seem to coexist in the same space and time, while technology enables (or forces) us to interact with peers in other spaces and times.

The notion of hybridity goes far beyond the concept of blending. While the former considers the introduction of digital elements into non-digital learning contexts (and more recently – the combination of synchronous and asynchronous modes of interaction), hybrid learning explores openly broader facets of learning coexistence. Hybridity can relate to learning with/without technology (e.g., Trentin, 2016), formal/informal learning, structured/unstructured, physical/digital artefacts and spaces (e.g., Ellis & Goodyear, 2016), teacher-student role interplay (Bennett et al., 2020) etc. Thus hybridity represents a more complex theoretical and practical construct and has duality of coexistence or even goes onto the merging of them (Eyal & Gil, this issue).

This book presents different facets of hybridity that come into play in various studies. It points to the potential those understandings yield to the present and future of K-12, higher education, or lifelong learning.

The Structure of the Book and Chapters Outline

The book is organized along three axes: Pedagogy, Technology and Space Design. Some contributions focus on a specific range in this spectrum, others traverse and connect between its parts. They span theoretical analyses, reviews, case studies and examples and design frameworks (e.g., principles and patterns). Table 1 maps the chapters according to the main axis (columns). Some chapters relate to more than one axis – thus we have added a colour to indicate primary and secondary focus, (Grey = General, Green = Pedagogy, Blue = Technology, Pink = Space design).

The book starts and ends with chapters that correspond to the general outlook of HLS (Chapters "Hybrid Learning Spaces – A Three-fold Evolving Perspective", "Hyper-Hybrid Learning Spaces in Higher Education", and "Forward Looking: Predictions for the Future of Hybrid Learning Spaces"). Eyal & Gil (Chapter "Hybrid Learning Spaces – A Three-fold Evolving Perspective") consider the semantics of hybrid learning, and the tensions between the different interpretations

Table 1 The book chapters according to the PTS axes

Pedagogy	Technology	Space Design
■■ Eyal & Gil Chapter 2 ■■ Nørgård & Hilli Chapter 3 ■■ Bøjer & Brøns Chapter 4 ■■■ Fawns et al. Chapter 5 ■ Cook & Holley Chapter 6 ■ Velamazán, Santos & Hernández-Leo Chapter 7 ■ Wong & Looi Chapter 8 ■ Bülow Chapter 9 ■■■ Mor et al. Chapter 17	■ Pishtari & Rodríguez-Triana Chapter 10 ■■■ Martinez-Maldonado et al. Chapter 11	■■ Kune & Quillien Chapter 12 ■ Mor-Avi & Scott-Webber Chapter 13 ■■ Kohls, Dubbert & Münster Chapter 14 ■■ Simpson & Goodyear Chapter 15 ■ Warburton & Perry Chapter 16 ■■■ Mor et al. Chapter 17

Legend: ■ General, ■ Pedagogy, ■ Technology, ■ Space design

of this term. On one end of this spectrum, we find hybrid as a synonym for blended learning, emphasizing the intermix of physical and virtual spaces in the context of rigid conservative educational structures. On the other end, we see unbounded multi-dimensional fluidity, allowing learners (and teachers) to move freely between physical, social and organizational spaces – while maintaining their connection with a shared educational endeavor.

Toft, Nørgård & Hilli (Chapter "Hyper-Hybrid Learning Spaces in Higher Education") coin the terms *Hyper-hybridity* and *Hyper-hybrid learning spaces* to highlight the emergence of new educational contexts, characterized by multiple dimensions of hybridity. Such contexts, or spaces, blur the boundaries between online and onsite, synchronous and asynchronous, but consequently and more importantly – the boundaries between formal and informal education, academic and work-based, and eventually between learners and teachers. Such contexts create powerful surprising opportunities for learning, but their complexity raises the risk for confusion and frustration. Thus, the design of learning activities needs to provide clear support points and enable constant re-negotiation of the space and the activities within it.

Part I focuses on **innovative pedagogies** of HLS. Bøjer & Brøns (Chapter "How Co-design Can Contribute to the Ongoing Development of Hybrid Learning Spaces by Empowering the Users") demonstrate how pedagogical and epistemic practices are intertwined and interdependent with space and technology. Engaging teachers and learners in a scaffolded process of co-design of educational spaces opens up possibilities for reflection, meta-epistemic discourse and self-determined learning, while creating unique opportunities for teachers' professional development. Such a process is in itself a hybridisation of the educational structure, blurring the boundaries between teacher and learner.

In Chapter "H2m Pedagogy: Designing for Hybrid Learning in Medical Education", Fawns, Markauskaite, Carvalho & Goodyear report on an adaptation of the ACAD (Activity-Centered Analysis and Design framework) framework to offer academic staff a professional development course called "Agile Course Design for Professional Education". This course scaffolded participants in a process of reflecting on and designing for professional education in the age of COVID19. The limitations of social distancing triggered a renewed focus on learner agency and flexibility, and an inspection of the efficacy of educational practices. Thus, necessity and external challenges can drive innovations which will have value long after the current crisis is behind us.

Three cases transforming into online/hybrid learning in the time of Covid19 are presented in Cook and Holley' Chapter "Covid-19 Lock-Down: Hybrid Learning Cases Using the Lens of the Zone of Possibility", set within a framework of Zone of Possibility (ZoP). The authors inquired how the design process can advance or bridge effective communication and an understanding of social context in a ZoP. Their findings identify critical factors: contextual framing, pedagogic implications and implications for design for case study analysis. An emergent meta-design principle is implied for future design, acquiring the name 'Respect Learners' Zone of Possibility'.

Velamazán, Santos and Hernández-Leo (Chapter "Socio-emotional Regulation in Collaborative Hybrid Learning Spaces of Formal–Informal Learning") highlight the issue of socio-emotional regulation in the context of formal and informal hybrid learning context. With study data collected from students' activity within the content area of Mathematics they offer to further investigate and design ways to support students in improving their socio-emotional regulatory skills through hybrid learning contexts.

Wong and Looi (Chapter "Seamless Hybrid Science Learning: Streamlining the Techno-Pedagogical Designs for Wider Diffusion") present and evaluate in a two-year study a set of pedagogical design principles known as C2FIP (Connectivity, socio-Constructivist learning, Formative assessment, leveraging resources in Informal settings, Personalized learning) for hybrid seamless learning. Their qualitative descriptive study in real-world contexts allows an assessment of the proposed design principles and points to a complex landscape of hybrid science learning. Adoption of the design principles may require a deep enculturation process across multiple stakeholders (teachers, learners, curriculum and instructional designers, etc.), since such principles involve an integrated view of some important dimensions of hybrid learning such as individual/collaborative/classroom, formal/informal, formative/evaluative, personalized and inquiry.

Bülow (Chapter "Designing Synchronous Hybrid Learning Spaces: Challenges and Opportunities") looks at synchronous hybrid teaching, a specific case of hybrid learning, when students in different locations, including the physical class, engage in learning in a shared learning space. Looking through the ACAD framework, he synthesizes insights from a review of 47 recent papers. The chapter unfolds the challenges and opportunities pertaining to the design of learning that many institutions adopted, due to pandemic, but apparently was in use beforehand.

From this review, he formulated guidelines for supporting activity-centered learning design for learning in a post-pandemic future.

Part II puts more emphasis on **technological issues** underlying hybrid learning spaces. Pishtari and Rodríguez-Triana (Chapter "An Analysis of Mobile Learning Tools in Terms of Pedagogical Affordances and Support to the Learning Activity Life Cycle") deal with the relevant domain of mobile and ubiquitous learning. Most specifically, the chapter considers both pedagogical and orchestration affordances for the m-learning tools that have been analyzed. The authors propose a new framework, OA-LALC, which provides a very interesting view of the orchestration affordances for both Learning Analytics (LA) and Learning Design (LD) viewpoints in the different phases of the learning activity life cycle. It is expected that the framework can guide researchers in further studying an integrated view of LA and LD in current and upcoming hybrid learning environments. Finally, the chapter provides insights on the issues that arise when different spaces (digital and physical), learning settings (formal and informal) or contexts (indoors and outdoors, in-classroom and out-of-classroom) are considered in a hybrid learning context.

Martínez-Maldonado and colleagues (Chapter "Classroom Analytics: Telling Stories About Learning Spaces Using Sensor Data") present and discuss three data stories in which data traces are collected through sensors from classroom activities and meaningful classroom analytics are generated. Position and proximity sensors provide useful multimodal classroom proxemic analytics that may contribute to assessing pedagogical activity; informing the eventual re-configuration of the learning space; providing digital traces and analytics to students and teachers; and speeding up research cycles that currently depend only on observations. Researchers in hybrid learning spaces may build on the concept of classroom analytics and eventually bridge these classroom digital traces with those occurring in online or out-of-class spaces.

Part III emphasizes the **spatial design** of HLS. Kune and Quillien (Chapter "Co-creating Futures Through Virtual 'BAs'") take an interesting viewpoint for the hybridization of innovative processes common in education. They explore the Japanese concepts of BA, MA, WA, and KATA and how these foster co-creational collaborational activities. The authors discuss the interpretation of these concepts and their manifestations in online environments, clearly showing the shortcomings and challenges of current virtual technologies. Using the concepts for adapting the processes and technologies requires a more hybrid approach, the suggested design constraints and the personal reflections and thought experiments help the reader to concretize the ideas of this essay.

Mor-Avi and Scott-Webber (Chapter "Creativity Flourishes Using Hybrid Space Patterns") look closer at the impact of architectural solutions in educational settings which stimulate creative and collaborative processes. Based on conducted research, the authors identify several dimensions supporting creativity and learning which seem contradictory when interpreted as dichotomies. Applying the hybrid approach offers opportunities for intermingling these dimensions and in consequence allowing flexible space design which is adaptive to learners' needs. The resulting types of design patterns provide good guidelines for designers and architects of adaptive learning spaces.

The focus of Chapter "Patterns for a Hybrid Campus" by Kohls, Dubbert & Münster are good practices for creating hybrid learning spaces at university campuses. The authors start with the identification of hybrid space dimensions based on the ideas of hybrid pedagogy, blended learning, and seamless learning. These dimensions are explored with fictional design examples, followed by a presentation of their realization in a concrete case study. The authors use design patterns as a way to generalize their experiences and observations, the paper concludes with a specific pattern which can be applied by other designers of hybrid learning spaces.

Simpson and Goodyear (Chapter "Dialogic Teaching and the Architecture of Hybrid Learning Spaces: Alexander Meets Alexander") take the idea of dialogic teaching (by Robin Alexander) and describe its applicability in hybrid learning spaces. They provide two extensive examples of how the dialogic approach was reconfigured to match the move to hybrid learning in a mainly online environment. Descriptions of concrete implementations such as the use of traveling artefacts, the extension of the classroom space, or space transitions in online environments are complemented with a more architectural view on learning space design as also discussed in the work of architect Christopher Alexander.

Warburton and Perry (Chapter "Design for Balance: Addressing Challenges of Safety, Privacy and Identity Management in Online and Hybridised Learning and Teaching Spaces") bring together several related important concepts that characterize hybrid learning spaces, such as privacy, safety and identity, through a joint model and five design patterns. They contribute with emerging ideas towards hybridized learning, with a strong focus on recent experiences with the Covid-19 pandemic and social networks. Most interestingly, the authors suggest the use of place as the term to replace space, as "it allows learning designers to access relational, emotional and comparative thinking in their designs", since "place is authentic and always socially constructed, in other words somewhere that is emotionally and personally significant".

We conclude with the *Forward Looking* chapter ("Forward Looking: Predictions for the Future of Hybrid Learning Spaces") by Mor, Gil, Dimitriadis & Köppe that synthesizes insights from all chapters and distills some predictions for the HLS close and distant future. These predictions underwent a "quasi-Delphi" study to acquire validation and refinement, the results of which are laid out for current special interest and future research. Two predictions stand out: first, Hybridity has become the standard in post-COVID19 educational systems, but in the narrow sense of blended / HyFlex (dual mode, hybrid synchronous instruction) classrooms. The normalization of hybridity will open the door to more innovative forms – where dichotomies of formal-informal, academic-work etc. are blurred. While these more radical interpretations of hybridity (or hyper-hybridity) will never become mainstream, they will nonetheless become more common and the place for students' motivation might play a more central place in the learning process. Second, Hybridity also includes a shift from passive to active learners, which necessitates a fresh view on the design of the physical and virtual spaces – which will need to afford flexibility and empower learners and teachers to shape their learning context, and engage, in the words of Donald Schön, in a constant conversation with the materials of their environment. These are just two out of the 11 predictions we uncovered. These garnered the highest level of consensus. But we found the most disputed ones just as interesting, for they signify that this is a dynamic field, where the community is still exploring the boundaries of possibility and the governing rules of interaction.

Summary and Vision

In 1977, Christopher Alexander and his colleagues published their seminal book "A Pattern Language: Towns, Buildings, Construction", among the design patterns they advocate are "network of learning", "university as marketplace" and "shopfront schools". All three reflect a vision of hybrid learning spaces. Indeed, many of the ideas that we present in this book can be traced back decades and even centuries. Yet educational institutions, like many large institutional systems, are notoriously resistant to change.

Recent years have brought about the unprecedented combination of acute needs and technological availability, which have created the opportunity for these ideas to manifest themselves. As the world recoils from the pandemic, some of the emerging practices will be undone, some teachers and students will go back to their old habits and experiences. Others will maintain the new practices that have proven effective, and others still will combine old and new and seek new ways to improve both.

Our work on hybrid pedagogy and hybrid learning spaces started in 2016 with the 2nd EduPLoP workshop. The world has changed a lot since, and we see many of the results of this workshop applied in various educational fields. But in the last years – and especially during the pandemic – it also became clear that we still just have opened the door to this perspective in educational design which might, and hopefully will, have a larger impact on future education. It is time for some change, it is time for hybrid learning spaces.

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Part I
Into the Hybrid

Hybrid Learning Spaces — A Three-Fold Evolving Perspective

Liat Eyal and Einat Gil

Introduction

Hybrid learning has become a buzzword over the course of the Covid-19 pandemic. Google Trends indicates a sharp increase in the number of searches of the term *hybrid learning*, from the onset of the pandemic, with searches peaking during August 2020 (see Fig. 1). The term is used by departments of education, institutions of higher learning, and anyone wishing to introduce an innovative and up-to-date educational service or product to a broad audience. Although widespread use of the term began before the Covid-19 crisis, *hybridity* has become the need of the hour during the pandemic. In fact, there sometimes exists the impression that anything that is not *hybrid* is outdated and irrelevant.

Before moving on to formal definitions of learning, let us explore some examples of the use of the term *hybrid* in our everyday lives and workplaces. Hybrid vehicles are already a familiar concept. These vehicles combine the activity of two engines: gasoline and electric, operating alternately according to driving conditions, intended to reduce air pollution and save on fuel costs. In the field of medicine, hybrid medicine operates in the realm of telemedicine. Current medical services are partially provided at home through digital applications and devices that enable medical diagnosis and monitoring, such as via electrocardiograms, or ear imaging. Another example is a hospitalization room that can be converted into an operating room within minutes. Among the advantages are multi-functional equipment, saved

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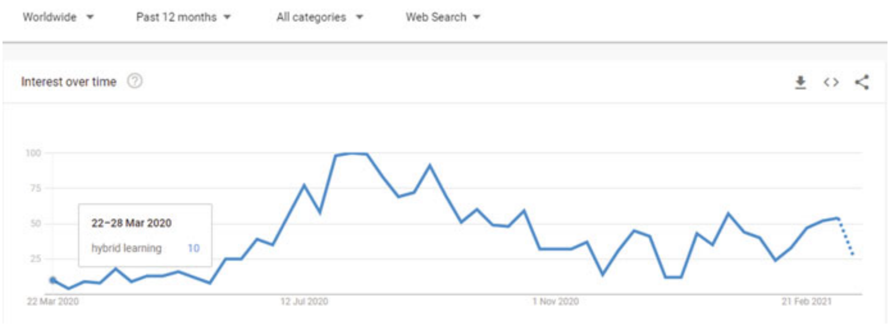

Fig. 1 The popularity of *hybrid learning* searches, as reflected in Google Trends between March 2020 and February 2021. (Data source: Google Trends, https://www.google.com/trends)

time, reduced costs, and effective treatment. A new trend is also emerging in the labor market, where organizations seek to employ hybrid workers. These are multi-skilled workers who can, for example, combine technical skills, such as programming, with marketing skills, financial savvy, and so on. The ability to view a business from different perspectives holds advantages for an organization, such as the identification of opportunities, the capacity to solve problems and innovate, and also might benefit employees' professional and personal development.

The above examples demonstrate the organizational, personal, economic, and social benefits of hybridity for at least some stakeholders. However, the frequent use of the term *hybrid* does not suggest that it holds the same meaning in all cases. Moreover, there are various interpretations of the term, even within a single field. With regard to education, the Covid-19 pandemic has presented an excellent opportunity to discuss *hybrid learning*. What are the different meanings of the term as they appear in the research literature? Are the meanings found related to technological developments?

In the following sections we map out the various meanings of the term *hybrid learning*. The main perspective is on teaching and learning processes and environments, rather than highlighting aspects relating to educational institution management and economic efficiencies. In addition, we suggest an updated meaning *of hybrid learning* to create a common language among researchers and educators. Finally, we examine the contribution of the term to teaching, learning, and learning design.

Hybrid as Blended

In the research literature, *blended* and *hybrid* learning often appear as interchangeable or synonymous terms. Some authors are uncertain which term to use and mention them both. As stated in one study, "these two terms *blended* learning and *hybrid* learning are used alternatively but refer to the same concept" (Olapiriyakul & Scher, 2006, p. 288). The ERIC Thesaurus refers to *hybrid* learning as an obsolete term and synonym for *blended* learning. Thus, temporarily, blended learning replaced hybrid learning, residing under "Teaching Methods."

Garnham and Kaleta (2002) define hybrid courses as "courses in which a significant amount of the learning activities has been moved online, and time traditionally spent in the classroom is reduced but not eliminated." Most courses that were taught at that time (i.e., the start of the twenty-first century) started off as face-to-face (f2f) courses. The authors' definition was based on the experiences of four academics from different disciplines at the same institution, who transformed their teaching into a hybrid model. The number of students in their classes ranged from 15 to 200. The purpose of hybridity was to "reduce class seat time" and "promote active independent learning." The instructors reported that this kind of learning enabled them to better achieve course goals than in regular f2f courses, measured by the level of interaction and engagement of learners, flexibility, reduced commuting time, and the quality of learning outcomes. At the same time, the instructors asserted that they had to invest significant time in planning their lessons and learning to work with the technology. Students reported their experience with this model of hybrid learning as positive, stating that it required more effort than passively sitting in a class and that they were required to better manage their time.

Other researchers have similarly defined *hybrid* learning as combining f2f learning with access to online learning tools (e.g., Hall & Davison, 2007; Hrastinski, 2019; Watson, 2008). "Hybrid or blended learning refers to a combination of face-to-face learning, including but not confined to lectures, and online learning" (Garrison & Kanuka, 2004; see also Lack, 2013; Means et al., 2009; Reasons et al., 2005).

So far, the term *hybrid* appears to imply a somewhat technical change in study methods, as a result of external technological developments that allow for altered learning environments, without any specific reference to the complexity that might be involved in teaching/learning. It is a continuation of learning rather than a profound change. This is true for the Macmillan Dictionary 2007 Buzzwords list, where *blended learning* is defined as "a method of learning which uses a combination of different resources, especially a mixture of classroom sessions and online learning materials" (Macmillan Dictionary, n.d.).

It was initially assumed that *blended* learning, or diverse teaching methods utilizing online environments, would be a key factor in disruptive innovation in education (Christensen et al., 2008). Christensen et al. (2008) claim that the traditional educational system suffers from intrinsic problems such as teacher-centered methods and curricula, unified and fixed learning approaches, and inaccessibility of quality education. They maintain that hybrid/blended learning will successfully solve at least some of these challenges by creating tailor-made teaching adapted to students' needs in terms of level, style, topics, and schedule. Using the internet, students will be able to consume quality content even if there are no such services in their residential area. However, despite the increased number of learners in

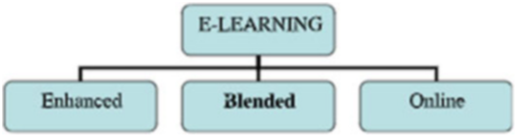

Fig. 2 A continuum of e-learning (From Garrison & Kanuka, 2004)

the blended approach and the variety of possibilities it offers, it seems that a fundamental disruption has not occurred.

Schank (2001) offers a cynical view on *blended learning*. He describes it as being taught both conventionally and partially online, but the emerging *blended–hybrid* product neither disrupted education nor lived up to expectations. In most cases it preserved classical pedagogy. Educational institutions still control the monopoly of content in teacher-centered curriculum resources. While there are digital versions for some of these resources, teaching methods remain basically the same. Christensen et al. (2013) retreated from their own earlier prediction: "The models of blended learning that follow the hybrid pattern are on a sustaining trajectory relative to the traditional classroom. They are poised to build upon and offer sustaining enhancements to the factory-based classroom system, but not disrupt it" (p. 3).

The term *hybrid* perhaps naturally evolved, from a term that was used temporarily but later discarded. So far, *hybrid* and *blended*, when used synonymously, have focused on the place- and time-dimensions of learning. In other words, they refer to the varying ratios between f2f, physical meetings, and online learning via digital platforms/resources. Yet the term *hybrid* is moving towards gaining a different dimension. In a widely cited paper, Garrison and Kanuka (2004) distinguish between *blended* and other forms of learning that include opportunities for online learning. They present these learning forms on a continuum: enhanced f2f that incorporates technology, blended learning, and online learning (Fig. 2). Their conclusion is that *blended* is more complex since it represents a fundamental reconceptualization and reorganization of the teaching and learning dynamics.

Twigg (2003) classifies *blended learning* as five models: In the **replacement model**, lectures that are f2f are substituted partially or fully by online material (the flipped classroom). In the **supplemental model,** students are asked to attend the same number of class meetings, but to access technology or web-based materials as additional resources. The **buffet model** provides participants with a list of learning activities that includes both f2f and online formats. Selecting activities and materials depends on what is beneficial to learners' objectives and interests. The **emporium model** states that the ideal time for learning is when a student wants to study rather than when an instructor wants to teach; therefore, it eliminates all classroom meetings and allows students maximum personalization. The **fully online model** assumes that an instructor must be responsible for all tasks, interactions, and evaluations.

The above-mentioned review of what might be called the "first generation" *hybrid* definition indicates that there are two distinct worlds: one in which learning occurs f2f, and the other in which learning takes place through digital means, through distance learning and in the online environment. Each is a separate and distinct entity, and their combination is a heterogeneous mixture. That is, there may not be a uniform distribution of session types, and their ratio/quantity may vary as necessary. In some respects, the properties of each of these learning modes are kept separate, like oil and water, which are immiscible. Furthermore, in this mixture, the instructor or institution controls the online versus f2f ratio and course content, to the most part. The considerations are often related to the convenience of operating an academic institution curriculum or to economic factors, but they are usually not pedagogical considerations.

However, the ERIC Thesaurus describes *blended learning* with more elaborate pedagogical consideration, adding to this approach other combinations, such as individual and group instruction, self-paced instruction, and the lecture method. Therefore, the questions to be answered are, what makes the combination more than a technical platform, a mode of knowledge communication, beyond time and space? How does the pedagogical design of learning fit into this and is there more to *hybrid* than *blended*?

At this point, we suggest referring to the commonly used term *hybrid-flexible*, or the *hyflex* approach (Beatty, 2008). *Hyflex* is an instructional approach for course formats that combines f2f and online learning. Each class session and learning activity is offered in person, synchronously and asynchronously online. Thus, students can choose the time and place in which to study (Ferrero, 2020).

In the COVID-19 crisis, numerous institutions transformed regular classes into classes adapted for teaching in these times, by reducing the number of students per class and implementing social distancing. Furthermore, they added technological platforms that allow f2f and remote participants to join in online, enabling the students to choose from where to join the session. This can be viewed as a type of hyflex - blended learning, since it allows flexibility in the technical aspects of learning, similar to the **replacement model** (Twigg, 2003). In both formations, hyflex is not a pedagogical sought-after aim or an ideal, but rather an attempt to answer current needs, giving each student equal opportunity to participate with ample flexibility.

Hybrid as a Space of Merging Interactions

Hybrid as blended presents an approach that focuses on the location of the learner: in a classroom or in an online learning environment. Yet when students have a smartphone connected to the internet, their physical location is irrelevant. Thus, two somewhat static and differentiated states — f2f and online — progress into a more dynamic environment: “Hybrid spaces are dynamic spaces created by the constant movement of users who carry portable devices which are continuously connected to the Internet and other users” (de Souza e Silva, 2006, p. 262).

The state of being "always on" changes our perception of the two environments and defines our communication as either f2f or f2-computer. Thus, the distinction between physical space and digital space is somewhat obscured. A *hybrid* learning environment utilizes a mobile digital interface that obliterates the barriers between f2f and f2-computer, blurring confined limits.

A state of constantly being connected adds a social dimension to the learning experience, reflected in interfaces such as chat rooms, online games, and social networks. Thus, another version of hybridity is manifested in a combination of three overlapping spaces: mobile (virtual), social, and physical spaces. As such, "*hybrid* spaces merge the physical and the digital in a social environment created by the mobility of users connected via mobile technology devices" (de Souza e Silva, 2006, p. 263).

Metaphorically, hybridity might be moving away from the concept of "mixture" towards that of a "compound." In a compound, the materials do not retain their initial properties, but rather blend with each other, forming a new material with properties different from the properties of each constituent material. For over a decade, young people have not considered the web as a space separate from their daily lives. Rather, this space is part of their vivid reality (de Souza e Silva, 2006), a reality characterized by overlapping environments, and created by their integration via mobile devices. Since then, the impact of mobile devices and internet availability continues to unfold, and intermixed reality perceptions are at present more widespread and relevant.

As early as the 1930s, Dewey (1976) emphasized the importance of learning environments in the educational and learning process. According to Dewey, one of the important roles of a teacher is to create a learning environment suitable for raising children, by arranging the tools and materials that may be used as stimuli and by activating those strengths and interests of the child that are conducive to learning and developing. By the term "learning environment" Dewey meant the immediate environment of the child, for example, a farm environment or one that is rich in equipment and allows space for movement and action. This approach has inspired a location-based mobile learning approach, tailored for current technology and demand. It adopts the benefits of mobile technological methods (e.g., inquiry-based, visually displayed information and location-relevant information) for learning outside the formal classroom. Thus, the premise that the learning process can take place anytime and anywhere, through local interaction, enables the design of open-ended learning environments that provide ample possibilities for creating meaningful learning experiences. Learning tasks can be varied, including, for example, location-specific research projects, building place-based learning paths in a historical context, application development, mapping urban information, and contributing to the community. The environment may also contain resources locatable with mobile technology. However, the environment seems to be a key component in learning engagement, as Goodyear (2020) explains that hybrid learning spaces or novel complex learning spaces are "spaces in which students' activity is situated and supported by rich mixtures of material and digital tools and resources" and goes on to refer to the important role students play "in co-configuring the learning spaces and/or the learning tasks," referring to the ways students work with their peers.

The term *situated learning theory* is relevant to our discussion. This theory suggests that learning can be unintentional and exist within authentic activity, context, and culture. In contrast with most classroom learning activities that involve knowledge learned out of context, Lave and Wenger argue that learning is situated within a certain activity, context, and culture and that learning is also usually unintentional rather than deliberate (Lave & Wenger, 1991; Wenger-Trayner & Wenger-Trayner, 2020). It is this greater context of both deliberate and unintentional learning that play a role in hybrid learning and the various spaces it encapsulates.

An additional implication of the combination of mobile, social, and physical components is that learning becomes anchored in a context of social meaning. Learners do not engage in intellectual discussion only with regard to a specific topic, but are involved in human interactions as part of a social environment. Learning takes place with social participation (Lave & Wenger, 1991; Wenger-Trayner & Wenger-Trayner, 2020). Instead of asking what types of cognitive processes and conceptual tests are included in the process, they ask what types of social involvement provide an appropriate learning context. The social context for learning plays a central role in Trentin's (2015) perception of hybrid learning systems (HLSs): "HLS-teaching concentrates on the **relationship among learners,** and that between learners and the knowledge to be acquired. Students are helped to be more **autonomous**, **proactive** and responsible towards their own **learning processes**" (p. 6, emphasis added).

This socio-constructivist paradigm that focuses on the relationship between learners as autonomous, proactive entities responsible for their learning, combined with their constant online presence, produces an infinite potential of learning possibilities, but not necessarily those realized in an educational, institutional context. When institutions, accustomed to adopting curricula and having their teachers implement or at most interpret the curricula, realize that another world of unrelated learning is occurring outside the institution's walls, they try to close the gaps. One way to do this is the Bring Your Own Device (BYOD) approach (e.g., Alberta Education, 2012). Although this strategy allows individuals to use their private devices within an organization or educational institution, it also has clear economic benefits, and it changes the rules of the game by altering the institution's learning environment itself.

Trentin (2015) seems to support the dynamic aspect of hybrid spaces and the constant movement of users carrying portable devices. He asserts that if we want to create sustainable models for education, we need to understand both the conditions and the challenges for learning that exist in *hybrid* learning spaces. For example, teachers do not have enough training to plan activities suitable for such an environment. While in traditional teaching, the teacher conveys knowledge, the teacher's role in a hybrid environment should be to guide learners. Learners are not passive when they interact with content, the teacher, and their peers, autonomously and in groups. Learning is characterized as active and collaborative, and the content has a flexible attribute to it. The role of technology here is to encourage learners and contribute to the learning environment. Trentin (2015) presents hybrid learning space as a bi-dimensional model on the crossing axes of ’onsite–online’ and ’individual–collaborative’ learning.

However, there is a distance between this discussion and the designing of hybrid learning by teachers in educational institutions. Teachers require scaffolding to help them understand what learning structures are possible in hybrid environments in order to be able to achieve the required learning goals. In our opinion, teachers must compromise between the learning goals set by the academic institution and the variety of options available for learning. This seems to provide a path towards enabling sustainable teaching innovation, and leads to the term *design pattern*, which refers to practical knowledge formulated by experts that can be applied in different contexts and shared with others (Warburton & Mor, 2015).

Köppe et al. (2017) suggest a fresh look at *hybrid* education that utilizes educational design patterns. According to them, *hybrid* education is

> the use of educational design patterns that actively strive to cut across, circumvent or upheave traditional dichotomies within education such as **physical-digital**, **academic-nonacademic**, **online-offline**, **formal-informal**, **learning-teaching** and **individual-collective**. In doing so, hybrid education invites uncertainty, open-endedness, risk-taking, experimentation, critical creativity, disruption, dialogue and democracy (back) into the heart of education. (p. 1, emphasis added)

Their definition provides tools for the teacher planning his or her lessons to utilize educational design patterns. The practical aspect of the definition is the use of design patterns into which every teacher can mold their subject material and learning goals. Within these design patterns there is a continuum, from traditional teaching to educational methods in the digital age. Köppe et al.’s definition reflects critical pedagogy, utilizing democratic values that seem to have been neglected in traditional learning methods. It attempts to break down a homogenous reality into multiple meanings and possibilities. The result is an eclectic, multi-dimensional reality with a broader pedagogical potential. This potential may be realized through the choice and combination of dimensions and is repeatedly redefined within a design pattern for learning (Köppe et al., 2017).

Hybrid as Fluid

So far, the discussion of hybridity, both *hybrid as blended* and *hybrid as a space of merging interactions*, has dealt with the way in which the term “hybrid” addresses learning as a part of a formal framework, usually bound by systems and circumstances, and constraints such as place, time, and budget. Institutions need to translate learning to the framework and learner needs such as degree certificates, curricula, goals, assignments, and grades. Whether f2f or digitally, institutions use various systems to monitor students’ learning processes, and determine academic eligibility accordingly.

Fig. 3 Colorful fluid mixing in Fluid Simulation app, illustrating hybrid as fluid

However, *hybrid* in its fluid meaning emphasizes something else. **It is the learners' choice that crosses boundaries, rather than being limited with constraints**. The choice is the result of individual motivation and is not dictated by institutions or prescribed rules. True choice is possible only when there are no boundaries, or more precisely, when boundaries are blurred. Only then can the individual be fully autonomous. In this sense, *hybrid* has the characteristics of self-regulated learning.

In a like manner, "fluids, [. . .] neither fix space nor bind time," suggests Bauman (2013), describing a characteristic of this era. Fluids are substances capable of flow, depending on changes in the environment, which may be rapid and numerous. Fluids are also less predictable than solids. They are constantly able to change form, and thus adjusting to space, over time. Such is hybrid learning at present, illustrated by a colorful imaginary fluid mixing (see Fig. 3).

Stommel (2018) claims that "**all learning is necessarily hybrid**," and says "In classroom-based pedagogy, it is important to engage the digital selves of our students. And, in online pedagogy, it is equally important to engage their physical selves." He makes a distinction between *blended* learning, which he relates to as tactical, referring to different combinations of change in the learner's position, while *hybrid* pedagogy is a strategy that changes the concept of place and brings the types of learning that occur in physical and virtual spaces into a dynamic place. Therefore, Stommel asserts that the term *hybrid* in hybrid pedagogy is not just hybrid learning, and he suggests that we think holistically about the variety of types of hybrids that result from the ways we live our digital lives, both in academic and nonacademic spaces. In this somewhat philosophical observation, Stommel refers to an educational conception as a whole, which regards the formation of individuals' human identity as the center of the educational act. It is not the result but the process itself.

In *hybrid as blended*, the meaning of hybridity is rooted in the somewhat "physical" location. In hybrid as merging interactions, the meaning is rooted in the environment, while in *hybrid as fluid*, hybridity is rooted in a learner's autonomous identity. In support of Stommel's view of "process," a person does not belong to only one cultural group, but forms his or her identity in various, changing cultural circles, while each sharpens and changes the individual's identity (Burke, 2006). The process emphasizes identity as an unfinished process which is revealed gradually to the person and his or her environment throughout life. People undergo this journey of discovering and shaping their identities throughout their lives. The role of education, formal or informal, is to help the person discover and shape his or her identity. As Stommel (2018) explains: "Hybridity is about the moment of play, in which the two sides of the binaries begin to dance around (and through) one another before landing in some new configuration" and goes on to state that it is expressed in the crossroads of binary pairs:

> Physical Learning Space / Virtual Learning Space; Academic Space / Extra-academic Space; On-ground Classrooms / Online Classrooms; Permanent Faculty / Contingent Faculty; Institutional Education / Informal Education; Garden-walled Academia / Open Education; Scholars / Teachers; Academic Product / Learning Process; Disciplinarity / Interdisciplinarity; Performed (School-y) Selves / Real (Vulnerable) Selves; Individual Teachers, Students, and Scholars / Collaborative Communities; Learning in Schools / Learning in the World; Analog Pedagogy / Digital Pedagogy; Use of Tools / Critical Engagement with Tools; Machine and Machine-like Interaction / Human Interaction; Passive Learning / Experiential Learning; Teaching and Learning / Critical Pedagogy.

These dichotomies and the continual crossover between them create a network of possibilities in which every node is temporary for the specific need in real time. Autonomous learners continuously make decisions about their own learning. They determine what and when to study, manage their own time, decide what resources are appropriate for the learning goals they have set for themselves, adapt learning strategies, and create valuable new knowledge for others in the world. They expect to contribute to the learning of others as well as to their own learning, and see themselves as experts in specific contexts. This learning shapes a learner's identity which in turn creates further learning. Unique identity is the unifying factor in any framework in which learners find themselves. There is a mixture of work groups and leisure groups, between which learners move easily. They gain new knowledge and incorporate it into their current understanding so that their expertise changes dynamically to suit their current needs. This is part of being a lifelong learner. Since identity is fluid, learning is fluid, too.

Nørgård & Hilli (2022) interestingly relate to *hyper-hybridity*, which may reside at the meeting point between *hybrid as a space of merging interaction* and *hybrid as fluid*. They assert that "multiple hybrid dimensions are engaged and hybridized at the same time", and "demand that we rethink and hybridize time, space, and structures so they become neither time-bound nor space-bound" (p. 8). However, they do not see the learner's motivation as necessarily central to this process.

Let us zoom-in on one example to demonstrate the fluid aspect of hybridity. This example occurred in a class in a course relating to future/active learning spaces, taught by the second author for M.Ed. students in the first wave of the Covid-19 pandemic in Israel. In this synchronous class, we hosted a lecturer from abroad who spoke about the design and impact of active learning environments. One of the students joined the Zoom meeting from her phone in her car, and during the presentation, we actually could observe her attentive participation from the car, then the walkway, elevator, and finally, as she switched to her computer at home — where she asked an extremely relevant question. Furthermore, she took some of the insights presented (about learning spaces) to her principal at school, because the student saw the knowledge as so relevant and practical as to be applicable (changing the library to an active learning space), and corresponded with the class and guest lecturers about it.

This example demonstrates how the learning process continues almost uninterruptedly through different spaces, formal and informal, from theory to application, college and school, and over different digital platforms, resulting in enhanced learner motivation to bridge them all.

Metaphorically speaking, a 3D container holds hybrid learning in its fluid state, dictating its limitations. Educational systems try to adopt the fluid hybridity components via learning innovation trends rooted in understanding this perception. Examples would be micro-accreditation that makes it possible to study mini-courses to be fulfilled from any place and time; MOOCS, where one can choose a subject, lecturer, and university to study (often) free of charge; and flexible learning environments, in schools or flipped classrooms. These are attempts by educational systems to adapt their understanding of fluid hybridity and apply it so as to remain relevant and adapt to the needs of learners. Yet a truly fluid hybrid resists fixed boundaries of teacher, time, place, curriculum, goals, and methods of teaching, learning, and assessment. In fact, the attempt to define the concept of hybridity as fluid would be a contradiction to its meaning.

This raises questions about the future of higher education, particularly around how to increase its relevance to all three interpretations of hybridity and accommodate them with appropriate learning spaces.

Discussion: Integration of Insights

In the attempt to encapsulate *hybrid* learning and the space in which it operates in higher education, we presented an evolution of interpretations and meanings of the concept, as related to education and learning. We first looked at *hybrid as blended*, emphasizing the interchangeability between the meaning of the terms. Essentially, *hybrid as blended* focuses on the place in which learning occurs, whether online or f2f, and the need to replace one with the other, sometimes due to technical or economic considerations. In this domain, the hyflex model (Beatty, 2008) blends in seamlessly.

We then presented *hybrid as a space of merging interactions*. Here, *hybrid* learning spaces are created by the constant movement of users who carry portable, internet-connected devices, and thus are dynamic spaces (de Souza e Silva, 2006). This hybrid beyond blended reflects the merging of the physical and the digital together with a social network and environment. It might be supported by design patterns and/or diverse learning environments. Hybridity here is not a mixture but more of a "compound." There is a greater relevance of learning as being situated in a specific context and HLS teaching concentrates on the relationship among learners, and between learners and the knowledge to be acquired.

Thirdly, we looked at a new proposed interpretation: *hybrid as fluid*. Here, fluidity represents a greater flow in and between dichotomies such as formal/informal, with/without technology, homework/no homework, and so on, with an emphasis on a motivated learner identity that moves autonomously across dichotomies. In these *hybrid* spaces of learning, there are no "just-in-time rules." Rather, learning proceeds in and beyond technology and space, instigated by the drive for learning and curiosity. Fluid hybrid learning is an ever-changing hybridity that is not bound by conformity and is characterized by breaking boundaries as necessary.

In this respect there is something about *hybrid as* fluid that has a threshold nature, being transient and lacking marked signs. Since we constantly need to learn quickly, in real time, this learning is always instigated from a question or an inquiry. In the same way that water uses or can be freed from conduits to sustain it, learning can be freed from previously accepted norms or confining scaffolds.

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Hyper-Hybrid Learning Spaces in Higher Education

Rikke Toft Nørgård and Charlotta Hilli

Introduction

In recent years, we have witnessed initiatives from higher education institutions and scholars to push against pervading neoliberal or corporate higher education (Barnett, 2017) and focus more on creating dialogic knowledge through critical-creative partnerships, academic engagements, and co-creation of future knowledge and competencies beyond the immediate applicability within a course or study programme. Examples of this move towards more connected, dialogic and hybrid higher education can be found in e.g. the Connected Curriculum strategy from University College London (Fung, 2017), The Near Future Teaching initiative from The University of Edinburgh (Bayne & Gallagher, 2019), Staley's book on alternative universities (Staley, 2019), Barnett's recent book on the ecological university (2017), Besley and Peters compilations on the creative university (Besley & Peters, 2013; Peters & Besley, 2013) as well as the emergence of the field of hybrid education. Here, we find a visible shift within higher education institutions towards educating for hybrid learning in an unknown future, where society and university become more closely connected and integrated into each other.

This emerging higher education framework is a framework for learning that enters into connected dialogue and collaboration with the world through taking action in the form of thinking, doing and being beyond the course, study programme, or institution. Overall, higher education in the form of hybrid courses entails opening up institutions, study programmes, and courses to meet, think, work,

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and learn in, for and with the world (Nørgård et al., 2019). Prior work within hybrid education accentuates how higher education through notions of hybridity can invoke productive entanglements, networking collectives and new learning spaces for connected, networked and ecological teaching and learning (see e.g. Cohen et al., 2020; Nørgård et al., 2019; Hilli et al., 2019; Kohls et al., 2017, 2018; Köppe et al., 2018a, b; Pedersen et al., 2018; Zitter & Hoeve, 2012).

The present chapter investigates a higher education course in the form of a hybrid learning space aimed at supporting hybrid learning among students by offering cross-national collaboration. In the course, teachers and students from different countries (Denmark and Finland), disciplines, and study programmes found themselves moving between spaces, tools, and theories to become better at thinking, working, and learning together in relation to the joint theme 'Digital change in education'. Based on the analysis of the learners' experience, we suggest two new concepts, *hyper-hybridity* and *hyper-hybrid learning spaces*, to highlight the complexity involved in teaching and learning based on the design principles described below and previous research discussed later on. As this chapter's analysis will show, hyper-hybrid learning spaces pose a number of challenges that are relevant to consider if higher education institutions want to integrate and carry out hyper-hybrid learning spaces wherein multiple hybrid dimensions are put into play and integrated into each other at once. Forms of entangled collaboration are often part of hybrid learning spaces as participants move between e.g. physical/digital, synchronous/asynchronous, informal/formal, or structured/unstructured spaces (Stommel, 2012; Ellis & Goodyear, 2016) or teacher/student roles (Bennett et al., 2020) to create something new together.

Cook et al. (2020) highlight an inherent openness in hybrid courses that offer teachers design opportunities to structure them more freely. Such openness creates both potentials and challenges as tasks can be authentic, but also ill-defined, and students can be both more relaxed or more stressed within a hybrid learning space. Overall, hybrid learning and hybrid learning spaces point towards the formation of hybrid learning cultures and practices that open up for participation and engagement beyond the traditional boundaries of the institution, course or learner role. In this, lies dormant a complexity that carries with it an entanglement of learning in relation to pace, path and place that reconfigures and redefines what it means to teach and learn in such learning spaces (O'Byrne & Pytash, 2015). Consequently, designing, teaching and learning in hybrid learning spaces requires that we 'think and act otherwise' in relation to time, space and roles which demands changes in the ways we organise, carry out and understand higher education teaching and learning.

However, hybrid learning spaces often focus on one or only a couple of hybrid dimensions – e.g. hybridizing synchronous/asynchronous learning, integrating online and onsite learning spaces or moving the classroom out into public spaces, or integrating the public in the classroom. In the case, described in this chapter, all of the above hybrid dimensions were at play and integrated into each other in the course, thus, creating what we call a *hyper-hybrid learning space*.

We begin by introducing theories on hybridity relevant to the analysis. In the method section, the learning space, the online interviews with five students, and the diffractive analysis are discussed. The analysis is then presented, and the four agential cuts made in the data. In the concluding discussion, we return to the analysis, theories, and implications for practicing hybrid learning spaces in higher education.

Hybrid Learning Spaces and Complexity

The notion of hybridity seems particularly apt when trying to grasp both the university's changing mandate and higher education learning beyond courses, study programmes, or institutions. Generally, hybridity strives to cut across, interweave or circumvent traditional dichotomies within higher education such as online-onsite, digital-physical, formal-informal, university-society, disciplinarity-transdisciplinarity, learning-teaching, study-work, individual-collective, student-citizen. In this way, hybridity is centered around the entanglement of concepts, formats, domains that becomes transfigured into new complex configurations (Rorabaugh & Stommel, 2012; Stommel, 2012). As such, hybridity cuts across, transforms, or even transgresses traditional boundaries and asks teachers and learners to reflect on the reasons for upholding traditional dividing lines in higher education learning.

Overall, hybrid education promotes horizontal connectedness across activities and subjects inside and outside higher education institutions (Istance & Dumont, 2010). Through hybridity, students become engaged in real-world contexts, professional development and authentic, complex tasks and challenges that invoke active learning processes (Baartman & De Bruijn, 2011) to reduce the gap between education, work-life, and society by creating integrated and merged connections between higher education institutions, professional practice, and the public sphere (Zitter & Hoeve, 2012). Working with hybrid learning spaces, the following distinction between hybrid, hybridity and hybridization can be made: *A hybrid* (such as a hybrid learning space) describes the meeting and merging of two separate forms that then come to constitute a new and previously unknown species or composite. *Hybridization*, then, is the method that describes the process of amalgamation or merging resulting in a new hybrid. Finally, the notion of *hybridity* encapsulates the relationship between the hybrid (a figure) and hybridization (process). Hybridization then denotes the process of bringing new 'species' of learning spaces into existence through cross-fertilization or cross-breeding existing ones that allow the emergence of new hybrid learning spaces created by the interaction between two or several previously known dimensions or forms.

In a previous article (Hilli et al., 2019), we identified five principles for designing hybrid learning spaces that were then applied to the design and organisation of the course we describe in this chapter. The five developed design principles guiding the design of hybrid learning spaces were: *1. Rhizomatic places and knowledge forms, 2. Dissolving dichotomies in education, 3. Creating a niche in the environment, 4. Breadth and depth of the collective, 5. Value-sensitive spaces* (Hilli et al., 2019). The design principles were then put into action to form what turned out to be a genuinely hyper-hybrid learning space for students and teachers learning and working together across countries, disciplines, and courses to build a shared understanding of the themes 'hybrid pedagogy', 'value-sensitive design' and 'learning spaces'. This hyper-hybrid collaboration resulted in a student-organised open webinar wherein they shared their knowledge on the themes with the world as well as the launch of a co-constructed open web resource with theory, methods and designs for digital change in education (https://digitalchange.home.blog).

In Hilli et al. (2019), the design principles created a complex entanglement of hybrid dimensions and herein we positioned hybrid learning spaces as fusions of separate parts that offer new breeds of open-ended teaching and learning practices to invite rhizomatic, polyphonic, and heterogenous knowledge forms. Through this, hybrid learning spaces become a way to work against dichotomies, as learning in the learning space was simultaneously "physical *and* digital, process *and* product, for the individual *and* the collective, for the university *and* the world, formal *and* informal, synchronous *and* asynchronous and so forth" (ibid. p. 77). Different media platforms, elements, and places are put into action to create an ecology of teaching and learning that forms complex entanglements of people, materials, contexts, and media. In this way, we saw hybrid learning spaces as constituted by collectives of people, networks, and communities that fuse their personal learning environments with their group learning environment to learn together across media and platforms, creating both breadth and depth when participants' engagement, knowledge, projects, and ideas are mixed and shared collectively. Furthermore, hybrid learning spaces were approached as value-sensitive spaces with certain ethical values imbued into them, in this case, open-endedness, risk-taking, collaboration, and mutual care. Overall, in designing such hyper-hybrid learning spaces the imperative of being sensitive to the ethical implications of these new practices was foregrounded as well as accepting that this would require everyone in the learning space to change their way of thinking, doing, and being together towards more connected, fluid and entangled teaching and learning practices (Hilli et al., 2019).

Such entanglements of cross-national, multilingual, cross-disciplinary collaboration in hyper-hybrid spaces may look impressive and beautiful as a described hybrid course design on a meta-level, as we formulated it in the 2019 article. However, as is the subject under investigation in this chapter, such hyper-hybrid learning spaces might look, feel and be experienced very differently by teachers and learners when carried out and lived through in actual practice. As we will show, more diverging and complicated experiences emerged when we discussed the hyper-hybrid space and learning processes with the students. Putting educational attractive but conceptual design principles to the test in actual practice provided insights into the complexity of such learning experiences when students were asked to navigate the hyper-hybrid learning space designed and organised based on the above-mentioned principles.

Hyper-Hybrid Learning Spaces

In the present chapter, we want to examine some concrete implications of a 'hyper-hybrid learning space' for student collaboration by posing the following questions: *What entanglements of course structure, learning spaces, and time can be identified within the student collaboration? What effects did the entanglements produce in relation to student collaboration?* Entanglements, as defined by Karen Barad (2007, p. 139), are intertwined material-discursive phenomena. This means that matter is not a passive object limited to the material world. The material is in constant and dynamic relations with the discursive. Physical spaces and ideas are entangled with "other materials" (Barad, p. 29), and the discursive world is entangled with the material world; both are essential to understanding. Ideas (e.g., curriculum, course design, course structure) are entangled with spatial (e.g., learning platforms) and temporal (e.g., deadlines) matters making the discursive world entangled with the material world. Matter and meaning cannot be separated from each other and they do not preexist as single entities rather matter and meaning are part of and together produce a phenomenon. To Barad (2007), matter and meaning are intra-actions that are entangled and ongoing forever. Intra-action is a concept Barad (ibid) uses to dissolve dichotomies between matter and meaning and highlight the intertwined relationships between them. Through different intra-actions matter and meaning can become agentic and produce different effects from within that phenomenon. Of interest are the produced effects that different entanglements have on material-discursive practices (i.e., the relationships between matter and meaning). In an educational context, like in this study, interesting effects are those that matter for students' knowing/becoming/acting in the world. The diffractive analysis (discussed in the method section) makes visible where dynamic and complex entanglements (e.g., synchronous/asynchronous activities, online/onsite spaces) of hybridity intersect and why they mattered to the students.

Reshaping learning spaces towards hyper-hybridity and complex higher education learning beyond the campus and courses highlights both the challenges and opportunities of blurring the boundaries between a) the roles of teacher, learner, citizen and professional, b) the locations of onsite, online and offline and c) the time of synchronous and asynchronous. This will often create unexpected experiences for both teachers and learners where something 'other' emerges from the hybridization process (Zitter & Hoeve, 2012). The potentials of learning in hybrid or hyper-hybrid learning spaces come from modifying and manipulating dimensions such as time, space, place, pace, and educational structures to empower teachers and learners to collaborate across contexts beyond the campus (O'Byrne & Pytash, 2015).

As such, the focus on hybridization of learning spaces highlights the challenges and opportunities which transpire from the dissolution, amalgamation, or transgression of boundaries between contexts of learning such as online/offline, onsite/offsite, synchronous/asynchronous, informal/formal, or structured/unstructured and the hybrids that emerge from these processes. Hybridization carries with it an inherent complexity as it engages in the interweaving of formal and informal structures of learning, the synchronicity of onsite and online spaces, the combination of physical and digital tools mediating an individual's interaction with the world and society and the entanglement of roles that the individual occupy in the world: 'people connect and interact through a hybrid network of physical and technology-mediated encounters to co-construct knowledge and effectively engage in positioning practices necessary for their work' (Cook et al., 2015, p. 125). In hyper-hybrid learning spaces, multiple hybrid dimensions are engaged and hybridized at the same time. Here, discourses, formats, contexts, environment, roles, tools, spaces etcetera enter into entanglements with each other to form something 'other' – a hybridity of both interaction and experience within the hyper-hybrid learning space. Consequently, hyper-hybrid learning spaces accelerate and accentuate the experiences of complexity by embracing multiple spatiotemporal differences and fusing multiple dichotomies into new breeds to take full advantage of the benefits of each side of the spectrum (Meydanlıoğlu & Arikan, 2014).

Overall, hyper-hybrid learning spaces demand that we rethink and hybridize time, space, and structures so they become neither time-bound nor space-bound. Such spaces can bring higher education learning beyond both campus, curriculum and course by creating hybrid entanglements across several countries or courses, bring in practitioners or experts, move the classroom out into the open (online or onsite), and invite students to present their work to the public in the form of open webinars or websites. In this way, hyper-hybrid learning spaces create complex opportunities for expanding and enhancing curriculum- and campus-based learning and create advanced hybridization of the learning experience. In the case analysed in this chapter, the teachers have applied digital technologies, systems, and resources in their teaching to intentionally create a hyper-hybrid learning space based on the framework and design principles described in Hilli et al. (2019).

Method – Hyper-Hybridity in Practice

This article uses the theoretical framework discussed above on hybridity to explore the implications of a hyper-hybrid course collaboration between Aarhus University in Denmark and Åbo Akademi University in Finland. The course ran between February and May 2019. It included three teachers and thirty students (15 from each university). The Danish students took the course as part of their 20 ECTS course on Design: Theory, method and practice as part of their master program on Ict-based educational design, while the Finnish students had one 5 ECTS course on Digital dimensions in education. In the end, the Finnish students got another 5 ECTS for Collaborative processes in companies and organizations due to the course workload. The course included theories on hybridity, online collaboration, digital learning spaces, media ecologies, and online collaboration discussed in a previous article (Hilli et al., 2019).

The course consisted of seven webinars online (Zoom) paired with online collaboration (Google Drive, WordPress) according to the participants' schedules

Table 1 The course outline and hyper-hybrid spaces

Hyper-hybrid spaces	Aim	Communication form
Zoom	Lectures Introduction to group assignments Teacher facilitation Present book chapters	Synchronous Spoken and visible through camera and microphone Written in chat
Google Drive (Hangout, Google documents)	Course material Shared group processes (literature reviews, planning prototypes, finalize book chapters)	Synchronous Written chat messages Spoken and visible (Hangout) Asynchronous Written comments and texts
Social media (Messenger, WhatsApp)	Group decisions and planning	Synchronous
Workshop in a physical setting (library, school, higher education institution)	Test and evaluate the prototype	On-site and synchronous (spoken, written)
WordPress	Present final book chapters	Asynchronous Written texts

(see Table 1). The student groups chose social media platforms to communicate (Messenger, WhatsApp). The groups investigated three themes (hybrid pedagogy, value-sensitive design, digital spaces) through a Design-Based Research approach (Bakker, 2018; Barad & Squire, 2004) and designed prototypes relating to their chosen theme. They also wrote theoretical chapters in a jointly made digital book called *Digital Change in Education*. Here, the students were expected to find two articles each and then annotate them collaboratively to produce a literature review of their chosen theme. In the second part of the book, the groups studied Design-Based Research and prepared and tested a prototype in an educational setting (e.g., school, library) through an onsite workshop. In the third chapter of the book, the groups presented their final prototype and connected it to the book's first and second parts.

The concluding webinar of the hyper-hybrid collaboration was a public mini-conference in the form of a webinar where each group presented their chapters in the book and addressed the audience's questions. The webinar ended with a closed session and joint reflections on the course.

It became apparent from these discussions and the written evaluations that the participants were critical of the course's outline and workload. This made us curious, as we wanted to learn more about how they perceived the hyper-hybrid course. Therefore, a follow-up focus group interview was planned in September 2019 with seven participants. These participants were asked to join the group interview because they took part in the whole module of 20 ECTS and major in Ict-based educational design. Due to their field of study, they were assumed to have in-depth knowledge and interest in hybrid course designs. The interview was expected to provide more in-depth insights into what happened during the course and how the participants felt about it (Dilshad & Latif, 2013). The group interview would ideally provide different perspectives on the course and its hyper-hybrid layout via the participants' experiences (Merriam & Tisdell, 2016). Unfortunately, it was impossible to find time for a group interview. Instead, five participants agreed to add individual answers in a shared online document which they did during October 2019. This way, they could build upon what others had written, although they did not specifically refer to each other's texts. One participant wrote in English; the others wrote it in their mother tongue Danish. Online interviews are reasonably easy to instigate as participants can answer the questions in their own time. In written form, online interviews are transcribed directly in the participants' own words (Salmons, 2012).

The interview guide was semi-structured and included open-ended questions around seven themes (see Table 3). Names and personal information were changed or excluded from the transcript to protect the participants' identity (Merriam & Tisdell, 2016). Four women and one man participated in the online interview. They have been given gender-neutral names (Kim, Taylor, Riley, Parker, Robin) to protect their identities. Hilli translated the Danish answers to English.

The Diffractive Analysis

We analysed the online interviews diffractively (Bozalek & Zembylas, 2017; Lenz Taguchi, 2012) to identify patterns of differences in the hybrid entanglements that mattered for the student collaboration. According to Donna Haraway (1997) diffraction produces difference patterns or differences that carry meaning. Haraway (1992, p. 300) writes: A diffraction pattern does not map where differences appear, but rather maps where the effects of difference appear. Haraway (1997) use diffraction as an optical metaphor to think with patterns of differences to produce new meanings. Reading texts diffractively means paying attention to and respecting even the smallest of details that matter within different entanglements. Diffraction can open up, cut apart, or cut together entanglements that matter depending on the researcher, the theories, and the context of the study (Barad, 2007). Diffraction is not about comparing quotes or applying codes, or themes to the material; diffraction means that the researchers entangle themselves with concepts, the material, the context to open up new ways of thinking about the phenomena by putting concepts to work (Jackson & Mazzei, 2017).

Diffraction provided us with an analytical framework to examine student collaboration within the course through the participants' voices and perspectives. We enacted four agential cuts (Barad, 2007) in the interviews that materialized the *hyper-hybrid entanglements* (see Table 2) while reading the interviews through each other and through theories on hybridity as presented in the theoretical sections. Jackson and Mazzei (2017) suggest that this kind of thinking with theory is a way to (post)qualitatively study human and material entanglements by letting theories and concepts challenge the knowledge produced in the study. The entanglements are not representative, nor do they offer a final answer to the research questions. Diffraction generates new questions and challenges us to read between the lines

Table 2 The entanglements, the different materialities and their implications identified during the analysis

Agential cuts	Hyper-hybrid entanglements	Materialities	Implications
1: Confusion arises within the hyper-hybrid collaboration	Openness and flexibility.	Different study points, different curriculums, different courses.	Confusion, frustration, hesitation. Increased study efforts, uneven workloads.
2: Hyper-hybridity cutting across spatial and temporal matters	Moving across countries, universities, subjects, participants.	Different online (Zoom, Hangout, Google Drive, Messenger, WhatsApp) and onsite (home, on-campus) spaces. Temporal differences (a/synchronous communication).	Personal and professional development. Informal and formal learning opportunities.
3: Chaos unfolding in the hyper-hybrid collaboration	Ongoing negotiations (teachers-teachers, teachers-students). Online communication. Onsite communication (workshop).	Different online (Zoom, Google Drive, Messenger, WhatsApp) and onsite (libraries, schools) spaces. Different deadlines.	Chaos, frustration, fatigue. Unclear guidelines and goals. Difficulties in coordinating group work. Difficulties to focus the group work.
4: Moving between hybrid spaces in the collaboration	Moving across spaces, lives, activities and temporal matters.	Different life situations. Temporal differences within the groups. Different online spaces (Messenger, WhatsApp).	Dynamic intra-actions within groups. Distance between groups.

or to focus on unexpected effects that we may understand better by reading new theories or concepts. This kind of research process is never finished rather it is in a constant state of becoming. Agential cuts change with the researchers, readers, and the context (Barad, 2007). Diffraction means accepting the role we as teachers (and researchers) played in how the course unfolded, and we cannot claim an observer stance (Lenz Tagushi, 2012). As the authors of this chapter were also teachers of the course, it constituted an inherent entanglement with the students' processes and the studied phenomenon. The course design is a material-discursive practice we as teachers enacted through the spaces and activities we chose (see Table 1); as the analysis will show other entanglements unfolded between the students (see Table 2).

The analysis produced entanglements that were initiated by us as researchers. Hilli did an initial reading in the Fall of 2019 and suggested theories on hybridity concerning space, time, and course structure that Nørgård engaged. Nørgård then added theories on hybridity to continue the analysis in the Fall of 2020. Diffraction was chosen to challenge our understanding of the course design (described shortly above and at length in Hilli et al., 2019) and because we wanted to provide new knowledge about hyper-hybrid courses with the help of theories and concepts on hybridity (Jackson & Mazzei, 2017).

While reading the interviews diffractively, we identified feelings of frustration and confusion among the participants. Feelings still present with most participants several months after completing the course in June 2019 with excellent grades. This made us wonder about the effects of the course design, spatial and temporal matters on student collaboration. This wondering led us to formulate the two research questions to continue the analysis: *What entanglements of course structure, learning spaces, and time can be identified within the student collaboration? What effects did the entanglements produce in relation to student collaboration?* The analysis took place in shared online documents where interesting considerations on material-discursive practices and their implications were highlighted and related to hybridity and the interviews. We read the interviews through each other and through theories on hybridity several times. It resulted in a generative process (see Table 2) where the concept of hybridity was put to work in relation to the entanglements that mattered to the students (Jackson & Mazzei, 2017). In the following section, quotes from the interviews are included to provide examples of the difference patterns within the four agential cuts, the entanglements cut open and why they mattered to the students.

Analysis – Hyper-Hybrid Entanglements

Agential Cut 1: Confusion Arises Within the Hyper-Hybrid Collaboration

In the first agential cut, we identified *confusion* and *hesitation* among the participants due to the course's flexible and open structure and unclear guidelines from the three teachers about student collaboration. The lack of communication between the teachers became entangled with the confusion and frustration felt by the participants. The participants were given mixed guidelines by different teachers about the course, making it difficult for them to move ahead with the joint projects. The hyper-hybrid course also became entangled with other related courses, which added to the participants' confusion.

> *In hindsight, the course was a learning experience, but it is unclear what was part of GO: IT and what was part of our design subject. It was in no way less confusing when the Finnish students left when we started the literature review, which meant the same Danish group worked together in all courses. That period during the spring still seems like a confusing, very cumbersome, and hesitant experience. However, I have a sense of what a design process is like, which is a good learning experience.* (Riley)

Two courses across two universities created material-discursive entanglements relating to the different study points and curriculums. The Finnish students received 10 ECTS, while the Danish students received 20 ECTS. Several Finnish students dropped out of the course, leaving one group without any Finnish students. Thus, the workload of that group changed when three students suddenly left. The *different curriculums* and the *different study points* became entangled with the flexible and open course structure and the uneven workload among participants. The course structure offered flexible ways forward within the themes/subjects, which added to the confusion and workload. The groups and the teachers were unable to properly address these differences and challenges.

> *I feel many of the Finnish/Danish collaboration advantages were lost when it took so long for us to figure out what the assignment was. Our ECTS points, and thus, the workload was uneven. Our education was different, making our conditions different. This would have been okay if it had been addressed and we could have planned accordingly.* (Kim)

Agential Cut 2: Hyper-Hybridity Cutting Across Spatial and Temporal Matters

The second agential cut through participants' different *online* and *physical spaces*, the different *subjects/themes*, and the teachers and the participants' different *backgrounds*. Many participants felt the course opened up processes of personal and professional development. These processes became entangled with formal and informal learning spaces (Zoom, Google Drive, Messenger, WhatsApp) and onsite spaces (home, on-campus). Sometimes these hyper-hybrid entanglements took place synchronously during the webinars and group discussions – other times when participants completed individual or collaborative assignments asynchronously.

> *Overall, it's been a good learning experience and a well-organized process; it was interesting on a personal and educational level. The ideas of joint teaching practice that is interprofessional and interinstitutional are visionary, mostly since the process was inspired by different subjects making it three simultaneous activities – the one the Finns participated in, the one the Danes participated in and the one we all participated in. Online education benefited greatly from this outline through the course design, joint discussions, group activities, and interprofessional collaboration. For every webinar, there were good slides and detailed descriptions of what was to come and mandatory activities besides the teaching sessions. It made it easier to understand where we were going and what the aim was.* (Parker)

Agential Cut 3: Chaos Unfolding in the Hyper-Hybrid Collaboration

In the third agential cut, we opened up the *chaos* that the hyper-hybrid course design produced. The teacher collaboration seemed chaotic and unorganized to some participants as the first agential cut revealed. The hyper-hybrid course design meant that the goals were re-negotiated as participants wanted clarifications from the teachers. The focus of the collaboration took new directions as participants formulated ideas on the themes for the projects. The groups consisted of ten to eleven members requiring coordination on different platforms (Zoom, Google Drive, WordPress, Messenger, WhatsApp). It took time and energy to coordinate the collaboration because many people communicated about the unclear assignments in different online spaces. Chaos unfolded when the course design did not support establishing a good group dynamic between the participants acting in different spaces. The coordination between participants and spaces became difficult in relation to several deadlines. The participants tried to navigate the hyper-hybrid spaces while working towards different deadlines without fully knowing what they were supposed to do, making the process chaotic and cumbersome.

> *I have mixed feelings about the project. First and foremost, it was chaotic in my view. The project seemed unstructured and unorganized, it often felt like it had to be rushed through; there were many deadlines that we had to keep in mind while planning and coordinating our group processes. The aim of the process has not become clear to me. It was exciting to collaborate with other students and learn how to create a good working environment.* (Robin)

All Danish participants organized a workshop in a physical space (e.g., library, school) to learn about the user experience of the prototype they were preparing. While doing this, they realized the chaotic process they were part of as they could not specify what they were supposed to do. Another spatial effect of the workshop was that the participants met face-to-face, which focused the hyper-hybrid collaboration when they entered into dialogues with their end-users. Thus, the theories during the course became relevant through practical experiences during the workshops.

> *Our workshop was probably the most thought-provoking learning experience. During the workshop, I could see how chaotic our project in reality was and how significant the difference was between other people's perceptions of our project and what we were trying to do. I would recommend doing workshops because we get a different knowledge from real life, which enriches the very virtual course work.* (Robin)

Agential Cut 4: Moving Between Hybrid Spaces in the Collaboration

In the fourth agential cut, we opened up spatial and temporal entanglements relating to the collaboration within and between the groups. The *hyper-hybrid spaces* used became entangled with the *activities* on different digital platforms. The participants adapted different a/synchronous spaces to their needs during their studies and their personal lives. Group communication often took place on a social media platform the groups decided on (e.g., Messenger, WhatsApp). It offered them an opportunity to reply in their own time as they had difficulties finding time to meet and work synchronously on the projects.

We understood each other and our private life that sometimes was in the way of meeting. But as it was a hybrid course, we did much writing between each other through messages. And as a result of this, it is essential to have a place where we do not have to be online at the same time – like Messenger. (Taylor)

Although the asynchronous hybrid learning environment (Google documents, Zoom recordings) was open to all participants, it did not support them in following the other groups' processes. The intra-actions between participants became entangled with assigned activities. Activities between the groups were not enough to benefit from the open spaces and the shared knowledge within the different group projects.

I thought the change between the different technologies was dynamic and varied. In the future, it would be beneficial with more activities between the groups. Our group often felt alone with all the things we were doing, and we did not know what the other groups did. I feel this is specific for online education because if we were in the same physical space, we could peek over each other's shoulders. A closer connection between groups should not be limited to open documents or presentations. It should also be part of the activities. (Parker)

Discussion

In the diffractive analysis (Barad, 2007), entanglements of course structure, learning spaces and temporal dimensions were materialized. The open and flexible hyper-hybrid course structure produced dynamic material-discursive entanglements of online/onsite spaces, online/offline activities, Denmark/Finland, curriculums, subjects, and course goals. These entanglements produced the student collaboration and were also produced by the teacher/teacher, teacher/student, student/student collaboration. Hybrid courses allow teachers and participants to continuously and collaboratively manipulate and modify the course work (O'Byrne & Pytash, 2015). This study suggests that hyper-hybrid collaboration between teachers and students can be rewarding in the form of high grades (the exam papers) and impressive products (the webinar and book), but it can also be challenging and confusing.

One unresolved issue was the lack of clear goals and guidelines for group work. The course design (see Hilli et al., 2019) would have required constant negotiations between the teachers and the students to refocus the course structure and clarify the course work, projects, and book took shape within the hyper-hybrid learning space. The synchronous space (Zoom) became a shared *hyper-hybrid space* for negotiations during the course. However, this study suggests that negotiating the goals of course work and design projects need an extended amount of time and presence from teachers in the hyper-hybrid learning space. Köppe et al. (2017) point out that hyper-hybridity requires that students dare to take risks, tolerate frustration, and accept that there may not be clear goals or a strict structure. Following from our analysis, teachers need to embrace and endure students' frustration, struggles and confusion (cf. agential cut 1) through taking the time to 'stay with the trouble', be in the hyper-hybrid space with the students and be open for discussions with students who may be struggling with the many different entanglements they try to negotiate during a hyper-hybrid course.

The two universities' material-discursive practices meant that the courses generated different study points and followed different curriculums. This closely resembles hybrid working places where employees might work across cultures, time zones, languages, and work environments (cf. Cook et al., 2015; Zitter & Hoeve, 2012). Here, the *hyper-hybrid entanglements* within the student collaboration produced professional development and authentic and dynamic learning experiences as the participants from two different countries, study programmes and courses got to know each other through collaborating and communicating on a shared project (cf. agential cut 2). Students learned to participate in work processes and construct a shared working environment across formal and informal learning spaces as they studied online, at home, on-campus, or elsewhere (cf. Baartman & De Bruijn, 2011).

However, in this study, the entanglements of different digital platforms, study points and curriculums also created negative effects for the collaboration. The students were unsure of the aims of the course work while they hesitantly were trying to negotiate how to proceed with the different tasks on different platforms to meet the deadlines (cf. agential cuts 1 and 3). As study points are related to the workload a student can be expected to carry out during a course, they need to be considered in the course design and negotiated in relation to the student collaboration during a hyper-hybrid course. Likewise, moving between different curriculums and subjects requires extra attention in the course design so the content is negotiated with the students in relation to activities and deadlines during the course. This study shows that the openness and flexibility of a hyper-hybrid learning space (cf. Cook et al., 2020) can be confusing and chaotic for the students when different structures (curriculums, subjects) and temporal matters (deadlines) become entangled with the online/onsite, synchronous/asynchronous and other hybrid dimensions.

Overall, the *hyper-hybrid learning space* supported the open and flexible course design as participants could use synchronous and asynchronous tools depending on the activity, context, and working environment of the different groups. The participants also added tools if the collaboration benefited from it (Messenger, WhatsApp). Hyper-hybrid student collaboration produced personal and professional development spurred by the different spaces used, disciplinary knowledge, different curriculums, and the diversity in the experiences that the group members brought into the collaboration (cf. agential cut 2). Hyper-hybrid collaboration can support lifelong learning, professional development as well as complex and connected digital practices if higher education institutions are open to dialogues with the outside world (Barnett, 2017) and transitions between higher education and professional practices (Istance & Dumont, 2010; Zitter & Hoeve, 2012).

A hyper-hybrid learning space and course design needs to include recurring intra-actions between groups of students through activities or assignments to support further entanglements between space, time, and students (cf. Cook et al., 2020). In this course, the collaboration within groups became meaningful as activities and spaces became entangled (cf. agential cut 4). The collaboration between groups became less successful because of a lack of activities that opened up the shared space. A future and significant entanglement would be to invite different groups to learn from each other through complex experiences and new breeds of collaboration (cf. Meydanlıoğlu & Arikan, 2014) as an integral part of the formal curriculum and extended presence and meta-communication on the 'natural' complexity, frustration, confusion and changeability of hyper-hybrid collaboration and spaces - both within higher education and future work life.

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Appendix

Table 3 Interview guide

I	What are your general thoughts and feelings about the hybrid course?
II.	How did you manage the course workload? Did the webinars and course materials support your learning process? What other support would you have liked?
III.	How did you perceive the guidance and instructions from the teachers? What support should a teacher provide in a hybrid course?
IV.	How did you manage and perceive the digital environment (Google Drive, Zoom, webinars)? What would be the ideal digital learning environment in a similar hybrid course according to you?
V.	You also had workshops on-campus or on-site – what do you think of them? Are they important in a hybrid course like this, why so? What are the benefits and drawbacks of students organizing workshops as part of their master thesis projects like you did?
VI.	How do you perceive the Danish/Finnish collaboration? What were the benefits of it? What were the drawbacks? What supports online collaboration like this according to you?
VII.	If the course ran again in the future –how would you design it as a participant?
	Other comments regarding the course?

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Part II
Pedagogy

How Co-design Can Contribute to the Ongoing Development of Hybrid Learning Spaces by Empowering the Users

Bodil Hovaldt Bøjer and Mie Guldbæk Brøns

Introduction

Physical spaces are an important consideration in education and essential to understand when planning any kind of learning situation. It is almost impossible to understand the practice of social relations without the spatial distributions they take place in (Crampton and Elden, 2007). The link between the design of educational spaces and various types of pedagogy has received growing attention in recent years (e.g. Woolner, 2010; Brøns, 2019, 2021; Boys, 2011; Bøjer, 2019b, 2021; Martin, 2009). However, large funds are being invested in building and rebuilding educational environments with questionable educational underpinnings, resulting in new-built spaces that do not match the pedagogical practices (Goodyear et al., 2018).

Martin (2009) calls the building a 'finished beginning' (p. 87) and argues that the teachers have a tendency to passively accept the spaces as provided. There is a need to find ways through which teachers can gain authority to redesign or reconfigure the spaces and incorporate these as active elements in hybrid learning spaces. A challenge in this process is that skills in or knowledge about architecture, design or spatial behaviour are not part of teacher professional development. Although teaching is a spatial practice, teachers' understanding of the relation to the physical environment is limited and often influenced by personal experiences from their schooling. The profession is shaped by its history and the buildings it has taken place

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in, therefore lacking professional spatial understanding, reflections and discussions (Brøns, 2021).

'Hybrid learning space' is a relatively new concept of growing interest within educational research, in particular in relation to higher education. The term refers to an interplay of 'spaces' that are not just physical but also digital, social, conceptual and informational (Kohls, 2019), thereby enabling different forms of learning activities (Köppe et al., 2018a, b). Hybridity in education dissolves existing dichotomies and divisions such as physical-digital, formal-informal contexts, learning-teaching, student-teacher roles and individual-collective as it stresses the mixture and fusion of these traditionally separate parts (Hilli et al., 2019; Kohls, 2019). Therefore, in a hybrid learning space, learning is pursued in a network of entangled activities, relations and roles and takes place in both digital and physical spaces.

Little research exists about hybridity and the role of the physical space in hybrid learning spaces in primary education. Thus, this chapter builds on research about hybrid learning spaces in higher education and research on the relationship between learning spaces and pedagogical practices in primary education.

As researchers and practitioners, we have often experienced how newly built spaces aiming at supporting new pedagogical practices, often influenced by notions of hybridity, were not used as intended by the designers. This can either be attributed to the designers' and architects' lack of understanding of the pedagogical environment, lack of support by the school organisation in the transformation and inhabitation process or the users' lack of understanding of the potential of the physical framework as a tool in their methodology. In this chapter, we pursue the latter perspective as we examine the potential of co-design as a means of developing a hybrid learning space, where the physical space is included as part of the teacher's pedagogical toolbox. Our hypothesis is that approaches from co-design can support interdisciplinary collaboration between the designers and users of learning spaces and through this, inform a development towards hybrid pedagogy and hybrid learning spaces in primary education.

To answer this, we will first define what characterises a (hybrid) learning space in primary school. The primary teachers' role is of great importance in hybrid learning spaces; thus, the aim of the two following sections is to discuss what teacher professionalism is, how it is (dis-)connected to the physical setting and how teachers can develop an environmental awareness. In the fourth section, we clarify why we work with interprofessional collaboration and co-design as a tool. Building on the understanding that there is a need to develop better awareness and competence to utilise space as part of teacher professionalism, we then present the empirical study. In the study, co-design was used as a means of collaboration, joining professions and aiding teachers to develop competences to create and use hybrid learning spaces. We present the findings from the study before finalising the chapter with a discussion and conclusion of the overall research question that this chapter pursues: *How can co-design contribute to interprofessional collaboration between designers, teachers and students and hence support the development and use of hybrid learning spaces in primary education?*

Hybrid Learning Spaces and Primary Education

In this chapter, we alternate between the terms 'space', 'learning space' and 'hybrid learning space' as we refer to either the physical setting in which educational practices take place (space) or the combination of the physical setting and educational practices (learning space and hybrid learning space). Our choice of the terminology 'space' over 'place' is made from the perspective that the term 'place' is conditioned by lived experiences (Ellis & Goodyear, 2016, p. 157) whereas 'space' can be used in the discussion on a conceptual level without getting into the users' personal perceptions (for an elaborate discussion on the use of space/place see e.g. Ellis & Goodyear, 2016).

Over the years, the idea of the learning space as identical with the confines of the classroom has been challenged and a broader notion has emerged (Hilli et al., 2019, Zitter & Hoeve, 2012). Mulcahy et al. (2015) define a learning space as a product of interrelations and materially embedded practices that comes into existence with its users. Behind this definition lies a relationalist perspective, where space and its occupation are understood as inseparable and interlocked parties in a mutually constitutive relationship. This is in opposition to a realist perspective, where space and occupation are considered in a binary framing as separate and different aspects that reflect each other (Mulcahy et al., 2015). In the latter perspective, the space-practice relationship is considered causal, which means that the physical surroundings are expected to change pedagogical practices automatically. However, as both practice and research show, a new spatial design does not automatically lead to a change in practice (Brøns, 2019; Bøjer, 2018; Imms & Byers, 2017). Space is, as Boys (2011) points out 'a relationship rather than a setting or entity' (p. 31). In this perspective, the interplay between space and practice is intricate, dynamic and dependent on a variety of social and material factors (Bøjer, 2019b). Thus, a learning space can be described as a network rather than a fixed entity and is continuously developing and changing. This applies to traditional as well as hybrid learning spaces.

In hybrid learning spaces, contexts, roles and media are intertwined and fused in new ways (Hilli et al., 2019). Hilli et al. (2019) explain the hybrid learning space as:

> 'a context of learning that not only moves beyond distinctions between online and offline spaces, but also often challenges divisions between teacher/student roles, formal/informal contexts, analogue/digital communication/media and other traditionally separable dimensions. Hybrid Learning Spaces and hybrid pedagogy offer new 'complex hybrid breeds' and as such potentially new possibilities for collaboration in higher education' (p. 67).

Thus, in a hybrid learning space, the interplay between physical space and practice is increasingly complex and interdependent as they enter into a network consisting of multiple relations and elements. The physical spatial settings can no longer be ignored and separated from the pedagogical practices but form part of the relations that collaboratively constitute the hybrid learning space.

The idea of blurring the lines between or dissolving the dichotomies of teacher-student, formal-informal, local-online is also present in the discussion of primary education development in the twenty-first century. Pedagogical approaches such as blended learning, deep learning, creative learning and project-based learning, emphasizing e.g. collaboration, exploration, creativity and student agency, increasingly become the new norm along with other hybrid principles such as collaborations with cultural institutions and other real-life resources in society to facilitate learning activities.

In primary education, teachers have a more prominent role in guiding the students than in higher education and even more when hybrid principles and hybrid learning spaces are applied. The students are too young and inexperienced to be responsible for their own learning and when dichotomies such as physical-digital, formal-informal, student-teacher and individual-collective are blurred or even dissolved, navigating the context and environment becomes more complex and difficult. The younger the students are, the more important it is for the teacher to be physically present to guide them (as we have seen evidence of during COVID-19 (Qvortrup et al., 2020; OECD, 2020)). Thus, the main activities and learning take place at the school, even when using digital/virtual spaces.

In primary school development, it is commonly accepted that the physical spaces can enable or hinder certain pedagogical practices. Therefore, new/innovative learning spaces with emphasis on, as is the case for hybrid learning spaces, openness to 'collaborative learning where student agency is important for the collective efforts of students to be beneficial' (Hilli et al., 2019, p. 67), are coveted. These are often characterised by a flexible and/or open layout with breakout spaces off the main teaching spaces in order to support creative and innovative teaching methods that will promote the development of competences such as creativity, communication, collaboration and critical thinking. Competences which hybrid principles also aim to foster (see e.g. Köppe et al., 2018a, b). As such, the physical space plays a vital role in hybrid learning spaces in primary education, which is why we address the relation between space and practice in this chapter.

Teacher Professionalism and Relation to Space

Applicable to hybrid learning spaces, whether for higher or primary education, is that a reflected and purposeful pedagogy is expected (Guerriero, 2017; Hilli et al., 2019). The dynamic and flexible frameworks require a different way of teaching than traditional schooling and thus, a conscious reconsideration of pedagogical practice. The educational environment is characterised by a willingness to experiment and collaborate, have more dialogue than instruction and working with enquiry-based exploration instead of towards a known result (Hilli et al., 2019). Hence, the expectations for the teacher are higher and more complex than in a traditional setting (Guerriero, 2017).

In most schools, teacher practices still take place in traditional settings, which support explicit teaching and have well-defined places for the teachers, strongly influencing their pedagogical choices (Brøns, 2019, 2021). In Australasian schools, for instance, classrooms still make up for approx. 75% of learning spaces (Imms et al., 2017) despite Australasia heavily investing in innovative learning environments. The traditional spaces and teacher-centred pedagogy have been produced and reproduced by the teachers' agency through a long history (Brøns, 2021; Martin, 2002).

There is a dynamic relationship between the physical environment and the teacher's pedagogy, which the teachers should be aware of and which should be deliberately developed (Martin, 2002, 2009; Bøjer, 2019b). Several researchers (Martin, 2002; Lackney, 2008; Bøjer, 2019b) put forward a call for teacher training and retraining in both awareness of the possibilities of the spaces in relation to practices and the competences to use these didactically.

An OECD investigation into teacher professionalism and twenty-first century demands stresses that teaching is a complex and cognitively-demanding activity and improving teaching requires specific and purposeful professional development and time (Guerriero, 2017). According to the report, it takes 5–7 years for a teacher to develop their knowledge and skills sufficiently to have an impact on student outcomes. One of the main differences between a novice and an expert teacher, Guerriero (2017) explains, is their ability to apply knowledge and make a professional judgement, which derives from both theoretical and practice-based knowledge'. They define this as 'working knowledge of contextually-specific experiences' (in Guerriero, 2017, p. 104). Neglecting to recognise either the theoretical or the experience-based knowledge would be a devaluation of teacher professionalism (Guerriero, 2017). Again, we are reminded that teaching is a spatial practice, because in order for experiences to be contextually-specific, the space in which they take place would have to be considered. What is more, this calls for ongoing professional development of the teachers' spatial skills if they are to include spatial considerations in their professional judgement, which we elaborate on in the following.

However, current systems of teacher education and training often fail to provide the training needed in this matter, as teachings in the interrelations between space and practice and the didactical potential of physical spaces are not part of the curriculum. Furthermore, teachers of today are submitted to a lot of internal and external pressure and demands concerning i.e. learning goals and rarely have the time to experiment with spaces and practices (Bøjer, 2019b).

From Unaware to Competent Users of Hybrid Learning Spaces

> When teachers realise that they have control, they can feel empowered by the same environment that once would have defeated them (Martin, 2002, p. 154).

As the quote implies, there is a strong link between a teacher's awareness and understanding of the possibilities provided by a physical environment and ability to actually use these possibilities as part of their pedagogical toolbox. However, as Martin (2002) points out, awareness in itself does not necessarily lead to active exploitation. Being aware of the qualities of a space is not equal to feeling in control of and being able to take advantage of them. Therefore, according to Martin (2002), it is necessary for teachers to learn how to constructively question their physical environment as well as to proactively look for redesign solutions if they are to take control and feel empowered by the spatial settings.

Martin (2002) defines these two abilities as *environmental awareness* and e*nvironmental competence*. She explains awareness as the ability to understand how the environment relates to human activities and competence as the knowledge of and ability to redesign the environment to fit teaching practices. The same terms are used by Lackney (2008), who explains environmental awareness and competence as 'the ability to understand and effectively use physical instructional space for pedagogical advantage' (p. 133). In a study about teacher environmental competence in elementary school, Lackney (2008) discovered how educators generally lack a common language for discussing their environmental experience and concerns in relation to practice and the competences to effectively use the physical environment to support their practices (Lackney, 2008). This dilemma continued even after Lackney (2008) had facilitated workshops to raise the environmental awareness and competence of a group of teachers. Only a few of them were able to articulate problems and come up with alternative solutions and very few were motivated and prepared to act to improve their conditions afterwards.

Thus, we claim, training teachers in environmental awareness and competence is about establishing a consciousness about the space-practice relations, developing a language for discussing these and gaining on-going practical experiences with the use of spaces. As we will discuss in the following sections of this chapter, it is our hypothesis that participatory design methods, e.g. from co-design, have the potential to create an arena for the training of these competences in the form of a hybrid learning space, especially if the methods are applied in situ as part of the regular educational practices.

Often, a learning environment is used unconsciously without consideration of the spatial settings and their influence on practices. Therefore, a third condition, besides environmental awareness and competence, deserves attention: environmental unawareness.

Summing up, there are three ways to inhabit a space:

(1) *Being there,* which means using the space as a neutral frame or container (*environmental unawareness)*;
(2) *Being aware* of the possibilities of the space in relation to practice, but not feeling confident and empowered to use them actively (*environmental awareness)* and;
(3) *Being confident,* knowing how to use and redesign the space to support one's teaching practices (*environmental competence).*

By addressing and working with the possibilities of the space, users can move from environmental unawareness to awareness and competence. This will enable them to challenge and develop their spaces to fit individual requirements and teaching strategies (Martin, 2002). An arranged space can be used as a deliberate teaching strategy that complements and reinforces other strategies to support learning (Martin, 2009), thus becoming part of the teacher's professional toolbox. As Lackney (2008) showed, there is a need for theoretical as well as practice-based training in the relations between space and practice in order to achieve the goal of environmental competence. As discussed earlier, the teacher's professional judgment derives from theoretical as well as practice-based knowledge. This also applies to hybrid learning spaces. When planning hybrid educational practices, teachers need to be aware of the role of the physical space as part of the hybrid learning space. By obtaining environmental competences, teachers become aware of the possibilities and limitations the space poses for the dissolvement of the dichotomies between e.g. informal-formal learning, teacher-student role and virtual-physical presence and are thereby able to work with these in order to create the arena for learning.

Co-developing Environmental Competences Through Interprofessional Collaboration

Creating successful learning environments requires interprofessional collaboration between designers, managers and users (teachers and students) in order to secure the space-practice relationship. Not just during the design phase but also after the users take over, in order for them to inhabit and feel authority in their new spaces (Bøjer, 2019b). There is a need for an exchange of knowledge concerning creation, management and use of the spaces. Goodyear et al. (2018) suggest that it is necessary to become more sophisticated about the forms of knowledge that are associated with the different practices and participants in the (design) project. They explain that the kinds of knowledge relevant to the designers in the design process are not equal to the kinds of knowledge that are needed to organise the use of the spaces by the managers or to actually use the new spaces by the teachers and students. Thus, it is crucial for the parties to collaborate and exchange different kinds of knowledge in order to secure the alignment of space, practice and organisation. As experts of each their field, designers, users and managers have extended knowledge concerning their professional relation to the learning environment. However, these three areas might be difficult and sometimes impossible to match if the parties do not collaborate to align knowledge and practices.

Collaboration is important for the teachers' sense of professional development, growth and competence. Research suggests that professional development through collaboration 'can be a source of support and empowerment for teachers in schools undergoing change' (Rutkowski et al., 2013, p. 27) and lead to higher job satisfaction, which is important for the continuation of any development at a school. If the teachers choose not to get involved with the development of the physical environment, there is a risk that they, influenced by the history of their profession, unintentionally, will arrange furniture in ways that do not support their pedagogical intentions (Brøns, 2021; Martin, 2009). They will either let the spatial setting control their teachings or attempt to teach in ways that are obstructed by the space.

The move from unawareness to competence can be pursued in various ways. Our suggestion is to use participatory design methods, in particular co-design, as means to engage the teachers in active exploration of the relations between pedagogical practices and the physical environment. A goal in this process is to empower the teachers with the competences to utilise and experiment with their spaces as a part of their pedagogical toolbox. Through working with and in the space and in collaboration with the students and designers, as the empirical studies presented in this chapter will exemplify, an understanding of the design as well as ownership of the space emerges - and simultaneously, a hybrid learning space is created.

Co-design

Co-design derives from a participatory design tradition, the origin of which is linked to Scandinavian systems design in the 1970s. The core of co-design is the collaboration between designers and non-designers (a term that refers to people who are not trained in design) throughout the design process from problem clarification to design solution. In co-design, the users play a central role in the design process as experts of their own experiences, contributing to the formulation of and the solution to a given problem (Sanders & Stappers, 2008). Through this, the design process becomes a democratic and collaborative arena engaging both designers and users simultaneously (Storni, 2015).

Co-design offers a wide repertoire of tools, applications and techniques aimed at making participants *talk* about existing practices and future visions, *make* tangible things or prototypes to describe future objects, concerns, opportunities or ways of living and *enact* possible futures (Brandt et al., 2012; Bøjer, 2019a). The 'tell', 'make' and 'enact' activities are often intertwined, take place simultaneously in participatory design practices (Brandt et al., 2012) and aim to inform the design process that follows. Each co-design process is planned in relation to the particular participants and context.

Co-design is mostly used in the pre-design phase to create a common platform from where the design can evolve. However, in the empirical studies described in this chapter, the co-design activities were separated from any design phase in order to explore whether this approach could contribute to the development of environmental awareness and competence. Co-design was selected due to its active inclusion of non-designers in the design activities and its potential to initiate and facilitate discussions about imaginable futures (Bøjer, 2019a).

Effective collaboration in participatory design processes of learning spaces requires more than the sum of the individual knowledge involved in the project. The reason for this is, according to Goodyear et al. (2018), that the key users of the spaces might have difficulty explaining their experiences in relation to the environment as they mostly react to it unconsciously. Co-design supplies the tools and methods to help the participants communicate about abstract and hidden needs and experiences (Bøjer, 2019b).

Using Co-design to Break Down Boundaries

The empirical studies took place in a Danish public school in 2018 and were performed using a Research through Design (RtD) methodology (Frayling, 1993) as part of Bøjer's PhD-project 'Unlocking Learning Spaces – an examination of the interplay between the design of learning spaces and pedagogical practices' (Bøjer, 2019b). In RtD, research reflections are generated in action (Schön, 1983) through the design processes and tools that become means to acquire knowledge (Bøjer, 2019a). The qualitative methods used to collect data consisted of a mix of co-design tools (Sanders & Stappers, 2012, 2014) and ethnographic methods, e.g. photo documentation (Holm, 2014), participant observation (Szulevicz, 2015) and semi-structured interviews (Tanggaard & Brinkmann, 2015).

For 3 months, two teachers and their class (24 students, 11–12 years old) participated in a co-design process, actively exploring the relationship between space and new pedagogical practices. They tested two furniture prototypes (Fig. 1), aimed to support explorative and hybrid learning processes, and participated in three workshops, facilitated by a spatial designer and Bøjer.

Fig. 1 One of the furniture prototypes. Source: Bøjer (2019b)

The project took place at the school during regular school hours and involved both teachers and students in their classroom and adjacent breakout space. The sliding glass wall dividing the class and adjacent space was kept open to create an activity-based learning space better suited for a pedagogy incorporating hybrid principles. We altered the physical layout of the spaces during the workshops in order to blur the lines between the traditional roles of teachers and students. With room for the students to be more active and less need for the teachers to control movements, we asked the participants to choose their working spots according to individual preferences. These physical alterations, together with the prototypes, were meant to foster actual in situ experiences for the teachers, that would support their development of environmental awareness and competence.

The process was designed as a hybrid learning space, where design, space and pedagogy as well as process and product were interwoven. The hybrid approach encouraged entangled and interprofessional collaboration between teachers, students and designers. During the process, they worked together to explore new pedagogical practices and the relations between space and practice, moving between roles (designer/user/learner/teacher) and media (tactile materials/spatial elements/digital platforms). The overall aim was to explore how to support the development of teachers' environmental competences.

Often teachers' professional development take place disconnected from the everyday practice on a location off the school premises in a course, conference or workshop without students, or during student free days within the school grounds. This makes it harder for the teachers to utilise the knowledge acquired because of its contextual-specificity. Things that seem easy when tried without students or physical/material boundaries can be too complex to incorporate in everyday situations without additional training. Thus, it is pertinent that the teachers become learners in their own habitat in real time, while being bound to their professional teacher role and identity. One could claim that during the process the teachers are themselves in a hybrid state of learner and teacher.

Co-designing often needs staging in order for the participants to be able to express themselves creatively and move beyond the obvious and well-known. In order to promote critical and creative reflection on space and practice, we applied a hybrid collaboration pattern, Re-mediation, as proposed by Köppe et al. (2018a, b):

> Re-mediate the task and ask the learners to do something somewhat familiar, but in a different way or through a displaced or refocused lens, in order to promote more reflection on what they're doing and critical inter/action through playful confrontation with unexpected opportunities and challenges' (p. VII).

Re-mediation was attempted by providing the teachers and students with a variety of materials and individual and collaborative co-design assignments that required them to re-think their usual way of teaching and learning in relation to the physical surroundings. The intention was to examine whether co-design would provide the teachers with insights into the social, relational and physical elements of the space-practice relationship, i.e. the needs and experiences of the students in relation to the interplay between learning activities and the physical learning

Fig. 2 Dotting spaces, categorizing learning activities and building models of furniture and spaces. Source: Bøjer (2019b)

environment, thereby contributing to the development of environmental awareness and competence.

This was achieved using a so-called 'toolkit' (Brandt et al., 2012). Sanders (2000) explains that toolkits help the participants express their thoughts, feelings and ideas in e.g. collages, maps and stories, because 'the stuff that dreams are made of is often difficult to express in words but may be imaginable as pictures in your head' (p. 4). The assignments in the workshops combined materials, activities, spatial elements and pedagogical practices in collaborative design processes focusing on the entanglement between teaching and learning practices and the qualities of the physical surroundings.

They included dotting of spatial objects and areas, categorising learning activities and building small models of imaginative learning spaces and furniture (Fig. 2). They were planned to consist of in situ exemplar activities, using the furniture prototypes in the model making, activating the physical environment as part of the discussions and sharing experiences via online platforms. The teachers participated in the workshops, sometimes solely as learners doing the assignments and at other times also as teachers, helping the students.

Through re-mediation the boundaries between pedagogy and space, teacher and learner and user and designer dissolved. The teachers became learners as well as designers in the process, actively re-designing spaces and practices by which it became visible how space and pedagogy are inseparably intertwined. In between the workshops, the teachers explored new pedagogical strategies to include the prototypes in their teachings and in the process, they transferred re-mediation to their own teachings, i.e. asking the students to create literature reviews as a 3D

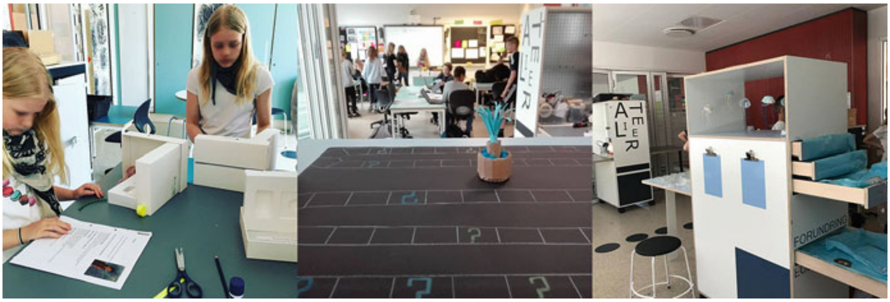

Fig. 3 Hybrid principles were applied in between the workshops when exploring new types of assignments such as 3D-literature reviews in boxes, mathematical board games and an exhibition about goblets. Photos uploaded to the project's Instagram account 'unlockinglearningspaces' by the teachers, 2018

installation in a cardboard box instead of a text. The focus on breaking down the barriers of the traditional spaces and introducing the possibility of creating tangible formats resulted in various new ways of working with routine school assignments, which also included the development of mathematical board games, a sensuous exhibition about goblets and an interdisciplinary project about good cities in collaboration with two other classes and their teachers (Fig. 3).

Findings

The intention of the entire process was to examine whether the hybrid collaboration between teachers, students and designers brought forward by the co-design activities, materials and the prototypes would contribute to the development of the teachers' environmental awareness and competence and hence, support a pedagogical move towards hybrid learning spaces.

Through observations during the workshops and information from the semi-structured interviews, co-design was experienced to provide means to actively engage teachers and students in an experimental process in collaboration with the designers, where they explored the interplay between space and practice in relation to their everyday practice. They gained practice-based experiences of the spatial possibilities while also reflecting on the space-practice relationship, hence linking environmental awareness and competence. The methods and activities inspired by co-design and the prototypes were found to initiate and facilitate discussions about abstract pedagogical philosophical issues concerning learning and teaching (i.e. how do individual students learn best or how can we (teachers) implement creative practices in our literary assignments to the students?) through very concrete artefacts, activities and subjects (i.e. the experience and spatial layout of a learning space). The co-design process created a hybrid learning space where the roles of the designers, teachers and students were entangled as they collaboratively researched the interplay between space and practice. The co-design approach brought forward information on the students' spatial needs and preferences in relation to different learning situations and made the teachers explore, discuss and reflect on their practice and use of the spatial settings. The prototypes prompted the teachers to rethink their teaching practices and apply a more hybrid pedagogical approach. In addition, the process provided insights into the actual practices of the users, which the designers can use when designing new educational spaces. Thus, the designers became learners as well.

Our findings show that participatory design methods have the potential to facilitate teacher training processes in environmental awareness and competence and thus, contribute to the development of hybrid learning spaces. Follow-ups on the empirical studies indicate that the process of teacher training in environmental awareness and competence should be ongoing or at least, take place for more than 3 months and three workshops. In the semi-structured interviews performed after the process, both teachers explained that they felt more aware and competent of the spatial possibilities. However, approx. 18 months later only one of the two teachers was using the space more actively since the process (explained in an email correspondence with Bøjer). This corresponds with the findings by Lackney (2008), showing that teachers participating in workshops had gained enhanced awareness but still lacked competence.

Discussion and Conclusion

In this chapter, we have explored how co-design can be used as a hybrid pedagogical activity to contribute to the interprofessional collaboration between designers, teachers and students and hence support the development of teacher environmental awareness and competence. In turn, this has the potential to further the inclusion and development of hybrid learning spaces in primary education.

The physical setting of learning spaces tends to remain quite stable over the course of a year, even when teachers have the possibility to make changes (Brøns, 2016; Martin, 2009). Martin (2002) points out how teachers, who question the physical settings, are also the ones less satisfied with their own classroom environments, which seems to be a first step towards change and empowerment of the teacher in activating the spaces. However, a flexible physical setting does not produce a flexible or open-ended organisation or practice (Brøns, 2021). Innovative spaces with flexible furniture and digital media do not automatically lead to innovative and hybrid teaching practices. As Rivlin and Wolfe explain, 'it is rare for a person to move a chair once it has been placed—even in one's own living room' (Woolner et al., 2007, p. 62). This requires a change in mindset towards enhanced awareness of the spatial qualities and imperfections.

Teachers need organisational support and professional training in environmental awareness and competence if they are to be able to use the physical spaces to integrate hybridization into their pedagogical toolbox. Unfortunately, it is rare for schools to prioritise ongoing professional development of the teachers' spatial mindsets amidst all the other daily responsibilities (Brøns, 2021). If the organisation does not support the innovative and risk-taking behaviour that accompanies modern education, it will hinder teachers' willingness to experiment (Ellis & Goodyear, 2016). Uncertainty or lack of confidence within the teaching staff will hinder professional development and teachers will seek refuge in familiar physical settings and pedagogy. This retreat into old practices can be seen as a result of lack of training in how to utilise the (new) possibilities of the space as part of their pedagogy, thus returning to the safety of default practices (Lackney, 2008).

The empirical case displayed the contribution of co-design to the ongoing development of hybrid learning spaces by adding hybridity to collaborative activities and engaging teachers, students and designers in collaborative and experiential exploration of the space-practice relationship. Through this, environmental awareness and competence developed, which in turn empowered the teachers to understand the physical space as an integrated part of their pedagogical toolbox. Potentially, this will prompt teachers towards a more hybrid pedagogy, where the dichotomy between space and practice is dissolved as both become inseparable parts of the same pedagogy. By becoming environmentally aware and competent, the teachers are empowered to use and alter the physical spaces to support a variety of online and onsite teaching and learning activities.

The co-design process took place in situ in a real-life educational context and through this, alignment of the learning environment was created. Through dialogue, experimentation and open-ended collaboration involving the physical environment as a pedagogical tool, the users and designers dissolved the dichotomy between designer/user, learner/teacher, process/product and space/pedagogy. Instead, they co-existed and, influenced by each other, teachers, students and designers co-designed a shared educational world.

The challenge concerning interprofessional collaboration with external partners such as designers in change processes is that most often this takes place as a short-term praxis. External partners will leave the collaboration at some point, which, if it happens too early, endangers the integration of the new practices.

The co-design activities and materials were found to work as a mediating method for communication and collaboration between teachers, students and designers, bridging the gap between theory and practice. Potentially, the approach could also be used with a larger group of teachers using the same learning space and during the design process of a hybrid learning space as it creates an arena for discussion and provides activities and tools to explore new ways of combining space and practice (Bøjer, 2019b). However, co-design processes are time-consuming, context-specific and have to be planned for each specific situation, which might be seen as a challenge and hindrance in the everyday educational context.

This study was limited to one project involving designers and users. Further studies are needed to substantiate the potential of co-design as a means to support teachers' professional development of environmental awareness and competence and its significance for the further application of hybrid learning spaces in primary education.

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H_2m Pedagogy: Designing for Hybrid Learning in Medical Education

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Introduction

This chapter falls into five main sections. In the first, we introduce the practical context—set by a university's urgently-formulated strategies for dealing with the uncertainties of teaching during the COVID-19 pandemic: a 'digital first' model for hybrid learning. In the second section, we analyse some core challenges this strategic change presents for those staff whose responsibility it is to strengthen educational design capabilities within the university, looking specifically at challenges in medical education. We express this in terms of H_2m pedagogy, set within the broader context of design for learning. Our "chemistry" notation indicates the influence of the 2-metre requirements on the structural composition of the hybrid model (H). The third and fourth sections present and reflect on a course created to strengthen university teachers' design capabilities. Insights gained from the first run of this course help illustrate some design principles and sensitivities for H_2m learning that we summarise in the last main section.

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Practical Background: An Institutional Strategy for Hybrid Learning

In May 2020, in response to the COVID-19 pandemic, the University of Edinburgh announced the September launch of *a hybrid model* for all on-campus programmes (University of Edinburgh, 2020). Teaching would be neither fully online nor fully on-campus, but able to take place in either or both modes, with remote and on-campus learning taking place together, and with a possibility to change mode and location quickly and without major disruption. Buildings would operate at a maximum of 30% capacity, and restrictions to lecture theatres, labs and other teaching spaces might be in place for some time. Further, there was a need to account for potential recurrent outbreaks of COVID-19, which meant that students and staff might have to self-isolate at short notice. This, in combination with the uncertainty of ever-changing national and institutional guidance, meant that a “digital-first approach” was advocated, where most learning would be online. The university’s aim was to protect the ability of students to continue learning while also being mindful of students’—and teachers’—sometimes precarious physical circumstances and fragile wellbeing. The university’s guidance acknowledged that homes can be difficult workplaces and that not everyone has good access to computers and the Internet.

There were significant challenges in changing from a predominantly on-campus educational model to a hybrid one within a very short timeframe. However, the university characterised these challenges as also being opportunities for pedagogical innovation: to “build new approaches which not only mitigate the immediate COVID-19 crisis but which build our capacity for creative, resilient and future-facing pedagogy longer-term” (University of Edinburgh, 2020). This was not an unexpected rhetorical move; in fact, the hybrid model was already under development before COVID-19, created by the Edinburgh Futures Institute (EFI) as a part of the university’s effort to contribute to tackling complex social and global challenges. The EFI’s hybrid model focussed on innovative combinations of online and offline learning to bring a greater sense of reach to the physical campus, irrespective of the mode of learning. The endorsement of hybrid pedagogy therefore was both an adoption of a plan “B”—to be used when on-campus education is impossible—and an acknowledgement of the creative pedagogical, cultural, emotional and strategic value in combining on-campus and online educational practices (Bayne et al., 2020).

Core Challenges: Sharpening Design Capabilities

With extensive IT and digital education support structures, it might appear that the university already had the necessary infrastructure for a fast transition to hybrid learning. However, digital education specialists (e.g. learning technologists) were either based in discipline-specific academic teams, or provided general support but were not resourced to work with teachers on their discipline- or context-specific challenges. Design patterns, principles and other kinds of general design knowledge could help teachers (Cremers et al., 2017), but teachers' full reliance on the design knowledge of others is unlikely to be sustainable as generic design principles need to be resituated and enacted in a specific context. Thus, design is inseparable from other daily tasks, roles and expertise of the teacher (Goodyear, 2015). This entwinement is particularly pronounced in professional disciplines with specialised physical environments and situated practices, such as in clinical education.

The hybrid model brings the physical (material and digital) environment into sharper focus. It can be hard to notice how physical conditions shape knowledge practices and learning in routine situations (Knorr-Cetina, 1999; Markauskaite & Goodyear, 2017a), but this becomes more visible when things cease to work well. Coping with restricted availability, absence, or change relating to material elements can necessitate major reconfigurations of course design. In particular, 2m requirements created significant challenges (and opportunities for ingenuity) for clinical programmes that depend on specialist equipment, purpose-designed (learning) spaces and specialised interactions with other people—not just students and teachers, but also professional practitioners and clients. While there were exceptions to the 2-metre physical distancing rule (e.g. examination of patients during clinical placements), we use '2m' as a shorthand for the related set of restrictions, regulations and policies that influenced operation within shared physical spaces.

In Medicine, the development of professional expertise normally relies on access to some specially-configured social and physical environments (clinics, wards, etc.), and the 2m restrictions required significant design changes. For example, the need to control numbers of people in a room and to clean equipment between uses meant that there was less time available for learning to use specialist devices, such as ECG machines. Reduced access needed to be complemented with off-site preparation and follow-up tasks. A number of other pedagogical challenges arose from the need for medical students to engage in complex working practices, through interaction with qualified healthcare practitioners and patients in authentic environments. An example, which we examine later in the chapter, was learning to act capably in Emergency departments.

That material environments are deeply embedded in professional knowledge practices and cultures, yet barely visible to many educators—and almost absent in educational theory—presents particular challenges. As Yeoman and Carvalho (2019) note, "educators are seldom trained to understand how their epistemology or conceptual structure of learning relates to the material structures of learning" (p. 64). The complexity of hybrid education "creates a need for design-oriented skills in those engaged in designing for learning" (p. 65).

Design frameworks for hybrid learning, and examples of past hybrid design practices from which to learn, are still scarce. Fortunately, there are some theoretical perspectives where the emphasis is not so much on media, instruction or content, but on the conceptual, social and material assemblages needed to support students' learning activity. From such perspectives, design for hybrid learning is not so different from design for on-campus or online learning in terms of how design is done. Instead, the differences relate to the (re)combination of different design elements and understanding of their affordances: what is fixed, what can be designed in advance, and what needs to be left to teachers and students at "learntime". Mixing different ways of learning (direct teaching, individual practice, collaborative discovery, etc.), different media and tools (material, digital), different spaces (on-campus, off-campus, etc.), and different aspects of learning (conceptual, social, material, etc.) is familiar to those who study and design such assemblages.

The following exploration focuses on how these ways of framing and supporting design can help clinical educators embrace the challenges and affordances of design for hybrid learning in a 2m world, or "H_2m design". At the same time, we argue that, as unusual as the conditions are, they do not call for fundamentally different design principles and processes.

The Response: Framing and Supporting Design for Learning

To assist teachers to transition to hybrid learning, a team in the Medical Education department offered a professional development course called "Agile Course Design for Professional Education" (ACDPE). The rest of this chapter is based on our experiences designing, facilitating and reflecting on this course.

Our description is inherently recursive: designing a course to help other people design courses; teaching teachers to teach students in more flexible ways, and so on. We start with a clarification of roles—see Table 1.

Table 1 Designing to strengthen design capabilities in clinical education: the main roles

Role	Description
Authors	The four of us writing this paper—whose discussions also helped shape the design of the ACDPE course.
Course team or facilitators	The team of three people at the University of Edinburgh who led and facilitated the ACDPE course. The lead author of this paper (TF) was a member of this team, along with Derek Jones and Gill Aitken.
Teachers, teacher-designers, course participants	University of Edinburgh academic staff in the College of Medicine and Veterinary Medicine who took the ACDPE course in 2020. We use the phrase teacher-designers to foreground designerly activities within teachers' work.
Students, learners	Students for whom the teachers participating in the ACDPE course were designing.

ACDPE Course

ACDPE was a fully online pilot course that brought together 20 clinical educators for a period of 6 weeks (July to August 2020). The course focused on building teachers' capability to design courses responsive to the dynamic H_2m context, acknowledging the importance of preparing students and teachers to negotiate the uncertainty and complexity of the future in connection with COVID-19. ACDPE asked for teachers' willingness to experiment with constructing and deconstructing their designs-in-progress, helping their peers, sharing ideas, and debating the needs of future students.

Most participants had also previously completed a 5-week course on online teaching. Data from this first course provided contextual information for the design of ACDPE (e.g. teachers' perceptions of students' studying conditions, learning needs and benefits of on-campus and online modalities for their disciplines). These insights contributed to our conception of tools to support H_2m design.

ACDPE included three main kinds of activities:

- *Week 1*—teacher-designers worked in groups of 4-5 to design a single task for their students under the design brief of "*How to make the most of studying in lockdown*". The ACDPE task asked teachers to consider how to help their students to be more productive, within constrained learning conditions. The task had a dual purpose. It was an authentic challenge, intended to help teachers think through their students' needs and circumstances. It also familiarised participants with the ACDPE course structure.
- *Week 2*—each teacher-designer compared their group's design with those produced by other groups. During this week, they also shared the first iteration of their individual design, using customised templates (in which each teacher-designer would continue to develop their course designs) with the ACDPE cohort.
- *Week 3-6*—teacher-designers completed two additional cycles of comparison and revision of individual course design work, which included their insights from comparisons with the work of peers to improve their designs.

Some key features of ACDPE's design were:

- A framework for analysis and design that alerted teacher-designers to the main areas on which they needed to focus: the ACAD framework coupled with H_2m pedagogy.
- A new template intended to scaffold the work of teacher-designers. The template embodied some of the core ACAD and H_2m ideas, including requiring teacher-designers to make their design rationales explicit, in order to help students *complete or co-configure* those designs.
- A process for supporting the development of the teachers' design work, based on Nicol's (2020) comparison model.

ACAD Framework and H_2m Design

ACAD, the Activity-Centred Analysis and Design framework (Goodyear & Carvalho, 2014; Goodyear et al., 2021), treats learning activity as an emergent phenomenon. It cannot be entirely predicted in advance. While it acknowledges that learning activity can be influenced and shaped by a number of design choices made in advance—tools, tasks and social arrangements—the ability to distinguish between such 'designable components' and 'emergent learning activity' is crucial.

ACAD draws attention to three structural dimensions of design: set design, epistemic design and social design (Fig. 1). These situate emergent co-configuration and co-creation activity at learntime. Structural elements related to the material and digital tools and resources, including furnishings and spatial arrangements, are framed as part of set design. Tasks and other suggestions of things for learners to do are part of epistemic design. The social organization of learning—groupings, divisions of labour, roles, etc.— is part of social design.

Our H_2m design framework is based on ACAD, with a particular emphasis on flexibility and adaptability, and an openness to imperfection, messiness, and unpredictability. Thus, two main features of the ACAD conceptualisation of the design problem space are helpful with respect to H_2m. Firstly, ACAD emphasises the proactive role of students in interpreting, customizing and fine-tuning what

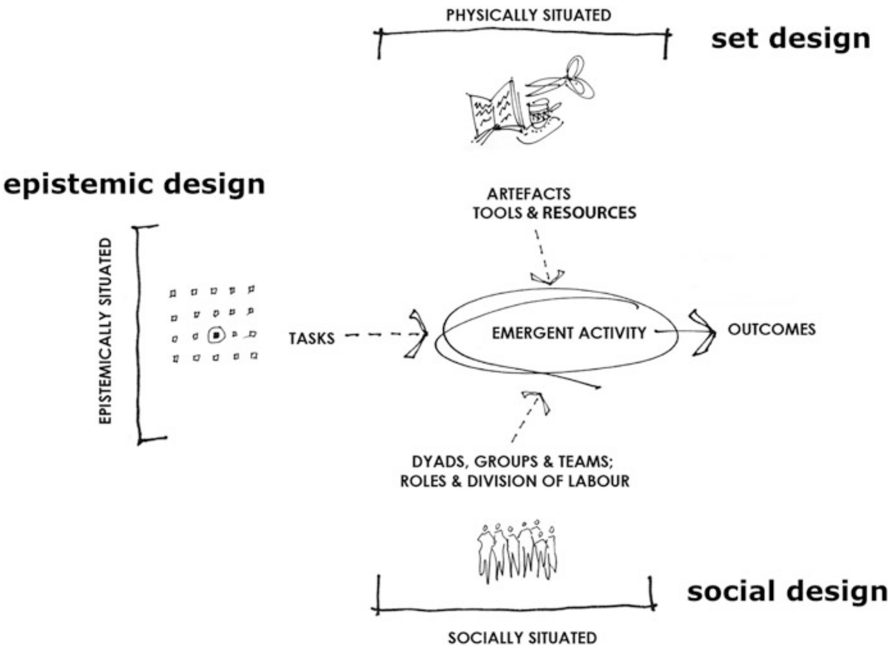

Fig. 1 ACAD framework. (Adapted from Goodyear & Carvalho, 2014, p.59)

has been designed for them. University students routinely reconfigure the tasks that have been set, the spaces in which they work, and the roles and divisions of labour suggested to them by teacher-designers (Goodyear, 2015; Sun & Goodyear, 2019). So learning situations are not predetermined by design; they emerge from embodied learner interaction with a task in the world – rather in the way that Dourish (2004) conceives of emergent 'contexts' in HCI. Students play a key part in *completing* designs. This has several implications. They need to understand the logic of what has been designed for them, in order to complete the designs in productive ways. They need to understand how to make productive adaptations quickly, when circumstances change (e.g. when moving activities from hospital to home, because of a lockdown). Indeed, knowing how to create productive learning environments—how to reconfigure congenial hybrid learning spaces—is an important but rarely acknowledged component of becoming an autonomous learner (Trede et al., 2019). In other words, ACAD draws teacher-designers' attention to the breadth and importance of student agency, and this is particularly important in the diverse and unstable study settings of students during the COVID-19 pandemic.

Secondly, ACAD distinguishes between epistemic (task), physical and social design components to make it easier for teacher-designers to focus on each of these in turn, when possible, while not losing sight of the fact that they become entangled (and hard to separate) at learntime. Thus, when an on-campus learning activity has to be redesigned for H_2m, ACAD makes it easier, at design-time, to think through the implications for changes in each of the three kinds of design components. A change to the nature of a task may have implications for physical design and vice versa. The loss of an element of the social design may be compensated by a tweak to the task design, etc. Of course, it may not always be possible, during design, to separate the epistemic component from physical or social components (e.g. a learning task for using an ECG machine cannot be designed without considering features of an ECG machine), but this does not reduce the usefulness of the analytical activity. Rather, it helps identify those aspects of design where change in one component (e.g., physical space or equipment) can be consequential for learning. The challenges of H_2m caused by the need to distance physically do increase the importance of examining the limitations of any given learning situation.

Both the template and the design of ACDPE itself were underpinned by these considerations.

The Template

Templates have a long history in professional work: providing scaffolding that enables novices to accomplish complex tasks that they do not yet have the skills and understanding to complete autonomously (Markauskaite & Goodyear, 2017a; Turnbull, 1993). The teacher-designers were supported by a customised template in which they articulated the learning tasks and rationales for their courses, and which made the design thinking process more visible and tangible (Markauskaite &

Table 2 Template section 1—overarching ideas

Heading	Prompts
Description	50-150 words about the course.
Purpose & aims	What is the point of the course, what should it achieve?
Learners analysis	Who are the learners, how many, what are the expected challenges?
Values	Beliefs about what is important and how learners best learn.
Timeframe	How long is the course, how is it structured?
Assessment	How are knowledge and performance connected to outcomes and values?

Table 3 Template section 2—details of design elements

Heading	Prompts
Task instructions (epistemic design)	How students should do the proposed task.
Set design	Prompts to consider digital and material resources.
Social design	Prompts to consider social arrangements (e.g. pairs, groups, scripted roles).
Timing	When this task would run, how many hours of learner's time, how would they pace themselves.
Learning before/ during/ after	Prompts to think beyond the direct learning from the immediate task, by also asking what students would need to know beforehand to succeed at the task, and what they would need to do afterwards to consolidate that learning.
Rationale	A reflective prompt asking why the task was designed in this particular way.
Evaluation	How the teacher would ascertain how well the chosen design worked.

Goodyear, 2017a). The template foregrounded core design elements, and reminded teacher-designers about the need to consider relationships between those elements. It incorporated the ACAD dimensions and H_2m sensitivities as highlighted above, and invited teacher-designers to reflect on issues that are deeply entangled in design for learning but often left implicit (e.g. values, knowledge and background of the learners, the pace of engagement in activities). It also prompted teachers to think about how to foster robust connections between what students are learning and doing, and their future professional activities and experiences (Markauskaite & Goodyear, 2017b).

The first part of the template scaffolded overarching ideas that would inform each course and help situate the design within a particular context (Table 2).

The second part of the template invited teachers to focus on the design of learning tasks (Table 3). Again, scaffolds were provided to break down complexity and guide teacher-designers in considering multiple, overlapping design elements.

The third part of the template invited teacher-designers to engage with design at a higher level of abstraction. Teachers were prompted to attend to significant relationships, such as alignment between tasks, assessments and intended course outcomes, and to write an overarching rationale stating how they saw design elements combining into a coherent whole in ways that enacted their values. The last prompt asked teacher-designers to reflect on how their design would help students to understand what they had learned and what they would still need to learn in future (before and during qualified professional practice). We saw this as a particularly important aspect of H_2m, where circumstances might make it impossible to meet the original intended outcomes of the course.

Comparison and Dialogue

The ACDPE course followed a "design and compare" process, based on David Nicol's model of self-generated or "internal" feedback (Nicol, 2020) which advocates asking learners to explicitly compare their own work with that of others. Teacher-designers produced design work (scaffolded by the template) and then compared their designs with the work of their peers. The aim was to create opportunities for them to progressively draw out principles and parameters of good course design (e.g. by pointing out differences and discussing why these matter). Resources (e.g. journal articles, blog posts, Twitter conversations, infographics or videos) were also used as comparators with the teacher-designers' own understandings, principles and designs. A separate template scaffolded the comparison process.

Part of the rationale for using Nicol's (2020) comparison model was that educating professionals can be a complex enterprise, where one size does not fit all. The structured moments of comparison reduced reliance on expert-designers as sources of wisdom, and created possibilities for teacher-designers to generate their own meaningful connections, insights, and sustainable design principles.

Details of the design and comparison templates, the course structure, and the task instructions are available in our open educational resource workbook (https://open.ed.ac.uk/agile-course-design-for-professional-education/).

Lessons Learned: Case Example

We used a case study approach (Yin, 2003) to draw out some challenges and contextual considerations of H_2m design for complex medical practice. For this chapter, we have selected the case of participant Morag (pseudonym), who, for the ACDPE course, designed a 3-week module in Emergency Medicine to help 30 final (6th) year undergraduate medical students learn to work "*as a core part of a clinical team, seeing patients, practising clinical skills*." Morag is a Consultant in the Emergency Department (ED). She is highly experienced as both clinical practitioner and educator but has had very little experience with online or hybrid education (though she had recently taken the online teaching course). She has a diverse group of UK-based and international students with some professional placement experience but her students usually have had little experience of seeing patients independently, making clinical decisions and seeing “*the spectrum of sick patients that present to the ED.*” Morag identified some common challenges for her students: *“Navigating the busy (at times chaotic) environment of the ED without feeling lost; some need more guidance than others to get ‘hands on’.”*

Morag’s case is instructive because it emphasises the importance of compassion, collaboration, and a safe and supportive learning community, while dealing with complex practical and logistical challenges. For example, across the practical modules of the undergraduate medical programme, part of Morag’s role involved coordinating a large number of clinical teaching staff working in unfamiliar conditions *(“We’ve got 40 tutors who are doing online learning for the first time”*).

Below, we briefly describe three tasks designed by Morag for her students before considering how her proposed designs address some important themes of H_2m. Excerpts are taken, with Morag’s consent, from discussion forums, tutorials (voice and text chat), and completed design and comparison templates. Ethical approval for the research was given by the Edinburgh Medical School ethics committee.

“Design Your Lockdown Workspace”

In Week 1, Morag’s group designed a task aimed at helping students to plan a “*study space that works for each individual [student] specific to their circumstances*”. It involved students evaluating their current study space, researching attributes of productive learning environments, and then drawing an achievable, improved study space. This drawing would be shared with student peers for discussion and comparison. The aim was not only that students would end up with improved studying conditions, but that they would learn valuable things about how they study, and also share something of themselves with peers and tutors, thus contributing to the building of trust and community. In learning about how others were adapting their own spaces, students would develop a richer collection of strategies, which ultimately could help them cope with constraints imposed by the H_2m mode.

“Patient Journeys”

In the first individual design cycle, Morag developed an “empathy task” aimed at increasing students’ understandings of what it is like to be a patient. In pairs, students would identify an appropriately complex case, and then, having obtained the consent of the patient and the other staff, would “shadow” them for a week. From this, each pair would produce an infographic related to the patient’s, relatives’ and carers’ experiences, and the students’ reflections on these. The infographics would then be shared with the wider class for discussion. The shadowing under H_2m mode required rethinking social design, as these practical placements were organised in hospital wards that students could visit in lower numbers than normal, using a tightly-organised schedule.

"The Resus Case"

In the second individual design cycle, Morag added a task in which students would write a 500-word reflective account of a real "resus" (resuscitation) case they had seen in the previous 2 weeks. She explained: "*Emergency Department resus rooms are where the sickest, most time critical patients are treated . . . Most often errors are caused by a failure of non-technical skills, rather than a lack of knowledge*." The task built on a tactical decision-making session that the students would have done in a previous year, with the purpose of helping them to understand the contribution of "human factors" to clinical errors (e.g. "*being HALT (hungry, angry, late, tired), feeling cognitively overwhelmed and the impact of our emotions*"). These accounts would be shared via the discussion board, with a follow-up task to explicitly compare their account with those of others. This task relied on learning and sharing strategies about tactical decision-making, and could be quickly adapted and conducted remotely under an H_2m mode.

While there are many facets of Morag's experience that could be usefully examined, we focus on themes around: assumptions and inclusivity; structure, flexibility and mess; and future-oriented design.

Theme 1: Assumptions and Inclusivity

The "design your lockdown workspace" task recognised that, in an H_2m context, supporting students to configure their own learning environments is important. However, comparison with the designs of other groups helped Morag to think differently about agency and inclusivity:

> *All of these courses will have a wide variety of students who will have different constraints placed on them during lockdown. Not everyone will have the ability to create an 'ideal' study space . . . asking students to design a workspace and submit anonymously might help, or could they design their 'ideal' workspace and describe three aspects that they could actually apply to their own workspace . . . ?*

This insight prompted Morag to turn to research on the current study conditions of university students, which reminded her that "*we need to design learning activities that will not inadvertently contribute towards 'otherness' in online learning.*" In other words, designers need to be careful not to base designs around unreliable assumptions about who students are and what their conditions are like. Similarly, following a comparison of her individual design with Hager and Hodgkinson's (2009) "Moving beyond the metaphor of transfer of learning" in Week 5, Morag wrote the following about being mindful of different individual needs when designing tasks like the "patient journey", set in complex environments:

> *If I designed my course solely around participation in context I may fail to account for the variation between my learners. If as a student you quickly and easily demonstrate the*

ED 'identity' then you will fit into the 'social context' more easily and be offered more opportunities for participation, than say the quieter student who may 'get lost' in the environment of the ED.

Therefore, scaffolding to help quiet students avoid "getting lost" in clinical settings might usefully focus on supporting a gradual increase in participation in context.

Theme 2: Structure, Flexibility and Mess
It was apparent from the teacher-designers' discussions across the ACDPE course that there was no "correct" design for complex situations such as H_2m. Design required a balance between what needed to be learned, what the teacher believed in and was comfortable and confident doing, perceptions about the students' particular needs, preferences and circumstances, and the available resources. In describing previous versions of her course, Morag noted that it could be "*... very prescriptive about: 'this is leadership... this is calling for help, this is team working' ...* ". She contrasted this approach with results from her colleague's research, which showed that

you ask junior doctors what they found stressful about looking after acutely unwell patients... and actually it's so much more deep and complex. We say to students 'call for help,' but actually there are a hundred million levels under that of who, when, why, my competence, my role, my hierarchy... we've been guilty, probably for 15 years, of oversimplifying human factors.

Morag's ACDPE designs featured some careful scaffolding of complexity, with prompts to help students make sense of dynamic and complex experiences.

...any tasks that help them structure patient learning opportunities should be beneficial. Without tasks such as this they run the risk of being passive observers, with limited meaningful learning.

Morag's tasks combined structured activities (e.g. brainstorming or reflecting on previous learning and possible future learning) with scaffolded social interactions aimed at building community and creating opportunities for peer review and dialogue. Morag also proposed ongoing, informal conversations as an important aspect of the evaluation of her approach, rather than only evaluating at the end. In this, Morag displayed a developing understanding of the need to balance preparation, forethought and structure with flexibility. This was particularly important in the context of H_2m, so that teaching practices could be adapted to the particular needs of students on her course that year, or to other emerging constraints. This was coupled with a growing sense of the impossibility of controlling "the student experience", particularly where teaching was done by many different contributors.

...we're obsessed by trying to deliver the same product to everyone... but over the last week, I've been thinking, does it actually matter? What they're getting from people delivering what they're good at and what they want to do is actually better than what we want them to deliver... It doesn't matter what we do, they're never gonna have the same experience.

For Morag, letting go of the perceived need to standardise teaching could free teachers up to teach in ways that suited and motivated them, and this should have a number of benefits, including a greater capacity to adapt in the situation. Morag was able to see that what has been designed in advance is actually not static. Rather, design often evolves through tweaks and adjustments at learntime, and also as students co-configure what has been set in place. In her design process and in her students' work in the H_2m context, she recognised the importance of avoiding perfectionism, and the benefit of sharing and discussing early work and thinking in progress. In conversation with others, she came to the position that for this flexible and adaptive model of teaching, the teacher needs a strong foundation of relevant knowledge, and sufficient preparation to be able to act spontaneously. She suggested that others with less confidence might be supported by teaching alongside a more experienced teacher.

> *I've kind of decided the only way to do it... it's a massive investment of time but for the first 5 week block I'm pretty much going to double up with all the tutors just to help that process... So there's someone there who's got a wee bit more confidence... one of the things with online teaching is, people need support.*

This onerous approach demonstrates that loose design does not mean less effortful design. Morag's recognition of the need to balance structure and flexibility within teaching mirrored her design intentions, which were about scaffolding students to recognise and explore complexity within a high-pressure environment.

Theme 3: Future-Oriented Design

The H_2m context highlighted a principle that we see as relevant to any professional programme: it is not possible to learn everything that is necessary for future practice. Morag noted that, even outside of an H_2m context, "*in reality maybe we have to challenge our belief that graduates are ready for practice and accept that a huge amount of learning required for this 'boundary transfer' will take place after rather than before*." This shows a shift in Morag's focus towards helping students to develop a greater awareness of what they *actually* learn (which cannot be assumed to mirror the stated learning outcomes), and how this relates to what they will need to learn in the future—to learn how to learn. It calls for a reorientation of what should be learned in medical school and how such learning might support what is still to be learned after graduation, which would then form a basis for action, during and after a course, led by the students themselves. In other words, teacher-designers might recognise the limits of their control and responsibility, and design for sustainable learning in which the primary aim is not to produce guaranteed skills or knowledge in their students, but to cultivate the capacity for their students to continue to develop such skills and knowledge in the future.

Of course, discipline-relevant skills and knowledge will be an important element of this capacity. However, these should not be seen simply as acquired by and residing within the individual student, but as emergent in activity in complex settings. In Morag's regret that previous courses had "*oversimplified human factors*", we hear a call for foregrounding materials, emotions, and embodied experiences within design tasks for medical education. Our proposed H_2m pedagogy advocates making the rationale for this explicit so that students not only complete the designed tasks in appropriate and meaningful ways, but learn to appreciate these often invisible aspects of the patterns of professional practice (Markauskaite & Goodyear, 2017a).

Discussion: Designing for H_2m Learning

ACAD worked well in supporting the design of ACDPE and the teacher-designers. Its use also allowed us to see that H_2m design calls for particular sensitivities. Amongst the main lessons for the teacher-designers were the need to avoid perfectionism and embrace design messiness. Designers often deal with complex problems to which there are multiple potential solutions, and teachers cannot entirely predict or control what will happen at learntime. The H_2m context, however, seemed to heighten this unpredictability, calling for flexibility and adaptability.

Teacher-designers also realised that not everything can (ever) be learned, particularly where specialised physical elements and complex practice are concerned. Designs may have to compensate for unexpected changes in the physical or social situation, but also for the unavoidable limitations of any educational programme that aims to prepare students for professional practice.

Teachers constantly zoomed in and out, thinking about individual elements, the relationships between these elements, and how "design parts" relate to the "learning whole". Morag's case demonstrated some central relations—or dimensions of hybridity—that matter in designs for professional H_2m learning.

- *Spatial relations:* Designs should focus not only on creating shared environments, but also on helping students fine-tune their individual learning environments so that a whole H_2m assemblage—distributed across physical and digital spaces—works well for them.
- *Structure-activity relations*: An important area of design decision-making is the relationship between what is designed ahead of time and what the teacher leaves to unfold at learntime (when more is known about context, student needs, etc). There is a fragile balance between (too) loose and (too) tight designs. Advance knowledge of what the teacher, or their teaching assistants, may be able to improvise at learntime is a factor here.
- *Temporal relations:* H_2m designs for professional education need to extend over longer time scales—paying more explicit attention to the relationship between current, non-practice learning tasks and ongoing learning within future practice settings. Students' awareness of how their learning extends across time is an important aspect of H_2m learning.

Authentic design tasks, scaffolded by the template, the comparison model, and dialogue with peers, helped teacher-designers notice these key relations and purposefully design their courses to take account of them. Our case example has helped us to identify some principles that apply to any domain but are heightened in the H2m context:

- Inclusivity requires dialogue with students, flexible designs and adaptability at learntime.
- Accept imperfection, mess and incompleteness, and engage in open discussion of the limitations of the emergent learning activity within the course.
- Discussing these limitations with students can help them prepare for the learning that they need to do after the course.

Conclusions

This chapter shares some insights drawn from a professional development course to help clinical educators redesign their courses for a hybrid model, in response to the COVID-19 pandemic and physical distancing regulations. The course featured a design template underpinned by the Activity-Centred Analysis and Design (ACAD) framework (Goodyear & Carvalho, 2014; Goodyear, Carvalho & Yeoman, 2021), which provided adaptable principles that can be applied to hybrid models in dynamic circumstances. The ACAD framework also illuminated particular sensitivities that are heightened in the context of highly-constrained, unpredictable and unstable learning conditions. This combination of principles and sensitivities—what we call H_2m pedagogy—encourages teachers to avoid perfectionism and embrace students' agency, while respecting the need for flexibility and sensitivity to students' circumstances and challenges, including scheduling, technology issues, workload and caring pressures, and mental and physical wellbeing. Thinking about H_2m pedagogy and design also helped recognise and compensate for students' restricted access to specialised equipment and workspaces, and their reduced opportunities for participation in complex forms of professional practice. Use of ACAD, the template and Nicol's (2020) comparison model helped draw teacher-designers' attention to the importance of relationships and dependencies between design components, the relevance of community-building, and the need for richer forms of student support. These lessons are heightened in H_2m, but they apply across a wide range of circumstances.

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Covid-19 Lock-Down: Hybrid Learning Cases Using the Lens of the Zone of Possibility

John Cook and Debbie Holley

Introduction

The leap to online learning as a response to Covid-19 has, for those in academia, seen the shifting of learning from a blend of online and face-to-face, mainly framed by the affordances of institutional Virtual Learning Environments. However, a severe limitation is the organisational perceptions that adding on a video-conferencing platform (e.g. Zoom, Go-to-meeting, MS Teams) has transformed the underpinning pedagogies and is facilitating active student-centred learning. As our individual work, leisure and learning all intertwine in the same 'place' that can typically be our home, the spaces and ways in which we collaborate are as yet under theorised, and the technological determinants driving collaborations are not yet fully understood. Our chapter responds to the need to investigate and, indeed, represent a more nuanced theoretical proposition. Thus, the work is positioned along two axes of pedagogical theory and practice.

Stommel (2012) suggests that a "hybridity pedagogy" changes the notion of "place of learning" and invites us to fundamentally rethinks our conception of place. Indeed, Ellis and Goodyear (2016, p. 150) have argued that the connections between "place and learning" can be subtle and powerful and that to "understand them, one needs to understand complex, shifting assemblages involving human beings and things: material, digital and hybrid"; they argue that the boundaries between the physical/virtual are becoming increasingly permeable. For educational contexts, the implications are the enhancement and promotion of study activity in space

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and time. Cook's (2015) work identified two dimensions of hybridity in learning spaces: the interweaving of formal and informal social structures in an activity system, and the combination of physical and digital tools mediating an individual's interaction with the world and society. Drawing upon the work of Bernstein (2000) and Daniels' (2008, p. 164) "zone of possibility", and framed by Educational Design Research, Cook (2015) argues that: "people connect and interact through a hybrid network of physical and technology-mediated encounters to co-construct knowledge and effectively engage in positioning practices necessary for their work". The propositions that underpin the theoretical framing of this chapter, and future work, are twofold. First, the proposition that people "learn from each other in groups (a Zone) that calls for orchestrating social supports (navigation and bridging aids) so that learners can benefit from the ideas of others (Possibility) ... [this can be] seen as a framework for enabling a "Zone of Possibility"" (Cook, 2015, pp. 125). Second, the proposition that because "bridging positioning practices as successful communication were found to be significant" in the Zone of Possibility (ZoP), the concept if the ZoP "should be redefined as a **place** where individuals can overcome the constraints of expectations and power structures to effect desired change" (Cook et al., 2020, p. 1158, our bold).

Furthermore, Ellis and Goodyear (2016) propose four key constructs that are needed for progress in learning space research. We observe that the ZoP concept aligns with aspects of these constructs. The first key construct is learning capability, and the ZoP is viewed as learning as participation, in that it "foregrounds knowing rather than knowledge and shared activities rather than possessions" (Ellis & Goodyear, 2016, p. 154). In relation to second key construct of space and place, we agree that it is helpful to "think of space as that which allows movement, then place is a pause; each pause in movement makes it possible for location to be transformed into place" (Ellis & Goodyear, 2016 p. 157, citing Tuan, 1977); the transformations looked for in a ZoP have much in common with place. We further agree with the observation made in the context of the third key construct of built form (i.e. physical, virtual, hybrid) that "technological developments are leading to a growing interpenetration of the material and the virtual 'worlds' " (Ellis & Goodyear, 2016, p. 158). Our case analyses demonstrate this fluidity, and this plays forward into our findings. The fourth key construct explores the affordances of 'objects, artefacts, tools and texts'; clearly these "add value only to the extent that they are assembled together into effective configurations" (Ellis & Goodyear, 2016, p. 160).

Our research question (RQ) originates in the body of work summarised above (i.e. Cook, 2015; Cook et al., 2020), and offers a lens to frame the examination of our emergent cases:

RQ In the context of Hybrid Learning Spaces, how can the design process and design thinking advance or bridge 'successful communication' and an understanding of social context in a ZoP?

Bridging arises when people from various backgrounds make connections entering social networks that offer more inclusive opportunities. These kinds of networks literally create ‘bridges’, “which is they allow people, who might not have had the possibility to encounter one another in their daily lives, the opportunity to become acquainted” (Tomai et al., 2010, p 265). One of the main conclusions of earlier work is the importance of bridging positioning practices as ‘successful communication’ and an understanding of social context in hybrid contexts, i.e. the ZoP (Cook et al., 2020). Case study 2 provides an example of supporting bridging where a tutor places students in a study group and steps back. Supporting large-scale bridging as a mechanism for expanding an individual’s social context (to effect desired change) will include an undertaking to develop or adopt ‘low flying’ or ‘low overhead’ meditational tools that address ethical and privacy concerns of citizens. These should also sit easily in users’ learning, cultural and work practices, (e.g. see Case 3 redesigns for Digital Wellbeing). The ZoP can thus be viewed as having significant overlaps with Ellis and Goodyear’s high level description of the meaning and structure of learning space, where a learning space can be “viewed as different configurations and affordances of space designed, provided, supported, evaluated and renewed to enable learners to develop their understanding and skills” (Ellis & Goodyear, 2016, p. 175).

To set out investigating our RQ, our stance is that the ZoP concept needs to be viewed as a more specialised and design led learning space. We frame our Hybrid Learning Space pedagogy (the ZoP) through three cases: Bristol Jazz Workshops, Goethe University Frankfurt students, and Bournemouth University (UK) Nursing academics. Each is singular and unique, but all provide examples of the ZoP learning space transformed to learning place. This chapter offers a brief overview of our research methods, reviews the cases and concludes with contextual, pedagogical and design implications; the latter includes a ZoP meta-design principle (an overview) called “Respect Learners’ Zone of Possibility”.

Our chapter has many synergies with other chapters presented in this book. Specifically, the ‘hyper-hybrid entanglements’ explored by Toft and Hilli (Chapter “Hyper-Hybrid Learning Spaces in Higher Education”) has many fascinating overlaps with the concepts of ZoP and interpenetration presented in our chapter. Furthermore, our work shares many conceptual and practice concerns with Simpson and Goodyear (Chapter “Dialogic Teaching and the Architecture of Hybrid Learning Spaces: Alexander Meets Alexander”). Like our 3 cases, Simpson and Goodyear aim to reach an understanding of how the approaches to constituting a ‘dialogic classroom’ may be of practical help when the classroom itself undergoes an unexpected transformation. The capacity to reconfigure plans in response to change requires an approach that can be developed with insights into the dynamic interplay of ‘space, (place-)time and human activity’; this is something that the lens of the ZoP also explores below.

Research Method

To explore our Research Question and challenge our own preconceptions of space, we draw upon participant research methods (Case One/Two), which can broadly be framed within the ethnographic tradition (Kawulich, 2005). However, when researching in a period of exceptional change, such as Covid-19, the more traditional notions of what it means to be a participant observer are bounded by established ways of working. Thus we drew upon the work of Ropers-Huilman and Winters (2010), exploring their approach to complexity in theoretical and paradigmatic understanding. This draws upon the intersectionality between theorising, knowing and implicating, and offers insights into negotiating the fluidity of spaces 'between' wholeness among individuals and groups (Case Three). The jazz case we offer in this chapter can thus also be interpreted in terms of the 'wholeness' in and amongst the individuals and the group. The 'space in between' concepts offer a 'way of knowing' and frames Cases 2 and 3. Case 2 is located in the space where more formal teaching and learning takes place. Case 3 is positioned as a loose collection and collaboration of individuals and groups seeking solutions as they move to learning online.

Research Schema Each case takes the following format: contextual framing, case description, pedagogic implications and implications for design; and this format generally follows through to the conclusions. Table 1 provides an overview of the three cases.

All three cases follow Yin (2014, pp. 16) in that they are empirical investigations that explore a contemporary phenomenon within a real-world context. The analysis adheres to the guidance of Ellis and Goodyear (2016, p. 174), whereby "learning space includes all material and non-material elements of the space and their affordances for learning in relation to learning outcomes ... Simply put, if the space supports experiences that promote understanding and related learning outcomes, then the purpose of the space is realised". Thus we draw upon multiple sources of evidence, and triangulation of methods, through this lens.

In the first case Cook acts as a participant observer (Kawulich, 2005) as well as being the workshop double bass player. Cook discussed the research proposition with his fellow workshop participants; explained the role of researcher and the concept of Hybrid Learning Spaces. Informed consent was obtained from all participants in Case 1 and 2 for anonymous reporting of comments and evaluation results. Names used are not the real names of participants. In Case 3 Holley was a co-facilitator with the faculty learning technologist in a 'summer of tech' in which fluid 'radio show' type workshops scaffolded the efforts of staff to move their resources online. In particular, they worked with a team of academic nurses, who were required to meet a new set of guidance offering far more freedom of curricula delivery, yet paradoxically constrained by their professional body requirements. This final case makes no claims to formal evaluation, but instead takes a reflexive stance in developing theory into the new fluidity of space and place afforded by the

Table 1 Overview of case studies

	Case 1: Bristol Jazz Workshops: a holistic hybrid approach	Case 2: Goethe University Frankfurt students	Case 3: Bournemouth University: supporting student nurses learning during the pandemic
Informal/formal	Informal learning in the community	Formal learning online	Semi-formal
Number of participants	10	12 participants 'face-to-face' (2019) and 7 participants 'fully online' (2020)	62 nursing tutors in the first instance, cascaded to 5 departments and over 150 individuals
Research tool/analysis	Observations/evaluation: Field notes and analysis of video calls; texts and images used with participant informed consent	Observations/evaluation: Questionnaire and tutor field notes; informed consent obtained	Observations/evaluation: learning design case following Conole and Wills (2013)
Researcher role	Cook acts as a participant observer	Cook tutor	Holley was a co-facilitator
Research foci/emphasis	Bridging digital literacy / designing for interpenetration	Following iterative critical thinking cycle/pattern is important	'Vocabulary' of digital learning success framed the Community of Practice. Learning design supported staff by offered mechanisms for scaling up

Covid-19 pandemic. In terms of the various research foci that Ellis and Goodyear (2016, p. 164) put forward, our cases take the following emphasis. Case 1 offers the physical (the musical instruments) and the virtual (the means of communication) to take a holistic stance in its coverage of the situation; Cases 2 and 3 offer a "Virtual learning spaces (formal) where someone in a teaching role is supervising activity in the space" (Ellis & Goodyear, 2016, p. 164).

Case 1. Bristol Jazz Workshops: A Holistic Hybrid Approach

Contextual Framing

The Bristol Jazz Workshop is one of the country's longest established jazz education projects. Normally, four groups meet once a week in the back room of an English pub in term time under the guidance of a professional musician-tutor. Each group is introduced to 3–4 tunes a term and is guided to play as an ensemble a tutor-written orchestrations of the tunes, and are shown how to adopt a 'jazz language' (e.g. when improvising) by their tutor. The four ensembles would perform in front of each other at an end of term event. Many of the musicians have been in these ensembles for several years. Due to the Covid-19 lock-down, the Bristol Jazz Workshop went fully online in summer semester 2020 (April to July), with some surprising consequences.

Case Description

In the new online set up, the workshop tutor Sam would email the group individual musical parts for a new piece to be studied. The group would discuss this in a weekly Zoom meeting and organise the process of recording first, and remotely, the rhythm section and lead melody line (a quartet) version of the current tune with Sam providing critical and motivational comments. Other workshop participants would then be asked to add their melody line (head-in and head-out). In the ensuing weeks Sam would send more music sheets that covered ideas about how to solo on the tune (jazz language); these solos would be added to the recording.

Cook took great interest in the fact that when faced with the challenge of recording individual parts and solos at home, probably for the first time, Chris the alto sax player reported that he got the best sound quality results when resorting to recording in his wardrobe. Fred, one of the sax players, provided another example of hybridity: half way through recording one of his solos apparently, as reported in a Zoom meeting, his son came in to ask him a question. Fred kept playing sax with one hand and pointed to the door with the other; on his recorded solo in one of the four tunes completed that term you can clearly hear his son asking "why?". This is a good example of the way that technological developments are leading to a growing *interpenetration* of the material and the virtual 'worlds' (Ellis & Goodyear, 2016, p. 158), here we get the interweaving of work and our family lives; the digital and the physical; our leisure and learning seem to coexist in the same place and time. In the early days when they had technical difficulties, Sam and Nigel had a partner-wife hovering at the side of the screen who sorted problems out for them. On one occasion Carl (piano and a surgeon) was on call and had to travel off to his hospital and hence missed the video conference. The point being again, that due to the lock-down many of us have mashed-up (interpenetration) our work, home and family lives, our leisure, our teaching and learning.

The group's version of Recado Bossa Nova (*), one of four pieces that we learnt, was achieved by the players sending over their recorded parts digitally, with Cook compiling it all layer-on-layer in to Ableton Live 10 Suite software (generically known as a Digital Audio Workstation). Sam did the arrangement(s), critiqued and encouraged. Indeed, in Zoom and emails we learnt much about the jazz language and musicians under study. By common consent it was observed that it had been lots of fun listening to Sam 'go off on one' about the likes of Chet Baker and Hank Mobley; this brings jazz to life online, particularly the mixed views on Chet's singing! Recado Bossa Nova was written by Luiz Antonio and Djalma Ferreira; it was recorded famously by Hank Mobley featuring Lee Morgan on the 1965 album Dippin' (**). These musicians play Recado faster than us but make it seem effortless; the groove is very danceable and the solos are excellent. For Cook's solo in our version (only his 3rd attempt at a 'take' and it shows!) he is using one of the lessons from Sam, sent via PDF and explained in Zoom, called "Developing the simple line using Harmonic Minor Scale".

The above analysis (i.e. the text in the section above) was provided to all participants via Facebook and email. Comment was invited. Here are three interesting responses:

Fred: "Great analysis John [i.e. Cook], with home schooling, home working and then doing the workshop online it's been a particularly digital few months. In the wider sense this period has probably pulled an older population back in sync in regards to the possibilities of technology. I was sceptical at first but Sam structured it really well and the recording work gave us targets and more importantly a focus. I found recording frustrating (but always did historically) and I think it makes you focus on the bad bits more than you perhaps do in live performance....it adds a certain amount of tension to improvising and playing as well. However it has been very helpful and thanks for pulling that side of things together. If god forbid, we are locked down again I wouldn't hesitate to repeat the process again as music is always more satisfying communally".

Sam: "Well said John Cook and well put together. I think we've all done well to adapt so quickly and make the most of the situation. Really enjoyed the sessions and the results are excellent!"

Nigel: "Just to say thanks for all the time and expertise you've put into making us sound at our best! It would have been a far less rewarding experience without the incentive of these recordings".

Supporting the bridging of digital literacy (related to the **RQ**) was an early challenge and needs more work in an area where participants did not have the basics to record at home. However, Sam the tutor said to Cook in an email towards the end of the course: "everyone seemed to have learned a lot from recording and hearing themselves placed in the track". Cook's response was to agree that all musicians had risen to the challenge; despite the playback not being exactly what was expected/wanted. Carl and Cook were of the opinion that we had learnt more than in the normal face-to-face workshops.

Pedagogic Implications

Although tutor led (partially formal learning), this case is being used as an example of informal learning under disruptive constraints caused by Covid19, where participants are tutored online about a specific tune and specific musical scales in order to create their joint artefact (a digitally recorded tune, which acts as a replacement for the end of term performance). However, participants also learned informally from each other and private research. For example, they learnt about spatial acoustics (recording may be better in the wardrobe), about using conference call software, and about digitally recording themselves. Also, the case provides at least one example of the important Hybrid Learning Space concept of interpenetration.

Implications for Design

Bridging digital literacy was sometimes tricky in the early stages of the online course and more work needs to be done in this area, e.g. where participants did not have the basic equipment and knowledge of how to record at home. Similarly, designing for interpenetration needs more thought.

Case 2. Goethe University Frankfurt Students

Contextual Framing

The short course under discussion here is called ‘Digital tools and innovation’ and takes place as seven sessions of around 3 hours each. The course was written and taught by the first author (Cook) in English at Goethe University Frankfurt. Because English is the students’ second or third language, group sizes were small and ranged from 12 in 2019, and 7 in 2020. The course explored how to design technology to mediate learning in traditional and emerging sites of lifelong learning. Students were usually at undergraduate level (but occasionally Masters level) and were usually taking a major in Educational Sciences. Teaching-learning took the form of a combination of lectures, seminar discussions, group work and individual student work. The course was first taught face-to-face in 2019 as two ‘compact weekends’ and appears as a face-to-face, taught, case study in Cook et al. (2020). In the Summer of 2020 this same course was repeated but took place entirely online due to Covid-19. Formal course evaluation results (these are handled by a central university service) from both years will be compared to address the RQ.

Case Description

In April–May 2020 Cook acted a tutor for a small group of 7 students on the short course ‘Digital tools and innovations’ at Goethe University Frankfurt. This was the first time Cook had performed wholly online teaching and learning. The small seminar group used Adobe Connect. Cook produced lesson plans (with learning outcomes) for all his sessions and shared them with learners in advance. Following lots of preliminary email support, in the first session some scene setting took place from Cook. All sessions involved lots of active, participatory, small group learning. Dialogue and co-inquiry took place in a Zone of Possibility (see *Implications for Design* below). The sessions in particular generated a good debate about the ethics of Google Lens (a camera based, object identification, mobile phone app with an underlying neural network). Cook's goal was to meet the course learning outcomes by using bridging to create a ZoP. Break-out groups were crucial for bridging in a participatory way. A break-out is where the tutor sets the task and allocates/negotiates the time but is not present in the break-out group; these are easy to achieve in Adobe Connect and which can do it automatically.

Evaluation of student perception of any course is run by a central university unit at the request of the tutor, who gives a brief explanation of the evaluation including details of privacy and anonymity, and then gives the link to the students so they can carry out the preset survey on their own. Note that scores in the evaluation were: 1 = do not agree at all, 2 = do not agree, 3 = mostly do not agree, 4 = mostly agree 5 = agree, and 6 = agree entirely. In the 2019 the small group more or less consistently gave scores 6 out of 6 on all centrally provided survey questions. In the 2020 evaluation the scored dipped slightly to around 5 out of 6. The 2019 evaluation was done retrospectively whereas the 2020 evaluation was done while the session was active. Specifically, evaluation results averages from 8 scored questions were as follow. Summer 2019 average score was 5.9 (n = 4). Summer 2020 average score = 5.2 (n = 7). That said, one student's 2020 evaluation comment seems to support the assertion that dialogue and inquiry took place that was participatory in nature: "Good introduction to a little-known area. Constant and extensive exchange between students, as well as the promotion of participation. Very nice, flexible and pleasant atmosphere". Further, the 2020 answer to this question: "1.8 The other students contribute to a constructive learning environment" increased on the 2019 score of 5.5 to score 5.9 in 2020 (the maximum is 6). However, disappointingly the answer to the question "1.1 Attending the course has resulted in a noticeable increase in my knowledge level", dipped a full point from 5.6 in 2019 to 4.6 in 2020. Perhaps this response to the open ended question explains this: "1.11 Please name three things about this course that could be improved upon": "The discussions were quite short due to the technological novelties. Not really possible to go into a lot of detail the relevance of the topic is clear, I would have wished for a better in depth knowledge".

The balance online needs to be struck between making short informed presentations, promoting participation and keeping the attention of students; the cues for the need to go into depth in a subject may not have been present online. Also, we acknowledge that the survey sizes are small, but for us it is more about digital dialogues and how this feeds into the ZoP and design; indeed this case will (below in implications) touch on points around patterns, plus iterative and agile design. Furthermore, the lessons learnt from this case were taken into the first author's two Winter Semester 2020 courses (both wholly online) enabling him to achieve nearly 6 out of 6 on all the survey feedback.

Pedagogic Implications

Break-out groups have the potential of promoting student dialogue one step away from the power imbalance of having the ‘professor’ in the room (bridging). Tasks need to be carefully designed to encourage this.

Implications for Design

The following iterative cycle/pattern is important: tutor led introduction of concepts; then break-out groups for promoting student dialogue one step away from the power imbalance; report back to the group with questioning from peers and tutor; repeat the cycle with slighter harder tasks, highlight the need for critical thinking (e.g. arguments backed-up by evidence that is correctly cited and referenced); eventually flip the classroom so that learners develop agency to research a topic in groups and present to the class; ongoing linking of the previous to the assessment for the course in order motivate participation.

Case 3. Bournemouth University: Supporting Student Nurses Learning During the Pandemic

Contextual Framing

The requirement to move learning online under the Covid-19 lock-down immediately posed unique challenges to Nursing teams across the UK. Delivering a Professional Curricula under Nursing and Midwifery Council (NMC) accreditation is complex, and rightly, highly regulated. The call in March 2020 by Public Health England (2020) mobilised student nurses, who were within 6 months of graduation, into clinical settings to support the NHS; they subsequently completed their degrees in practice. Highly specialist academic staff lost access to their health simulation teaching suites overnight; this all required fast pace adjustment to continue to offer learning opportunities supporting students to develop skills that needed to be ‘signed off’ as a pre-cursor to entry to their practice placements.

Case Description

The Nursing team pride themselves on delivering a high level of content knowledge and skills to trainee nurses, and the approach very much draws on the Community of Practice (CoP) work that Wenger (1999) advocates. The work on the ‘humanisation’ curriculum led by Todres et al. (2009) influenced and created a shared ongoing culture of value-based teaching and learning. As the Corona Virus pandemic impacted, this motivated team wanted the very best for their students. The curricula offering normally comprises predominantly face-to-face content and supported skills lab work. With the clinical skills emphasis, blended learning typically took the form of materials uploaded to the institutional Virtual Learning Environment (VLE) and the use of Talis-Aspire reading lists. A fast transition was needed to move content online for our cohort of now distance learners.

The institution responded to Covid-19 with what could be described as a ‘streetlight approach’ (Cohen et al., 2020); valuing what can be measured and setting in place a suite of ever-expanding instructions for academic and professional staff on ‘how-to’ use the tools available in the VLE. This disjoint between the formal university offering and the practice of the community can be located in the Ellis and Goodyear’s (2016, pp. 150) high level analysis of the complexity of research into learning spaces. Our educators were confronted with the challenges of promoting ‘connected learning’ to a now fragmented student body; some in the hospital wards completing online final units for their degrees; some at home with their own complex work/life challenges; some needing expert skills sign off; and all needing a reconnection with their studies, values and obligations to the profession they had chosen.

Holley (second author) and Moran (the Faculty Learning Technologist) quickly identified a deep unease with institutional suggestions for teaching online. Online delivery was viewed as being a ‘second rate’ experience for students; and, furthermore, staff were concern about their skill set in delivering in this unfamiliar setting. The ZoP was familiar to Holley; and in it she identified the offering of a safe ‘place’ where individuals could overcome their own constraints of expectation, a place-binding (Ingold, 2011, in Ellis & Goodyear, 2016) at the intersection of the paths people create and follow in their daily lives. The community focus of the nursing team prompted the ‘Corona Virus Teachinar Unit’ initiative, an agile response, enabling a contextual and targeted peer learning space. Run as a daily ‘Tech Chat Show’, all were welcome, to share concerns, worries, successes and to draw upon the expertise of the facilitators. It quickly evolved into a community hub for checking in, scenario planning, and to gain insights into the uses of Technology Enhanced Learning (TEL) tools in pedagogical settings, framed in a low hierarchical (power) structure in that there was no obligation to feedback, to be chased up for implementation data, or to attend. The sessions had any formal ‘demo’ sections recorded, and the conversation themes identified from the session summarised and posted by Holley/Moran on the announcement page of the Unit. The approach was framed as a hybridity or duality where the values underpinning the nursing ethos (on one side), ran in parallel to community building between the facilitators, nursing academics and nursing academics within their wider teaching teams (on the other side). This duality was rolled out as a community/sharing model of practice as nursing academics worked with their nursing students in the very different set of delivery circumstances posed by Covid-19.

Conole and Wills (2013) suggests learning design can be codified in a number of different representations, some of which we list below. The 'Actioned Through' label alongside illustrates how we built this aspect into our design, and also includes related brief comments on how it links to the ZoP:

- Textually based narrative case studies, describing the key features of the Learning Activity and perhaps barriers and enablers to its implementation.

  Actioned through: 'The John and Debbie Daily Chat' write up, drawing upon the narratives shared in the daily drop-in session. Although we had online learning expertise, we deliberately avoided power structures and facilitated a shared construction of knowledge with our participants, as they interacted with us and each other.

- More formal narratives, against a specified formal methodology such as the concept of pedagogical patterns, which provide a structured mechanism for representing good practice.

  Actioned through: Holley personal blog, 'Hashtags Handhelds and Handbags' (***) where links to useful external resources were highlighted, tweeted and picked up by the wider sector and some staff. In this way we supported bridging in ZoP terms.

- Visual representations, such as a mind map or formalised UML (Universal Modelling Language) use case diagram.

  Actioned through: Moving towards pedagogical conversations, visual models have been shared to conceptualise student digital learning journeys; co-created by the facilitator and the community online at a particular online session.

- Vocabularies (Currier & Campbell, 2005), such as taxonomies, ontologies or folksonomies

  Actioned through: Daily online drop-ins, run through the 'Virtual classroom' where TEL vocabulary was demystified and unpacked in relation to the user context. Again, in this way we supported bridging.

- Models (Mayes & De Freitas, 2004; Conole, 2010), foregrounding a particular pedagogical approach (such as instructivism, problem-based learning or an **emphasis on a dialogic** or reflective approach).

  *Actioned though: a socially-constructivist lens, drawing upon the ZoP and deliberately aimed to minimise power imbalances between the 'experts' (the facilitators) and the 'staff as students' whom are experts in their discipline. The dialogic was our preferred model and enabled us to weave in Hybrid Learning Space pedagogy (*Cook et al., 2020*).*

Thus the nurses were simultaneously the student and the teacher, the community builder and the modeller of community building; modelling the nursing values with compassion in strange new circumstances, we sought to reconnect the students with the values of their chosen profession. This blurring of boundaries (delivered, with heartache, worry and anxiety) has echoes with the 'unexpected and interleaved experiences' described by Cohen et al. (2020, pp. 1039). These occurred as students and academics found themselves on Covid wards together (many of our nursing academics signed up for the 'nursing bank to support the NHS' initiative); and these blurring of boundaries (interpenetration) also occurred where both academics and students found themselves working around complex home/caring/childcare arrangements so typical of a feminised workforce. The interpenetration between the material and virtual became the norm, as students and staff learned very quickly to harness their mobile devices to access learning 'on the move' in the complexity of different spaces. Digital Wellbeing, a key component identified by Biggins et al. (2017), was at the heart of our approach to interacting with staff, as they self-developed alongside the more interactive sessions offered.

Pedagogical Implications

Minimise power relations through dialogic ways of working, where existing knowledge and expertise is acknowledged, and the conversation is about multi-modality and bridging for the end-user, the student.

Implications for Design

Our learning design supported staff by offered mechanisms for scaling up (e.g. deploying 'The John and Debbie Daily Chat' write up, these drew upon the narratives shared in the daily drop-in session). Key emergent design features were co-creation, visualisation and confidence in the 'Vocabulary' of digital learning success framed the Community of Practice approach with our Nursing academics. The approach was quickly escalated to the Faculty Incident Group; we were requested to roll out the approach across all five departments.

Conclusions

We now present three categories of conclusions that address our Research Question: contextual framing, pedagogic implications and implications for design.

Contextual Framing

Each case study is unique and bounded by its specific context. By drawing them together, framed as responses to Covid-19, and viewed through a reflective lens, we can identify the point of orientation that Ellis and Goodyear (2016, pp. 174) identify, i.e. that “learning outcomes of students in learning space give meaning to the structure of physical and virtual learning space and to their interplay. In this sense, learning outcomes drive the activity of learners who engage with the elements of the space in order to achieve them”. Indeed, the participants in each case gave their own meaning to the structures of physical and virtual learning spaces and the interplay between. In Case One, the music was the primary medium, and it is interesting to observe how the desire to co-create enabled bridging between virtual and material spaces; this encompassed the physical, the music instruments, and the associated online communications referring to digital artefacts; these are so much more than ‘just’ the spoken word. The bridge is the technology and the dialogues were mediated by the tutor, and these enabled the whole flow of creativity, information and knowledge construction that we see in expert and learning musicians. The second case offers bridging positioning practices through the student contributions to the learning environment; and the technology mediates the power role of the tutor, to enable a more (but not totally) equal power relationship. Learning outcomes were formally given at the start of the short course but were framed so that students could co-construct meaning in groups. The third case study actions bridging through the lens of pedagogical dialogues, co-created visual models and, similar to case study two, the tutor was actively seeking to orchestrate social supports and frame the ‘place’ as the ZoP.

Our work has methodological implications, as the insights of the participant observer and reflexive practitioner framed by the transformative possibilities of intersectionality offers what Ropers-Huilman & Winters (2010, p. 40) suggest are ways to disrupt, transgress and deconstruct unified, homogenised categories of identity, and its associated possibility of changes in social structures. Through the lens of the ZoP, it is a place for individuals to effect desired changes. By clearly acknowledging the power relationships in our different case studies, we “remember we are always implicated both by what perspectives are represented in a given situation and by those that are not represented” (Ropers-Huilman & Winters, 2010, p. 46). Access to technology is not free, and the use of technology does not occur in a political vacuum. We are mindful of our positions of privilege as we seek to develop theories and models called for by Ellis and Goodyear (2016); and welcome the ethical stance that framing this body of work on hybridity entails (Cohen et al., 2020, p. 1042). The combination of observational and experiential data of this work aligns with the need that Ellis and Goodyear (2016, p. 181) argue is vital.

Pedagogic Implications

The various forms of hybridity found in our cases offer examples of the interpenetration of online and off-line spaces, and not a naive notion of a 'merging' solution. All cases illustrated that 'interpenetration' is an important hybridity concept, and we argue the distinction Ellis and Goodyear set out (2016, p. 181) needs further work post-Covid. Their work seeks answers to broader questions around how to distribute activities across a workspace, ways of collaboration, modifying spaces to make them better for ones' activity – we can see that intentions are far clearer in a fully online taught world. Observing what Fred (Case 1) actually did when his son burst in to the room whilst a recording session was underway is important from a HLS perspective. Fred also commented that "In the wider sense this period has probably pulled an older population back in sync in regards to the possibilities of technology. You could feasibly run a workshop with anyone in the world. I was sceptical at first but Sam structured it really well and the recording work gave us targets and more importantly a focus". Clearly dynamic bridging took place in Case 1 with places within places and further inter-generational interactions and affordances seeming to be coming to the fore. Also, the participatory notion of how all the participants in Case 1 move within the ZoP, how they inhabited and reconfigure the space-place, how they (we) created and experienced a congenial learning places can be clearly identified.

Bridging digital literacy (related to the **RQ**) was sometimes problematic in all cases; in Case 1 in the early stages participants did not have the basics to record at home; in Case 3 expertise was at first in face to face teaching. That said, in Case 3 the agile Corona Virus Teachinar Unit proved crucial; the interpenetration between the material and virtual became the norm, as staff and students learned very quickly to harness their mobile devices to access learning 'on the move' in the complexity of different spaces.

Implications for Design: Meta-Design Principle "Respect Learners' Zone of Possibility"

Design principles emanate from and connect to theories of learning and instruction, they can be at several levels of specificity; the one presented here articulates the Zone of Possibility concept based on the above case study implications. The meta-design principle is called "Respect Learners' Zone of Possibility" and captures abstract theoretical ideas and projects them into the problem (practice) domain. Our meta-design principle follows this template (see Cook et al., 2020): (i) Description, (ii) Theoretical background, and (iii) Tips (Challenges, Limitations, Trade-offs, Pitfalls)

(i) Description

Professionals, students and life-long learners engaged in social learning want to present themselves in the best possible light, i.e. people will position themselves in different ways depending what they deem as the best way from the perspective of their professional, student or life-long learner role, contingent on the circumstances of a particular situation. They do not want to expose themselves professionally, academically or personally. Also, learners are being positioned by actors in their activity systems. Consequently, we are designing for a Zone of Possibility (ZoP). This means that we as designers need to be aware of potential multiple layers of power relationships and design bridges when, for example, learners ask for or give social support or receive recommendations. First, encouraging learners to observe peer group interactions to build up a picture of the cultural norms of the group they are entering; assist construction of an online persona by building on the profiles of key peers who seem closely related. Second, when learners interact, they bridge (connect) to the cultural aspect of learning by bringing to light the alternative views held by other learners and the criteria used to interpret ideas. Third, enable learners to identify when authorities (actors) are positioning them within the group. In this way our tools mediate identity and knowledge building through participation in a Zone of Possibility.

(ii) Theoretical background

Background theory is as follows. Vygotsky's (1930/1978) Zone of Proximal Development (ZPD) is commonly understood as the range of practices which the learner cannot invoke on her own, but can engage in with the support of a 'more capable peer'. Positioning is viewed in recent Cultural-Historical Activity Theory (e.g. Daniels, 2008) as being in a systematic relation to the distribution of power and principles of control. Thus social positioning underlies practices of communication and gives rise to the shaping of identity. The implication is that a 'subject' inhabits a space of possibility, thus a subject would be represented by a socially structured Zone of Possibility rather than a singular point. Bridging arises when people from various backgrounds make connections entering social networks that offer the chance to be more inclusive (Tomai et al., 2010, p 265).

(iii) Tips (Challenges, Limitations, Trade-offs, Pitfalls)

When designing for social learning in Hybrid Learning Spaces, you must always acknowledge and respect the existing social and organisational fabric which determines learners' perception of which practices will be appropriate. This is the Zone of Possibility (ZoP): the range of bridging practices within the ZoP which the learner perceives as socially and organisationally acceptable and that further acknowledge power structures and positioning practices.

Proposing any new practice has the potential to fail. Thus a trade-off between the following ZoP tips will help:

- As Case 1 showed, bridging digital literacy can sometimes be tricky (a challenge) in the early stages of an online course and needs attention, e.g. where participants did not have the basics to record at home. A tip is to present examples of the new practices to learners before implementing them (e.g. a recorded artefact) to confirm that they perceive them as acceptable.

- Before you introduce any innovation, (if possible) the challenge is to carefully observe and analyse existing practices to identify the boundaries of the ZoP. A Case 2 derived challenge is the requirement of following iterative cycle/pattern: tutor led introduction of concepts; then break-out groups for promoting student dialogue one step away from the power imbalance of having the 'professor' in the room; then report back with questioning from peers and tutor; repeat the cycle with slighter harder tasks highlighting the need for critical thinking (e.g. arguments backed up by evidence that is correctly cited and referenced); eventually flip the classroom so that learners develop agency to research a topic in groups and present to the class; linking the previous to assessment for the course in order motivate participation.
- As Case 3 illustrated, an important challenge is to start from where your learners are, rather than notions of where they 'should be' (the latter is a pitfall), as is respecting and acknowledging existing skills and expertise brought to the 'Zone'. Driving fast paced change in a pandemic is about working with people *with and through* their values, and the innovation is through helping them to modify and change their space/place perceptions.
- Designing for interpenetration is a challenge and needs more work.

Further work will take forward the above meta-design principle as the basis for developing mediational tool for Digital Wellbeing.

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Links

* Link to Workshop recording of Recado Bossa Nova on SoundCloud: https://soundcloud.com/dovetailcollective/recado-bossa-nova-final

** Hank Mobley & Lee Morgan – 1965 – Dippin' – Recado Bossa Nova: https://www.youtube.com/watch?v=9MC74Bw-RGI

*** Hashtags Handhelds and Handbags. http://drdebbieholley.com/blog/

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Socio-Emotional Regulation in Collaborative Hybrid Learning Spaces of Formal–Informal Learning

Mariano Velamazán, Patricia Santos, and Davinia Hernández-Leo

Introduction

This chapter explores hybrid learning spaces (HLS) in the sense of spaces outside school where students collaborate in groups without teacher intervention. These learning opportunities may have been designed by teachers but they are actually enacted informally. This kind of hybridity –that mixes formal and informal learning– (Ellis & Goodyear, 2016) is the main focus of this study.

Two of the five trends in HLS (Ellis & Goodyear, 2016), imply two key challenges: (a) giving more agency to students, and (b) that agency needs/implies the students' regulation. Agency is one of the most important capacities to be developed in education and collaborative learning because it has to do with student motivations and interests (Ahn & Clegg, 2017; (Ingold, 2008; Goodyear et al., 2018); Scardamalia & Bereiter, 1991; Tchounikine, 2019). The regulation of learning is needed when, for example, students are outside of school and there is no teacher orchestrating the situation. If we add collaboration to that mix—another key skill for the twenty-first century (OECD, 2017)—we place this chapter in the field of co-regulation and socially shared regulation (Hadwin et al., 2018; Järvelä & Hadwin, 2013).

In the case of the gymkhana that we present, three groups of students are observed collaborating during an outdoor activity (solving math problems). At that age, more experience collaborating for school purposes is a skill that should be promoted. But if emotional issues arise, they can have a strong impact on the students' performance. As we will show, in this kind of context, socio-emotional factors seem to emerge more freely than in more formal settings.

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These socio-emotional processes requiring some kind of control are invisible to members and do not activate automatically; being aware of them requires learning and experience (Järvelä et al., 2020). According to Järvelä et al. (2016), groups do not necessarily recognize nor react to challenging collaborative situations. Thus, they need to be alerted to and learn to regulate, those processes.

The gap that we try to describe and address is that among all these regulatory processes, the least studied are emotion and motivation (Järvenoja et al., 2019). Feelings of wasted time, discouragement and socio-emotional challenges can make a group fail (Barron, 2003). Thus, regulation of social and emotional issues during collaboration is a key factor in a group's performance (Järvelä et al., 2015) and is under-researched in HLS (and adjacent areas of research such as computer-supported collaborative learning, CSCL) in contexts outside school without teacher intervention.

Our main research question is: how has socio-emotional regulation been tested with the use of technology. In the chapter we explore existing research and tools for emotional regulation.We identify the need to design tools that support socio-emotional regulation *during* collaborative activities in HLS (not only *at the beginning*). In order to support the need for further knowledge to understand this gap, we studied social interactions and socio-emotional regulation in groups that were not supported by any technology. Our goal for future research is to gather insights for how to support students' needs with asynchronous tools that afford their collaboration in HLS where the digital and physical merge. This is another dimension of hybridity that we plan to develop in our future work.

This chapter is structured as follows: The first section is an overview of previous research about social and emotional regulation in CSCL from a situational perspective in order to set a common background of core concepts. Then, the chapter presents a review of the tools designed by researchers in order to learn about socio-emotional regulation during collaboration. Finally, we present an analysis of the observations of students collaborating in a hybrid learning context that illustrates the gap described earlier.

Theoretical Background

Social Interactions: Cognitive and Socio-emotional Effects

Learning in collaboration involves social interactions that affect cognitive and socio-emotional processes (Isohätälä et al., 2020; Kreijns et al., 2003, 2013; Kreijns & Kirschner, 2018). For example, cognitive processes comprise thinking, shared knowledge building and shared understanding. Socio-emotional processes refer, for example, to forming groups or establishing a group climate (Kreijns et al., 2003). Some of these processes are internal; they take place inside individual learners' minds and emotions. However, they also unfold when members interact with each

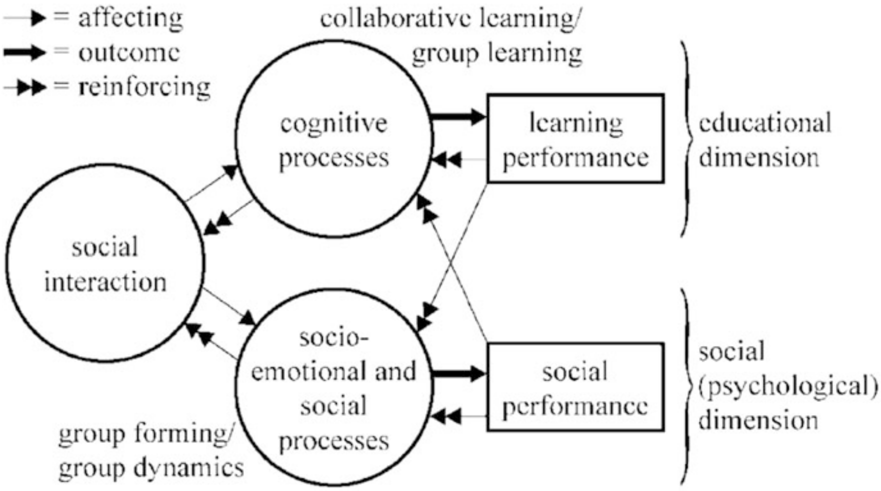

Fig. 1 Kreijns et al. model, 2003

other (Goffman, 1983). These social aspects of CSCL were studied and modelled by Kreijns et al. (2003) (Fig. 1).

The model was extended 10 years later through the addition of an 'educability' attribute (Kreijns et al., 2013). This refers to the educational affordances that support collaborative learning. A few years later, Kreijns and Kirschner (2018) proposed a second extension; the hedonicity attribute. This concept expresses the degree of enjoyment and positive experience that (online) collaborative learning tools provide. With this concept, they posit that the influence of the games and putting a fun spin on interaction will result in learning that is not only effective but also something to be enjoyed (Fig. 2).

The Kreijns & Kirschner model (2018), a mix of formal and informal learning, is especially relevant in HLS because the above-mentioned 'hedonicity' attribute makes the model more complete, up-to-date, and appropriate for young collaborators.

We now focus the scope of our study on a particular type of social interaction during collaboration: regulation.

Regulation in Collaborative Learning

Regulation of learning is a key strategy for cyclically planning for, monitoring and reflecting on the cognitive, behavioural and emotional (including motivational) conditions of learning whenever needed (Isohätälä et al., 2020; Pintrich, 2000; Zimmerman & Martinez-Pons, 1988).

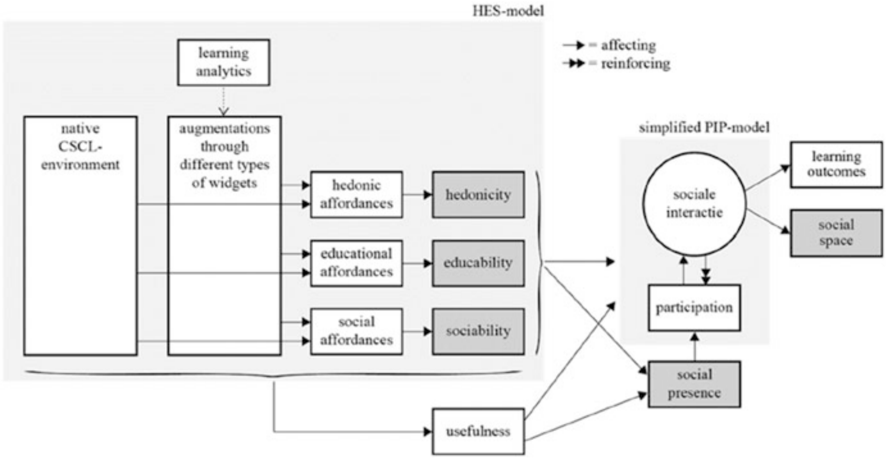

Fig. 2 Kreijns & Kirschner model, 2018

A recent review of self-regulation learning models (Panadero, 2017) describes their history and evolution and compares them according to different aspects, including their conceptualization of motivation, emotion and context. The model proposed by Järvelä and Hadwin (2013) is based on situated perspectives of learning (Greeno et al., 1996) and proposes three modes of regulation in collaborative settings: self-regulation, co-regulation (one member helps regulate another member) and socially shared regulation (regulation of the group as such).

All models of regulation refer to three phases: planning, monitoring and reflection. Some also mention the influence of personal history and previous experiences of collaborating.

In this chapter, we are focusing on social interactions but more specifically on interactions that lead to co-regulation and socially shared regulation. We are focusing on the monitoring phase of regulation because, as we will show, the monitoring phase is the least researched.

Now we will zoom in a bit to focus more on a kind of regulation: socio-emotional regulation. This, above all, is manifested when students encounter social challenges during collaboration. These challenges have been described (Hadwin et al., 2018) and refer to communication, unmotivated group member(s), unequal participation or distribution of work, unsupportive group climate, different styles of interacting and difficulty communicating due to language barriers.

Several tools have been developed by researchers to support different modes of regulation in collaboration. Below, we present some categories that previous researchers have suggested.

From the point of view of how CSCL tools can be leveraged to support groups in regulating collaboration, Miller and Hadwin (2015) proposed two types: (a) scripting tools that structure and guide collaboration by specifying, sequencing and distributing activities and roles to be enacted (Dillenbourg, 2002; Fischer et al., 2013), and (b) group awareness tools that help group members access information about behaviour, knowledge or social aspects so that they can use this information to coordinate collaboration by themselves (Janssen & Bodemer, 2013).

Regulation in scripting tools is usually performed by teachers, who flexibly orchestrate and modify the structured sequences of activities (Amarasinghe et al., in press). Conversely, HLS contexts (outside school, no teacher supervision) require self-regulation support approaches that promote students' agency.

Järvelä and her colleagues (2015) used the concept of affordances (Gibson, 1977) to categorize many of the research tools that have been designed for CSCL. They observed that most of them have focused on the educational and/or technological affordances, and too often have overlooked the *social affordances* proposed in our chosen model of social aspects of CSCL (Kreijns et al., 2003, 2013; Kreijns & Kirschner, 2018). We have found no research tools exploring hedonistic affordances in CSCL (Kreijns & Kirschner, 2018).

Review of Socio-emotional Regulation Tools in CSCL

We have reviewed (see Table 1) a set of scripting and awareness tools designed to support different aspects of socio-emotional regulation according to the model of regulation presented by Järvelä and Hadwin (2013). The table provides the name of the tool, the authors, a description and an indication of the regulation studied.

None of the prior research have studied regulation in hybrid contexts without teacher supervision, in the way that we propose in this chapter. All of the tools are tested in formal contexts and address higher education or university students (except the EmATool, that was used by primary school students).

Most of the tools deal with the planning or reflecting phase of regulation. Only three are specific to socio-emotional regulation: SEST, S-Reg and EmAtool. From these three, only the last two are awareness tools.

Discussion of Two Socio-emotional Regulation CSCL Tools

Because our point of interest is the agency of students in contexts outside of school without supervision, we chose to analyse in more detail the two tools that are awareness tools, provide social affordances and deal with socio-emotional regulation: *S-REG* and *EmATool*.

Table 1 Socio-emotional Regulation Research Tools

Tool	Description	Regulation
Reflector (originally part of VCRI and tailored by Phielix et al. (2010) and (Järvenoja et al., 2013)	Stimulate group members to **reflect** and/or co-reflect on their individual behaviour and the overall group performance.	Social aspects of groups in CSCL
Radar (originally part of VCRI, then tailored) Phielix et al. (2010); Järvenoja & Järvelä, (2009); Järvenoja et al., (2013)	The radar tool was tailored (from VCRI) to promote awareness of individual SRL and SSRL. The students completed the tool individually. After that, they could see each others' radars on the screen	Self and socially shared regulation
SEST: Socio- emotional sampling tool (scripting tool) Webster & Hadwin, (2013)	SEST supports learner regulation by scripting and prompting learners to monitor and evaluate their current emotions before, during and after the task. SEST requires learners to fill in the blanks and choose items from drop-down menus.	Self and socially shared regulation: emotions
IPT & SPT: Individual & shared planning tool (scripting tool) Hadwin et al., (2013); Miller et al., (2013); Miller & Hadwin, (2015)	IPT and SPT help learners define tasks, set goals, make plans and reflect on the challenges encountered individually (IPT) or collaboratively (SPT) using a series of questions asking them to fill in blank text boxes before each task.	Self and socially shared regulation: Planning
OurPlanner Järvelä et al. (2015)	OurPlanner and OurEvaluator facilitate shared planning and evaluation based on SPT. OurPlanner promotes aspects of SSRL such as task understanding, planning, goal setting and strategy use.	Socially shared regulation: Planning
OurEvaluator Järvelä et al. (2015)	The focus is on evaluating what the group has been doing. OurEvaluator provides an opportunity for the group to evaluate their joint efforts and to reflect on which aspects of their regulation might need to be changed for future performance.	Socially shared regulation: Evaluation

(continued)

Table 1 (continued)

Tool	Description	Regulation
S-REG tool Järvenoja et al. (2017)	This tool aims to support group members' awareness of the motivational, emotional, and cognitive states of the collaborative learning and prompts groups to activate appropriate group-level regulation to respond to the group's situational needs.	Co-regulation and socially shared regulation
EmAtool Järvenoja et al. (2019)	This tool aims to increase awareness of motivation and emotions in a given situation. The tool also helps the student become more aware of motivation and emotions, which may in turn aid the student in self-regulation	Self-regulated learning Monitoring

S-REG Tool

This tool was designed to explore how and when students enacted co-regulation and socially shared emotion and motivation regulation in collaborative learning activities. The S-REG tool prompted the group to find the most appropriate regulation strategy for a given situation. After the tool was introduced, students were instructed to use it at the beginning of each collaborative session (Fig. 3).

We describe some characteristics of the tool and the experiment that we think needs further discussion:

- The tool was tested and used in phases and in a quite rigid structure that could become an obstacle to a natural, fluid collaboration among members. As we said before, students were instructed to use the tool at the beginning of each session. We think that testing the tool this way could make it become an obstacle; it was not designed to be available *when needed* by students. Thus, it does not support the process of emergent co-regulation and shared regulation.
- The tool does not fit the context of collaboration because it requires *changing attention* from face-to-face collaboration to using a screen.
- There is a traffic light indicator that represents the emotional and cognitive state of the group. If it is either red or yellow, the tool prompts the members to explain why from a list of "pre-stocked options, namely challenges." We wonder if a list of predefined options is a good way to check the emotional state of a member.

The authors imply that because the tool was used at the beginning of each collaboration session, it influenced the observed increase in co-regulation moments. The discussion of the utility of the tool concluded that the tool was "useful for creating a balanced condition for collaborative learning", but we are concerned

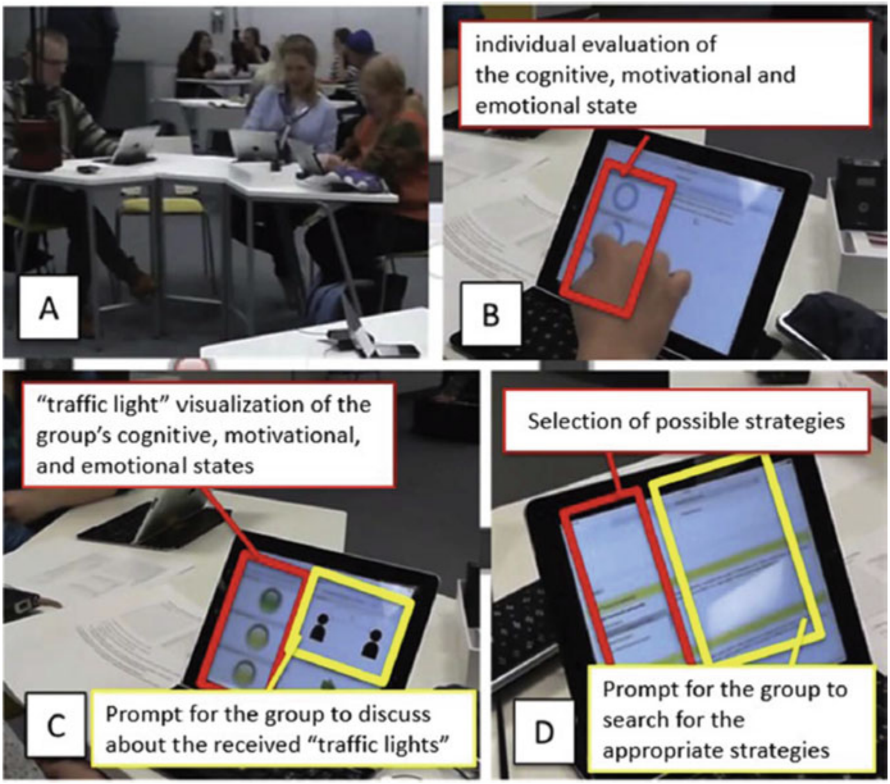

Fig. 3 The S-Reg Tool by Järvenoja et al. (2017)

about the limitations presented above, especially those referring to testing the tool only at the beginning of each session.

EmATool

This tool was designed for trying to raise students' awareness of their perceived emotional state and motivational goals. More precisely, the tool did that through three components: (1) an evaluation of the student's emotional states in terms of valence (negative–positive), (2) an explanation for their emotional state, and (3) the selection of their motivational goals (Fig. 4).

The emotional state of the student (1) was input on a slider from negative to positive using smiley emoticons. The explanation for that emotional state (2) was introduced by answering an open question: "Why?" The motivational goal of the moment (3) was chosen from five options: "learn new things", "have fun", "perform well compared to others", "not stress" and "do the same thing as others".

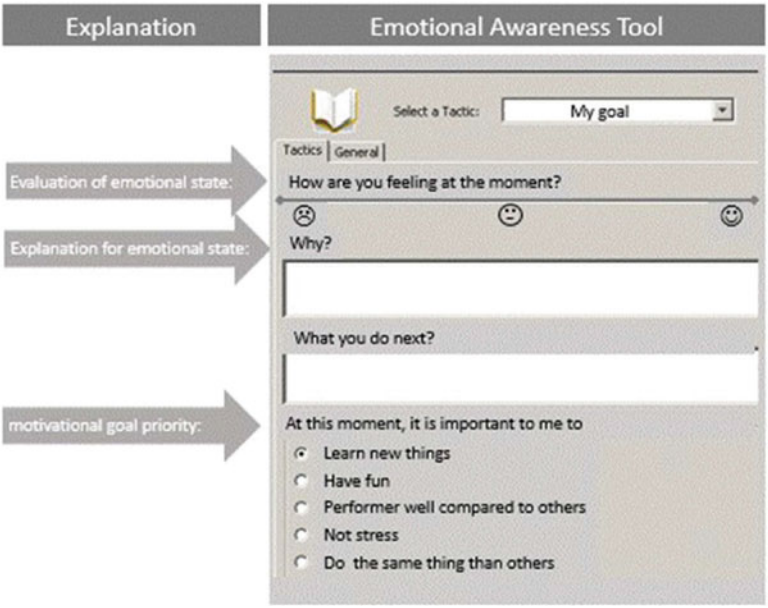

Fig. 4 Part of the interface of the EmATool by Järvenoja et al. (2019)

The authors considered that these three EmAtool components were enough to capture a students' situational emotion and motivation.

From the analysis offered by the authors, we hypothesize some pitfalls that could be further investigated:

- From the paper, it seems that the EmATool was also used only at the beginning of each session.
- Situational motivation was operationalized to include students' evaluations of emotional state and motivational goals at that time, but "that time" meant only the beginning of that session. From our observations (see our Illustrative Case Study section below) it appears that emotions and motivation fluctuate during collaboration as well.
- It seems to us that the tool does not cover the complexity of goals, emotions and challenges that students may encounter during collaboration. The five options to set the motivational goals seem inadequate.
- We find it difficult to report the emotional states and their fluctuation during collaboration because it requires a shift from face to face collaboration to the digital, disconnected use of the tool.

Conclusions of the Literature and Existing Tools Review

As we have shown in the theoretical background and in the review of socio-emotional regulation tools, there is a lack of research about social interactions and emotional regulation in spaces outside school without teacher supervision. As we will show in the following section, hybrid learning contexts are rich in socio-emotional challenges.

We have shown that the tools do not test important research (reviewed above) about regulation in collaboration. For example, they include a very small set of emotions, very few options about strategies and the integration of the tool within the flow of collaboration is very cumbersome. In general, the two selected tools have tested emotional and motivational "states" before collaboration (or at the beginning of it) in order to increase awareness. Only one of them was integrated in a CSCL tool. Furthermore, no hedonicity affordances (Kreijns & Kirschner, 2018) have been tested.

Observations from an HLS Activity

In this section, we observe an innovative formal–informal hybrid learning activity to explore the extent to which previous work missed tackling some socio-emotional regulation issues present in this kind of scenario.

Context: Description of the Gymkhana Activity

This particular gymkhana has been taking place for 20 years, with around 20 high schools participating each year. It gathers approximately one thousand fourth-grade secondary school regular students (15-year-old) in groups of four. The groups disperse around base points that have Math word problems located in the open streets of the old Jewish quarters in Seville. Students must first find these base points and locate the object of the problem in order to solve it and move forward. Students get points for the problems they solve. During the gymkhana, the groups of students work on their own, with no teacher supervision, and are free to use any resource they have in solving the problems.

Instrument, Participants and Data Analysis

Our research instrument was observations. Our aim was to obtain insights from the "life" context as it unfolded without any control over it (Baškarada, 2014);

Zelkowitz & Wallace, 1998). The main criteria for the observations was to document interactions and conversations about socio-emotional regulation. The data collection instruments included field notes and still pictures that were analysed concurrent with data collection (Twining et al., 2017). The field notes summarized dialogues, conversations and processes. The (58) photographs analysed recorded data about personal interactions and the context. The role of the researcher (first author) was observer-as-participant. Due to the context of the activity (being outdoors on the move) the data was analysed concurrently to collecting them (Twining et al., 2017). This real time analysis consisted on choosing to annotate just the data related to our research question.

The participants were three groups observed (A, B and C) and had four members of secondary school students. Data collection took place during two rounds of the activity (the years 2018 –groups A and B– and 2019, group C). Data collection took 2.5 h for each group A and B and 4 h for group C. In all cases, the groups were formed on the basis of previous friendships; teachers were not involved in group formation.

In order to analyse the data, a *thematic analysis* approach (Braun & Clarke, 2006) was used to identify, analyse and report on patterns (themes) in the collected data. The observation notes were reviewed, looking for examples of socio-emotional regulation. We chose two examples based on how roles emerge in the context of our study.

Illustrative Examples of Socio-emotional Issues in HLS

As we noted in the Introduction, we will now show that the hybrid learning context of these examples (students collaborating on their own, outside school, mixing formal and informal learning) demands regulatory awareness and skills anywhere, anytime during collaboration. To begin with, we introduce an example of how emergent roles determine social interactions (and performance) during group work. The second case describes unresolved socio-emotional issues within a group due to a lack of awareness and a lack of an emotional regulation strategy or solution.

Example 1: Emotional Implications of Roles

The roles that emerged were tightly connected to the tasks they had to perform. In spite of that, in all three groups, we observed the casual emergence of leaders whose opinion counted more than the others (according to the comments of the other members, based on their better grades). This had a clear effect on the social interactions of the group, and previous research about self-regulation has not explicitly tackled this issue. Based on the analysis of what students did and said during our observations we can briefly describe the role of the leaders of each group and how this affected the emotional dynamics of that group. The leader of one of the groups (A) was also a listening person, who was open to hearing her friends' opinions. The members of the group were very active and engaged; they kept attention and were focused. This contributed to better group dynamics; more proposals were generated, resulting in more constructive feedback and a better learning experience for the group's members. The leader of the other group (B) was somewhat reserved and did not promote much conversation. The dynamic of the group was very static, and no real collaboration was observed. The members had a positive climate and no issues, but they worked on their own and basically accepted the leader's opinions. The third leader (group C) was quite authoritarian and nothing could be done or decided without her approval.

We observed that if roles change among members of the group (like in group A), the interactions were more productive. If the roles were clearly established and fixed, the members tended to accept the opinions of the leaders and/or students who usually had better grades (groups B and C). These groups also had more trouble making decisions and had a tendency to remain blocked when the leader did not know what to do. We observed members of group C wasting a lot of time because they were all waiting for the leader to make up her mind about what to do. If they had been in class with the teacher, the teacher could have taken the initiative to unblock the group, but without her presence, the group remained passive. Could the design of a digital tool provide affordances to foster role changing?

Example 2: Roles Determine Unresolved Challenges in Emotional Regulation

Building a shared understanding of the problem was also a source of personal friction. Verbalizing how to model or approach a problem was difficult and led to misunderstandings and lost opportunities. For example, a problem about the area of a "star of David" made out of ceramics and embedded in a wall led one student to draw a model on her notebook. They all agreed about the drawing but were not able to *see* how to use it to calculate the area of the star given the area of one of the external triangles. One of the girls started to verbally explain her proposal (which was actually correct) but the others did not understand it. There were several reasons for the refusal of her proposal. First, her explanations were not entirely clear; she seemed shy, and although she tried several times, she never managed to communicate her idea. Second, she was not very self-confident, and the rest of the group had a slightly diminishing opinion of her so they did not pay much attention to her. After a few trials, she had begun rejecting her own proposal as "nonsense". Nevertheless, a few minutes later, when the girl who played the role of the leader of the group went somewhere else and the shy girl was alone with another girl, they started to complain about the "leader" not listening and just keeping to her own proposals and opinions. Could the design of a new digital tool avoid these situations?

Discussion and Further Research

As we have shown from our observations, we detected that identity and emotional issues outside school without teacher supervision are inherited, at least partly, from formal class culture. Moreover, these aspects unfold more freely and openly in hybrid contexts that mix formal and informal learning outside school and there is no teacher supervision. Considering the examples of observations we just presented, we believe this situation would be very different if teachers had been present, but we have no way to assure this apart from our impressions of what we have seen in other situations when the same students were in front of the teacher.

There were few socio-emotional challenges, but they appeared *during* collaboration. When students are in an informal context (outside school without teacher supervision), we doubt that having an awareness tool at the *beginning* of the collaboration, such as those proposed by the analysed related work, would be efficient enough to help them regulate later, when they need it. Our observations suggest that future work in this vein should consider a focus on tools for integrating emotional awareness affordances that are available in the monitoring phase, *during* collaboration. Research questions would include: How important are these affordances for students? How can emotional regulation be organically integrated in an asynchronous collaboration tool so that it does not become an obstacle for usability or cognitive load? What happens if socio-emotional issues remain unresolved? What information (if any) should be made available to teachers?

We have chosen examples that show socio-emotional challenges, but during the observations, we also saw that students enjoyed the activity and had real fun. This connects with the concept of *hedonicity* (Kreijns & Kirschner, 2018) that we introduced earlier and that we did not see supported in the previous studies or with the tools.

It is our understanding that the challenges described by previous researchers (Hadwin et al., 2018) in the theoretical background do not pay enough attention to the importance during collaboration of roles that are inherited from class culture. We have shown with our examples that these are very important when students are young and are outside school without teacher supervision. This issue has been addressed in CSCL through macro scripts that assign fixed roles to students. Nevertheless, we think more effort could be put into understanding how to design for (socially) regulating emergent roles. This way, as we stated in the introduction, we are promoting students' agency, which is key in HLS (Carvalho et al., 2016; Goodyear et al., 2018).

Concerning HLS, the case observed and described in this chapter is based on an activity where digital technology was not used. However, based on our observations during the activity, we wonder how this kind of activity could be digitized. For example, how could we design technology that afforded to avoid the *failure* described in *Example 2*? Could it be allowing the possibility to send anonymous messages (text, photos or drawings) to the chat?

Limitations

Our data collection was limited in the number of groups observed. Although we found a few clarifying examples from three groups, more observations are needed to understand more different behaviours and reactions and shared patterns across groups. It could also be argued that being the gymkhana presented here such a specific activity, the observations and conclusions of this chapter are difficult to generalize.

Another limitation is the lack of recorded audio/video material. The decision to not record audio/video was made because the students being observed preferred not to be recorded. In order to keep the researcher in a more invisible and unobtrusive position within the group work, field notes were selected as the method of collecting data. However, we know this decision has a price in terms of the amount of data gathered, particularly related to body language and non verbal interactions.

Conclusion

We think we have described an area where more (designed-based) research is needed. The HLS case described in this chapter contributed to giving students freedom to open more socio-emotional issues, a sense of agency and a change in their understanding of some previously unknown *spaces* into appropriated *learning places* (Ellis & Goodyear, 2016). Not only did they discover and enjoy parts of the city previously unknown to many of them but we could say that because of the nature of the gymkhana and the problems, ordinary spaces become places as teachers and students appropriated them through the activity. This results in students acquiring a broader sense of the subject matter because they did not know math could be embedded in those things or places. We were positively impressed by their surprise ("I didn't know this could be math") and thus, by their change of perception of the topic. We think there is room for a deeper understanding and appreciation of formal school if we provide scaffolds and opportunities for students to connect it with their personal interests and motivations (Carvalho et al., 2016).

Looking into the future, our plan is to design and develop a mobile collaboration application that would include affordances for socio-emotional regulation on top of usual knowledge-building features. This app would be developed following a design based research methodology and tested to check if students improve their regulatory skills *during* collaboration (especially the monitoring and reflecting phases).

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Open Data, Ethics and Conflicts of Interest The ethics procedure followed the principles, tools and procedures for high- quality research (e.g. privacy, confidentiality, clear information, security, anonymity; Twining et al., 2017). Consent was obtained from all participants. Anonymized data excerpts were taken from the observation notes. There are no potential conflicts of interest in the work.

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Seamless Hybrid Science Learning: Streamlining the Techno-Pedagogical Designs for Wider Diffusion

Lung Hsiang Wong and Chee-Kit Looi

Background

Seamless learning is when a person experiences a continuity of learning, and consciously bridges the multifaceted learning efforts, across a combination of locations, times, technologies or social settings (Sharples et al., 2012; Wong, 2015), ideally with the support of one-mobile-device-per-learner (1:1) settings (Chan et al., 2006). Over a decade of work, our team's research and practice of the pedagogical model of seamless science inquiry learning (SSIL) has yielded impressive results. Since the successful proof-of-concept in a seed school in 2008 and 2009 (Looi et al., 2009; Seow et al., 2009), the initial pilot in a primary school (which took place between 2010 and 2013) (Zhang et al., 2010) produced data showing that the students enrolled in SSIL lessons performed significantly better in the open-ended questions in formal assessments as well as data showing improvement in higher-order thinking skills (Looi et al., 2014) and self-regulated learning (Sha et al., 2012). The learning model was diffused to 10 schools by 2015.

Despite successful implementations in those 11 schools, there were key issues in the earlier teaching toolkits that hindered direct and efficient scaling up to a larger pool of schools, For one, the teaching toolkits were originally developed around 24×7, 1:1 setting. Not all students in the local primary schools, however, possess their personal devices which can be used for their learning. To address this issue, we embarked on a follow-up, practice-oriented project to derive alternatives beyond the Bring Your Own Device (BYOD) model. This chapter constitutes a descriptive study on the follow-up project which was carried out between 2017 and 2018. That is, the positioning and the scope of this chapter are more descriptive than evaluative.

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Specifically, the role of social media in connecting students' cross-contextual learning efforts in seamless hybrid learning will be explored and explicated.

Literature Review

Seamless learning has been identified as one of the advanced learning approaches that can address the needs of twenty-first century learners (Looi et al., 2010; Sharples et al., 2012). With the salient characteristic of bridging multifaceted learning efforts across a variety of learning settings, the intention is to nurture a habit-of-mind in students to continually carry out the trajectories of learning-unlearning-relearning, and learning-application-reflection through recontextualisations of previously constructed knowledge (Wong et al., 2015).

Seamless learning is well-aligned with many other learning notions that educational researchers have been advocating over the past decades, such as hybrid learning, inquiry learning, experiential learning, self-directed learning, collaborative learning, authentic learning, blended learning, flipped classroom, critical/creative thinking, personalised learning, lifelong learning, etc. (see Wong (2015, pp. 10–14) for a comprehensive discussion on the relevancies between these learning notions and seamless learning). Some of these learning approaches may inherently suggest that learning across multiple contexts yet has not foregrounded the key feature of "bridging". For example, the situated learning construct put forward by Brown et al. (1989) has often been used to guide the design of single-setting activities (such as outdoor mobile learning trails). What researchers and practitioners often ignore is a rise-above argument in the stated paper that a constructed concept "will continually evolve with each new occasion of use because new situations, negotiations, and activities inevitably recast in new and more densely textured form" (p. 33). This argument encapsulates the essence of seamless learning. In turn, seamless learning can be regarded as a meta-learning construct that informs the designers of all the other learning approaches to design cross-contextual and bridged learning processes.

The notion of seamless learning was incepted into the context of mobile learning by Chan et al. (2006) which advocated the use of mobile technology in 1:1, 24 × 7 setting to facilitate individual students' ongoing, cross-contextual seamless learning. This seminal paper launched the line of research on and practice of mobile-assisted seamless learning which has later been spread to more than 40 countries, with science being the most popular domain that seamless learning has been applied to (Wong, 2015). Over the years, there has been a gradual shift of researchers' perceptions on mobile-assisted seamless learning from a technology-driven perspective (e.g., Hwang et al., 2008; Ng & Nicholas, 2007) to a curriculum design perspective (Looi & Wong, 2013; Obisat & Hattab, 2009) to the fostering of a learning culture (Milrad et al., 2013; Toh et al., 2013).

The earlier perception of having 1:1, 24 × 7 (i.e., personal devices as the "learning hubs" (Zhang et al., 2010) of individual students) as a mandatory enabling condition for seamless learning has been challenged in recent years. Rather than taking it as a special form of 1:1 mobile learning, more recent literature argues that seamless learning is a modern learning notion at its own right – as an aspiration (Sharples et al., 2012), a habit-of-mind (Wong & Looi, 2011) or as a set of metacognitive abilities (Sharples, 2015). Thus, alternative technological support models have been proposed, such as the "division of labour" (i.e., using different devices, computer sets or even non-digital tools available at different locations) model (Wong, 2012; Wong & Looi, 2011) and the use of social media (Charitonos et al., 2012; Laru & Järvelä, 2015).

Social media are increasingly used for supporting students' communicative and creative endeavours (Greenhow et al., 2009). Social media support process-oriented learning by promoting student-student and teacher-student interactions. More importantly, social media afford situating of learning in multiple contexts through the same social network. For science learning, science teachers may create topical social media items to solicit student responses in and out of classroom, or encourage the students to generate social media of specific curricular themes, or on any day-to-day encounter that triggers the students' curiosity. The posting of such student artefacts does not necessarily mark the end of the artefact generation process (Wong & Looi, 2010). Instead, leveraging the reply feature, the social media can be transformed into a social mediator for subsequent cycles of collective reflection and (re-)production (Lewis et al., 2010), social meaning making (Wong et al., 2010), or knowledge co-construction (So et al., 2009). Furthermore, designing seamless learning processes around social media would free the students from relying on 24×7 access to their personal devices, as typical social media spaces are accessible by multiple platforms or devices (i.e., the "division of labour" model of seamless learning).

Broadening Adoption of Seamless Learning

The reported study was informed by the academic field's re-conceptualisation of seamless learning as a learning approach at its own right, rather than a special form of mobile learning which must be materialised with a 1:1 setting (Wong, 2015). To address the above-stated challenges in further diffusion, we strived for:

1. Adapting the pedagogy and design principles for less reliance on 1:1 access;
2. Streamlining the design principles in order not to overwhelm the teachers and yet preserve the essence of SSIL.

For achieving the first goal, an alternative techno-pedagogical model was proposed that combines social media and multiple devices such as school and home computers, and schools' or family members' handheld devices. Individual students may switch between these devices at their convenience to access to a common social media space for SSIL activities. To ensure sustainability of the model, we did not develop a new platform. Rather, we guided the teachers in sourcing for suitable existing online tools to facilitate the implementation of their lesson designs. This is known as "division of labour" model (Wong & Looi, 2011) in the seamless learning literature. Our focus was on lesson redesign, which leads to the second goal.

Regarding the second goal, three sets of design principles were indeed proposed in our team's prior publications respectively, namely, Zhang et al. (2010), Wong (2013), and Looi and Wong (2013), with six to eight principles being laid out in each set. In this follow-up project, the design principles were streamlined into five salient points: C^2FIP (Connectivity of learning spaces, (socio-)Constructivist inquiry learning; Formative assessments with student artefacts; leveraging resources in Informal settings; Personalised learning). Teachers were guided to develop new lesson plans informed by C^2FIP for enactment given the resource availability of neighbourhood schools.

The five principles are elaborated below:

- Connectivity of learning activities across contexts. Make the learning process cross-contextual, not just encompassing formal and informal settings but also in both individual and social settings, and both physical and digital environments. The student artefacts created in one activity can be fed into subsequent activities. The learning experience will become more holistic and authentic.
- Socio-Constructivist inquiry learning: Facilitate an interplay of individual and collaborative inquiry learning. Encourage diverse "ideas" from the students during various learning activities, and help them connect ideas or pieces of knowledge (e.g., between concrete and abstract knowledge, between prior and new knowledge) through various means such as concept mapping. Make students' diverse thinking visible and therefore shareable, and later synthesise the knowledge.
- Formative assessment: Different forms of student artefacts created at various learning activities can be used for formative assessment. The teacher may design for systematically fostering the students' peer and self-evaluation skills. This not only about "learning how to learn" and the nurturing of critical thinking, but also for mitigating teachers' load in reviewing student works in a long run.
- Leveraging resources in Informal settings: The students' out-of-class, day-to-day living spaces may offer authentic learning resources and therefore make their learning more relevant and meaningful. Examples include incorporation of appropriate online resources, designing mini-activities with parental/family involvement, facilitation of out-of-school learning trails at suitable sites.
- Personalised learning: Incorporate different learning modalities to suit different learning styles, and allow flexible learning pathways for individual students whenever possible. The learning experience should be student-centred, and perhaps encourage interest-driven learning out of class (i.e., individual students to connect their hobbies with formal science learning), and group students with similar interests together to stimulate informal peer learning.

Method

We worked with three primary schools in Singapore for implementation over two academic years. Our intention was to guide the participating teachers in piloting the revised SSIL model in selected lesson units (2–4 lesson units per school). Four cross-school professional development (PD) sessions were also conducted for the participating teachers to share their designs and enactment experiences, and co-construct new teaching strategies.

Before the beginning of the first-year intervention and before the second-year intervention respectively, the participating teachers selected their pilot class levels and curricular units to design and implement the SSIL lessons. Table 1 summarises the key information of the implementations carried out in the three participating schools. In total, seven student cohorts were involved in the study. The cohorts are differentiated by school, year and level, e.g., school S1's Primary 4 (or P4 in short, 4th Grade) students (from two classes) in year 2017 is considered one cohort. One or two lesson topic(s) were selected to be designed as SSIL lesson(s).

Each SSIL lesson lasted for 2–3 weeks with intertwining in-class and out-of-class, and physical and online activities. To implement each lesson topic, the teachers sourced for one or two social networking tools (as shown in Table 1) for the students to share and discuss their artefacts. All lesson plans required students to use computer or handheld devices with Internet access at home to carry out certain home-based learning activities on stipulated social networking platforms (see Table 1) at times. About 5% of the participating students whose families did not have the access to the required Information and Communication Technology (ICT) tools were allowed to stay back at the schools after class to perform the social networking activities at computer labs. In addition, during some of the in-class lessons where students were required to work in groups for digital artefact creation and/or online activities, school-owned tablets were loaned out to the students.

A qualitative descriptive study on the lesson enactments was carried out for us to yield in-depth understanding of whether and how the design principles of C^2FIP could be materialised. The research question that guides the descriptive study is:

RQ: How might the implementation of SSIL lessons at the participating schools impact the students' learning experience and the teachers' instructional practices in the aspects corresponding to the SSIL design principles of C^2FIP?

To address the research question, the following set of qualitative data were collected for analysis,

- Semi-structured pre- and post-interviews with selected students (one high-, one medium- and one low-progress student per class)
- Semi-structured pre- and post-interviews with all participating teachers
- Video and audio recordings of in-class lessons
- Student artefacts posted online and peer discussions

Table 1 Summary of implementations carried out in the participating schools

School & year	Classes & teachers	Number of students	Lesson topic (month of enactment)	Social networking tools used
S1, 2017	S1P417-1 (T11) & S1P417-2 (T12)	56	Light and shadow (July)	Padlet, Google Classroom
S1, 2018	S1P518-1 (T11) & S1P518-2 (T12)	53	Cells (February) Human systems (April)	Padlet
S2, 2017	S2P417-1 (T21) & S2P417-2 (T22)	43	Light and shadow (May) Heat (September)	Padlet
S2, 2018	S2P418-1 (T21) & S2P418-2 (T23)	50	Light and shadow (April) Heat (July)	Nearpod
S3, 2017	S3P417-1 (T31) & S3P417-2 (T32)	59	Heat (July) Human digestive system (September)	MC Online[a]
S3, 2018	S3P318-1 (T32) & S3P318-2 (T33)	59	Materials (April)	MC Online
	S3P418-2 (T34) & S3P418-3 (T35)	69	Heat (July)	MC Online

[a]MC Online is a Singapore-based Learning Management System which was deployed in many local primary schools during the time the study was carried out. The Social Learning Wall module with social media features of MC Online had been adopted by teachers at School S3 for the purpose of implementing their SSIL lessons

(Sx = school IDs; P3xx-y/P4-yP5-y = class IDs, with xx denoting the year, y denoting the semester, and P3, P4, P5 denoting third, fourth and fifth Grade respectively; and Tzz = teacher IDs)

Findings and Results

Student Practices of SSIL

We uncovered important and somewhat consistent patterns across all three schools in students' practices of SSIL. This was done through applying (qualitative) constant comparative method (Strauss & Corbin, 1990) of students' online posts and peer comments, one-to-one interviews and class recordings. With a simple coding scheme that comprises the codes corresponding with the five design principles of C^2FIP, we categorised the patterns/findings around these principles to see how the application of individual principles in the SSIL lessons have (or have not) transformed the ways the students learned. Some of the evidence are conceptually or operationally overlapping across multiple themes (design principles). We categorised the evidence in this way to make a better sense of the impact of the five design principles.

Connectivity of Learning Activities across Contexts

The teachers designed their lesson plans which largely adhere to the cycle of (optional) “flipped learning at home” → “in-class learning engagement” → “out-of-class observations/applications” → “online social reflection” (i.e., peer comments and knowledge co-construction). Such learning flows had effectively guided the students through the process of “recontextualisation” in their learning journey.

Some of the participating teachers (T11, T12, T21, T32) indicated during the pre-interviews that they had experiences in implementing flipped learning (Flipped Learning Network, 2014) in the past. Thus, they incorporated such activities to their SSIL lesson plans, which had also influenced other participating teachers in their subsequent lesson designs. For example, a SSIL lesson may begin in students being instructed to view a relevant YouTube video or research online on a given topic at home prior to the first in-class lesson. In the second year of study, to tackle the issue of students not paying the right attention on the key information to pick up from the materials, the students were required to find answers to some guiding questions by the end of the activities.

For example, in class S3P418-2, after being exposed to the basic concept of heat in the classroom, the students were tasked to take a picture at home or download a photo from the web that captured an example to show how heat was transferred, created graphical representations of the underlying mechanism or explaining it in their words, and shared them on the Social Learning Wall of MC Online to stimulate further discussions. The two examples in Fig. 1 demonstrate how the students created multimedia artefacts to demonstrate their understanding in the concept in focus.

A side benefit of such learning flows is that it had resulted in the students’ greater engagement in learning as the lesson designs broke the “usual patterns” of regular science classes. As one teacher described,

> The engagement level was higher when I did seamless learning. It wasn’t only because in and out of class, but during the lesson itself. ... They anticipated, what are we doing today, why are we doing this. ... I thought through different activities, we got the students to be very engaged, they felt very excited on what is coming up next. I asked some of them to give me feedback. They enjoyed the activity, and would rather have this activity rather than teacher just telling them what to do. (Teacher T11, post-interview)

Socio-Constructivist Inquiry Learning

The students were actively learning in the informal setting through online portals. They co-constructed knowledge by posting and commenting on their peers’ works. That is, they made their ideas sharable for comparison and scrutiny, which led to negotiation of meaning. The benefit of carrying such activities online was articulated by a student as below,

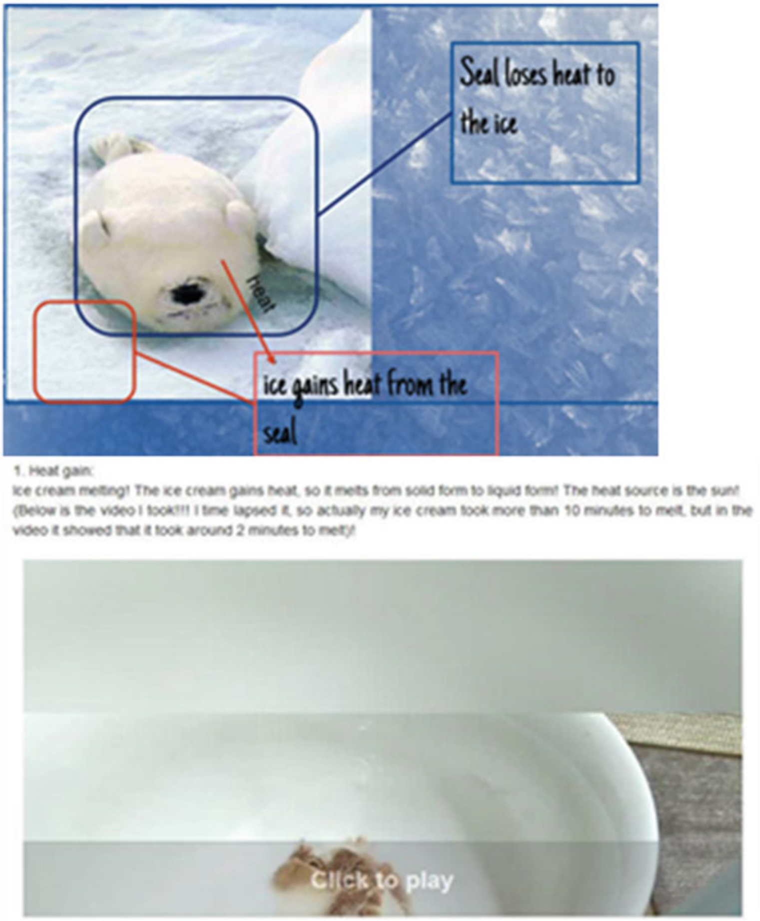

Fig. 1 (Top) a graphical representation on heat transfer with a web image; (bottom) a self-made video with caption to elaborate heat transfer (from class S3P418-2)

> The online portals enabled me to get the answer faster as I did not need to wait for classroom discussion. It was also interesting to read my friends' comments. (A student from class S1-P417-1, post-interview)

Examples of idea sharing and peer comments are given in Fig. 2. They are taken from the "heat" lesson at the class S1P417-1 where the students were instructed to identify examples of heat sources.

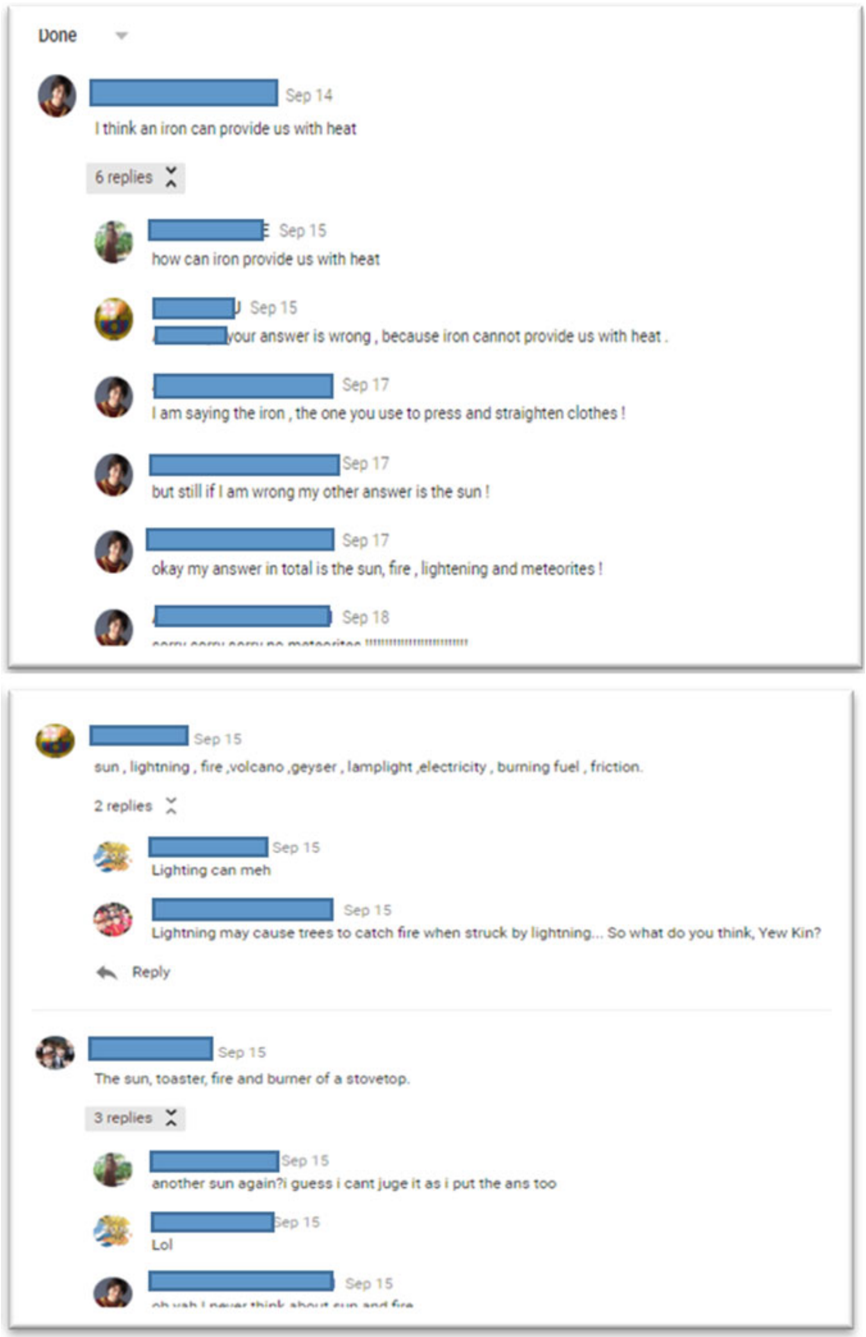

Fig. 2 Students' idea sharing and peer comments in the "heat" lesson at S1P417-1

Cross-Contextual Formative Assessment

Various types of student-centred activities that required students to develop and share ideas, opinions or artefacts in the class-wide social space (either posting them online or presenting them in the classroom) have effectively served as the means for formative assessments. This is because the peers were then being encouraged to scrutinise their views, compare alternative views from classmates, or provide feedback to improve their works. As the students deemed online social learning spaces as being semi-formal and low stakes, they were more willing to tinker and express diversified opinions.

> They get to go online to discuss. To them it's like chit chatting with their friends, less scared to make mistakes because it's in an informal setting. (Teacher T24, post-interview)

Figure 3 presents two screen captures that illustrate such observations.

Leveraging Resources in Informal Settings

Most SSIL lesson designs required the students to collect data out-of-class which constituted rich resources for their subsequent deeper learning. Even if some of the student-generated materials were flawed, these would become the basis for peer review and knowledge co-construction (Wong et al., 2010). The examples in Fig. 1 are two types of such data collected in informal settings. Another task under the same lesson required the students to conduct interviews with two family members or neighbours by asking them to compare the temperatures of the plastic handle and the metal blade of a pair of scissors, and to explain why the temperatures are different (see Fig. 4).

An unexpected learning gain took place where a teacher-student dialogue was focused on how to identify credible sources or verify the information during the students' web searches (an informal resource) as one of their SSIL learning activities. This constituted an opportunity to learn a topic related to new media literacy.

T31:	There are some reliable sources, textbook, MC online resources, yes, reliable because we check them. But where else? If you check internet it is also somewhat reliable. But how to make sure the information you check from the internet is reliable?
Student1:	Just don't search Wikipedia
Student2:	eah don't' search Wikipedia
T31:	Okay, Student3?
Student3:	Go to many websites and see whether the answers are the same.

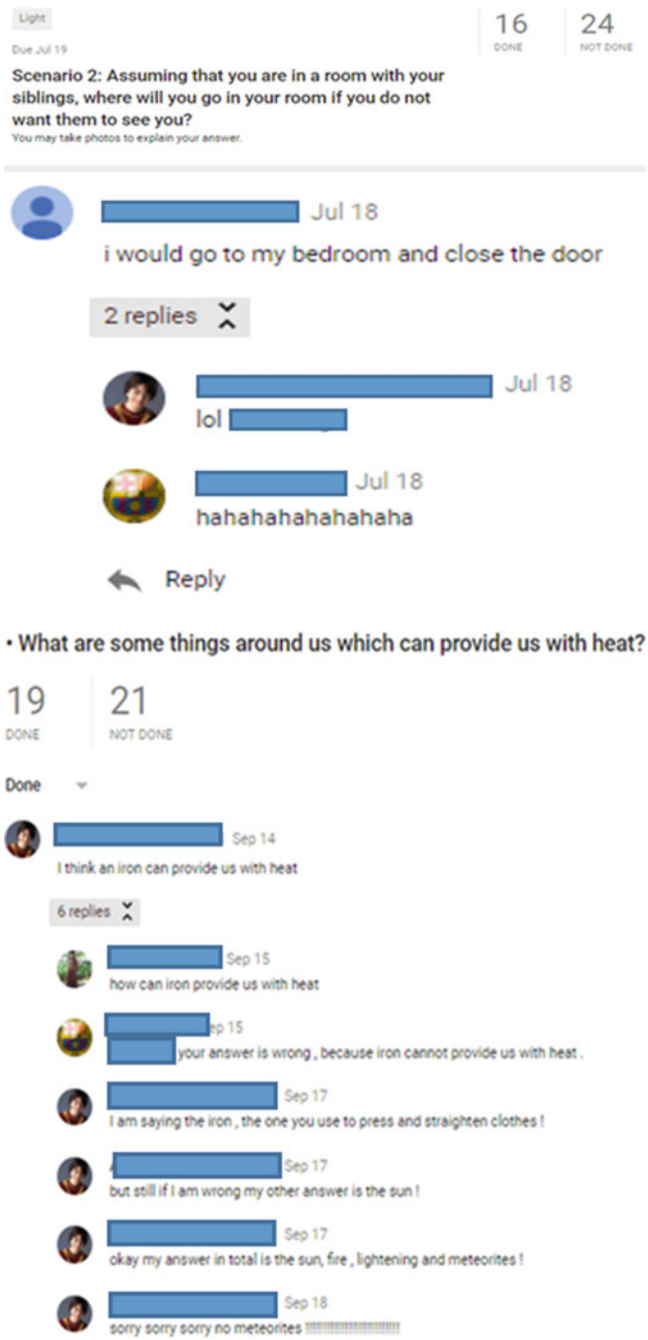

Fig. 3 Students' easy-going and yet potentially constructivist peer interactions online (from class S1P417-2)

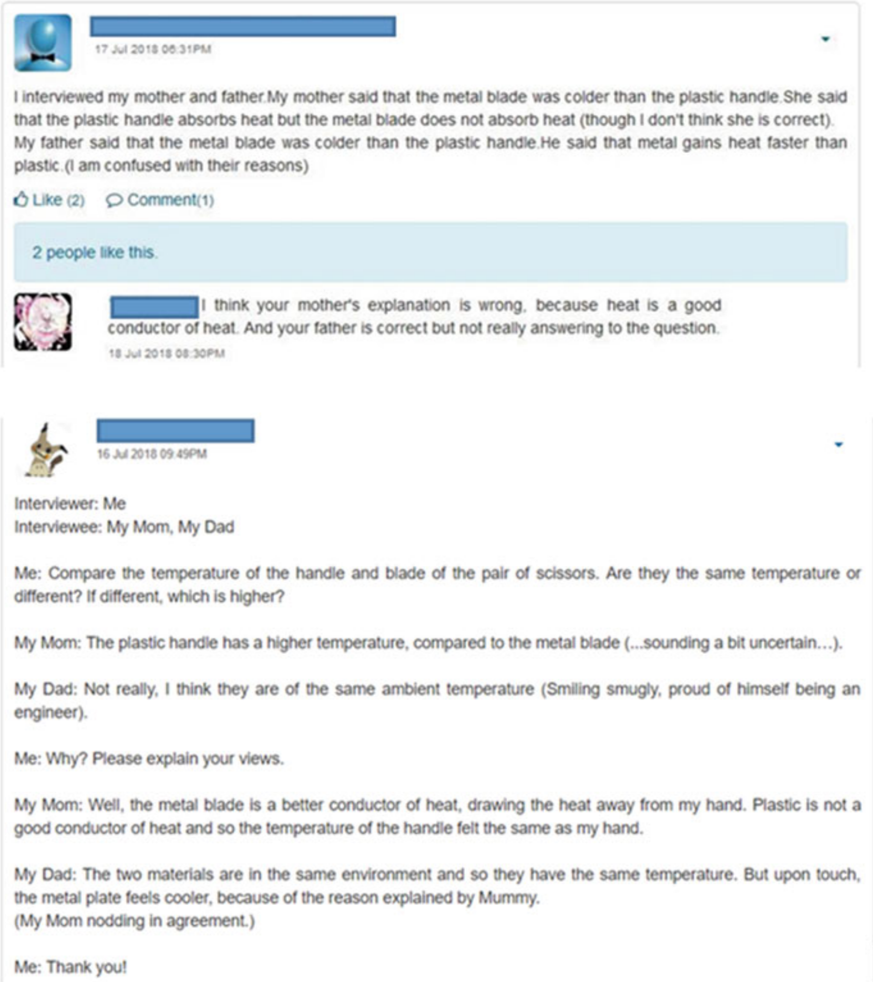

Fig. 4 Students conducted interviews at home pertaining to the temperatures of handle and blade of a pair of scissors, and scrutinised their interviewees' views (from S3P418-2)

T31: Yes, we call this triangulate. Triangle has got three sides, right? That means you don't only look at one. Look at three sites to make sure that all the different points of view are talking about the same thing, so Student3 is very clear in saying that if you go to one website that tells you that saliva is not a digestive juice. ... Then if the other three, or if you really want to be very, very sure, five websites say the same thing, very likely to be accurate. (The lesson "human digestive system" in class S3P417-1)

Personalised Learning

We positioned this as an optional design principle in response to participating teachers' feedback, given the systemic priority of covering the national curriculum-imposed learning objectives and limited time available to facilitate differentiated learning or interest-driven learning. The teachers appreciated the rationale behind this principle and had been attempting to give students greater freedom in deciding what and how to learn whenever the circumstances allowed, which may constitute a small degree of self-directed learning. An excerpt of an in-class teacher-student dialogue demonstrates this (note: Student1 and Student2 belonged to the same group),

T21:	I would like you to write down what are you trying ...
Student1:	To find out if the material takes the least time to melt the popsicle.
T21:	Okay, the material. So, you can write the aim of the experiment. Then, think about what are some of the materials you will need for making it? *(afterward, at group presentations)*
Student1:	The aim is to choose a different type of bag is good for ice popsicles to not to melt for at least 15 minutes.
T21:	Okay. The aim is different. They have a time there. At least 15 minutes. So what are the instruments, what other additional instruments that you guys will need? *(i.e., the teacher allowed the student group to set their own experiment goal and helped them to accomplish that)*
Student2:	Instruments are thermometer, different type of bags, like metal, leather and foam. Ice popsicles, salt, Ziplock bag and plastic bottles.
T:	Student2, what kind of instrument do they need? What are the variables that you have kept the same? Beside what they have said earlier?
Sttudent1:	Room temperature
T21:	So that is environment, right?
Student1:	Size of the bag. Volume of ice popsicle.
T21:	Wait wait, they have one more, they have volume of popsicle. Okay we also need that to be the same. What else?
Student1:	Temperature of ice popsicle. The environment. Amount of salt.
T:	Amount of salt. Why salt?
Student2:	The salt can keep the ice don't melt so fast. *(The dialogue continued where T21's subsequent questioning made the students realise that salt was not needed in the experiment given the objective they had set.)* (The lesson on "heat" at S2P417-1, July 2017)

A teacher's observation may be an indication of an increased level of self-directed learning among her students,

> To facilitate independent learning, let's say in online discussion, if their friends stated a wrong fact, they would research why the friend was wrong and gave a correct concept to them. In the past, they wouldn't do it, because they wouldn't come prepared before lessons to answer the questions. (Teacher T12, post-interview)

Teachers' Reflections of Teaching Practices

As reflected in Table 1, ten teachers were involved in the study. The teachers' experiences in teaching the science subject in Singapore primary schools ranged between 2 and 17 years. Among them, T11, T23, T31 and T33 were Science Heads of Department (HODs) of their respective schools in the years of their study participation, while T21 was the ICT HOD of his school. According to our pre-intervention interviews, all teachers had been adept in practicing the national curriculum-aligned inquiry learning underpinned by the 5E model of science instruction (Bybee, 2002), which include five phases of learning process, namely, Engage, Explore, Explain, Elaborate and Evaluate. Nevertheless, prior to the study, all of them were predominantly and habitually facilitating in-class student learning activities with additional homework as learning reinforcement. They hardly employed ICT or potential learning opportunities offered by the out-of-class, authentic environment to complement their teaching. A special case was T11 who reported that she had been practicing flipped learning in delivering selected lesson topics.

We qualitatively coded the transcripts of teacher interviews and classroom lessons, again around the five design principles of C^{2}FIP. The intention is to investigate teachers' implementations of and reflections on these salient features of seamless learning. The key findings are presented as follows.

Connectivity of Learning Activities across Contexts

All but one (T34) teachers viewed this most salient concept of seamless learning positively. Some of them perceived the learning approach as a vehicle to overcome the limited class time.

> Seamless learning is something that the students get to experience and understand the concept based on what they have discovered outside the classroom, with the help of technology. (T32, pre-interview)

> For seamless learning ... we are really trying to think of the way to make learning happen in the informal situation whereby something that is not intentionally build upon in class ... we really try to engage our learners in different contexts, different environments, I think it will bring out learning more, rather than to say that every time we run into time constraint in school whereby everything is so rush. That is what I am hoping to achieve by seamless learning. (T21, post-interview)

Other teachers have however raised the caveats of implementing such lessons. While the accessibility of ICT at home (despite a high percentage of students having that, there are always a few underprivileged ones around) has been a commonly known issue which teachers could find ways to work around, two teachers cited the parental support factor in operationalising such learning journeys that foreground connectivity, For those lessons we tried out, I really needed them to do the pre-lesson activities before the class sessions. It really depended on whether the parents were actively involved in such activities ... some parents who cared enough would make sure their kids do, and feedback to me. For middle ability classes, the family is an important factor. (T11, post-interview)

... a lot of them *(the students)* will definitely like to go to YouTube, and like to Google, because they are digital natives. But I feel that it could also struggle with their parents... I guess it was the parents who restricted the usage of the phones, because the parents have not seen the beauty, and say, 'I don't want to give you so long to surf.' ... Maybe next year when we start again, it is useful to communicate to parents that, 'we are on this project where your child will...' If we have a meet-the-parents session at the right of the beginning, that could be a possibility. (T21, post-interview)

Socio-Constructivist Inquiry Learning/Cross-Contextual Formative Assessment

The two design principles are combined in the discussion here because they are often implemented hand-in-hand. The key concept of the former is a hybridisation of "social", "constructivist" and "inquiry" learning. In the participating teachers' SSIL lesson designs, inquiry learning usually takes place at in-class small-group experiments with well-defined procedures. Yet socio-constructivist learning is a broader umbrella term that covers not only such experiments but also other online activities that require students to individually collect and interpret data in authentic settings or on the web, which constitute rich resources for subsequent knowledge co-construction. Such individual-to-social trajectory can be regarded as a trajectory of cross-contextual formative assessment. The participating teachers' relevant comments have focused more on socio-constructivist learning in a general sense,

With seamless learning, they *(students)* are able to do research; otherwise they will have to go back to books and encyclopedia. Seamless learning helps to facilitate discussion. Deeper learning is not sufficient if just reading but do not provide comments. (T23, post-interview)

A teacher explained why online discussion activities were valuable even if not all the students participated in out-of-school online discussion,

... I did get maybe 30-40% responses. From what they responded, I could screenshot and use it for classroom discussion. To me, it didn't matter how many people responded; just needed to capture important points and share with the class. I could use it as a teaching point. It was very clear to some of the students ... I thought that one was actually a form of assessment because they checked on their own understanding. (T11, post-interview)

The following excerpt of classroom teacher-student discourse in the topic of light illustrates this. The pre-lesson home-based assignment required the students to share and explain ideas of hiding in the ways that their family members could not see them, with photos taken as illustrations. Then she initiated in-class discussion accordingly.

T11:	*(Showing Student A's post on a PowerPoint slide)* Where do you go so that your sibling cannot see you?
Student A:	Hide under my bed.
T11:	Why under the bed?
Student A:	Because play hide and seek want to find new place.
Student B:	Dark places in my room.
T11:	Which part of your room is dark?
Student C:	Behind the curtain, carboard.
T11:	Most of you are correct saying under the bed, behind the door, under the blanket *(according to their posts)*. Most of your ideas are hiding behind opaque objects. What do you recall about opaque during P3? (Many students raised their hands and T11 invited Student D to answer)
Student D:	Does not allow light to pass through. (The lesson on "light and shadow" in S1-P417-1, July 2017)

The teachers from school S3 moved one step further by formulating a principle to select suitable topics in the science curriculum to design seamless lessons. When being asked about their priority in implementing seamless science lessons, T31 elaborated,

> We want them *(the students)* to co-construct ideas. Why we chose these topics – heat and materials? Because these are the two topics that we find it very difficult to 'limiting' if teacher would have to give examples. With seamless learning their examples of applications will be more ... because they go beyond classroom, beyond the teachers, ... they search from real-life themselves, and they get from their classmates. So they get more examples that will help. (T31, post-interview)

Leveraging Resources in Informal Settings

Teacher T21 shared his reflection on the value of leveraging resources in informal settings to advance students' learning. This is a means to foster their "eyes of science" in their daily lives. First, when being asked to compare inquiry learning and seamless learning, he posited,

> I don't think I can compare. They are different things. Inquiry to me is I am giving the children the chance to talk, I am giving the children the opportunity to explore ... *(For example,)* today I am going to teach about heat traveling from a hotter region to a colder region; so the children can think (*imagine*) that heat will always travel from a hotter to a colder region. But I think inquiry is getting them to explore. Did they observe that heat really travel from hotter to colder region? What was the observation that they made? What kind of measurement can they make to prove that what they have said is true? ... In terms of seamless, I am just extending it to some other contexts whereby even be as simple as I may not need to conduct the lesson in my class. I would ask them to observe things that they have seen in their daily lives and they can really connect with. So I think it is sort of like complementing one another. (T21, post-interview)

He further reflected,

> When I taught the same topic in other schools, I found that the children would always have only remembered what was in the textbook, but a lower application in real life. Now we brought in the cake, the oven ... In the midst of doing all these, we are actually exposing them to see a lot of things available in their daily lives. Maybe they have seen them but not really thought or discussed about it. ... In the upcoming Summative Assessment 2 (i.e., the year-end school examination in Singapore schools), when it comes to applications, we must really look at these students who went through this (*SSIL lessons*), whether is it more evident that they are able to apply, as compared to a class which has not gone through it. (T21, post-interview)

Personalised Learning

As explicated before, it was virtually impossible for the teachers to facilitate "genuine" personalised learning among the students. Yet with this optional design principle in mind, the teachers had been consciously infusing activities with greater flexibility (in terms of how to execute them) or encouraging self-directed explorations and sharing. One teacher recounted her students' initiative of sharing and discussion on a topic not covered by SSIL, but perhaps inspired by the previous SSIL lessons they went through,

> The students initiated to send photos of caterpillar becoming a butterfly. We then started to count how many weeks it has been through and explained its survival rate. I linked this to the life cycle and built on this by asking whose butterfly is at the pupa stage. Then the students identified that this is a pupa and it is in silver, not brown; different butterflies in a different pupa colours, etc. (T32, post-interview)

Indeed, in general sense, self-directed learning does not equal personalised learning. However, the practice of self-directed learning by the students may elicit or promote personalised learning, particularly with the teacher's intervention to help an individual student optimise such a self-determined learning effort for the latter's learning need.

Yet the teachers still observed various relevant challenges faced by the students,

> Depends on the class. Some classes don't have the knowledge to go back and do self-directed learning. The self-directed ones are more willing to go on to the platforms to do self-directed learning before class. With this, we can tap on their prior knowledge. (T23, post-interview)

> For the experiment in Light, they'll experiment on how they will hide in such a way that their family members can't see them. I think it has to do with the crafting of the activities. Yesterday you showed us a sample lesson plan. It's more inquiry based. They *(the students)* have to design their own protocol. I don't think my students have achieved that level yet, I can see it only in my higher-level students. (T12, post-interview)

Implications and Discussion

Implications on Further Diffusion of Seamless Hybrid Science Learning

Apart from tangible deliverables such as new seamless science lesson plans, an important contribution of the SSIL project is a better understanding on what it takes to "bridge" the school-facilitated seamless science learning practice from 1:1 to the division of labour model. The outcomes of our study show both promises and challenges.

Despite an earlier doubt that the absence of learners' personal devices would undermine the potential effectiveness of seamless learning, SSIL's "division of labour" lesson plans were in general adhering to the first four design principles of C^2FIP (except with low degrees of personalised learning), managed to increase students' engagement level (because of the novelty in the learning activities and the use of ICT) and resulted in significant learning gains in the second year of implementations (in S2 and S3). The teachers have also acknowledged the value of SSIL lessons upon the end of the study, as they observed their students' positive changes in various aspects.

Student cohorts of S2-2018 and S3-2018 who all underwent the lessons of the second design iterations scored significantly higher in their post-tests as compared to the corresponding pre-tests. Thus, the study provides evidence support that seamless learning based on the "division of labour" model is not only a feasible but a good compromising technological model for 1:1 in seamless learning, given the current conditions in typical primary schools in Singapore, and in many other countries.

Yet, challenges are inevitable for the introduction of any innovative pedagogical model, such as not all students participated in the out-of-school online activities as instructed, the lack of parental support in or overt parental regulation of ICT-mediated tasks, and the small percentage of underprivileged students who have less or no accessibility of ICT at home. To tackle these issues, the teachers have put in measures to work around the constraints. These are by no means perfect solutions, yet they could at least mitigate the problems.

A more profound challenge for wider diffusion of seamless science learning is related to the schools' and teachers' willingness and readiness to implement longer term and more frequent seamless lessons. Indeed, seamless curriculum is more than redesigning lessons and putting technological resources in place. Seamless learning should be regarded as a culture, and, as advocated by researchers in the field, the learners need to be engaged in an enculturation process to progressively transform their existing habit-of-mind in learning.

Another key implication pertaining to teachers' growth lies in some participating teachers' reflections on how their involvement in seamless lesson design and implementation had impacted their own teaching styles which might potentially spill over to their routine teaching (even when they do not facilitate seamless learning), such as "talking less, letting students talk more", inclination to use ICT for lessons, and engagement with parents. Their in-depth exposure to advanced pedagogical models which is novel to them may constitute opportunities for them to think out of box, to reflect upon and challenge their extant beliefs about their practices of teaching – in how they interact with their students, assess their students, be more sensitive to their students' needs, and be more adaptive in both their lesson designs and actual teaching, etc.

Implementation of the novel pedagogical model in the participating teachers' classes might also draw students' talents or competencies, particularly relating to soft skills or ICT literacy, which are otherwise not manifested in regular lessons and standard class assessments. The teachers would then rethink their previous assumptions on their students' abilities and therefore adapt their lesson design or enactment accordingly. Thus, whether or not they continue to implement the pedagogical model in a sustained manner beyond the study, their involvement in the study is valuable to them.

Conclusion

This project addressed the adaptation of the SSIL model to fit the conditions of three schools in which the constraint of the requirement of one tablet per student was removed. This work demonstrates that through a process of scaffolding by the researchers, primary science teachers can be empowered to design good SSIL lessons that adhere to techno-pedagogical design principles. Research data analysis showed evidence of student learning as well as teacher growth in designing and implementing SSIL lessons (Voon et al., 2019, 2020). The project findings have led us to useable knowledge in terms of a deeper understanding of a hybrid learning model that is built on the seamless science learning, and how to bridge such practices from the use of 1:1 technologies to a division of labour model.

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Designing Synchronous Hybrid Learning Spaces: Challenges and Opportunities

Morten Winther Bülow

Introduction: Teaching in Hybrid Learning Spaces

The partial lockdowns and strict guidelines for social distancing have made synchronous hybrid teaching a practical necessity at schools, and, consequently, teachers at all educational levels have had to practice, experiment with and strategies for this type of teaching. Notably, these processes have involved most teachers regardless of their prior experience, interest or competence in this type of teaching. Since the challenges caused by Covid-19 are likely to remain on the agenda for years ahead, research knowledge on the challenges and opportunities related synchronous hybrid learning designs is called for.

This chapter is divided into four major sections. First, I motivate the treatment of synchronous hybrid teaching as it was practiced and problematised during the partial lockdowns in 2020–2021. To substantiate the claim that the general knowledge of this type of learning spaces requires qualification, I present findings from existing research and compare them with my own analysis of reflections from teachers in Danish upper secondary education on their practices.

In the second major section, the analytical framework that forms the structure of the review presented in the following sections is unfolded. Through an activity-centred approach based on key concepts presented in the ACAD framework (Carvalho & Goodyear, 2014; Carvalho & Yeoman, 2021; Goodyear et al., 2021), I intend to unfold an approach that highlights the coherence between the design dimensions of the learning designs realised in teachers' practices. Choosing this perspective in structuring the literature review makes it possible to change the point of view: "... from the science of learning to the pragmatics of educational design.

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'Pragmatics' is concerned with action – with how people make sense of things, and get things done, in real world contexts. ACAD aligns with the need for actionable knowledge." (Goodyear et al., 2021, p. 6).

In the third major section, I review academic writings published in recent years on the subject. The aim is to get an overview of present-day challenges and opportunities associated with this specific type of hybrid teaching – and to clarify what experiences have been gained with various types of planning and implementation of synchronous hybrid teaching in different educational settings. Based on a thematic review of literature, this section seeks to respond to the need of a more pragmatic insight into what can be learned from the experiences with synchronous teaching in hybrid settings. The review is structured in such a way that it focuses on the three design dimensions in the ACAD framework – the set design, the social design and the epistemic design – as they are presented in the literature.

The fourth major section contains an assessment of trade-offs between potential benefits and challenges associated with synchronous hybrid teaching and learning. The final part of this section discusses how the insights from this study can be used as a starting point in formulating principles for the improvement of upper secondary school teachers' pedagogical design competencies and possible organisational aspects and training processes, supporting activity-centred learning design principles and network learning in a post-pandemic future (Fig. 1).

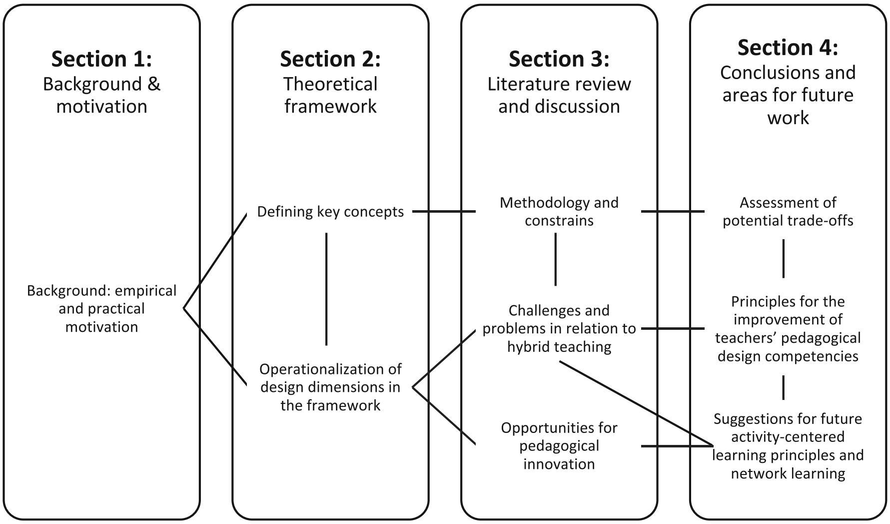

Fig. 1 Major sections of the chapter

Background and Motivation

In late 2019, Raes et al. published an extensive review of existing research on the knowledge of synchronous hybrid teaching. The review included 47 academic publications published from 2003 to 2017, focusing on the challenges and opportunities identified in teaching designs based on practises where both on-site students and distance students take part in learning activities at the same time, but at different places, sharing the same synchronous learning space. When zooming in on the opportunities identified in their review, I find that the existing research was primarily based on qualitative studies and delimited educational experiments evaluated over short periods of time – often a single course (Raes et al., 2020, pp. 269–290).

Despite these limitations, the organisational advantages of synchronous hybrid teaching were the most obvious, according to Raes et al. For example, the dropout rate was lower, and access to teaching became easier for students living in remote areas (Amarin, 2020, p. 798). In this way, educational institutions could cope with declining youth cohorts and offer disadvantaged students better opportunities (Ørngreen, 2015; Qiyun Wang et al., 2017). From the perspective of the students, distance learning provided a significant advantage in that they could choose courses and study topics that were not offered at their place of study. They pointed out that the possibilities for inviting experts and guest lecturers are much better in hybrid learning environments – and that this involvement of external resources was a significant contribution to an education with a global perspective (Bell et al., 2014; Munger et al., 2014).

In several publications, the experience of more freedom and better social connections between face-to-face students and distance students, and between the lecturer and the students, were mentioned among the most important findings. According to research, it is also more likely that a synchronous hybrid learning environment enhances the experience of control and the possibilities for planning (Lakhal et al., 2017; Qiyun Wang et al., 2017). Qualities such as career learning and practical experience of working methods and technologies that are common at workplaces in the Fourth Industrial Revolution are mentioned in a few of the sources. Raes et al. find the lack of systematic studies of the differences between the experiences of face-to-face students and distance students regrettable. Nevertheless, they find that the negative consequences of the hybridisation of the learning environment are limited – pedagogical as well as organisational. The students' motivation and their results seem to be higher or at the same level as those found in traditional face-to-face courses. Raes et al. made the following conclusion:

> *… all studies provided cautious optimism about synchronous hybrid learning, which creates a more-flexible, engaging learning environment compared with fully online or fully on-site instruction.*
>
> (Raes et al., 2020, p. 286)

Quite contrary to the findings above, one of the prominent voices in the Danish debate about the potential expansion of the use of synchronous hybrid teaching concluded: 'Hybrid teaching is impossible'.

> *(in) hybrid teaching, where teachers teach pupils present in the classroom, and those who participate online from home at the same time. It is not only a huge strain on the teachers, but also an impossible task . . . as a teacher, it is not possible to prepare for and deliver two simultaneous and meaningful courses with the establishment of close contact with both the pupils sitting at home behind the screen and the pupils who are physically present in the classroom.*
>
> (Kepler, 2020)

These critical conclusions were made by the chairman of the upper secondary school teachers union (GL) – the largest organisation for teachers in Denmark, representing more than 90% of all upper secondary school teachers. Although this view can be contradicted as Kepler might be confusing parallel and hybrid teaching, thereby missing the differences between these two very distinct modalities of teaching, the critical and rejective conclusion was empirically supported in my analysis of teachers' written reflections collected via the national Danish teacher training programme for upper secondary school education in spring 2020 (in Danish: *Teoretisk Pædagogikum*). This analysis of teachers' reflections is part of a pilot study that I conducted prior to the process of writing this chapter. I did a phenomenological analysis of a randomly selected sample consisting of 42 first-hand, self-reported written reflections from teachers (out of a total of 526 papers submitted in May 2020). These very honest reflections gave me a significant insight into the actions and considerations of teachers during the first lockdown and the subsequent return to synchronous hybrid teaching. It became clear that the hybridisation of the learning spaces influenced the teachers' learning designs in both negative and positive ways. However, most reflection papers portray the teachers' attempts to maintain the status quo. The fact that the teachers sought to maintain their intended learning designs illustrates a general idea among this cohort of teachers. Even when a large proportion of the students participated online, the tasks and the social organisation were not consciously and systematically adjusted to the new and hybrid learning space.

From the teachers' and the trade union's point of view, it seems that synchronous hybrid teaching is indeed a highly demanding and challenging – if not impossible – way to teach. But according to some students, hybrid learning designs do have the potential to cross-pollinate the more conventional learning spaces. As Angelone et al. concluded in the final part of their paper entitled Optimizing the Technological Design of a Blended Synchronous Learning Environment: "Blended synchronous learning has the potential to increase students' co-presence in support of a seamless learner experience and improve upon the flexibility and accessibility of course offerings if designed well." (Angelone et al., 2020, p. 235).

The issue that we are dealing with in this chapter is therefore whether synchronous hybrid learning spaces offer a relevant and practically applicable way in which educational institutions will be able to design their teaching and learning efforts in the future. The critical backdrop for this chapter's analyses of challenges and opportunities in synchronous hybrid teaching is the currently widespread rejection of hybrid pedagogy and designing for hybrid teaching and learning in formal education in some of the world's richest and digitally connected societies.

The intrusive debate amongst teachers and students about the ways in which teachers and schools should choose to define a suitable path that supports post-pandemic learning needs to be informed and challenged.

Theoretical Framework

As stated in previous chapters of this book, there are fundamental differences between blended and hybrid synchronous learning – and between parallel and hybrid teaching (Eyal & Gil, 2022; Nørgård & Hilli, 2022). Not only can spaces for hybrid learning be seen as more or less fluid and hard to analyse systematically. The definitions found in the previous chapters also leave room for different interpretations and thereby different approaches to operationalisation in relation to empirical work. While blended learning can be seen as formally organised as sequential activities with shifts between online teaching and on-site teaching (Zydney et al., 2020), hybrid synchronous learning, on the other hand, is defined as more complex learning activities taking place in several spaces synchronously or asynchronously (Butz & Stupnisky, 2016).

By defining the core concept not as hybrid synchronous instruction (Romero-Hall & Rocha Vicentini, 2017) or blended learning but as hybrid learning spaces, I seek to analyse the research literature guided by Goodyear's description of these complex spaces as "spaces in which students' activity is situated and supported by rich mixtures of material and digital tools and resources" (Goodyear, 2020, p. 1045). And he thereby refers to the important role students play "in co-configuring the learning spaces and/or the learning tasks" (ibid), and the ways the students work with their peers in specific social-material contexts (Carvalho & Yeoman, 2021; Goodyear, 2020, p. 1045).

This chapter thereby positions itself along the axis of Physical Learning Space / Virtual Learning Space, On-ground Classrooms / Online Classrooms, Learning in Schools / Learning in the World and Analogue Pedagogy / Digital Pedagogy (Hod & Katz, 2020; Stommel, 2012). By focusing on this multidimensional space for learning, I wish to clarify limitations and possibilities. The given hybrid learning context challenges current (learning) design principles by being synchronous and creating new dilemmas that force the teachers to seek new innovative solutions. In addition, hybrid learning spaces combine:

1. *physical and digital* places and spaces, offering a specific ecology of resources that can potentially be activated in the learning processes
2. *formal and informal* social structures, interlinking the triple presence of the classroom, the digital space and the homes of some of the students.

These contexts challenge the teacher's learning design. The teacher must acknowledge – and preferably activate – the students' 'home space' at the same time as the classroom, and the possibilities of the digital room contribute to learning (Goodyear et al., 2021; Green et al., 2020; Kohls, 2019). As Carvalho and Goodyear have emphasised, learning design does not only involve the teacher formulating instructions to students. It also includes considerations regarding how social and physical elements create an overall context influencing the learning activity. These social and physical elements provide new possibilities and impose new limitations on the current teaching.

For the purpose of assessing the design possibilities, the Activity-Centred Analysis and Design (ACAD) framework (Carvalho & Goodyear, 2014; Carvalho & Yeoman, 2021; Goodyear et al., 2021) is used as a frame of reference in the review below. In this context, the design dimensions are applied as analytical concepts which allow us to compare descriptions of learning designs in specific learning settings. In order to understand teachers' work on the designing for learning, we acknowledge that this strategic process involves teachers' exercising the difficult task of predicting intended outcomes by designing emerging learning activities. This design process is based on the teachers' experiences and the contextualised resources at hand. Consequently, learning design must be regarded as developing activities designed for learning – e.g., designing for 'learning situations' – but it should not be considered a direct path to specific learning outcomes.

The ACAD framework (Fig. 2) illustrates the relations between three structural dimensions. The set design, the epistemic design and the social design are open to alteration through the teachers' and students' co-design – and thereby the dimensions in focus are formed when trying to understand the specific design.

1. The social design accounts for the division of labour in the formal or informal learning spaces. This can be organisational principles such as group work, roles, peer feedback etc.
2. The set design or the technological and spatial design: The hybrid character of the learning space is clearly read in the technological and spatial design dimensions. Here, the bodily and digital being is the focus of the analysis, but temporal and chronological (synchronous/asynchronous), chorological (place-bound) and other contextual dimensions are in some cases also included.
3. The epistemic design describes the activities that the teachers plan and present to the students, such as tasks, challenges, assignments etc. The ways of structuring knowledge and knowing are integral to the epistemic design.

When we devise epistemic designs for learning, it is essential to recognise that teachers cannot design the learning itself; what students do and what they get out of the activity is not necessarily what we expect or intend. At the centre of the figure the emergent learning activities highlights learner's agency to co-configure what is proposed and the ways in which the designed environment can participate in teaching and learning practice. The student redesigns the planned activities and, in this way, also affects the learning outcome. But educators should be aware that they can design activities based on their expectations – and their understanding of the contextual conditions and resources that the students are offered. In order to explore how past attempts to develop and test specific design interventions that could enhance perceived usefulness of design principles, the objective of this chapter is to come up with an adequate answer to the question: How does synchronous hybrid

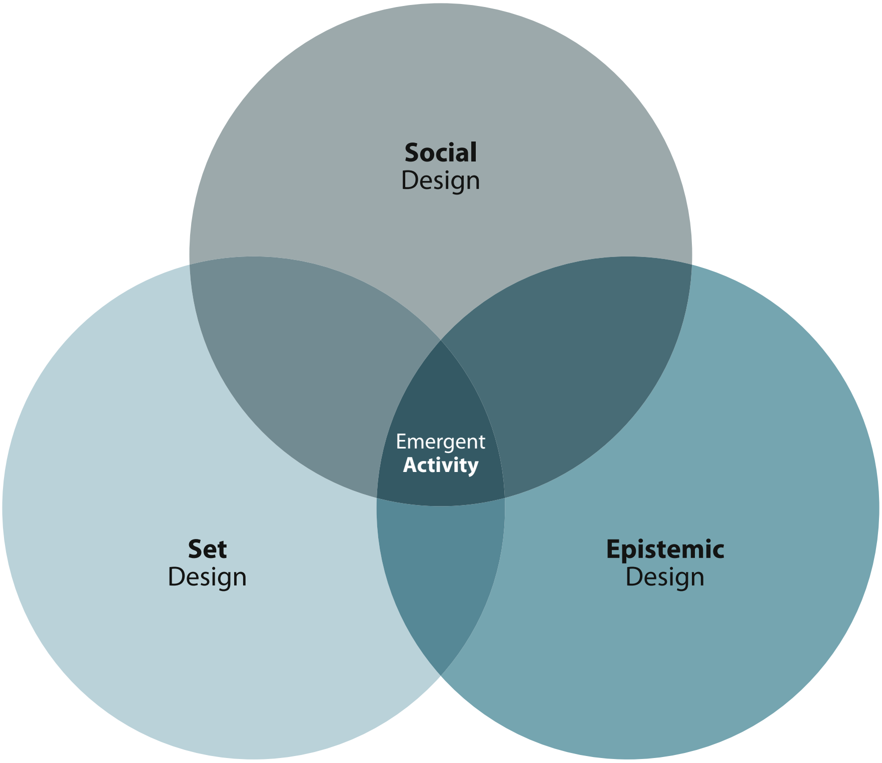

Fig. 2 Dimensions of learning designs. Modified version of the ACAD model (Inspired by Carvalho, Goodyear and others)

teaching challenge and support the learning-whole seen as the combination of the set design, the social design and epistemic design dimensions?

Research Approaches and Methods

In several instances, the applied literature focuses on analysing online teaching and blended learning. But in this chapter, the goal is more narrowly to discover and understand the possibilities and challenges specifically found in hybrid learning spaces that arise when teaching takes place in the classroom and online (for some students) simultaneously.

In the following review, different concepts have been used to guide the search for literature. Aside from "hybrid synchronous teaching", the following search terms have been applied:

1. Hybrid synchronous instruction (Romero-Hall & Rocha Vicentini, 2017)
2. HyFlex course design (Abdelmalak & Parra, 2016, 2016; Binnewies & Wang, 2019)
3. Synchromodal learning (Bell et al., 2014)
4. Synchronous hybrid learning (Butz & Stupnisky, 2016)
5. Synchronous online teaching (Bonk, 2020)
6. Fusion classroom (Amarin, 2020, p. 797)

These conceptualisations of types of learning spaces all describe situations where learning is situated and integrating the face-to-face and online environments simultaneously. To uncover the relevant literature, I performed a systematic search on the following electronic databases: Web of Science, ERIC and Scopus. The above definitions were initially used as keywords in the searches that were limited to the period 2019–2021. These limitations were made for practical reasons and because of the extraordinary conditions in this period. Aside from that, the review used as the point of departure for this chapter focused on literature from the previous period. For example, whereas Raes et al. looked at the literature published from 2003 to 2017 (Raes et al., 2020) and primarily dealt with limited educational experiments or courses testing synchronous hybrid learning, the partial lockdowns of educational institutions at a global level from early 2020 until now (February 2021) provided quite unique starting points for analyses on a completely different scale.

A search on Google Scholar, for example, yielded no less than 17,000 articles published in the period from 2019 to 2021 containing "synchronous AND hybrid AND learning". The searches in the more specialised databases produced more limited results – especially after a thematic narrowing that excluded all materials that did not meet the criteria "education – educational research", "social sciences", "peer-reviewed only" and "scientific education disciplines". After sorting out duplicates and irrelevant articles (including those that focused only on asynchronous, flipped or blended learning), I analysed 32 articles in full text. To illustrate the methodology, a sample of six analyses is presented in Table 1. All these articles have mutual qualities. They contain multifaceted interpenetrations of the hybrid learning spaces, and some of them also emphasise the high degree of agency and freedom as a quality.

How Does Synchronous Hybrid Teaching Challenge Learning?

Synchronous hybrid teaching places great demands on teachers' and students' digital competencies and their digital literacy. The quality of teaching is dependent on whether all participants have the necessary competencies to use the technology effectively. Therefore, the first challenge is to figure out which competencies are present, and how they are supported by the available software and hardware. In Danish upper secondary schools, it is common that students participating in classroom teaching transmit the classroom activities via webcam to students in

Table 1 Sample studies in hybrid synchronous teaching

Author and year	Title	Method	Designable elements: Set Location, spaces and artefacts	Social Stakeholders, actors from practices and roles	Epistemic Objectives, nature of practices and tasks	Findings
Angelone et al., 2020	Optimizing the technological Design of a Blended Synchronous Learning Environment	Comparative/case study: qualitative methods to iterative design N = 16	Multiscreen projections, swivel camera, classroom speakerphone	Course designated as here or there (HoT) 1. Mixed on-campus and online students 2. Separate online and on-campus students	Each session began with an activity or a lecture. Then the students met in breakout groups to have discussions about the course material, and the class ended with a whole-class debrief.	Blended synchronous learning has the potential to increase students' co-presence in support of a seamless learner experience and improve the flexibility and accessibility of the courses offered.

(continued)

Table 1 (continued)

Author and year	Title	Method	Designable elements Set Location, spaces and artefacts	Social Stakeholders, actors from practices and roles	Epistemic Objectives, nature of practices and tasks	Findings
Little & Jones, 2020	A Comparison of Student Performance in Face-to-Face Classes versus Online Classes versus Hybrid Classes Using Open Educational Resources	Comparative/quantitative survey	Specific software (My Accounting Lab)	Hybrid: Two sections met twice per week for 50 min for the purpose of answering questions about learning resources and assignments.	Multiple-choice exams that included questions that were algorithmic computational type questions. Also, all the questions were sorted.	Students performed better in the hybrid and online classes than in the face-to-face class. Synchronous hybrid learning creates a more flexible, engaging learning environment compared to fully online or fully on-site instruction.
		N = 135				

Smith et al., 2020	Are they paying attention, or are they shoe-shopping? Evidence from online learning	Comparative study/mixed methods study N = 30	Zoom (break out rooms)	1. Students and instructor logged on to Zoom 2. Hybrid format courses; some students physically in the classroom and some on zoom	–	When students and instructor were logged on to Zoom synchronously, the average attentiveness was greater compared to hybrid format courses where some students were physically in the classroom and some on Zoom.

(continued)

Table 1 (continued)

Author and year	Title	Method	Designable elements: Set Location, spaces and artefacts	Social Stakeholders, actors from practices and roles	Epistemic Objectives, nature of practices and tasks	Findings
Flynn-Wilson & Reynolds, 2020	Student responses to virtual synchronous, hybrid, and face-to-face teaching/learning.	Comparative study N = 45	Adobe connect and students located on campus	Students enrolled in virtual, hybrid (combination of face-to-face and virtual) and face-to-face classes over four semesters	Classroom discussions in disability-related courses in early intervention and deaf education.	Robust discussion is not encouraged in the online virtual synchronous courses in education. Results indicated that a learning curve exists in relation to virtual synchronous course delivery.

de Magnus et al., 2020	An Educational Laboratory Approach for Hybrid Project-Based Learning of Synchronous Machine Stability and Control: A Case Study	Comparative study: Comparing h-PBL (Hybrid Problem Based Learning) and traditional instruction	Controllers and machines in electric power systems	Hands-on experience in groups of three to four students	Solve power system problems in real machines and controllers.	The h-PBL laboratory had a positive impact on student learning and grades due to factors that include improving students' critical sense and their problem-solving skills, providing more opportunities for peer-to-peer discussion in group h-PBL activities, and increasing students' interest in and motivation to learn through practical engineering applications.
		N = 88				

(continued)

Table 1 (continued)

Author and year	Title	Method	Designable elements			Findings
			Set	Social	Epistemic	
			Location, spaces and artefacts	Stakeholders, actors from practices and roles	Objectives, nature of practices and tasks	
Zydney et al., 2019	Here or There Instruction: Lessons Learned in Implementing Innovative Approaches to Blended Synchronous Learning	Comparative case study: three different cases at two universities that illustrate different implementations of HoT instruction	Computer/TV monitors, speakerphones, wide-angle webcams, projector screens	In the hybrid approach, groups are heterogeneous (a mix of both "here" and "there" students) and facilitated in the web conferencing space	The hybrid approach incorporates aspects of both Virtual Flipped Classroom and Student-Facilitated approaches.	Sound pedagogical principles along with pragmatic considerations, such as class size, available technology and instructor skills, should guide decisions regarding use of these blended synchronous approaches.
		N = Up to 31				

isolation at home. This is just one of the ways in which students handle the challenges with little or no institutional support or formal demands. Both students and teachers profit from the flexibility and space where they can actively work with the technology and see new possibilities by testing and evaluating the new technological frameworks (Table 2).

Challenges Mainly Related to Set Design

Learning activities are physically situated. Students and teachers use the tools and artefacts at hand when designing for learning. Synchronous hybrid teaching always has unique set designs since the learning is physically situated both in a formal school context and in the students' homes. These conditions challenge the uniformity of the learning design and add an unpredictable and very complex dimension to the design of student activities. According to Flynn-Wilson & Reynolds, the technological configuration and limitations in the software used in the 'synchronous course delivery' do not affect the students' participation and their willingness to participate in open discussions.

> *. . . we thought that the difference between the more robust discussions in our brick-and-mortar classrooms and the less engaging discussions in our online virtual synchronous classrooms was due to limitations in the software that was being used. However, as the software became more sophisticated we did not see a concurrent increase in our students' willingness to engage in discussion nor an increase in the richness of discussion in our classes.*
>
> (Flynn-Wilson & Reynolds, 2020, p. 50)

Quite surprisingly, the students only preferred courses that were hybrid in design if they had tried it before and were comfortable with the set design. One determining factor linking technology and the social design was the teacher's ability to use the technology at hand and facilitate discussions in hybrid classes. The findings suggest that technical issues are closely related to the teachers' experience and thereby determine the students' satisfaction and participation (Flynn-Wilson & Reynolds, 2020, p. 55).

> *Generally, courses that were hybrid in design were the type of delivery students preferred – if they had the opportunity – once they were comfortable with taking virtual synchronous classes.*
>
> (Flynn-Wilson & Reynolds, 2020, p. 54)

Technology that made virtual or hybrid synchronous teaching possible was chosen over asynchronous online course delivery by most of the students. This preference was supported in other studies. Other studies comparing students' level of expressed satisfaction with the synchronous/asynchronous axes of learning design have found the same positive correlation between the level of synchronous teaching and satisfaction among the students. The interaction between students and faculty was more positive in the synchronous mode platform – and the level of

Table 2 A summary of challenges arising from synchronous hybrid teaching

Challenges that primarily arise from	
Hybrid set design location, spaces and artefacts: Tools and resources – The digital and material elements in the learning situation	The technology etc. requires habituation, and complexity must be handled (Flynn-Wilson & Reynolds, 2020)
	Teachers' competencies in navigating the set design are crucial to the learning outcome (Flynn-Wilson & Reynolds, 2020)
	Difficulty communicating to the whole group during the breakout session (Angelone et al., 2020)
	Insufficient technological and pedagogical support or inexperience (Shamir-Inbal & Blau, 2021)
	Students often feel ignored or neglected (Yang et al., 2020)
Hybrid social design stakeholders, actors from practices and roles: Scripted roles, division of tasks and social scaffolding etc.	Hybrid learning environments require teachers to coordinate the synchronous use of digital platforms (Ørngreen, 2015)
	Ambiguity about expectations, time pressure and mental exhaustion causing cognitive overload – hyperzoom/hyperfocus/zoom fatigue (Wiederhold, 2020; Zydney et al., 2019, 2020; Chemi, 2020; Chen et al., 2017; Green et al., 2020; Szeto, 2014; Zydney et al., 2020; Zydney et al., 2019)
	Experience of isolation and lack of attention from the teacher and the other students (Blad, 2020; Superville, 2020; Maxwell, 2020; Smith et al., 2020)
	Group size is crucial when designing for learning. Teaching larger groups may require help from trained support staff (Zydney et al., 2019)
	Interpersonal communication was lacking (Shamir-Inbal & Blau, 2021)
	Teachers' personal and family-related challenges and work-life balance (Shamir-Inbal & Blau, 2021)
	The students become spectators instead of participants and co-designers of the learning space (Qingqi Wang & Rasmussen, 2020)
Hybrid epistemic design Objectives, nature of practices and tasks: Exercises: Structure, sequencing etc.	The teachers have comparatively more demanding tasks of a technical and communicative nature in synchronous hybrid learning spaces (Zydney et al., 2019)
	Increased complexity and demands for co-presence (Bower et al., 2015)
	Distance students experience a sense of detachment and difficulties establishing learning cooperation across learning spaces (Szeto, 2014; Rambøll, 2020)

satisfaction increased as students took more courses (Flynn-Wilson & Reynolds, 2020, p. 55).

The technological limitations might not affect the student satisfaction in a measurable way, but the lack of relevant affordance is reported to affect the communication negatively in situations where the teacher uses, for example, breakout rooms in a video conference platform and the text messaging system limits the number of characters that can be sent. A student cited this as an obstacle, noting:

> *I had to wait until a person who was there relayed the information to me. The instructor also had difficulty monitoring the online chat while teaching and missed some messages from students who were having difficulty.*
>
> (Angelone et al., 2020, pp. 227–228)

In cases where the teacher focuses either on the students physically present *or* the distance students, students often feel ignored or neglected. Sequencing, speed and repetitive elements work differently in the various modalities. A number of studies have been conducted on students' behaviours in synchronous hybrid learning spaces, seen specifically from the students' point of view. Yang et al. carried out a large quantitative study where 41,781 Chinese dental students' behaviours were documented during the period February to May 2020. To summarise, the conclusions were:

> *face-to-face classrooms are significantly more conducive to student-teacher and student-student interactions (...) Internet-based discussion is a less effective educational method compared with in-person discussions, which involve more natural ways of communicating.*
>
> (Yang et al., 2020, p. 5)

Challenges on the organisational level are often associated with the physical environment, for example the architecture (small and insufficient classrooms), or they can be related to logistics and digital connectivity. Schools that do not give the teachers sufficient technical or pedagogical support are reported to cause a waste of resources and an unwillingness to use online tools. Supervision and encouragement are critical in order to cultivate students' capabilities to navigate hybrid learning spaces (Shamir-Inbal & Blau, 2021, p. 4).

Challenges Mainly Related to Social Design

Another challenge is the fact that the synchronous hybrid learning environment requires teachers to coordinate the synchronous use of digital platforms to a far higher degree than in learning spaces with other configurations (Ørngreen, 2015). It can be mentally exhausting for a teacher to facilitate and coordinate at several levels and use different technologies simultaneously. The teacher must be present in the interaction with the students. At the same time, an inner dialogue takes place aiming at continuous corrections and strategic involvement of relevant digital resources.

Teachers' mental strategies can be portrayed using concepts such as hyperzoom or hyperfocus (Zydney et al., 2019, 2020). Other terms such as zoom fatigue

(Wiederhold, 2020) or the even more comprehensive term academic fatigue (Chemi, 2020, p. 6) critically describe the exhaustion teachers may experience after a lesson where they have had to split their attention. As Chemi describes this experience:

> *There I was, with my brutal workload, obliged to deliver creative solutions under time pressure and psychological stress. I did it, but it was not enjoyable. It was not optimal. It was not to be repeated. Student voices were silent and silenced by a fast-paced problem-solving attitude relying on a number of assumptions about the students' pedagogical and relational needs.*
>
> (Chemi, 2020, p. 6)

The experience Chemi describes is characterised by the fact that student voices are given less space – less importance – in the learning design when time pressure and the demand of 'being in several places at the same time' exhaust the teacher. Teachers and students experience the hybrid learning spaces differently. Research shows that agreement in the interpretation of the norms and rules of the situation is essential for the learning outcome (Chen et al., 2017; Green et al., 2020; Szeto, 2014; Zydney et al., 2020). The feeling of being socially disconnected and isolated from classmates and the teachers is often described as one of the most critical consequences in classes where only some of the students joined via Zoom. For example, one participant reported that: "professors can forget about the Zoom students if they are not on Zoom themselves" (Smith et al., 2020, p. 205).

The lack of ability among teachers to share their attention equally between the students present 'in the flesh' and the students attending online made Smith et al. suggest that it might be better for all students to attend online rather than having some online and some in person (Smith et al., 2020, p. 205). But in a comparative study, Zydney et al. have suggested a possible solution to this problem. If the group size is small enough, the hybrid instructional approaches seem to have a much better chance of success. If students work together in groups of eight or below, experienced instructors can facilitate both audiences. The key word here is, of course, experience, which is mentioned in several articles. Much of the debate concerning the possibility of hybrid learning spaces has a misleading point of departure when not taking into consideration the possibilities of including support staff or allocating time to train the teaching staff or letting them rehearse carefully selected pedagogical patterns collectively – in different physical and digital settings (Zydney et al., 2019, p. 125).

Some students found it demotivating and distracting when the teacher was not physically present. In many cases, taking attendance was automated in anonymous ways, which makes the students spectators instead of participants and co-designers of the learning space. In a study of so-called resilient hybrid learning strategies, Wang and Rasmussen found that "explicit training of teams skills (including virtual collaboration) enhances the student experience and is also supported by wider studies of communication skills". (Qingqi Wang & Rasmussen, 2020, p. 11) Systematic scaffolding and continuous adaptations strengthen hybrid learning designs of this type. As they write conclusively: Context is key – and this 'key' implies negotiation with the students and allocating time for reflection (Qingqi Wang & Rasmussen, 2020, p. 12).

The work-life balance of both students and teachers might also be challenged by the hybridisation of the learning space. Students' and teachers' families obviously affect their ability to participate actively in learning. The biggest challenge might be the lack of boundaries between family time and study time. It can be a challenge when children or parents invade the learning space. For teachers, the time to design for learning is in a hybridised context radically altered.

> *Accordingly, boundaries between working time, family time, and leisure time are important elements in an individual's life, which need to be separate. Thus, during COVID-19 teachers felt torn between their duties at home and their duties as teachers.*
>
> (Shamir-Inbal & Blau, 2021, p. 19)

Challenges Mainly Related to Epistemic Design

The epistemic design refers to the various actions that the teacher wants the students to undertake. This design dimension is the most difficult to identify in much of the literature as most of the research in this area focuses on the set design and the social design. The different ways of structuring knowledge and the qualitative measures of knowledge within a specific field are very seldom mentioned or evaluated. Consequently, I use the descriptions of the teachers' and facilitators' tasks as a sort of proxy for the epistemic design dimensions making up the students' learning space. Teachers have many tasks when teaching in hybrid settings – and as the number of students increases, the tasks involved in managing this environment multiply. This type of teaching often needs more work than online or face-to-face classes.

> *In addition to delivering content and facilitating discussion, they need to monitor students in multiple locations, using multiple communication modes (e.g., voice, video, chat, and polling). Facilitating a web conference while leading a face-to-face group is daunting for many, causing a significant learning curve.*
>
> (Zydney et al., 2019, p. 129)

Teachers often have a wish to make the students' teaching experience as uniform as possible. However, it may be difficult to design and carry out the intended pedagogical strategies. Technology develops quickly: Conference systems are expanded with new features, for example raising one's hand, and the students themselves can easily get together in breakout rooms without the teacher dedicating one to them. Flexibility is increased. However, at the same time, complexity and demands for co-presence increase as well (Bower et al., 2015).

Based on a qualitative experimental study of 54 h of teaching a group of engineering students (N = 28), where half of the students were taught face-to-face while the other half participated synchronously through an internet-based video conference system, Szeto concludes that the teachers tended to focus on one of the groups and lower the teaching pace. The teachers tried to get the two groups to function synchronously. However, the consequence was that the students physically present were bored and evaluated the teaching less positively.

In fact, the instructor tried hard to synchronously bring his teaching across to the two groups in a virtual learning environment mediated by the video conference. This is the challenge he faced in the blended synchronous situation.

(Szeto, 2014, p. 4253)

The pattern in the interaction between students developed in an unexpected way in the experiment mentioned. The teacher's intention was that the students should interact synchronously in the virtual environment. However, a spontaneous pattern of interaction arose where the physically present students interacted with each other and demanded a more direct face-to-face supervision from the teacher. The online students had difficulties establishing learning cooperation across learning spaces. According to Szeto, no peer-feedback was established in the experiment. In the teaching situations, interaction was made difficult. Awkward silence and situations in which students talk at the same time and interrupt the conversation were common experiences in synchronous discussions. The possibilities to contribute with simultaneous comments (chatting) and raising one's hand were experienced as insufficient and a source of frustration. Distance students experienced a sense of detachment, which should be addressed. However, at the same time, several students say that they do not have sufficient self-discipline (Rambøll, 2020, p. 11).

The logic of these examples illustrates a widespread duality. While the transfer between different learning rooms challenges the teacher's planning and structure, it also creates a space of possibilities which encourages activation of functional digital learning tools, making learning processes network-based, broad, synchronous and iterative instead of individual and linear. One can look at the quotes as an indication of a widespread reluctance towards a transfer to hybrid learning spaces. The technological context has changed, but the norms and standards for what is considered good learning environments are fundamentally maintained.

Opportunities in Synchronous Hybrid Learning Spaces

The potentially positive consequences of increased use of synchronous hybrid learning spaces can be divided into possibilities related to set design, social design and epistemic design and to the evaluation of the students' learning (outcome). In the table below, the opportunities associated with synchronous hybrid learning in existing literature are systematically listed. The perspectives are divided according to the design dimension on which they have a particular influence: Set design (tools and resources), social design (roles and division of tasks) and finally the epistemic design (learning tasks/exercises: structure, sequencing etc.) (Table 3).

Table 3 A summary of potential opportunities in synchronous hybrid learning spaces

Opportunities that primarily arise from	
Hybrid set design (tools and resources – The digital and material elements in the learning situation)	Increased personal freedom and space for more students (Nielsen, 2013; Ørngreen et al., 2013; Qiyun Wang et al., 2017; Raes et al., 2020; Flynn-Wilson & Reynolds, 2020)
	Sense of co-presence helps students contribute to the discussion in a way that is most comfortable for them (Angelone et al., 2020, p. 224)
	Pedagogical flexibility, e.g., flipped classroom (Anson, 2015; Bower et al., 2015; Christensen & Hansen, 2020)
	Increased flexibility and greater control of their learning strategies (Binnewies & Wang, 2019)
Hybrid social design (scripted roles, division of tasks and social scaffolding etc.)	Partnering on-campus and online students (Angelone et al., 2020)
	Roles within the classroom distributed according to students' interests (Zydney et al., 2020)
	Increased possibility of participating as a distance student in cases of illness or quarantine (Qingqi Wang & Rasmussen, 2020)
	Opportunity to carry through and document face-to-face supervision (Davidsen & Vanderlinde, 2014; Gaudin & Chaliès, 2015)
	Technology levels out asymmetrical relations (Cook et al., 2020; Konnerup et al., 2019)
	A more student-centred learning environment, enabling more student ownership of the learning environment (Zydney et al., 2019)
Hybrid epistemic design (learning tasks/exercises: Structure, sequencing etc.)	Teachers design their own learning activities and free themselves from the routine content. More personal bottom-up initiatives (Shamir-Inbal & Blau, 2021)
	Improved intra-school coordination and strengthened digital school culture (Shamir-Inbal & Blau, 2021)
	The possibility of involving external experts and students' own resources ((Raes et al., 2020; Holm Sørensen & Tweddell Levinsen, 2019; Liu et al., 2018; Nielsen, 2013).
	Democratisation, innovative pedagogy and opening of the learning space (Green et al., 2020)
	Increased student motivation to learn when compared to traditional teaching (de Magnus et al., 2020)

Possibilities Mainly Related to Set Design

If we look at possible organisational advantages, an increased use of hybrid learning will create more space at educational institutions – not just space for more students, but also space as distance between students. The financial advantages are probably great. More students in fewer buildings and thereby minimised cleaning costs, less wear and fewer sick days. Thus, it becomes possible to increase the number of potential students, which has been seen historically in various contexts – especially when great distances have had to be overcome (Nielsen, 2013; Ørngreen et al., 2013; Qiyun Wang et al., 2017). It is difficult to measure environmental gains, but emission from transport to and from educational institutions can be minimised significantly.

Hybrid teaching may give increased freedom to plan one's life. The time previously spent on transport and social school activities may be spent on local activities and studying. In that way, hybrid learning can contribute to an increased presence and sociality. Educational institutions will have better opportunities to offer elective subjects or specific courses (or more exotic electives?) which are usually only offered at very few schools (Raes et al., 2020, p. 281).

Dialogical teaching and effective feedback take time, and this time becomes available by an increased use of didactical flipped classroom recordings (Anson, 2015; Bower et al., 2015; Christensen & Hansen, 2020). Synchronous hybrid teaching can give the participants a feeling of increased flexibility and greater control of their learning strategies. This is the conclusion reached in studies of so-called HyFlex environments characterised by students choosing themselves how to participate in a lesson, whether it is face-to-face or virtual (synchronous or asynchronous) (Binnewies & Wang, 2019).

Possibilities Mainly Related to Social Design

Some of the often-mentioned disadvantages of distance learning are challenges concerning student absence and declining completion rates. Conversely, it can be argued that the increased flexibility makes it possible for students to maintain in contact with their educational institution and fellow students in cases of illness or while waiting for test results. As mentioned above, it is common for students to participate in lessons with the assistance of fellow students. Offering the possibility of participating as a distance student in cases of illness or quarantine accommodates the wish for continuity regarding, for example, long-term project work. At the same time, it is a flexibility which develops study and career competencies in a society with increasingly more flexible workplaces and increased expectations of self-organisation (Qingqi Wang & Rasmussen, 2020).

The positive didactical potentials are also described in studies of more intimate learning spaces where students are supervised face-to-face. Emphasised advantages include a less disturbing environment and the opportunity to carry through and document face-to-face supervision (Davidsen & Vanderlinde, 2014; Gaudin & Chaliès, 2015). As Zydney concludes:

> *Extra time should be allocated upfront to set norms for both the classroom setting as well as how to use protocols within that setting. The roles within the classroom need to be distributed according to students' interests and experiences to allow participants to be fully engaged. This may also help address the issue of students getting distracted*
>
> (Zydney et al., 2020, p. 13).

In the way described, technology not only becomes a material element in the actual 'set design'. It also becomes an element in the social design of the learning space by ending or levelling out asymmetrical relations. The situation becomes more democratic when students as well as teachers join forces in the discovery of technologies. Furthermore, as a resource for the establishment of a fruitful epistemic learning design, technological frameworks – as shown in the examples above – provide flexible tools which support teachers' design and turn learning into a mutual endeavour (Cook et al., 2020; Konnerup et al., 2019).

Possibilities Mainly Related to Epistemic Design

Didactical and pedagogical advantages of synchronous hybrid learning spaces are closely connected to organisational advantages. The possibilities to include external experts and the opportunity for students to use resources from home in a school-based context in a more flexible way may have great advantages. In general, it is easier to cooperate with external partners and include students' own networks in hybrid learning spaces. As several studies have emphasised, opening learning spaces towards students' lives and including external expertise can strengthen social relations and be motivational for students. As an example, Sørensen, Levinsen and Liu et al. have emphasised the potentials of the hybrid social design in relation to strengthening global and innovative competencies, which not only exceeds geographical distances but also, according to experiences from Global Classroom courses, gives cross-cultural insights and experiences (Holm Sørensen & Tweddell Levinsen, 2019; Liu et al., 2018; Nielsen, 2013).

An example of democratisation and opening of the learning space comes from an experiment involving 300 nursing students and 27 teachers from New Zealand. Researchers designed a so-called transition programme where students participated in activities through voluntary and fun and informal online 'happy hour' sequences, which created a playful way of learning how to act in the new technological context. A significant lesson from the experiment was that it could have considerable advantages to include employees in knowledge sharing and utilise the knowledge and resource ecology that the context offers. Collaborative learning can be supported in the mutual development of didactical patterns and learning designs. Green et al. describe the plans as follows:

> *...we are bringing together teams of teachers to jointly develop pedagogical strategies that are socially engaging, pleasurable and productive. Whilst a sudden move to a digital teaching experience can be mentally taxing, there is much to be gained from working with others in a team teaching collaborative environment, for both students and teachers.*
>
> (Green et al., 2020, p. 15)

Conclusions and Areas for Future Work

The objective of this chapter was to answer the question: How does synchronous hybrid teaching challenge and support the learning-whole seen as the combination of the set design, the social design and epistemic design dimensions? The review of the literature published on research from 2017 to 2021 confirms most of the conclusions found in the reviews of earlier research on the subject. Hybrid synchronous teaching and learning is both possible and entails several significant benefits in terms of:

1. Set design: The physical and technological set-ups that support hybrid teaching include hardware such as microphones, wide-angle cameras and a reliable internet connection. The flexibility of these hybrid learning spaces supports innovative learning designs, for example a flipped classroom, and potentially gives both teachers and students a higher degree of control of their learning strategies.
2. Social design: Forming collaborative networked learning and the possibility of participating as a distance student in cases of illness or quarantine.
3. Epistemic design: The hybridisation of the learning space seems to support the teachers' innovative and differentiated development of their own learning activities. Epistemic designs are supported by adaptive teachers who free themselves from the standard content. Both collective and individual bottom-up initiatives that open the learning space to external resources and inspiration for more activating tasks are sustained by the formation of teacher-to-teacher support communities are more likely to form. Synchronous hybrid teaching supports a learning-whole with a higher degree of integration among the teachers as well as between the on-site and online students.

The review also shows that these findings are challenged by numerous design qualities that define the conditions and determines the level of success when it comes to the formation of hard learning spaces of this type. When designing for learning, teachers and schools need to be aware of certain design qualities. Most importantly:

1. Set design: When the necessary technological and physical conditions are not optimal, it will most certainly challenge the effectiveness of the teaching. A set design that supports the formation of an operative synchronous hybrid learning space must have the necessary technological affordances and form a learning space that supports the emergent learning activities. Screens and cameras need

e.g., to be set up very carefully to support participation by the students from home.
2. Social design: The shared learning space is highly influenced by the quality and social setting in classrooms as well as in private homes. If students are disturbed by family or the lack of access to sufficient technology, the benefits will be challenged. The number of students participating in each work group and the distribution of their responsibilities by the students' teachers and mentors have proven to be crucial to and often challenge the social design of the learning space.
3. Epistemic design: Tasks and assignments need to be adjusted, and the teachers have more demanding technical and communicative tasks in synchronous hybrid learning spaces compared to other learning spaces. The distribution of responsibility connected to the tasks needs to be adjusted and thought through according to the relevant set design and social design.

We can conclude that designing for hybrid learning in synchronous learning spaces is possible. But studies show that the outcome is challenged by the qualities of the design of the learning space: the multifaceted interplay of the social, physical and epistemic dimensions. The social design would optimally support the epistemic dimensions by reducing the complexity. All three designable elements or dimensions depend on the allocation of time and knowledge performed by the teaching staff and the students in collaboration. The design process should follow principles where qualities like time, technology, space for collaboration and work-life balance are taken into consideration.

Following the findings above future work should preferably investigate: (1) How the epistemic design dimensions affect the effectiveness and the learning outcomes in different configurations of hybrid learning spaces. In the literature reviewed in this chapter the epistemic design dimensions are mentioned but is seldom given decisive importance. (2) The possibilities of handling the trade-offs and challenge listed above by developing practical methods for involving students' ecologies of resources and thus providing teachers with tools for overcoming the barriers that exist for the successful implementation of synchronous hybrid teaching. A perspective that should be investigated further could be based on Lev Vygotsky, situational theories of learning and the analyses made by educational scientists such as Luckin (Luckin, 2010, 2018), Yeoman and Wilson (Yeoman & Wilson, 2019) and Cook et al. (Cook et al., 2020). Exceeding the barriers for successful innovation and Implementation of synchronous hybrid learning identified in this chapter is likely to require a far greater knowledge of the possibilities of involving learner's agency supported by learning designs that enable teachers to gain insight into the students' zone of possibilities. This vision is illustrated in Fig. 3 below, which shows a preliminary draft for a context-sensitive activity-centred design framework supplemented by dimensions of ecology of resources.

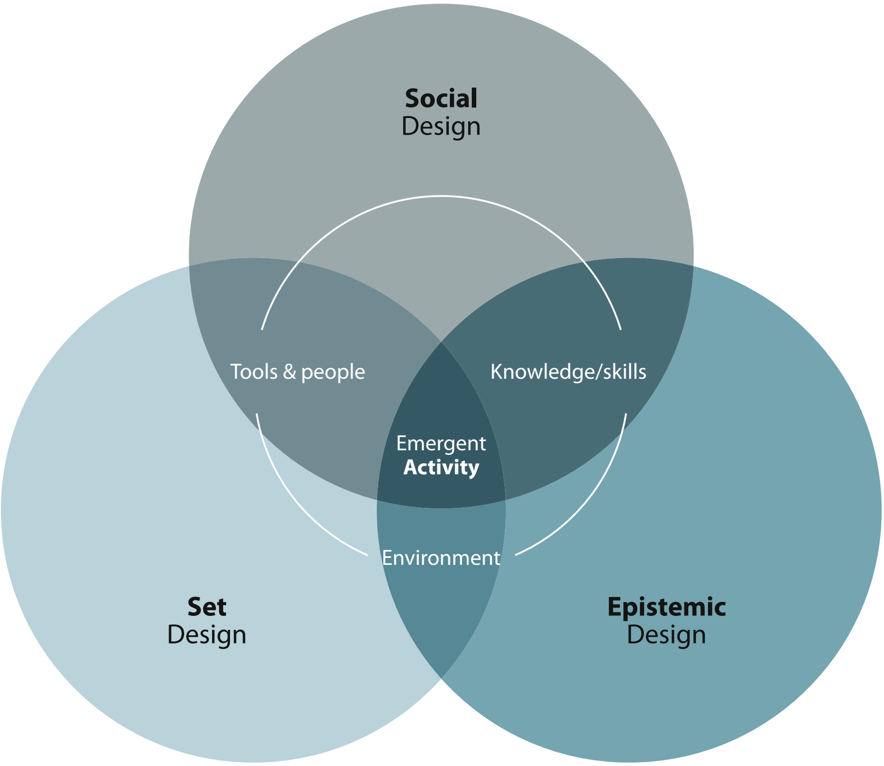

Fig. 3 Preliminary draft for a context-sensitive activity-centred design framework (Inspired by (Carvalho & Yeoman, 2021; Cook et al., 2020; Goodyear et al., 2021; Luckin, 2018; Yeoman & Wilson, 2019))

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Part III
Technology

An Analysis of Mobile Learning Tools in Terms of Pedagogical Affordances and Support to the Learning Activity Life Cycle

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Introduction

Mobile and ubiquitous learning have been promoted by both the growing popularity and availability of mobile and sensor technologies, as well as their pedagogical affordances (Sharples & Spikol, 2017). In this chapter, we use m-learning to refer to both mobile and ubiquitous learning, due to their interchangeable usage in literature, as well as their association with similar educational aspects and affordances (Hwang & Tsai, 2011). For instance, as an illustration of educational affordances, the hybrid nature of m-learning -where learning happens across distributed settings (indoor and outdoor), spaces (physical and digital), and contexts (formal and informal)- can help to extend the boundaries where learning happens, as well as supporting learner's autonomy, the continuity across contexts, and situated learning (Sharples & Spikol, 2017).

Apart from the aforementioned benefits, m-learning also entails additional challenges. For example, practitioners should take into account the multiple spaces, settings and contexts while conceptualising, authoring, implementing, regulating, assessing, and reflecting on the learning activity (Persico & Pozzi, 2015; Muñoz-Cristóbal et al., 2018). Furthermore, monitoring and evaluating m-learning activities (which might support practitioners' and students' awareness and reflection practices) requires collecting and combining data across different spaces and settings (Muñoz-Cristóbal et al., 2018).

The research fields of Learning Design (LD) and Learning Analytics (LA) have produced numerous solutions to approach these concerns. While LD has focused on facilitating practitioners to share, modify and reuse pedagogical plans, LA has

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proposed various techniques to handle learners' data that support evidence-based decision making of the stakeholders involved in the learning process (Persico & Pozzi, 2015). Recent research also underlines the complementary role that both communities can play for each other, where LD can make analytics more meaningful, while LA can inform design decisions (Persico & Pozzi, 2015; Rodríguez-Triana et al., 2015).

Despite the potential synergies between these two fields, few m-learning publications include elements from both LD and LA, as reported in a systematic review on LD and LA in m-learning (Pishtari et al., 2020). The authors conclude that despite the low explicit alignment, LD and LA have shared common interests, similar learning contexts and have offered complimentary support to m-learning aspects (Pishtari et al., 2020). Nevertheless, there is still a lack of awareness about *how m-learning tools have been used in practice to support teaching and learning practices*. Therefore, the current chapter builds on the aforementioned review and extends it further by analyzing the m-learning tools reported in it, guided by the following research question (RQ) and sub-questions (Sub-RQ).

RQ: What LD and LA affordances do the m-learning tools under review provide?

- *Sub-RQ1: What are the orchestration affordances of the m-learning tools under review throughout the learning activity life cycle?*
- *Sub-RQ2: What are the pedagogical affordances of the m-learning tools under review?*

To respond to Sub-RQ1, we looked at the orchestration affordances found in the m-learning tools (i.e., tools that included functionalities that afford specific orchestration needs). To achieve this goal (due to the lack of an analytical instrument that covers the entire life cycle of a learning activity, from both LD and LA perspective), we constructed an analytical framework of potential orchestration affordances throughout the learning activity life cycle (LALC), which was later used to evaluate the tools. Related to Sub-RQ2, to examine the learning affordances of the tools from a pedagogical perspective, we used the iPAC rubric for evaluating m-learning tools, based on iPAC, a validated framework that is rooted in m-learning pedagogies and used to evaluate m-learning scenarios (Kearney et al., 2012).

The rest of this chapter is structured as follows: in section "Orchestration affordances throughout the learning activity life cycle: The OA-LALC framework" we discuss the affordances that LD and LA could offer to different stakeholders during the LALC and construct a corresponding analytical framework of orchestration affordances; section "LD and LA in m-learning" presents the related work on m-learning; in section "Methodology" we introduce the methodology; in section "Results" we present the results from the analyses of the m-learning tools, in section "Discussion" we discuss the implications; while section "Conclusion" concludes the paper.

Orchestration Affordances Throughout the Learning Activity Life Cycle: The OA-LALC Framework

A learning activity is defined as a set of specific interactions of learner(s) with other(s) using specific tools and resources to achieve a set of intended outcomes (Beetham & Sharpe, 2007). To achieve those intended outcomes in an efficient and effective manner, LD and LA communities have proposed different solutions to support the involved stakeholders throughout the LALC. For instance, the LD community has proposed different strategies to support practitioners in the conceptualization and authoring of the designs (Pozzi et al., 2016). Also, the implementation of the design in a particular technical environment has received special attention in Technology-Enhanced Learning (TEL) (Muñoz-Cristóbal et al., 2014). Furthermore, the enactment of the learning activity has received the attention of the LA community, aiding the regulation of the learning activity, gathering evidence for the assessment, and informing the reflection (Persico & Pozzi, 2015).

Moreover, while various authors have focused on LD/LA guidelines intended for TEL developers (Dillenbourg & Jermann, 2010; Muñoz-Cristóbal et al., 2018), or researchers (Prieto et al., 2019), there is a need for a framework that helps with the design and evaluation of learning tools from the perspective of the main actors of a learning activity. As a first step toward such an analytical framework, in Table 1 we have compiled the affordances that LD and LA solutions could offer to the actors involved in the different phases of the LALC (as highlighted by the communities of LD and LA through theoretical and practical contributions). We call it the OA-LALC framework. Depending on the learning approach (teacher-driven or student-driven), these affordances might concern different actors (e.g., learning designers, teachers, learners) requiring support for their associated orchestration tasks. In this chapter, we will use the OA-LALC framework to guide the analysis of orchestration affordances for the m-learning tools reported in Pishtari et al. (2020).

LD and LA in M-Learning

As discussed in section "Orchestration affordances throughout the learning activity life cycle: The OA-LALC framework", the alignment of LD and LA practices might support the teaching and learning practices of the different stakeholders involved during an instance of the LALC. In the context of m-learning, this alignment could help when dealing with the complexities derived from the hybrid nature of m-learning environments (Muñoz-Cristóbal et al., 2018).

Nevertheless, as there are few explicit works where this synergy is visible in m-learning, in a previous systematic review, Pishtari et al. (2020) considered all m-learning publications with an interest in rather LD or LA. Results emphasize that although there is little explicit alignment (as only three papers focused both on LD and LA), both communities have considered similar learning contexts, while each of

Table 1 The OA-LALC framework and an overview of affordances that LD and LA tools could offer to actors (or actor needs) along with the LALC phases

LALC phases	LD affordances	LA affordances
(Re)conceptualization[a]	Formalize the goals of the learning activity[b,c,d] Model the context where the learning activity will happen[c,e] Search and browse existing LDs by content or context[b,d] Design using existing patterns, good practices, or pedagogical theories[c,d,e] Design in different social spaces (i.e., individual, or collaborative)[b,c]	Provide insights from analysis of previous activities[b,c,e] Provide context-related information (i.e., physical, socio-cultural)[e] Enable the automatic data collection (e.g., of learning design traces and artifacts)[b,c]
Authoring	Formalize the role of the participants in the learning activity[b,e] Designate the learning resources that will be used in the learning activity[b,c] Define the learning sequence[b,c]	Offer design recommendations (e.g., pedagogical or content-related) based on previous learning design and learning practices[c,e]
Implementation	Enable the manual/automatic design deployment in a TEL environment[b,c]	Enable the automatic data collection (e.g., of learning activity traces, outcomes or teacher interventions)[c,e]
Regulation	Enable the manual/automatic adaptation of design elements (e.g., time, tasks, activity flow)[e]	Enable real-time monitoring for an ongoing learning activity[e] Detect critical situations[e] Suggest regulation actions for practitioners, or students (in self-regulated learning)[e] Automatic interventions triggered by the data[e]
Evaluation	Enable the assessment of the learning outcome[c,e] Provide (formative and summative) feedback to learners[c,e] Assess the learning design[c,e]	Inform manual assessment of the learning outcome[c,d] Automatic (formative or summative) assessment of the learning outcome[c,e] Provide awareness of the regulation actions[c,d,e] Detect deviations from the learning design[c,d]
Reflection	Guide the reflection process (e.g., posing some questions)[b,c] Enable the re-design of the activity[b,c,e]	Inform the reflection based on the teaching and learning practice (e.g., extracting learning patterns)[b,c,d,e] Provide trend analysis (e.g., of teaching practices across different activities)[b,c,d]

[a]This phase refers both to the first time a design is created from scratch or when the design is refined

Based on [b]Persico and Pozzi (2015); [c]Rodríguez-Triana et al. (2015); [d]Pozzi et al. (2016); [e]Emin-Martínez et al. (2014)

them has produced mature contributions in their fields that are also complementary to each other (Pishtari et al., 2020). Thus, given the implicit alignment of research in LD/LA in m-learning, both communities could enable a sustainable process of researching that can have a direct impact on learning and teaching practices.

In order to enable an explicit alignment between LD and LA in m-learning, it is also important to ponder the role played by characteristics that are specific to this context. For instance, various authors have emphasized the support that LD can provide to facilitate pedagogically-grounded and contextualised LA (Persico & Pozzi, 2015; Rodríguez-Triana et al., 2015). In order to achieve the same synergy in m-learning, it is necessary to consider its specific pedagogical characteristics.

Kearney et al. (2012) propose the iPAC framework that identifies three specific pedagogical features/affordances of m-learning: personalisation, authenticity and collaboration. Personalisation includes pedagogical affordances such as agency, self-regulation, or customisation. Indeed, students in m-learning have greater control over the physical/virtual space, pace of learning and enjoy more autonomy over their learning content (Kearney et al., 2012; Pishtari et al., 2019b). Authenticity is related to the ability that m-learning tools have to create real-life and authentic learning scenarios, while collaboration, as feature, is related to the enhanced possibility that students have to create meaningful connections with each other, as well as the learning resources (Kearney et al., 2012). In this chapter, we will analyse the pedagogical affordances of the m-learning tools under review guided by iPAC (more specifically, the iPAC rubric for evaluating m-learning tools[1]).

Methodology

The current chapter extends the literature review on LD and LA in m-learning (Pishtari et al., 2019b, 2020), by analysing the m-learning tools that were reported in it, guided by our RQ and the corresponding subquestions (see Fig. 1). The 54 papers included in the aforementioned review reported 17 unique m-learning tools. We contacted the authors of the publications reporting each tool and asked for access to the tools (if possible) and/or to provide us with the answers to our questions. Finally, we were able to analyse nine tools (see Table 2).

To guide the evaluation based on Sub-RQ1 we created a Google Form based on the affordances of the OA-LALC framework (for further details, see the online version of the form[2]), while for Sub-RQ2 we used a form based on the iPAC rubric for evaluating m-learning tools[3] (further discussed in section "LD and LA in m-learning"). The authors of this chapter went through the functionalities of each tool and filled a preliminary version of the forms with the corresponding

[1] http://richprocter.co.uk/survey/mttep/rubric/?LMCL=rYfxl3&LMCL=zQYm_J

[2] https://forms.gle/7ZtuR7sMykBFkjq57

[3] https://forms.gle/eAKj5H8PbVcKnhSg6

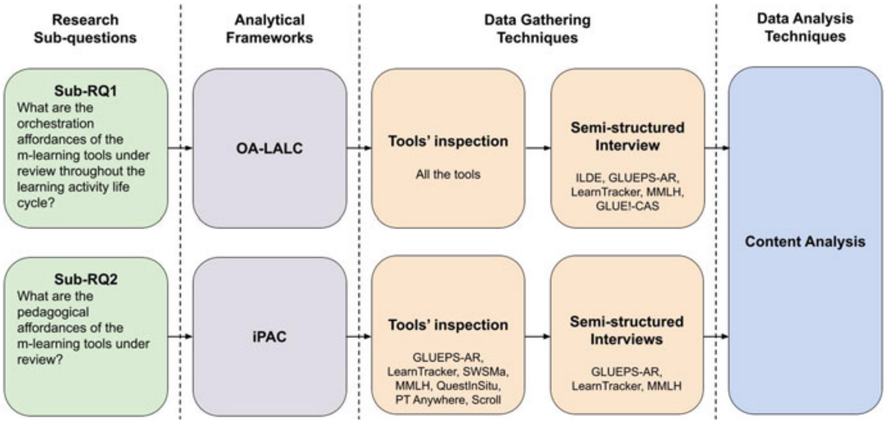

Fig. 1 Research sub-questions, analytical frameworks, data gathering (including the involved tools) and data analysis techniques

information. These results were later shared via email with the authors of the papers reporting the tools for further comments or clarifications. In the case of LearnTracker, QuestInSitu and GLUE!-CAS, the authors of the papers directly filled the forms. Furthermore, we had an interview with the authors of each tool to discuss/extend our 'annotation', or to clarify the answers that the authors had provided, in case of doubts (see Fig. 1).

For the tool evaluation using iPAC, we included only those tools intended to design learning activities (seven out of nine). GLUE!-CAS was not included, as its function was to provide LA for LD support to practitioners and did not facilitate learning activities through its interface. In the case of ILDE, the tool was excluded as it focused not on the design but on the deployment of LDs created in other authoring tools (e.g., LDshake or Collage) in different learning environments (e.g., in Google Docs or Moodle). The results from the interviews were analysed contextually, guided by the corresponding frameworks.

Results

In this section, we first briefly introduce the m-learning tools under review in Table 2. Results for Sub-RQ1 are divided into LD and LA affordances (presented respectively in sections "Sub-RQ1: LD affordances" and "Sub-RQ1: LA affordances"). Finally, section "Sub-RQ2: Pedagogical affordances" reports the results

Table 2 Description of the tools

Tool	Description
ILDE (Hernández-Leo et al., 2014)	A community platform supporting practitioners to (co-)design learning activities using different authoring and implementation tools integrated into it
GLUEPS-AR & Learning Buckets (Muñoz-Cristóbal et al., 2014)	Help practitioners to deploy designs created with different tools into different m-learning environments and to regulate the designs, during the enactment
LearnTracker (Tabuenca et al., 2015)	A reporting tool for practitioners and learners that manually records time logs of their learning and teaching practices (connected to a course plan)
SWSMa (Cooner et al., 2016)	A tool that helps learners to grasp ethical issues of using social media in social work. It is usually used by practitioners as a pre-teaching activity
Multimodal Learning Hub (MMLH) & Visual Inspection Tool (Schneider et al., 2018)	Allows researchers to create quick prototypes that collect multimodal learning data (in m-learning environments, through sensors), which are later analysed and visualised
GLUE!-CAS & GLIMPSE (Muñoz-Cristóbal et al., 2018)	GLUE!-CAS is an architecture for data gathering and integration in distributed learning environments. GLIMPSE is a tool for script-aware monitoring in CSCL scenarios
QuestInSitu (Santos et al., 2011)	Allows practitioners to design location-based learning activities based on questions and tests, to which learners respond after interacting with the contextual environment
PT Anywhere (Mikroyannidis et al., 2018)	A network simulation interface used by practitioners and learners to teach and acquire computer networking skills
Scroll (Mouri et al., 2018)	A mobile app that supports learning a foreign language in a situated environment (by allowing learners to log and search for relevant content based on their location and context)

for Sub-RQ2. For further details, see the extended versions of the analysis based on Sub-RQ1[4] and Sub-RQ2.[5]

Sub-RQ1: LD Affordances

This section presents the results related to Sub-RQ1 that correspond to the LD affordances of the OA-LALC framework. Figure 2 contains an overview of the results.

[4] http://bit.ly/LDLAaffordances

[5] http://bit.ly/iPACHLS

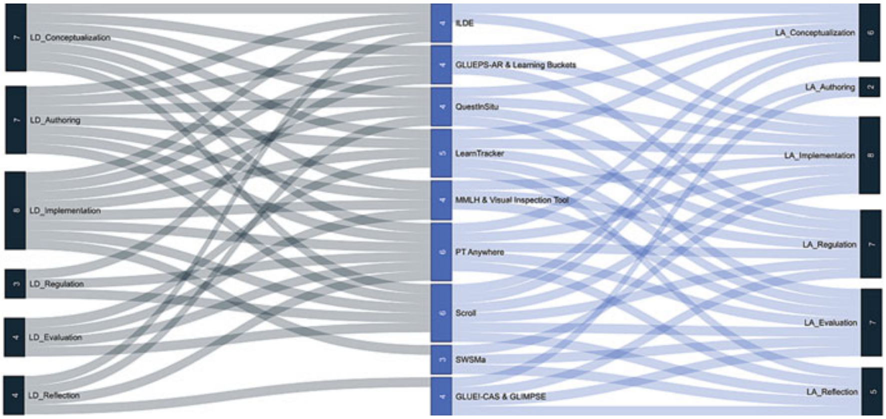

Fig. 2 Overview of LD (left) and LA (right) affordances per m-learning tool. All phases are represented with multiple tools, while all the tools include both LD and LA affordances. Few tools provided LA affordances related to authoring, as well as LD affordances related to regulation

From nine tools under review, four explicitly focused on supporting practitioners in the conceptualization, authoring and implementation of learning activities (ILDE, GLUEPS-AR, PT, QuestInSitu); in three tools the design was provided by the researchers (LearnTracker, MMLH, SWSMa); in one it was done by the learners themselves as part of their self-regulated learning process (Scroll); while one tool was exclusively focused on providing LA support for design practices (GLUE!-CAS). Figure 2 provides an overview of the LD and LA affordances identified in each tool.

Only ILDE explicitly distinguished between the design phases of **conceptualization** and authoring. For instance, in ILDE practitioners used a blank document, or a template (i.e., structured based on good practices, or pedagogical approaches) to reflect, collaborate and share ideas about the design. Furthermore, three tools allowed to specify the learning goals: ILDE and GLUEPS-AR where this was done by practitioners, as well as LearnTracker where it was done only by researchers, based on feedback from practitioners (as it required technical knowledge). Moreover, four tools allowed users to model the physical/virtual context of the learning activity. For instance, in ILDE, GLUEPS-AR and QuestInSitu practitioners could connect learning resources (e.g., a quiz or test) with a geo-location point or a QR-code, while in MMLH, researchers were the ones who integrated different sensors (part of the enhanced environment) with the tool. Additionally, although not as a primary goal, practitioners could reflect on the learning context through the network simulator in PT (i.e., on network representations that could be appropriate for specific topics, or categories of learners). In three tools it was also possible to search, modify and/or reuse existing designs rather by practitioners (ILDE and PT), or by learners themselves (Scroll).

In terms of **authoring**, two tools (ILDE and GLUEPS-AR) allowed practitioners to freely formalise the role of the participants in the learning activity. Moreover, in six tools it was possible to designate the learning resources used during a learning activity. While in ILDE, GLUEPS-AR, QuestInSitu, and PT this was done by practitioners, in the MMLH it was done by researchers, and in Scroll by the learners. The type of learning resources that was used depended on the tool. Most of the tools only allowed users to choose between predefined options (e.g., multimedia, or text notes in Scroll; or between a list of questions and test templates in QuestInSitu). With the exception of SWSMa (where the sequence of the activity was predefined by developers) and GLUE!-CAS (which was focused on LA), all the tools allowed practitioners/learners to modify the sequence of the learning activity at will, prior to its deployment.

In terms of **implementation**, with the exception of GLUE!-CAS, all the tools enabled the deployment of a learning activity. Supporting the deployment phase was one of the main objectives of GLUEPS-AR and ILDE, where practitioners could control (through a panel) what (tasks), when (time) and where (the m-learning environment) an LD was going to be deployed. QuestInSitu and LearnTracker also allowed practitioners to manually control the deployment, in PT and SWSMa it was done automatically, while in Scroll it was controlled by the learners themselves.

Regarding the **regulation** phase, only GLUEPS-AR allowed practitioners to adapt design elements during the enactment, through a control panel where they could manipulate the groups, as well as the different resources accessible to learners in specific moments. Moreover, in PT and Scroll, it was the learners who controlled the specific content, the time and the duration of each activity.

Concerning the **evaluation** phase, only two tools allowed practitioners to assess the learning outcome: MMLH, where this was done by manually annotating parts of the video/audio record of the learning activity; and PT, done both by practitioners and learners as part of a discussion session at the end of the activity. Furthermore, only LearnTracker allowed practitioners (and researchers) to provide in-app feedback to learners based on previous activities (as personalised notifications that contained tips for self-regulated learning), as well as to assess the design itself (i.e., by identifying students' low and high moments of productivity during the lesson, differences between the expected and real-time for specific tasks, etc.). In Scroll, it was an algorithm that provided summative feedback about learners' performance (e.g., new words that they had learned).

While GLUE!-CAS informed practitioners to **reflect** on the activity (e.g., based on the collaborative tasks that were not done by a group of learners and that could affect future phases of the design), ILDE also guided the reflection through a (teacher inquiry for LD) template. Furthermore, PT included a guided discussion session where learners could reflect on the learning outcome, as well as how to improve future activities. Moreover, while in ILDE, GLUEPS-AR and QuestInSitu practitioners could redesign their existing learning activities, in Scroll the learners themselves could modify the content that they (or others) had stored.

Sub-RQ1: LA Affordances

This section presents the results related to Sub-RQ1 that correspond to the LA affordances of the OA-LALC framework. Figure 2 contains an overview of the results.

All the tools (nine) included LA functionalities. Regarding the **conceptualization** phase, three tools (LearnTracker, QuestInSitu, PT) provided both insights from analysis of previous activities and information about the context (rather the learning context, e.g., LearnTracker provided insights about learners' trajectories; or the physical/virtual context e.g., GLUEPS-AR provides a map with information about the situated environment). Furthermore, related to the automatic data collection of the design process, four tools (LearnTracker, GLUEPS-AR, QuestInSitu, ILDE) collected design artifacts and traces (e.g., time created, modified and shared, etc.) produced by practitioners. Moreover, Scroll collected artifacts and traces of content created by learners (as part of their self-regulated learning process), which could be later used by others in their own activities.

In relation to the **authoring** phase, only GLUE!-CAS offered design recommendations to practitioners (e.g., guiding the selection of relevant learning tools), while Scroll used an algorithm to suggest content to learners (based on previous content created by them and their current location). Moreover, apart from GLUE!-CAS, all the tools supported automatic data collection (part of the **implementation** phase), rather as learning activity traces/outcomes (e.g., QuestInSitu collected learners locations and responses to tests), or as interventions from practitioners (e.g., in LearnTracker practitioners had to log their actions, while in GLUEPS-AR actions were logged automatically).

Regarding the **regulation** phase, six tools (LearnTracker, GLUEPS-AR, MMLH, GLUE!-CAS, QuestInSitu, PT) allowed practitioners to monitor an ongoing activity in real-time. Monitored aspects included learners performance and time spent by learners on specific tasks (e.g., LearnTracker), location (e.g., QuestInSitu), or resources used during the activity (GLUE!-CAS). Only three tools (LearnTracker, MMLH, GLUE!-CAS) automatically detected critical situations (e.g., GLUE!-CAS detected tasks not yet done by specific students, which accomplishment constraint the continuation of the lesson). Apart from Scroll (that used an algorithm to suggest content to learners in real-time), no other tool suggested regulation actions or automatic interventions.

In terms of **evaluation**, while six tools (LearnTracker, MMLH, GLUE!-CAS, QuestInSitu, PT, Scroll) supported the manual assessment of the learning outcome, and five tools (SWSMa, GLUE!-CAS, QuestInSitu, PT, Scroll) also automatically assessed specific tasks done by learners, no tool provided awareness about the regulation actions taken by practitioners. Furthermore, only GLUE!-CAS automatically detected deviations from the design (such as the example of constraints mentioned before).

Regarding the **reflection** phase, five tools (LearnTracker, SWSMa, GLUE!-CAS, PT, Scroll) informed a reflection process about the activity, rather based on teaching practices (e.g., with the time spent by practitioners on specific tasks, in LearnTracker), or learning practices (e.g., in SWSMa learners could reflect on the outcome that their decisions could have in real-life scenarios). Moreover, only LearnTracker provided trend analysis about both teaching and learning practices that went beyond single learning activities.

At the end of the interviews, we asked the authors behind each tool to mention any other relevant LD/LA functionality (affordance) not covered by the questions. Consequently, it resulted that in GLUE!-CAS, practitioners could also configure the LA process (e.g., choosing periods, or the importance of each task performed by learners). Furthermore, as all the tools were developed mainly for research purposes, researchers also played a crucial role during the LALC of each tool, rather directly (e.g., in MMLH they were the main stakeholders), or indirectly (e.g., by having access to the logs of the activities, thus also having a broader view of the teaching and learning practices).

Sub-RQ2: Pedagogical Affordances

This section presents the results related to Sub-RQ2. Figure 3 provides an overview of the pedagogical affordances identified in each tool.

Regarding the **collaboration** section of iPAC, it resulted that the tools offered no (or limited) opportunities to learners for online peer discussions (six tools), as well as no (or limited) opportunities for sharing/exchanging digital content (six tools). When available, such functionalities were usually implemented as a chat that learners used to communicate and share information (e.g., GLUEPS-AR).

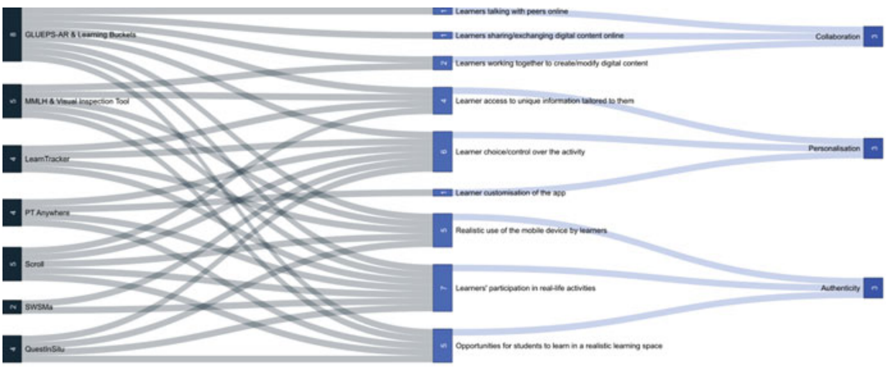

Fig. 3 Pedagogical affordances (in black, left) of the tools based on the three categories of iPAC (in blue, right) and their corresponding subcategories (in blue, centre). Most of the tools under review include authenticity affordances, thus supporting the design of real-life learning scenarios in real and contextualised settings, while very few tools provided affordances related to the collaboration section

Furthermore, most of the tools (five) did not allow (or offered limited opportunity for) learners to create/modify content together. GLUEPS-AR was one example of enabling this practice, where practitioners could share a whiteboard where learners collaboratively created digital content (as open educational resources). In Scroll, although learners were not directly collaborating with each other, they could access, modify and reuse content created by others.

Concerning the **personalisation** section, it resulted that in six (out of seven) tools learners had rather extensive choice/control over the activity (e.g., in Scroll learners controlled the timing, pace and the content of the activity), or some limited control (e.g., in GLUEPS-AR it is the practitioners who select what content learners can create or modify). Only in MMLH learners had to strictly follow the sequence and timing of the activities, as designed by researchers and practitioners. Nevertheless, most of the tools (six) didn't allow (or offered limited possibilities to) learners to personalise/customize the tool, with the exception of PT, where learners could extensively modify both the interface of the network simulator (choosing from different available topologies), as well as their profile (e.g., courses where they were enrolled). Regarding the learners' access to unique information provided to them, only four tools (GLUEPS-AR, MMLH, LearnTracker, Scroll) allowed practitioners (or learners) to create unique information for specific (groups of) learners.

Regarding the **authenticity** section, all the tools (seven) provided at least some opportunities for learners to participate in real-life activities, while five tools supported realistic (or partial) learning spaces. Meanwhile, the realistic usage of mobile tools included in the activity (similar to real-world experiences) depended on the objectives of the tool. For instance, in GLUEPS-AR, QuestInSitu, Scroll, MMLH and LearnTracker the usage was very similar to real-world experiences (as students had to take notes, perform measurements, navigate, collaborates, or communicate with the mobile devices) while in SWSMa and PT the usage was decontextualized or partially connected to real-world practices (as students used the devices mainly to access the learning environment).

Discussion

Based on the analysis of the selected m-learning tools, we can reflect on the practical LD and LA affordances already available (main RQ). Regarding *Sub-RQ1 (orchestration affordances throughout the learning activity life cycle)*, although only two tools (GLUEPS!-AR and GLUE!-CAS) were related to manuscripts that explicitly advocated an alignment of LD and LA practices in m-learning, all the tools included both LD and LA affordances. Therefore, they provide practical examples of the benefits of an explicit alignment. For example, although the main goal of QuestInSitu was to support practitioners in authoring and deploying activities outdoors when presented with a LA dashboard that was informed with results from the learning activity, both practitioners and learners emphasized its utility to support awareness and reflection practices (Melero et al., 2015). Moreover, LearnTracker (that provided mobile LA for teaching and learning practices) illustrates the other direction of a possible alignment. In it, analytics were guided by the design that practitioners created (e.g., practitioners specified the goals of the activity, while LA data-informed each of the specified goals) (Tabuenca et al., 2015).

All the phases of the LALC life cycle were present in the results. Nevertheless, with the exception of ILDE, the other tools offered little support to the design practices related to the conceptualization phase and usually jumped directly to authoring (which was largely supported). Apart from providing functionalities that support practitioners (or learners, in case of self-regulated learning) to search, modify and reuse existing designs (which were the most common affordances of the conceptualization phase), it is also important to enable digital environments where practitioners can collaborate with each other to conceptualise LDs (such as in ILDE), guided by good practices and pedagogical theories that are relevant to the context of m-learning.

For instance, the iPAC framework, which is rooted in m-learning pedagogies (Kearney et al., 2012), could be used to guide practitioners during the conceptualization phase, in order to consider learning scenarios that provide real-world experience to learners, as well as to select the technological resources that expand learners' agency and collaboration during the learning activity. Inquiry-based Learning is another relevant theory in the context of m-learning. For example, the inquiry-based learning model proposed by Pedaste et al. (2015) could be useful during the conceptualization phase (guiding the creation of inquiry learning activities), as well as to provide design recommendations that are relevant for inquiry learning (which was an underrepresented LA affordance of the authoring phase).

Only GLUEPS-AR supported practitioners during the regulation phase with LD affordances. Nevertheless, it required extensive technical knowledge from them. In more recent research, Rada, a location-based authoring tool, enables practitioners to regulate various aspects of the learning activity (such as learners' groups, learning content, etc.), without requiring extensive technical knowledge (Pishtari et al., 2021). LA affordances in the regulation phase have been underexplored (at least until the review took place). For instance, there has been little research about the impact of suggesting regulation actions to practitioners or including automatic interventions during the activities, in the context of m-learning. If implemented in an effective and efficient way, these affordances could help to address some of the main difficulties deriving from the hybrid nature of m-learning (i.e., practitioners should monitor the learning that happens across spaces and contexts) (Muñoz-Cristóbal et al., 2018).

The evaluation and reflection phases were best covered by the m-learning tools. Nevertheless, the only stakeholders considered were practitioners and learners (as part of their self-regulated learning process, such as in Scroll), while researchers usually played a supportive role. Meanwhile, it is important to consider also other stakeholders with an interest in LD/LA practices (Pishtari et al., 2019b). For instance, school managers might be interested to assess or reflect on the adoption and usage that specific m-learning tools find in practitioners and learners practices, in their schools. Furthermore, developers could also be interested in understanding how to improve the tools, in order to better support (technically) specific LD/LA affordances.

Although most of the reported LD/LA affordances are transversal to TEL, it resulted that m-learning tools have focused on supporting learning activities that happen across spaces, context-aware learning, as well as learning happening anytime and anywhere, rather through location-aware functionalities (e.g., QuestInSitu and GLUEPS-AR), or by promoting learners' agency and self-regulated learning (e.g., Scroll).

Regarding *Sub-RQ2 (pedagogical affordances)*, the evaluation using iPAC emphasized the role that m-learning tools play in designing real-life learning activities, where learners not only can learn contextualised knowledge that can be applied in real situations but also have extensive control over the learning activities (that stimulate self-regulated learning). The characteristics mentioned in the previous paragraph and here make m-learning tools a potential facilitator of hybrid learning scenarios, where learning can happen partially in physical environments (such as a classroom) and partially online, or in situated environments. Rather synchronously (e.g., where one part of the learners are in the classroom, while the other part online), or asynchronously (where learners divide their time between in-classroom and out of classroom activities).

Furthermore, the LD and LA tools under review did not include functionalities that would enable collaborative learning, such as facilitating learners to work together, discuss, or interchange learning artifacts. M-learning tools that support learners' collaborative practices would also help to create inclusive hybrid learning scenarios, where learners that are not physically present in the classroom can participate actively during the activities. From an LD perspective, m-learning tools should allow practitioners to design in different social spaces (i.e., individual or collaborative). While from a LA perspective, they should support practitioners' awareness and reflection practices based on learners' collaborative traces.

A limitation of this review is the exclusion of tools not meeting the inclusion criteria in Pishtari et al. (2020), tools that we couldn't access, or new ones, reported in more recent manuscripts. For instance, Rada (Pishtari et al., 2021) is an example discussed in previous paragraphs, while Smartzoos is a location-based tool that allows practitioners and learners to design learning content as open educational resources that can be used and modified by others (Pishtari et al., 2017). Furthermore, CasualLearn is another recent example that offers students semi-automatically created tasks (exploiting open web data), based on their location and learning context (Ruiz-Calleja et al., 2020). Further research is also needed in order to assess to what extent the aforementioned affordances lead to the expected/better learning outcomes.

Conclusion

This chapter analyses the LD and LA affordances of nine m-learning tools resulting from a systematic review in m-learning (Pishtari et al., 2020). We propose the OA-LALC framework and use it together with the IPAC framework, to look respectively at the orchestration affordances of the tools throughout the LALC and their pedagogical affordances.

Results emphasize the need to further support various elements of the OA-LALC framework that were underrepresented in the results, such as the conceptualization of m-learning activities based on pedagogical theories and good practices that are relevant to the context, as well as aligning practitioners LD and LA practices during the authoring and regulation phases. LD and LA have provided little support to learners' collaboration practices in the m-learning tools under review, such as supporting the group creation taking into account computer-supported collaborative learning patterns (LD), or raising awareness about the other members involved in the activity (LA). Supporting these practices might help to create inclusive hybrid learning settings (where both learners that participate physically in the classroom and online would have a similar learning experience).

Moreover, further inquiry is required about LA techniques that can be relevant in the context of m-learning, especially during the regulation phase (such as suggesting regulation actions to practitioners, providing automatic interventions, or informing self-regulated learning), as well as involving in the studies other relevant stakeholders with an interest in the LD and LA, apart from practitioners and learners (such as managers of educational institutions, developers, or teacher trainers). Finally, it would be necessary to reinforce the practical alignment between LD and LA in m-learning and we hope that our OA-LALC framework can guide TEL researchers and developers in the design and evaluation of their tools.

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Classroom Analytics: Telling Stories About Learning Spaces Using Sensor Data

Roberto Martínez-Maldonado, Lixiang Yan, Joanne Deppeler, Michael Phillips, and Dragan Gašević

Introduction

The technologies that support ubiquitous computing (e.g., the Internet, microprocessors, mobile protocols and affordable portable computing devices) are now enabling hybrid learning experiences to be designed for both physical and online spaces (Singh & Thurman, 2019). On the one hand, the increasing use of interactive devices and improvements in networked technologies are blurring the boundaries of the physical learning space by allowing teachers and learners to connect with digital content, systems and people located elsewhere (Kohls, 2017; Cohen et al., 2020). On the other hand, learning experiences are no longer confined to unfold in a particular physical place (e.g., the classroom or the laboratory). Instead, on-site and synchronous/asynchronous online learning tasks are being combined and blended, to various extents, often with the purpose of redistributing the study activity in space and time (Ellis & Goodyear, 2016). Yet, an underexplored opportunity enabled by emerging sensors and computer vision technologies is that digital data traces of the spatial behaviours of teachers and learners can now be automatically captured and rendered visible for the purpose of supporting teaching and learning (Pishtari et al., 2020; Chua et al., 2019), and space re-design (Waber et al., 2014).

Understanding how spatial behaviours in the physical learning space can influence learning is critical. Previous research has found that teachers' positioning in the classroom and proximity to students can strongly shape aspects such as students' motivation (Fernandes et al., 2011), disruptive behaviour (Gunter et al., 1995),

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self-efficacy (Koh & Frick, 2009), and engagement (Chin et al., 2017). Moreover, social interactions of learners with their peers in the physical learning space are associated with enhanced levels of emotional well-being (Montague & Rinaldi, 2001) and increased learning performance (Gašević et al., 2013) and are essential for developing twenty-first-century skills (Bell, 2010).

Evidence about such spatial behaviours, and how the physical learning space is actually used, is fragmented across various research areas (Ellis & Goodyear, 2016; McArthur, 2015) and rarely reaches educational decision makers and the designers of those spaces. The term proxemics has often been used to refer to the study of the maintenance of specific zones in physical spaces that people perceive as meaningful according to their culture (Danesi, 2006). Although proxemics has provided a theoretical lens to study classroom activity, measuring social interactions in physical learning spaces is often difficult in practice, as it commonly relies on direct observations (Hurst et al., 2013) and interviews (Ryser et al., 2009), which are hard to scale up and are susceptible to bias. This all makes it hard for educators, indoor designers, furniture providers and other educational decision makers to make informed decisions regarding the design and re-design of physical learning spaces to maximise the opportunities to improve teaching and learning.

This chapter focuses on the timely opportunity to use emerging, inexpensive positioning technology to generate evidence about the activity of teachers and learners unfolding in physical learning spaces that are becoming increasingly hybrid. The chapter discusses a facet of hybridity that is yet to be deeply explored: how can *digital* traces automatically captured from the physical learning space be used to make commonly ephemeral *face-to-face* teaching and learning practices available for automated computational analysis. We particularly discuss the potential of bringing learning analytics innovations into physical classroom spaces to inform pedagogical practice, space design, and design for learning. The term *Classroom Analytics* is used as a lens to connect proxemics, pedagogy, data and space design. We describe three short data stories that illustrate how analytics for classroom proxemics can enable: (1) the creation of interfaces that provide digital forms of feedback to educators about activity in the physical classroom; (2) new ways to assess pedagogical activity in hybrid learning spaces that can be used to inform space re-design or co-configuration; and (3) new approaches to analyse learners' activity in hybrid learning spaces that cannot be easily accomplished through observations.

Proxemics, Data, Spatial Pedagogy and Space Design

The body of work focused on the study of how teachers and students use the classroom space can be referred to as *classroom proxemics* (Martinez-Maldonado et al., 2020c). Foundational work on proxemics defined the cultural expectations of interpersonal distances (Hall, 1966), that is, the physical distance that individuals choose to maintain between themselves and others while interacting. By focusing on teachers, McArthur (2008) suggested the need for thoroughly investigating how the classroom design influences student and teacher perceptions of learning, spatial behaviours, interpersonal distances and practices in the physical learning environment. For example, some institutional architecture provides an optimal environment for teacher-centric practices. This is the case of lecture rooms, originally designed back in the nineteenth century (Barnard, 1854), that promote linear seat arrangements to maximise a teacher's monitoring and control, and students' attention directed towards the teacher. It is also the case of novel architectural approaches, such as open learning spaces (Reh et al., 2011) and flexible classrooms (Neill & Etheridge, 2008), which are challenging teacher-centric pedagogical practices by promoting flexibility, movement, integration, and student agency and choice.

The notion of proxemics has also provided a theoretical lens to investigate the impact of architectural design and the use of the space on classroom dynamics. Eberts and Lepper (1975) analysed how preschool children can be characterised by their spatial behaviours in the classroom and other school spaces. Jones and Aiello (1973) investigated variations in the interpretation of interpersonal distances according children's age and their cultural backgrounds in a primary school. Cardellino et al. (2017) studied the impact of interpersonal distances and the spatial configuration of the classroom on the number of students receiving high-quality visual attention from the teacher in the context of primary education. Similar studies have been conducted in the context of higher-education, for example, to investigate how teachers utilise the classroom space based on their individual characteristics or the learning tasks being enacted. In fact, this has been the focus of contemporary research, termed as Spatial Pedagogy (Lim et al., 2012) or Instructional Proxemics (McArthur, 2008; Chin et al., 2017), seeking to understand the meanings of certain areas of the classroom according to the spatial positioning of teachers in relation to students, and digital or material resources.

In sum, the research described above shows the sustained interest in understanding how teachers' and students' positioning in physical learning spaces, across all educational levels (i.e., from K12 to university) can impact learning. However, most analysis approaches have been based on self-reported rubrics, and observations made on a small number of classes. This has limited the kind of studies that can be conducted to understand spatial behaviours in terms of scalability (i.e., only a limited number of classroom sessions can be observed) and precision of the distance measurements which are critical for analysing proxemics (i.e., interpersonal distances are commonly approximated by an observed or self-reported by students and teachers). In fact, McArthur (2015) explained that this is one of the reasons why empirical research investigating how the same learning design is enacted under similar conditions across various learning spaces is very limited. This motivates the need for automated tools that can support the collection of accurate positioning and proximity data that can facilitate the scalability of classroom proxemics studies.

Analytics for Classroom Proxemics

There has been a growing interest in using sensing technologies to automatically capture activity data in classrooms and other learning spaces. Conducting systematic classroom observations by trained experts is still the most comprehensive method to capture rich information to deeply understand classroom phenomena. Yet, in recent years, several researchers have demonstrated the potential of using automatically captured data to identify patterns that can be hard to see with the "naked eye". Automated video analysis has been one of common approaches to data capturing and analysis. Video-based solutions have been used to model fine grained physical behaviours such as students' posture, gaze (Raca et al., 2015), and gestures (Ahuja et al., 2019). Similarly, some teacher's behaviours, such as walking (Bosch et al., 2018) and interactions with students (Ahuja et al., 2019; Watanabe et al., 2018) in lecture-based classrooms, have been automatically coded. Multiple synchronised cameras encircling the physical learning space have been used to identify approximate student locations and the types of social interactions and spatial behaviours of students in makerspaces (Chng et al., 2020) and secondary school contexts (Howard et al., 2018). However, these video-based technologies have not been used to provide precise positioning information that could be used to identify the exact positions of students and teachers in complex learning spaces (the only exception is the work by Chng et al. who used depth cameras to estimate interpersonal distances in a small makerspace). Moreover, at the moment, video-based solutions are still susceptible to occlusion and are therefore impractical to follow particular students over time.

For this reason, other researchers have been using alternative tracking technologies based on wearable micro-location technologies. Although teachers and learners have to wear a small tracker or a mobile device, the precision of the positioning data that can be captured can be very accurate. For example, Wake et al. (2018) proposed the use of bluetooth-based beacon technology to collect data from firefighters during training sessions to identify patterns and provide feedback for improving their performance in future emergency situations. Riquelme et al. (2020) have used the same technology to track students' mobile phones in a library setting and investigated the emerging roles that students enacted while collaborating.

Several studies have focused on creating interfaces that can be used by teachers to interact with data collected through indoor-location technologies. For example, Echeverria et al. (2018) used ultra-wideband (UWB) radio sensors to investigate how nurses work in teams during high-stakes simulation-based learning tasks in the context of nursing education. The positioning and proximity data of students and their teacher were automatically analysed and the results were visualised and presented back to them to provoke reflection on spatial strategies. Saquib et al. (2018) developed a system called Sensei that relied on small positioning trackers embedded on student shoes and that was used to automatically track teacher and student spatial behaviours in Montessori primary schools. The positioning data was visualised and made available to teachers to augment their manual observations, design individualised tasks for each student, and identify potential interaction needs for particular students. An et al. (2018) also investigated ways in which positioning data could be shown back to teachers to gain awareness about classroom teaching behaviours such as how they distribute their time across the students. An et al. also summarised the amount of time a teacher has spent in close proximity to groups of students and displayed this information using lamps located at each group's table (An et al., 2018) and heatmap visualisations (An et al., 2020).

In sum, there is an emerging interest in using sensing technologies to study classroom proxemics. Indoor-positioning technologies are very rapidly becoming more accurate, inexpensive, and portable. The next section illustrates how some of these sensing technologies have been used to automatically capture salient aspects of teaching and learning activity in three authentic learning spaces.

Three Illustrative Data Stories on Classroom Analytics

This section presents three data stories to illustrate the potential of analytics for classroom proxemics to support various aspects of teaching, learning and educational research. Each story presents the first-hand experiences that the authors of this chapter have developed for the purpose of enabling: (1) the creation of interfaces that provide feedback to educators about activity in the physical classroom; (2) new ways to assess pedagogical activity in learning spaces to inform space re-design or re-configuration; and (3) new approaches to analyse activity in learning spaces that cannot be easily accomplished through direct observations.

Data Story 1: A Teacher Dashboard About Spatial Data

Educational Context This story unfolded in the context of an undergraduate course—Socially Responsive Design. The story focuses on three randomly chosen 3-h tutorial classes (A, B and C) taught by the same educator in the same (8×10 m) classroom, equipped with moveable tables, a projector and pinnable walls. Three very distinctive learning designs were enacted in each of these classes. Class A involved continuous small team design work. Class B was divided into two parts: (1) group oral presentations in which each team, in turns, reported on their progress using the projector; and (2) team project meetings. Class C was also divided in two parts: (1) poster presentations, in which each team, in turn, presented their design prototypes pinned to the walls and close to their table (2 h); and (2) team project meetings (1 h). Each team used the same table in each class. More details about and empirical results from the study in which this story unfolded have been reported in an expanded format elsewhere (Martinez-Maldonado, 2019).

Data and Analytics The *x-y* positions of the teacher were automatically tracked using the Pozyx.io UWB sensor system at 2 Hz. The teacher wore a sensor by

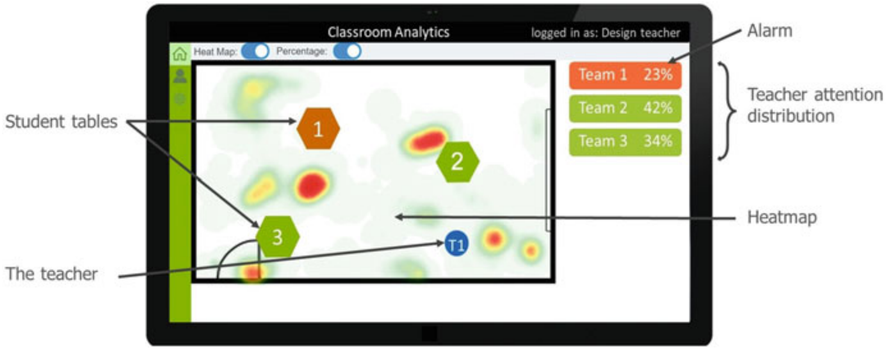

Fig. 1 Dashboard showing live the teacher's position (blue circle) in a (8×10 m) classroom and student tables (hexagons). Teacher-student attention time shown at the right (the least attended team is highlighted in orange

attaching it to her belt and additional sensors were located above each table, inside a casing, to automatically calculate the distance between the teacher and each team of students. Positioning data was presented to the teacher in two ways. A short debrief was conducted after classes in which the teacher was asked to reflect and comment on her spatial behaviours based on the visual representations of her data printed on paper. Additionally, a teacher's dashboard was made available during the classes through a personal computer located at the teacher's table (see Fig. 1). The sensors on each team table and the one worn by the teacher were represented as hexagons and a blue circle, respectively. A heatmap (using a gradient from green to red) of the teacher's position was presented in the background of the dashboard, where a red colour represented areas in the classroom where the teacher remained for a longer time. Proximity data was used to estimate the time the teacher attended specific groups working at the tables (measured as whether the teacher was within a range of 2.5 m (m) from the table sensor, considering the dimension of each table was 2×2 m). The least attended tables that had not been attended in the last t minutes ($t = 20$ in our study) were highlighted in orange colour.

Data Story Figure 2 presents three heatmap visual representations of the teacher spatial behaviours during classes A, B and C, which were presented to the teacher after the classes. For Class A the teacher mainly remained at the centre of the classroom (see Fig. 2, left, point 1). This teacher explained that at the beginning of the class she was standing in the middle of the classroom giving instructions to all students. Based on the learning design followed in Class A, students were expected to work in teams without interacting with other teams. Thus, the teacher divided her time by visiting one team after the other. This is reflected by clusters of data points located in close proximity to each student table (see point 2).

In contrast, in Class B the teacher sat behind a table from the classroom which she set up as a desk, and listened to the student presentations from there during

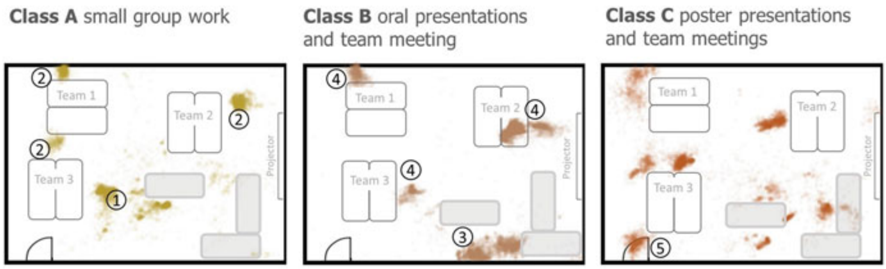

Fig. 2 Positioning data heatmaps from one teacher enacting the same learning design in the same learning space

the first half of the class (see Fig. 2, centre, point 3). Then, similar to class A, the teacher visited each team in the third hour of class B while students were having project meetings (see point 4).

Finally, for class C, the learning design promoted students and the teacher to move around the classroom spaces. During the first 2 h, all the students and the teacher would surround one table at a time, for students at that table to perform a poster presentation of their designs created before the class. For this reason, the teacher remained at different areas of the classroom that were not visited in the previous two classes (e.g., see the position close to the door in Fig. 2, right, point 5) to listen to the students' presentations at each table, mainly facing to the wall where students pinned their designed materials.

Implications for Teaching and Learning In sum, this data story illustrates how the spatial behaviours of the teacher can reflect the kinds of learning activities unfolding in the same physical learning space. This can have broader implications for learning spaces research. For example, although the three classes involved group work in different forms and to various extents, the role of the teacher and the ways she used the classroom space drastically changed according to the lesson plan. Scaling up the collection of teacher positioning data could enable researchers and designers of learning spaces to understand the meanings of the different areas of the classroom and understand how teachers appropriate the space in relation to tasks designed to support student activities and learning.

The most important lesson from this story is that feeding these positioning data back to the teacher in real-time (e.g., using the dashboard shown in Fig. 1) or for post-hoc analysis (e.g., like the paper-based representations shown to teachers in this study) can provoke reflections about how spatial behaviours with the purpose of supporting professional development. Moreover, it would be possible to identify the data signature of effective teaching practices that could be used for training novice teachers.

Data Story 2: Two Instructional Approaches in the Same Classroom

Educational Context The second story illustrates how positioning data can provoke reflection on different spatial behaviours and instructional approaches from two teachers enacting the same learning design in the same learning space. This story unfolded in the context of the undergraduate unit: Integrative Nursing in Practice. The study focused on six 3-h simulation classes (1–6) for which the same learning design was repeated. Two nursing teachers (T1 and T2) individually taught three classes each (1–3 and 4–6, respectively). The team-based clinical simulation tasks in these classes were conducted in the same (13.5×7 m) learning space that mimics a hospital ward equipped with 5–6 beds with a patient manikin in each. In these classes, between 23 and 25 nursing students were organised in five teams of 4–5 to look after a simulated patient each in a hypothetical scenario, while the teacher either enacted the role of the doctor or simply observed the practice of the various teams of pre-service nurses. The aim of the simulation task in this story was to help nurses learn how to react when a patient is having an allergic reaction to a medication. More details about and empirical results from the study in which this story unfolded have been reported in an expanded format elsewhere (Martinez-Maldonado et al., 2020b).

Data and Analytics Similar to the previous story, the *x-y* positions of the teachers were automatically tracked using the UWB sensor system. In this case, also the positions of some students were tracked so the data capture was normalised to 1Hz. The sensor was put inside a belly-bag which was worn by the teacher and students during the class. A debrief was conducted after the classes in which teachers were asked to reflect and comment on their spatial behaviours and those of the students based on the visual representations of their positioning data printed on paper. This story focuses on the contrasting instructional behaviours of the teachers. These data was presented to teachers as heatmaps of activity on the floorplan of the simulation classroom.

Data Story Figure 3 presents four heatmap visual representations of the teacher spatial behaviours during classes taught by T1 (classes 1 and 2) and T2 (classes 3 and 4). These heatmaps illustrate two contrasting teaching strategies which they consistently followed for the three classes each taught. T1 stayed either at the teacher's desk (see Fig. 3, both heatmaps at the left, point A) or circulating very closely to patients' beds where students were mostly working (see point B). T1 described that her teaching approach focused on coming into close proximity to one team at a time to review their skills and answer questions. T2 followed a completely different spatial approach for his teaching. He moved a chair to the middle of the classroom (see Fig. 3, both heatmaps at the right, point C) and remained there while, sometimes, getting closer to the patient beds. Although T2 also moved around the patient beds, he was not as close to students compared to T1. T2 indicated that he prefers to position himself at a central space in the class (where he placed a chair) or between Beds 4 and 3 (see point D).

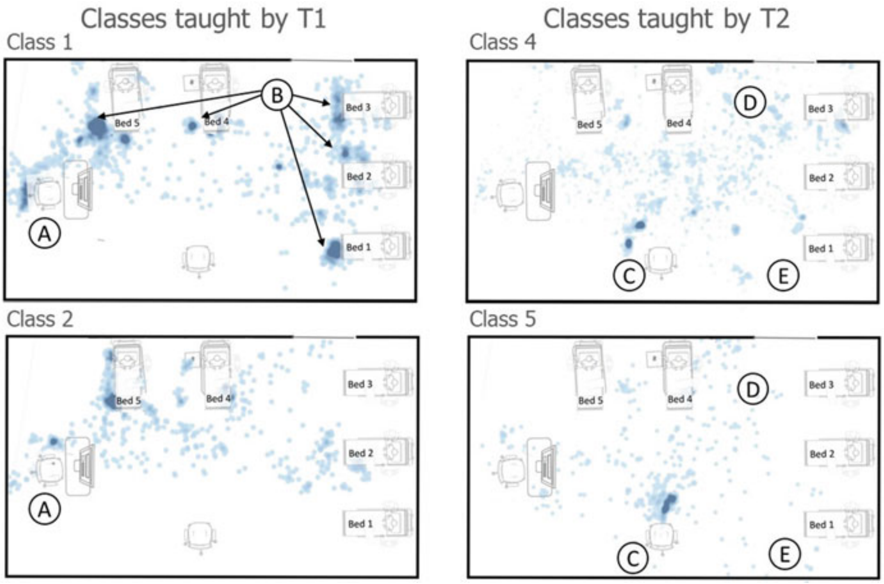

Fig. 3 Positioning data heatmaps from teachers conducting healthcare simulations in the same learning space. Classes taught by T1 (left) and T2 (right)

When the teachers examined each other's positioning heatmaps they could reflect on the pedagogical approaches each followed. T1 showed interest in the more supervisory approach followed by T2 and how T2 enacted the role of the doctor during the simulation. T1 also explained that she wondered if students adapted to the teaching approach of T2 and came to him to the central area of the classroom to ask for help.

Both teachers also identified a problematic feature of the architectural design of the classroom. Next to bed 1 there was a column that left very little space for the teacher to go closer to the students working in that location (see point E). This suggests the potential to investigate if there truly exist generalised issues with the indoor design of the built environment of the learning space or if some of these issues are actually just reflecting teacher preferences. Similar to the teacher who was featured in Data Story 1, T1 also emphasised the potential of using positioning data for training new teaching assistants.

Implications for Teaching and Learning Although the learning design is a critical factor that impacts the kind of observable spatial patterns that can emerge from the teachers' positioning data (as illustrated by Data Story 1), differences in teaching approaches can also break such 'expected' patterns. This emphasises the potential role of positioning data for assessing if the physical learning spaces are being used as intended and for identifying if the space is (at least temporarily) modified to fit the needs of a particular learning design or pedagogical approach. This is evidence that researchers and designers interested on the co-configuration of the learning space rarely have available.

Data Story 3: Tracking Student Spatial Behaviours at School

Educational Context The final data story shifted the focus from teachers' spatial behaviours to identify potential socially isolated students in physical learning spaces. This story involved 98 Year-6 students and six teachers (four full-time teachers, one aide, and one part-time teacher) in a primary school. The school building was designed as an open area with movable furniture that can be rearranged to adapt different types of pedagogies (as shown in Fig. 4). This wall-less area was divided into different learning spaces. Among many school subjects, students' social interactions in Reading sessions were particularly interesting as students were explicitly instructed to study in groups. Although students were assigned to four different spaces in *Reading* based on their prior attainment, they can still move freely around the learning spaces and interact with whom they desired.

Data and Analytics The physical positioning traces of students and teachers were captured over eight school weeks. A total of 23 Reading sessions were recorded and the duration of these sessions were between half to one hour. Both teachers and students were assigned with a Quuppa QT1-1 positioning tag (worn as a wristband) that transmits their x-y coordinates. Teachers kept a register of the tags and distributed them to the students when a school day would begin and collected them back at the end of the school day. These physical positioning data were captured by 14 Quuppa Q17 locators that were installed around the learning spaces (see Fig. 4). The locators captured positioning traces at 5Hz, and with an accuracy of 10 cm.

To identify potential socially isolated students, students' social interactions were modelled from their physical positioning traces. Meaningful social interactions were identified if two individuals were collocated within 1-m proximity for more than 10 s. For each Reading session, social network analysis was applied to extract the weighted degree centrality of each student, which was the total amount of time a student had interacted with others. K-mean clustering analysis was performed to group students based on the patterns of change in their weighted degree centrality. The 23 reading sessions that happened during the 8 weeks were segmented into four quadrants (Q1–Q4), each containing six/five consecutive sessions over a fortnight. Students' average weighted degree centrality was calculated for each quadrant, resulting in four features for the clustering analysis. Finally, in-depth analysis was performed to pinpoint critical times and potential reasons for students' decline in social interaction.

Data Story Four clusters of students were identified based on the changes in their social interactions over time (see Fig. 5). The social interaction of students in Cluster 1 remained constant throughout our study, whereas, students in Cluster 2 and 3 demonstrated increasing patterns in their social interaction with different initial values. Students in Cluster 4 were particularly interesting as they were the only students whose social interaction significantly decreased over time. This decline is potentially associated with the changes in the composition of their social ties with

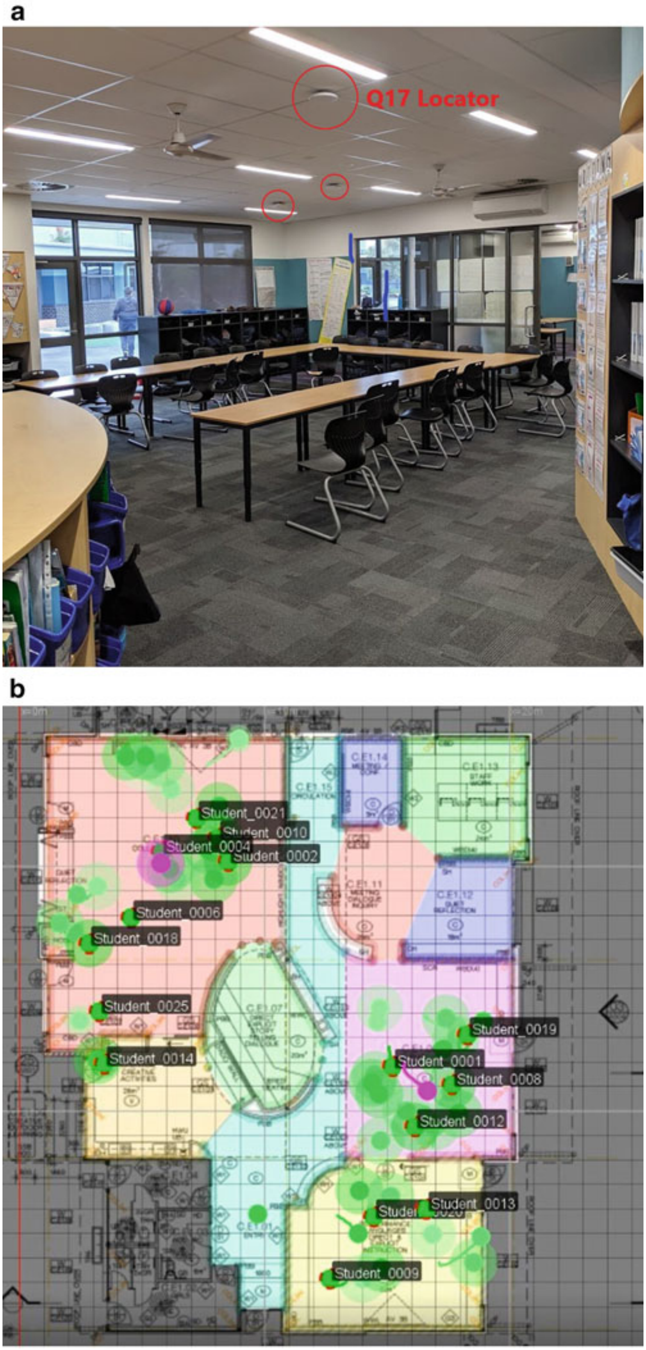

Fig. 4 A part of the learning spaces in the school building with the Quuppa Q17 locators installed on the ceiling (left). The learning spaces and illustration of the tracking system where the green/purple dots represent students/teachers, and the green/purple lines represent student/teacher movement (right)

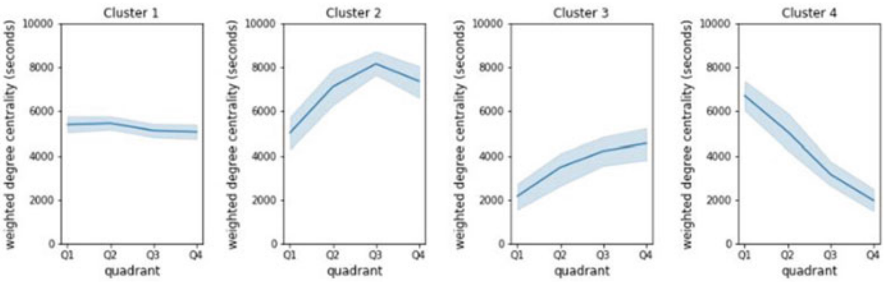

Fig. 5 Four clusters of students' temporality of social interactions in reading sessions (top)

other students. This observation directed the investigation towards the dynamics in students' social ties, especially for the students in Cluster 4.

Of the students in Cluster 4, the case of Student 98 is presented here to illustrate a suspicious case of a student becoming socially isolated. This student fully attended the Reading sessions but had the lowest average social interaction. Initially, Student 1998s social interaction was around the class average but suddenly dropped on the 14th of August 2019 (see the left of Fig. 6). Afterwards, the student's social interaction remained considerably lower than the class average. In-depth analysis of the changes in Student 1998s social ties revealed a substantial reduction from six to two ties when the sudden drop happened. In particular, the student had the strongest tie with Student 86 before the decline but this social tie cessation to exist afterwards. Whereas, a novel strong tie was formed with Student 49, whom Student 98 had never interacted with before (see the right of Fig. 6). These insights might signal that potential social conflict may have occurred between Student 98 and Student 86, which may have resulted in a ceased friendship, and thus, the decline in her social interaction as Student 98 attempted to form new social ties. If this low level of social interaction prolonged in Student 98, it would be necessary for teachers to investigate and identify ways to support this student.

Implications for Teaching and Learning This data story illustrates the potential of physical positioning traces in helping teachers to identifying socially isolated students. The non-intrusive and automatic features of positioning tracking can allow teachers or support staff to monitor in students who may become socially isolated and reflect on ways to support them. Although teachers can potentially notice if certain students may become isolated, it would be very challenging to observe behaviours of individual students longitudinally. The positioning technology can also enable teachers to monitor the social dynamics of students in many complex educational situations. For example, the social integration of a new student who joins a classroom after all other students already have become familiar with each other, and students' social well-being after school transitions. These scenarios would be difficult for teachers to comprehend with traditional survey and observation

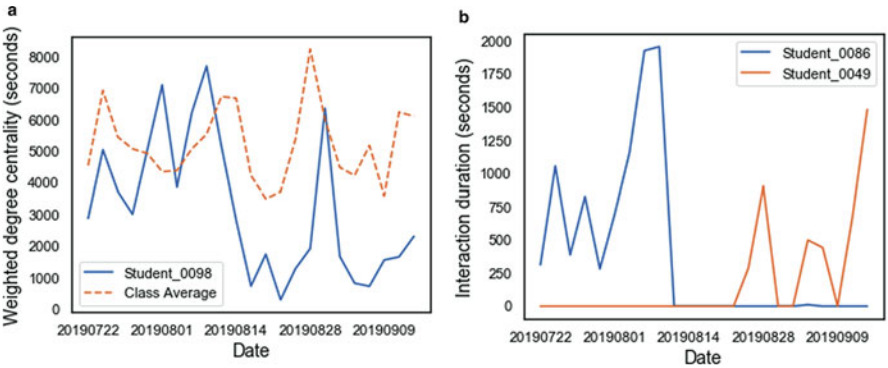

Fig. 6 Changes in the social interactions of Student 98 and the class average in reading sessions over the 8 weeks (left). Changes in the amount of time (y-axis; seconds) Student 98 interacted with Student 86 (blue line) and Student 49 (orange line) over the 8 weeks (right)

methods. Whereas, the utilisation of insights from physical positioning traces would augment their manual observation and equip them with the tools to deal with the increased complexity in the learning spaces.

Discussion

The three data stories presented above illustrated potential emerging contributions of multimodal classroom analytics to enable new ways to study the teaching and learning processes that unfold in physical learning spaces. There are various under-explored opportunities that can be enabled by indoor-positioning technologies. In this section, we discuss the potential benefits, challenges and caveats of using these sensing technologies in hybrid learning spaces.

Capturing Physical Aspects of Hybrid Learning Activity Moving beyond the analysis of data logged by personal computers (i.e., click-streams and keystrokes), using emerging technologies to sense other aspects of learning activity can potentially contribute to generating a deeper understanding of the *materiality* of learning (Sørensen, 2009). That is, the physical aspects of 'traditional' intellectual tasks intended to occur in physical learning spaces (Goodyear & Carvalho, 2014). The use of multimodal learning analytics and sensing technologies together can provide with new tool to understand how hybrid learning occurs in-situ. For example, it would be possible to generate evidence about how people use multiple physical and digital resources and devices in a physical space; provide real-time or delayed advise to teachers, space designers and eventually students, via dashboards or other computational tools; support smoother hybrid interactions in the physical space, at the individual, small group and classroom levels.

To realise the above, there still is substantial innovation work to be done. Yet, this chapter emphasises the current opportunity of extracting and analysing data from the physical learning space to generate a deeper understanding of *face-to-face* teaching and learning practices. This aspect of hybridity (i.e., making traces of activity unfolding in the physical world digitally available), can potentially serve to inform pedagogical practice, space design, and design for learning. For instance, Riquelme et al. (2020) and Saquib et al. (2018) used positioning sensors in learning spaces (namely a library and a classroom, respectively) to understand how learners interact face-to-face with each other while using a combination of digital and material learning tools (hybrid learning activities). These authors inspected how spatial behaviours can also provide cues about interaction among students and teachers during learning tasks that have been designed to focus on cognitive and social aspects of collaborative learning. Evidently, less conventional learning tasks that explicitly require the development of motor skills and spatial abilities, such as simulation based learning in healthcare (Echeverria et al., 2018) and fire emergency response (Wake et al., 2018), can directly benefit from analytics that automatically detect salient spatial behaviours for the purpose of reflection and improvement.

Multimodal Evidence for Advancing Spatial Pedagogy As illustrated in the first two stories, another potential area of application of the classroom analytics is to support teacher training, professional development and pedagogical practice. In their work on spatial pedagogy, Lim et al. (2012) identified the temporal meanings that certain areas of the learning space can take according to the intended learning design and the particular instructional activities occurring in such spaces (e.g., providing direct instruction to all students in a class, talking with some students, using gestures to explain abstract concepts and using classroom resources such as the whiteboard or digital presentation tools). Since activity happening in hybrid learning spaces is, by definition, complex, ill-structured and unpredictable (Cook et al., 2020), its analysis requires embracing the complexity of the multimodal interaction among people and physical/digital resources available in the environment. In our empirical work (Martinez-Maldonado et al., 2020c), while teachers showed appreciation of the potential of capturing traces of spatial behaviours to support their teaching practice, they also mentioned that more sources of evidence were needed to completely understand what was happening in the areas where they were physically positioned. Was the teacher talking to students or just observing? Was the teacher speaking loud to the whole class or to a couple of students who came to ask a question? Was it a class just after an exam so students were coming to the teacher to ask questions about their exam results? Not only does this call for a multimodal stance in which more data can be captured (e.g., audio and gestures) to give meaning to the positioning data, but also for the need of contextual information about the class to aid interpretation (e.g., did it happen at the beginning of the day or after/before a critical deadline?).

Space Design Assessment and Co-configuration Goodyear (2020) explained that creators of new spaces for hybrid learning are innovating and going beyond current design models. Other potential uses of the positioning data and analytics can thus include: supporting the assessment of these emerging space designs; providing evidence about how educators and students use and co-configure the hybrid learning spaces; and, eventually, playing a role in the creation of new design models for hybrid learning. This potential was illustrated in the second story. One of the teachers explained that there were limitations in the current classroom configuration due to two factors: there was a column obstructing the access to students working around one of the hospital beds, and the beds were too close so there was no room for the teacher to come close to those students from those sides. Regarding the first issue, positioning data could help understand how teachers and students actually use the space and resources of the classroom in relation to how they were envisaged to be used. In Data Story 2, although it would be really hard to change a structural column of the building to enable easy access to one part of the classroom, this information could still be useful for the interior designer or the architect of the learning space to asses the current design *in-use* and optimise the designs of future learning spaces. Designers of learning spaces rarely receive feedback on how the spaces they built are actually used in practice. Regarding the second issue, Goodyear (2020) suggests that learning space design is complex, and its consequences are often unpredictable, partly because teachers and students play an active role in appropriating and adapting the tools and spaces that have been designed for them. This way, positioning data could play a role in facilitating reflection on how the space can better support current practices. For example, if data from various classroom sessions confirm that the space obstructs the easy access of the teacher and puts in disadvantage to some students sitting in certain locations, the space could be re-configured permanently to minimise the issue.

Giving Meaning to Sensor Data The learning analytics community has mostly focused on the analysis of data logged by personal computers, often in the form of clicks-streams and keystrokes. However, even though 'clicks' are commonly associated to some discrete action (e.g., clicking on a button or dragging an icon), the community still faces the challenge of how to meaningfully model such clicks to higher-order educational constructs (Buckingham Shum & Crick, 2016). For the case of sensor data, it can be even more challenging to give meaning to the captured data which can be associated to unintentional actions or behaviours unrelated to the learning task. This is particularly challenging for positioning data captured from hybrid learning spaces since the whole learning space can be considered as the *interface* (Dillenbourg et al., 2011). The wide range of digital resources used by teachers and students can attribute different meanings to the same physical space. For example, in Data Story 1, the presence of the teacher in certain areas of the classroom had a strong meaning according to the learning design. Such meanings can change from class to class, during the same class or from one teacher to another (as illustrated in Data Story 2). Moreover, the presence of digital technology (e.g., teacher's computer or equipment used by students) can strongly shape the kinds of interaction that may occur. It can therefore be difficult to give meaning to positioning data and, without enough contextual information, there is a clear risk of misinterpretation. This has been highlighted by teachers who inspected their own data in various scenarios and who were concerned of potential biased interpretations of their data if shown to other people without contextual information (Martinez-Maldonado et al., 2020b).

Human-Centred Design of Interfaces The three stories showcased how positioning data can be useful to provoke reflection. But much more work still is needed to design user interfaces for classroom analytics that can be used by teachers, designers, educational decision makers or students. For example, the third story presented the analysis of a student that may have potentially been isolated in the school. Timely communicating this insight to teachers could have contributed to the formulation of strategies to support this student if the student was indeed facing social challenges. In some cases, students can also benefit from curated representations of their own positioning data. For example, in work conducted in parallel to Data Story 2, sensors were worn by nursing students for them to later reflect on their positioning and teamwork strategies (Fernandez Nieto et al., 2021). These positioning traces hold promise in supporting students and educators to reflect on potential errors made and in finding ways to optimise the use of space in emergency scenarios. Future work can focus on finding other ways in which students can benefit from positioning analytics in more regular learning situations. Yet, a critical question remains: how can interfaces for classroom analytics be designed with integrity?

Particular Ethical Considerations Potential ethical issues can emerge if the positioning or similar positioning data is simply shared with others without a clear purpose or contextual information. These can include misinterpreting the data, making unjustified judgements about performance or using the data for punitive purposes. To create effective interfaces using classroom data, we propose to apply human-centred design approaches to give an active voice to teachers, learners, and other educational stakeholders in shaping the design of interfaces they will end up using. This is work that the authors of this chapter are currently contributing to by conducting data-driven interviews with various stakeholders to understand their actual needs and preferences regarding how their data can be used and shared for the purpose of helping others (Martinez-Maldonado et al., 2020a,b,c). Moreover, future work in this area should consider the analysis of the trade-offs in using wearable and video-based technologies in the classroom, and the particular ethical issues that can emerge in tracking more than clicks and keystrokes (i.e., student actions that may not be related to the learning task at hand).

Concluding Remarks

This chapter has presented three data stories that illustrate potential educational uses of classroom analytics, with a particular focus on spatial behaviours of teachers and learners in physical learning spaces. Indoor-positioning technologies are rapidly evolving, enabling novel ways to study how learning activity actually unfolds in learning spaces. We discussed potential ways in which classroom analytics can complement current methodologies, based on direct observations and ethnographic analysis, in learning spaces research. But we also illustrated how classroom analytics can enable to contribute to the automated capture of evidence that can provoke reflection on spatial behaviours according to the learning design (Data Story 1), productively compare the instructional approaches of different teachers (Data Story 2), or to detect students who may be facing social challenges in school and that may require closer attention (Data Story 3).

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Part IV
Space Design

Co-creating Futures Through Virtual '*BAs*'

Hank Kune and Jenny Quillien

The great tragedy of the 'to do list' is that it was written by the person you were yesterday. (David Whyte)

Force Majeure

No need here to belabor Covid-19, our unanticipated present, our unclear next steps, or our difficult-to-imagine future. Nor do we need to dwell on the mad rush to move everything – learning, teaching, collaborating, solution-seeking, deciding, briefing, coaching, counseling, researching, sharing – on-line. Experimenting as we go, fumbling with tools not yet mastered, spending endless hours at the screen, we often finish our day feeling drained. But here we are – so, let us, forthrightly, devise effective and convivial virtual environments for learning and innovating together.

Our Chosen Pursuit: Focused Solutioning in Small Groups

In this essay, we eschew any number of topics relevant to the general theme of hybrid learning spaces and drill down into the specific needs of small groups co-creating

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solutions to common challenges. The reader will be aware that we deal with the available video-conferencing tools, but not in context of either video-conferencing or mandatory learning. Our focus is collaborative solutioning, involving participants who take part on their own initiative. Participants need to develop a collective sense of each other and underlying issues, share information comfortably, request and offer clarification, and openly admit to not-knowing. In many cases, the willingness to speak frankly requires trust – which does not come automatically in physical spaces – so how can it be fostered online? Although we are intrigued with the necessity of dealing with multiple small groups working in parallel in larger-scale interventions, we do not attempt to address that level of complexity in this short essay.[1]

A Road Map for the Reader

Our query is pragmatic: how do we leverage distributed collective intelligence online, what are the elements which make encounters effective, and what are our technological requirements for the future? Throughout the essay, we do our utmost to maintain a sanguine but respectful eye on the wise legacy of Marshall McLuhan: *the medium is the message* (McLuhan 1964). Digital tools enhance and extend some normal human powers but hinder others. We need more clarity about these advantages and handicaps since such distinctions point to design constraints and priorities for new software and platforms. To share our explorations:

First, as a heuristic, we propose *BA*, a Japanese concept for developing learning environments as shared contexts for knowledge-creation. An unfamiliar idea forces us to question our assumptions: for example, that individuals are the basic building blocks of groups, or that we think of *space* as an emptiness that gets filled in, or *place* as a context or stage. *BA* throws us into an unfamiliar ontology of mutual dependence, impermanence, and non-separation.

Second, we complement the basic component, *BA*, with sibling concepts *MA*, *WA*, and *KATA*.

Third, as we consider *KATA* (creative routines), we find ourselves engaged in yet another query – more philosophical in nature. We turn to the work of poet David Whyte to further consider how to ground and animate encounters in a virtual *BA*.

[1] While there is some resonance with the field of CSCL (Computer Supported Collaborative Learning), after consulting recent research in this field we decided that it was not relevant enough to our topic to include a discussion of it in this essay.

Fourth, we entertain a few initial thoughts about *BA* as both a context for knowledge creation and also a context for co-ownership of knowledge: an online Commons.

Our conclusions are personal, idiosyncratic. We offer no hard science or rigorous experimentation. We conduct interviews, thought experiments, engage in desk research, reflect on our experiences, and then share with the readers what this journey has brought us.

The Japanese Concept of *BA*: A Different Perspective

Overview

Clumsy translations of *BA* into English include: space, place, energy field, gestalt, realm, scene of a crime, occasion, situation, table area in a card game where the cards are laid out, party, session, and indications of an if/then supposition.[2] Ideograms for *BA* convey "upward pushing energy" where the starting point is the whole (not the parts). For our purposes here, we define *BA* as an *evolving energy field of interactions which houses understanding, knowledge, wisdom, and relationships.*

A *BA* anchors human engagement in time and space but unlike Western concepts of space and place *BA* cannot be divorced from human beings: it is something human beings come together to create. The *BA* is where everyone shares a sense of purpose. A *BA* resides, to some extent in-between participants, however, a *BA* can also be ghostly, as when people active in an early phase leave, and are replaced by others – and yet early phases continue to inform later phases. Integral to *BA* will be its appropriateness, affective qualities, and comfort, and some of these qualities will be emergent from the energy of the location that is chosen.

The concept of *BA* dates back to Zen philosophy and Japanese martial arts, but our immediate springboard is the 1998 article by Ikujiro Nonaka and Noboru Konno. Their interest was then (as ours now) in learning and knowledge co-creation. More specifically, they were wrestling with explicit versus tacit knowledge and their mutual enrichment.

Very briefly, Nonaka and Konno look at two axes of tension and then consider a spiraling growth of a *BA* through four stages.

[2] Compiled from diverse sources. See for example http://www.romajidesu.com/dictionary/meaning-of-ba.

The axes: One axis contrasts formal learning (explanation, reading, research) with informal (practice, empathy). The other axis looks at the mutual reinforcement of explicit and tacit information, on one end, and on the other, the quality/robustness of the energy field itself.[3]

The spiral of growth: First, the *Originating BA,* the initial energy field of early socialization, allows individuals to 'hang out' in the same context with their hunches, craft know-how, and wisdom – much of which is not easily explained. Storytelling conveys emotions, experiences, and personal models. Trust, appreciation, commitment, and a willingness to speak authentically come into existence. The individual is embraced by the group, transcending personal boundaries and perceptions – hence, non-separation and mutual dependence. Participants are synchronized. Tacit understandings become collective.

In the second stage, labeled the *Interacting BA*, the knowledge now embedded in the shared context can be distilled and communicated. Think of it, metaphorically, as salt being crystallized out of sea water.

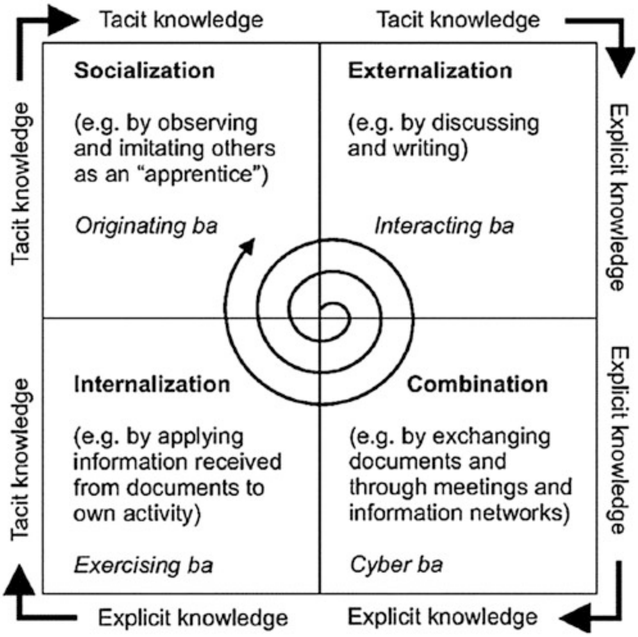
Cyber BA: A Prescient Concept from 1998

> *The third phase, the Cyber Ba, is a "place of interaction in a virtual world instead of real space and time. . . Here, the combining of new explicit knowledge with existing information and knowledge generates and systematizes explicit knowledge throughout the organization. Cartesian logic dominates. The combination of explicit knowledge is most efficiently supported in collaborative environments utilizing information technology. The use of online networks, groupware, documentations, and databases has been growing rapidly over the last decade, enhancing this conversion process."* (Nonaka & Konno, 1998).

A third phase, *Cyber BA*, combines and compiles information, often asynchronistically and outside the originating group. Freshly leveraged knowledge (concepts, rules, best-practices) becomes available to be integrated back into the *BA*.

In a fourth turn in the spiral, *Exercising BA,* explicit knowledge is internalized back into tacit understanding. Learning now comes through continuous self-refinement. The new tacit understanding is put to work in the outer world, forcefully animating strategy and innovation.

[3] When attempting to translate this model to the virtual world, we should consider that the movement from tacit understanding to information living in stories, to explicit documentation to information which can be managed and manipulated by computer, and then re-assimilated into tacit understanding, is extraordinarily difficult and, as yet, not entirely mastered. However, it is the essence of this second axis and the spiraling complexity of knowledge within the growing *BA*.



The model (known as SECI: Socialization, Externalization, Combination, Internalization) is, of course, a simplification. In reality, the stages overlap. (Diagram from Samim.io)

Examples of BA in the Physical World

An Aikido dojo. The dojo contains what you need, ready to hand, but nothing extraneous enters the space. Rituals of opening and closure frame the *BA*-in-action and reinforce shared values. The student experience is structured: from rolling out the mats, to entering the space, to meditation, to practice. In guiding the apprenticeship, instructors work with a dual vision: one eye to the group and collective requirements, the other eye on individuals and their different needs. Learning proceeds with each exercise adapted in response to the previous one. At all times, the students remain spatially aware of themselves, their immediate partner, and others on the mats. Learning (along the two axes described by Nonaka and Konno) involves a play between *tacit* (assimilation of why and how moves are made) and *explicit* (explanation, demonstration, and inquiry). Before and after the formal lesson, members socialize (a thickening of the *BA*).

Partial aspects of *BA* closer to Western habits include executive retreats where formal sessions are enriched by bar talk. The physical layout of a neighborhood pub – fireplace, cozy chairs, recognizable habits of regular customers – cues us into comfortable routines. Experienced workshop leaders intuitively know what it means to hold a space for a group, sometimes dynamically drawing a boundary, sometimes keeping a more tolerant eye on things; themselves maintaining the dual vision of group and individuals.

Design Constraints for a Virtual BA

Because we are exploring how to best provide virtual arenas for solution-seeking in small groups, we now ask: What design priorities does our journey, so far, suggest?

Situational Awareness This is an abiding concern. As the name implies, Situational Awareness considers how an environment enables us to be aware of what is going on. In traditional workplaces, small groups problem-solve within the full context and complexity of suppliers, clients, colleagues, boss, deadlines, etc. In comfortable small group discussions, anyone can focus on the person speaking and, at the same time, also remain aware of the group as a whole. A good moderator will know, at all times, who is silent but assenting, who silent but dissenting, and who needs to be invited to speak up. This is to be human: we have heads that swivel, eyes that scan, the most subtle cueing of muscle tension tells us worlds about how our neighbor is feeling, our cocktail-party-auditory-filtering-system allows us to pick up and track important conversations among competing but insignificant ones.

During *Originating BA* trust and mutual understanding take root. Participants need to sense and take stock of each other: see faces, read body language, assess mood, hear voice tones and modulations, observe interactions. As the *BA* continues to integrate new understandings, the participants must continue to see and hear each other well.

Virtual platforms today, such as Zoom, MS Teams, Google Meet, or Skype, do not offer adequate Situational Awareness with the key affordance of simultaneous speaker and group view. Leaving aside more extravagant technologies such as CISCO Webex Boards, inhabitable robots, or adaptations of Second Life, what improvements can we make for better Situational Awareness using the free or affordable platforms available now?

For easy starters, we must realize that speaking credibly to a camera is not the same as chatting live. It means placing ourselves in front of a window or lamp so that our faces are gently illuminated without the harsh shadows produced by overhead lighting. On most desks, a laptop needs to be placed on a few fat books so that the camera is eye-level rather than up-the-speaker-nostril-view. We have choice of backdrop: our living room with armchair, favorite photograph, or a computer-generated screen of a spaceship. Whatever our choice, we convey a message about ourselves and our desired presence. Perhaps learning to habitually work with two screens, with one screen for speaker view and the second for participant lineup would help. In all cases, a network of separated participants is only as good as the weakest node. A participant with a mike but no camera, or a poor-quality audio, or inadequate bandwidth weakens the whole.

Zoom Meeting

Extremely poor Situational Awareness. The serial line up of atomistic talking heads just doesn't cut muster. We should also consider the psychological effects of this 'gallery' view on some participants: everyone on stage at the same time, being stared at
Image: Shutterstock

Here is some sense of being in the same room with others. The costs are high. What is it worth to 'sort of' feel that you are in the same room with your colleague on the other side of the world?
Image: Wikipedia.com

What might we do with avatars and Second Life for co-solutioning? (For a YouTube illustration see early adapter Grady Booch on *Agile Dimensions interviews IBM Grady Booch*. But does this improve Situational Awareness? No, it seems there is less here than with a talking head. https://www.youtube.com/watch?v=HtPD77szFZk). Image from Wikipedia.com

Spare We need to judiciously decide what we absolutely require and do that extremely well, then forget the rest. We need spare but robust software and platforms – such as short and intuitively clear menus and links that work. For example, with guests for online meetings we want a flawless join function.

Calm Technology Much of the reported fatigue of working online stems from overload caused by excessive demands made on the same sensory channel: being required to listen to two things at once, read two things at once, or attend to pop-up messages, e-mail alerts, chat messages, which all use the same channels.

We should consider more Calm Technology which informs but does not demand focus (Weiser & Brown, 1996). To explain: Imagine you are driving. You hear the normal motor noises but pay them no mind – until a change in those noises suggests that something is amiss. Then you bring it front and center. We humans have evolved to handle both a continual scanning of peripheral information and emergencies. How can we design software and platforms that better exploit this ability? Light, for example, is informative and not does compete with listening or reading. Using light buttons to communicate a desire to intervene, or remaining time for a presentation, would be peripheral and less fatiguing than a chat box message.

Supportive Orchestrations A keen eye for possible adaptions from effective physical *BAs* will serve us well. Three ideas used at Future Centers[4] are immediately available: First, hosting.[5] A personal welcome and initial framing of activities.

[4] Future Centers are facilitated innovation-enabling workspaces allowing people to develop practical solutions to business, organizational or societal problems in co-located high tech/high touch environments (Dvir, 2008).

[5] Skandia Future Center in Sweden emphasized hosting for creating the right frame for creative activity, allowing people to explore different and provocative futures. Hosting enhanced harmony, openness, and trust, as well as intellectual challenge and an entrepreneurial spirit (Kune, 2008).

Second, framing[6] with special entry experiences – films, animation, music, visuals – to establish another world with other expectations.[7] Third, immersive images.[8] with predictable effect, such as mountaintops to stimulate broad vision or fireplaces for intimate conversation, are chosen by the moderator to support process stages (forming, storming, norming, performing) or group processes (socializing, divergence, convergence or decision-making).

A Family of Platforms with Search Functions A virtual *BA* (as it spirals between tacit and explicit information) will require spaces for synchronous group communication and also spaces for asynchronous tasks. There are efforts now to sew together possible platform cocktails – perhaps, say, Zoom, plus Slack, plus Google Docs, or Facebook, plus a dedicated wiki.[9] How we best manage recording and search functions remains a critical question since this is one area where digital tools can significantly enhance human powers.

Readily available today (and sorely underutilized) is the option of making any document, e-mail string, chat box, or Slack exchange, a ‘logical’ website. These websites can be searched in three standard ways: (a) find a chosen word, (b) double quotes to find a specific phrasing, (c) the google function of guessing what you might be interested in.[10] Google can also be used to index documents. A moderator or group can develop an ontology and metadata labels describing the kinds of things that will be discussed. This can also be done after the fact. Unfortunately, although the computer can greatly speed up finding needles in haystacks and organizing them, what it cannot do is think for us: it cannot identify what was important or innovative in a series of meetings.

Systemic Integration and Evaluation A virtual *BA* must function within a larger hybrid environment of tangible and intangible systems. A recent study by the Future Center Alliance of Japan (Kibi, 2020) concluded that inadequate innovation output was never due to lack of ideas, but to systems shortfalls where resources, people,

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[6] On entering the U.K.’s Royal Mail Innovation Lab a simulated ride in a lift gives a powerful message about entering a world where nothing would be the same. At the Shipyard in the Netherlands, an animation film about leaving your normal work and assumptions behind to enter a place for creative collaboration sets the frame for the hours that follow (Kune, 2008).

[7] Skandia Future Center used smell to frame the participant experience. The odor of tar greeted everyone entering the building, anchoring ‘navigation’ as a central concept in the sea-going journey of exploration they would undertake. Upstairs, the smell of freshly-baked cinnamon buns helped create a welcome-home comfort zone familiar to Swedish people (Edvinsson, 2002).

[8] LEF, a government future center in the Netherlands, bases its working method on insights from neuroscience and cognitive psychology. Visual images which have been tested in a fMRI and shown to have a predictable effect on how people act and interact in groups, can be projected on three or four walls of the workspace (Maturana Parraguez, 2018).

[9] Federated Wiki sites, which share pages circulating within a creative commons, may be a step in this direction. http://fed.wiki.org/view/federated-wiki. Accessed 11 October 2020.

[10] In an on-the-fly illustration of this, Richard Gabriel typed in ‘that US idiot’ and Google retrieved documents about Donald Trump.

culture, and incentives failed to dovetail. Design considerations for coordination, integration, and evaluation are still largely undeveloped.

Sibling Concepts of *BA: MA, WA, KATA*

BA does not stand alone. Three other concepts come into play: all interacting with the participants and the participants with them and with the *BA*.

MA

> *Thirty spokes share the wheel's hub;It is the center hole that makes it useful.Shape clay into a vessel;It is the space within that makes it useful.Cut doors and windows for a room;It is the holes which make it useful.* (Lao-tse, *Tao te Ching*, verse 11)

MA has to do with the enabling rhythms of spacing, timing, and lighting and how they affect the relationship or distance between individuals, between objects and between individuals and objects. The 'empty' spaces between objects is *MA,* and these spaces are as informative as the objects themselves. The silence separating musical notes is *MA*, transition spaces and times are *MA*, repetitions, punctuation, in-betweens are all *MA*. *MA* can be about taking things out – being 'spare.' Appreciating an emptiness, full of promise and possibility. In architecture it is an aesthetic of arrangement. In Aikido, *MA* refers to the appropriate distance between partners, requiring constant adjustments by each practitioner – forward, backward, sideways – for the relationship to work.

We need *MA* for reconciliation: highly important for co-solutioning. MA is the *free zone that allows dissimilar things to exist* (McGrath, 2018). This can be moments of quiet and awareness during which things settle and come together. It can be the appropriate alternating of explicit and tacit communication, of discovery and consolidation, of social and task. In online collaboration, with participants working from different countries and cultures, the thoughtful pause, talking less, and taking more time to digest what has already been said can be the most appropriate 'intervention.' This is the power of the space in-between.

Design Constraints for *MA*

MA can enable *BA* in physical, hybrid or virtual spaces, and we have annexed an example for each. Getting *MA* right isn't simple and we have annexed two stories: one success, one failure. Alas, for our central topic, we're in real trouble. Online tools for synchronous open-ended conversation are so utterly *MA* clunky that it becomes comedy. That sense of Alien Abduction as you, mid-sentence, mid-thought: *poof!* are evaporated from a break-out room and landed *poof!* into a plenary. That sad limp-wristed farewell wave at a screen as you *zap!* yourself into non-existence. Those the jerky non-sequiturs from a colleague who is desperately trying to both speak and acknowledge questions flashing at him from the chat box. That eye-rolling waste of time correcting microphones not on (or left on), working around links that don't link, and all that.[11]

WA

Most frequently translated as 'harmony' or 'peace', WA is the harmony born out of BA and MA. *WA* emphasizes the social and emotional, not the cognitive. *WA* refers to an awareness of interpersonal connections and a recognition that surrounding spaces sway and shape relationships (Lambe, 2019). In the eateries and clubs which Japanese frequent for after work socializing, ruffled feathers from the day get ironed out, colleagues re-synchronize, harmony is consolidated. At a superficial level, W*A* is about comfortable relationships. At a deeper level, *WA* is a collective subjectivity around a shared sense of purpose.

Design Constraints for WA

One critical function of the *Originating BA* is to establish *WA*. This brings us back to the requirements for Situational Awareness. It also points to a requirement for side time and space to ease a bit of tension or enjoy a quiet private word with a colleague.

In the immediate future we had best adapt an attitude of "everything helps" when it comes to building *WA* online.[12] Hosting will help. Posting photos and bios of group members will help. *MA* time allotted for *meet and greet* or smaller group breakout rooms will help. Organized email threads for pursuing conversations will help. *WA* greatly supports *BA*: it gives us the safety and positive regard we need to be genuine. It also relieves some of the pressure on technical requirements. The simple fact that we know and care about the people we see on the screen makes the deficiencies of the screen more bearable.

The speed and ease with which *WA* and *BA* get established can vary greatly. Slow if the start point is distance, ignorance, and chill. Fast if the participants are selected or self-selecting from a basis of shared interests and values.

[11] We do recognize that software developers have used platforms like Croquet SDK and Open Cobalt to create effective participatory virtual worlds for open-source collaborative decision-making, problem finding, and problem solving. See https://en.wikipedia.org/wiki/Croquet_Project and https://en.wikipedia.org/wiki/Open_Cobalt

[12] Most of the time, we choose face2face as better at promoting intimacy but the opposite can occasionally be true. Family therapist, José Giesen, reports that eliminating the institutional environment with its waiting room and clinical-ness can sometimes help. On Zoom, a client remains in the safety of home and distance.

KATA

KATA is sometimes translated as methodology, or process, or established patterns, or protocol, or the proper way to do things. Unlike protocols in our Western understanding, *KATA* implies an artful mastery of form, modifiable according to context and feedback. KATA has its roots in martial arts and is a wisdom for understanding the relationship between the body and movement and place as a pattern.[13] Nonaka refers to it as *creative routines* (Nonaka et al., 2008). In Aikido, *KATA* involves not just doing things in the right order but having so deeply assimilated the forms that understanding becomes unconscious fluid muscle memory. The Tea Ceremony master's movements are so internalized that he seems to be spontaneously making tea. *KATA* becomes the very wellspring from which appropriate, authentic, and beautiful gestures can be made.[14] *KATA* provides the structure, the skeleton which holds everything together.

Design Constraints for *KATA*

It is worth confessing to the reader that in earlier drafts, we had the usual problem-solving material in this section. It didn't fit. Our four Japanese terms called for a further search which led us to the work of David Whyte (2019). We propose the following as a nascent design guideline for *KATA*. These directives, germane to the *Originating BA* and the philosophy of mutual dependence and impermanence, remain useful throughout the entire process of co-solutioning – all the way through to prototyping.

- INVITATION. All conversations begin with a mindful invitation. The dialogue that ensues is between people who respond to that invitation.
- PERSEVERE. Things take time to ripen. Stay with an effort to harvest efforts.
- HEALTHY BA. Maintain the health of the *BA* – the container, the energy field, and its clarity of intentions. Harvest the presence.
- STOP DEAD-END CONVERSATIONS. Stop repetitive discussions which are not paving the way to a bigger future. People *do* know when conversations reiterating existing standpoints lead nowhere. These conversations are unlikely to get at significant underlying issues or unlock new potentialities.
- COMFORTABLY UNKNOWN. Develop a relationship with silence and the unknown (which requires good *MA*). Normally we are rewarded for having an answer. Satisficing (Simon, 1947) is our natural habit. We are quick to label

[13] Personal communication from Noboru Konno.

[14] The authors recognize the difference between *KATA*, protocol, and etiquette. *KATA* describes steps to follow in order to achieve mastery. Protocol is a system of rules that explain correct conduct and procedures to be followed in formal situations. Etiquette concerns the polite interpersonal behavior for performing them in a gracious and acceptable way.

things rather than leaving them in limbo for a while. Staying with the unknown requires *WA* robustness.

- TALK AT THE BOUNDARY. Place the conversation in the *only* place where things can actually happen. To explain: As you stand in the world with your expectations, the world fails to do what you would like it to do. Equally, the world has expectations of you and you fail to respond as anticipated. It is here, and only here, at the boundary of expected and actual, at the boundary of *you* and *not you,* that real conversations are possible. David Whyte calls this *the conversational nature of reality*. We tend to abstract ourselves from this boundary. Like turtles playing it ultra-safe, we prefer to pull in our heads, resort to pat scripts, sidestep genuine emotional pleas. The broader possible future that might happen, can only happen if we stay on the boundary – with our turtle heads out and on the line. The purpose of a *BA* is to house conversations at this boundary.
- NOT ACTING ALONE. Help members of the *BA* get past acting out the drama as if they were alone. No self or organization will survive a real conversation and keep its original identity. (Again, that's integral to *BA*.) The more we drop down into a deeper level of ourselves, the farther out on the horizon we can go – otherwise we keep the future reined in.
- LANGUAGE FOR EXPLORATION. Develop a language, vocabulary, and imagery large enough for the uncharted territory being explored.
- COURAGEOUS CONVERSATIONS. The conversations nobody wants but won't go away require courage. It makes for vulnerability. Authenticity requires being visible which is to be touchable and to be touchable means you can be hurt. We all know a myriad of ways of looking like we are showing up but not showing up. Everywhere we see people in positions of responsibility who – in calculating that they have no real skin in the game –block innovation that needs to come through their hands. For learners and innovators, moving the game forward means risk and trusting the relational space. A solid *WA* is pivotal to courageous conversations.
- BEAUTIFUL QUESTIONS. Develop a culture of what David Whyte calls *Beautiful Questions* which provoke, disturb, or suggest a different way of seeing. For example, we cannot be coerced into wholeheartedness or authenticity but sometimes a Beautiful Question invites us to belong to a bigger story and brings us forward. A Beautiful Question will take us both into and out of ourselves at the same time. For example: What is the generous thing for me to do in this situation? How can I come to this situation from a good place within myself? What does this moment want from me? A Beautiful Question will enlarge the context of the discussion. Beautiful Questions shape the *BA*, *MA, WA* and the way *KATA* is played out.

BA as Commons

A Kernel of Deep Coherence

The knowledge-capitalism of professional imperialism subjugates people more imperceptibly than and as effectively as international finance or weaponry. (Ivan Illich)

The *BA* – as we have seen – is an evolving/thickening whole. Participants find each other (*WA*), rhythms and differences are respected (*MA*), outcomes are co-produced (*BA*). It is all about co-creating; and perhaps also co-owning the fruits of the process. In other words, although co-ownership of intellectual capital is an obviously thorny realm (far beyond the scope of this essay), we do see the *BA* as a Commons.

Design Constraints for a BA as Commons

KATA Intellectual property rights (IPR) are notoriously problematic. We would need *KATA*. Without agreed processes, participants can be tempted to withhold ideas in the hope of leveraging them for a later competitive advantage. Even when the express intention is to address societal challenges and the public good, withholding can lead to inadequate proposals, lack of breakthrough, and intangible variations on the 'Tragedy of the Commons.'

We do have sources of inspiration. From Elinor Ostrom's 1990 study of traditional commons (finite resources such as fishing or grazing grounds), we know the importance of clear definition of resources and boundaries, collective choice and decision-making, fast and fair conflict resolution with graduated sanctions, and the value of local autonomy and polycentric governance. From the work of the Creative Commons movement (Lessig, 1999) we recognize the desire for freely available resources, use and remix with clear attribution of sources, technology that makes openly licensed material easier to discover and use. All of which enables sharing knowledge and creativity (Lessig, 2001).

Technology We would need tooling beyond anything that we have talked about so far. For inspiration we turn to Ivan Illich (1973) on 'tools for conviviality'. He takes 'convivial' both in the everyday sense of friendly, enjoyable, lively, and in the sense of tools that give us a chance to enrich our environments with our own efforts and visions. These tools (like the telephone or e-mail) would not involve obligations or certifications but remain under our control. We could use these tools easily and as often or as seldom as we want – and our use would not restrain others from using the tool. Since we would be accomplishing our objectives in our own way, we would be expressing meaning through action. Such tools, proposes Illich, would enhance a "*graceful playfulness*" in our personal relations.

Thought Experiment and General Observations

The authors did several thought experiments (Annex 2), imagining the stages of the co-solutioning process within a digital *BA,* the effects of existing technology, and the promise of possible next-generation technologies. From that exercise we see more clearly just how exacting – and deeply different – on-line technologies really are.

In Our Different Roles

First as participants. In the kinds of conversations necessary for a *BA* to succeed, we progress through stages of 'talking nice and talking tough' to reach a reflective dialogue. However, to move further – to reach a 'generative dialogue' resulting in co-creation – we must be fully present (Kahane, 2007; Scharmer, 2008). To be genuinely and humanly present in a virtual environment requires more than mastery of tools. It is a fundamentally different endeavor, neither simple nor trivial.[15]

Second, as moderators and designers, we must assume greater responsibility for integrity and structure. In physical environments, we often opt for as much participant self-organization as possible and facilitation with a very light hand. However, when we work online, with the handicaps of weaker Situational Awareness and the absence of fluidity, normal feedback, and subtle cueing, our old approaches fail us. Different skills must come to the fore. Meta-interventions – hosting, holding the space, structuring reflective space, assuring documentation – must keep the process on track. Micro-interventions, mostly in the form of *KATA* yet to be developed, are necessary for turn-taking, techniques such as fish bowl, disruptive use of the chat function, dovetailing efforts, summarizing.

Co-creating futures means imagining complexly and facilitating through a mindful balance of consistency and surprise. A powerful metaphor or image is more powerful when woven throughout the process, but also, the process benefits from the unexpected twist, play, joke, or different perspective.

Prototyping within virtual *BAs* needs to be completely thought through or we fall into the trap of designing what the designers think users need rather than finding

[15] The popularity of video games, and especially massively multiplayer online games**,** show that people do have the ability to transfer their sense of self into an avatar on the screen, collaborating with other players physically far away to achieve mutual goals. Unfortunately, this is rarely achieved outside of a gaming setting. The best games do have viable stepping-stones for addressing issues of *BA*, *WA*, and *MA*, situational awareness and calm technologies. *KATA* also plays a big role in gaming, but not as part of the game design; it emerges over time, and is assimilated by new players in a manner akin to enculturation. [*Adapted from comments by David Lomas and Dave West*].

out what is actually called for.[16] And, as facilitators, we are not yet clear on what convivial spaces and tools actually entail.

Third, as community leaders, we must take on increased responsibility for infrastructure, be it technical, such as bandwidth; or cultural, such as codes of conduct for intellectual property and privacy.[17]

Purpose and the Nature of Emergence

Each *BA* emerges around a specific shared purpose. Purpose must, therefore, be the motor which drives the spirit, style, and uniqueness of each *BA*. For example, only purpose can determine what is a Beautiful Question. We really haven't looked at how purpose animates a *BA*. That would require several in-depth case studies – say, one *BA* concerned with conflict resolution, one with family therapy, and another for addressing climate change issues.

> *Wanderer, your footsteps are the road, and nothing more; wanderer, there is no road, the road is made by walking. By walking one makes the road, and upon glancing behind one sees the path that never will be trod again.* (Antonio Machado, *Campos de Castilla)*

That said, as purpose, understanding and solutions emerge, it is also now more evident to us that this emergence truly happens only as a 'conversation' at the boundary. As we move towards a wise and grounded future we will begin with one foot in the mire of *now* and one eye on the horizon. It is here that we will discover our potential selves, the potential other, and the potential future. We cannot, à la Peter Pan, blithely escape through a window into a virtual future, leaving the present behind. And the path is made, of course, by walking.

Technology

As for technology, two fundamental design constraints will require game changing innovations as yet to be invented. First, as already identified, Situational Awareness. Second, the subtle cueing and fluidity necessary for self-organization, which we saw

[16] Here too, we find the tail wagging the dog. All too often, online instructors and the conveners of online meetings try to use the platform tools by force-fitting the information into an existing platform and allowing the platform to dictate how the output could be 'interactive' (adapted from comments by Lyn deMartin and David Lomas).

[17] Issues of diversity are important here. Whether one is examining diversity between genders or among generations, exploring racial or regional differences, issues of interpreting verbal and non-verbal messages through the multiple lenses of languages, histories, religions, values, languages, image, ideals, and accepted ways of behaving, dealing with diversity in the virtual *BA* will be more complicated than in the physical world (adapted from comments by Lyn deMartin).

clearly only with the thought experiment. Self-organization in the co-solutioning phases is always the foundation for ownership of results and implementation later, hence its importance.

In the short term, we can focus on what we can already do more effectively now: compose more interesting small groups from all walks of life and geographies; and really use the record and search functions to analyze work-in-progress for overlooked key ideas, *ah-ha* moments, turning points in group awareness, group-think, and other relevant issues that are more easily identified with these technologies.

We can also communicate to more technologically savvy colleagues what we see as improvements that may not be terribly difficult. Would it not be simple enough to compile libraries of music clips and images to support group processes (forming, storming, norming), or group functions (diverging, converging, deciding), or activity protocols (listen & reflect, suspend judgement, seek clarification, signal your assigned role (e.g. De Bono's *Six Thinking Hats* (1985)). We could have images of metaphorical avatars, for example animals: a rabbit timid but fast, an elephant slow but powerful, a weasel sneaky but clever. Could our colleagues build us a system of algorithms for collecting, clustering, labelling (and visualizing) ideas that we could organize according to group-generated meta-labels?

Perhaps less simple but still feasible would be processes to quickly transcribe and package recorded sessions along with any accompanying visuals or documentation so that a group could proceed to a next phase with fast turnaround. This would greatly support activities such as SWOT analysis or question framing. Could our colleagues build us an environment for taking advantage of the non-linear nature of virtual *BA*, in which participants from all ages and all walks of life could participate easily? In other words, make the technology and the instructions for participants as intuitive as possible. And after that: better technical support for prototyping, systems integration and evaluation (although we assume that requires a longer time horizon).

According to conversations with computer scientist Richard Gabriel, we can expect better recording transcriptions, image search functions, incremental improvements on talking heads, Google glasses, and Second-life-style avatars. However, Gabriel warns us that although many of the obvious improvements on ordinary platforms would actually be technically trivial to deploy, today's industry is not all that interested. The industry is not into making gracefully playful tools for conviviality, nor in seriously rethinking platforms for online communities. Rather, the focus is on keeping users locked into products and minimum effort to stay ahead.

Author Takeaways

Shortly after we began this essay, we agreed that we should be selfish. We would write a piece that helped us, each in our own way, to answer our own questions.

Our queries and motivations were different. Although it is somewhat atypical of co-authored essays, we will conclude separately, in our own voices.

Jenny Quillien I am more bah-humbug about online collaboration than Hank. I surrendered only because of *force majeure*. In fact, I harbor an abiding sneaky suspicion of infeasibility. There is a fourth Japanese concept of space, *TOKORO* (McGrath, 2018) which we did not discuss in the essay. I think it doesn't apply. *TOKORO* means actual physical location and the way of being present there; it also points to *genius loci*, i.e., the spirit of a place, the meeting and melding of all that makes for uniqueness and depth of place. If *BA*, *WA*, and *MA* can look inward, *TOKORO* places things and events within an even larger story in the way that if, – say, your office were in New York City – then there would also be something of the Big Apple in your office. Does having a backdrop poster of the Manhattan skyline on Zoom qualify as *TOKORO*? When Hank and I started this project we assumed a clear dichotomy between a physical and virtual *BA*. Now that boundary seems to warrant closer examination. But for me personally, the absence of *TOKORO* speaks of an upper threshold of possibilities. For me there is a difference in 'realness' between the actual Hamlet drama taking place in that dank dark Danish castle, *Hamlet* acted on stage in a London West End theater, *Hamlet* in Second Life with avatars, or talking heads reading lines on Zoom.

My dislike of online work has been essentially aesthetic. I was interested, therefore, in exploring the Japanese concepts because they are profoundly aesthetic in nature. For me, the next best place to look for improvements lies with *MA*. Finding the right rhythm between tacit to tacit, tacit to explicit, explicit to explicit, explicit back to tacit. Finding the beautiful *MA*s as a group lets go of the old and invites the new, as the group moves between noisy talk and quiet, or distinguishes between what they want off and on record. I'm curious about the appropriate *MA*s between technologies – online chat, e-mail, libraries, databases, drafts and final documents. I'm interested in experimenting with collaborations where we front load *MA* zones of socializing. Can we speed up the building of *WA* and thereby improve the quality and tempo of the *BA* itself? Additionally, making the connection between the Japanese vocabulary and David Whyte's work was an aesthetic *aha!* moment.

All that said, my ultimate take-away is trading in my bah-humbugism for fascination. Most good *BA*s today are serendipitous rather than the result of competence. This is a real design problem. But for much of the foreseeable future, I think, we can profitably work with the Alexandrian method of misfit correction. You make your best guess at what you need (perhaps different *MA*, or a provocative Beautiful Question, or more calm technology), plug it in and then watch what doesn't work well. It is a bit like your dentist who puts a crown on a tooth. The best guess crown goes on, the dentist has you tap down on blue ink paper, and then scrapes away the excess enamel – the misfit – and does this repeatedly until the fit is just right. I'll end with a quote from Christopher Alexander's 1964 book: *Notes on a Synthesis of Form* "*... in a real design problem... We are searching for some kind* *of harmony (fit) between two intangibles: a form which we have not yet designed, and a context which we cannot properly describe.*"

Hank Kune I'm a societal innovator. It's my calling. I've spent much of my working life with public and private organizations supporting groups interested in proactively co-creating the future. I think of myself as a sort of midwife. My expertise is in methodologies. For years I've worked with Futures Centers. From my experience, one of the biggest difficulties is getting groups to recognize and contend with underlying issues – the real problems beneath the surface ones. I'm curious and hopeful about the power of the material outlined here to help us do that more effectively. Further elucidating *the conversational nature of reality* into more detailed *KATA* would be a useful big step.

For much of what we suggest, there are no protocols. No one knows how to do it yet. But that should not stop the dreaming, designing, learning by doing. Once there were no protocols for putting a man in orbit around the earth. There were no protocols for putting 100 times the computing power that accomplished it in a smartphone that fits in your pocket. Going alone, or walking with thousands of others: It is exhilarating to be the first.

We all remember Henry Ford's quip about the world never asking for a car but only for a faster horse. Marshall McLuhan reminded us that, when faced with a new situation, we tend to march backwards into the future, looking through the rear-view mirror. But just imagine the fast prototyping – perhaps within 5 years – of user-friendly immersive environments; of synapse-sensitive systems responsive to subtle user signals in the individual's online workspace: psychomotor 'swiping', affective signals (pulse, heartrate) and cognitive cues (orchestrated keyword logic); of intuitive systems putting participants with resonating ideas together, and anticipating the possible consequences and implications of choice-point options; of special smart-pens communicating information about mood and emotion through pulse-rate and body temperature when touching the screen; of full-scale Back Office facilities for virtual *BA* functioning like Mission-control service centers.

Anyway, nobody wants to go back to how it was. Aside from financial and time-consuming costs of travel and its excessive carbon footprint, people have always complained about ineffective meetings, conferences, seminars, and workshops. Online collaboration is still in its infancy. There are many paths it will take. But we're never too old to learn new tricks, master new technologies, discover we were wrong, change our minds.

Just as physical space, digital space needs to be designed and orchestrated to facilitate conversation, creativity, collaboration and learning. The more we are facilitated to think, imagine and work together in digital space, the more the *BA* becomes a house for innovation. In *The Poetics of Space*, Gaston Bachelard explores how we experience space through metaphors of the 'house' and images of containers of every kind. Since Jenny ended with a quote from Christopher Alexander, I will end with one from Gaston Bachelard (1964): "... *if I were asked to name the chief benefit of the house, I should say: the house shelters daydreaming, the house protects the dreamer, the house allows one to dream in peace... the house is one of the* *greatest powers of integration for the thoughts, memories and dreams of mankind.*" In just this way we must learn to unlock and experience the attic, cellar, closets, drawers, and jewelry boxes, corridors, and corners of the virtual BA.

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Annexes

Annex 1: Examples and Stories of MA

***MA* in Physical Space** The Iba Lab at Keio University is one large simple room with generous windows. Around the periphery next to the windows are bean bag chairs where students work independently. In the middle is a large table. Small groups can form and dissolve quickly. Plenary sessions are held at the central Table. *MA* is the in-between that allows for both synchronous working together and asynchronous independent work – and also the moving back and forth between the two modes. It is the *MA* which allows for Situational Awareness – contributing to both *WA* and *BA*.

***MA* in Hybrid Space** In Seats2Meet (The Netherlands and elsewhere) both members and incidental users can register online for an available 'seat' – a place at a table, lounge chair, or booth – and, at the same time, indicate what they are working on, whether they are looking to meet other people working on similar things, or are available to share ideas and knowledge about these topics. They come to work on their own projects, but can also check who else is registered in order to see if anyone they know – or have been hoping to meet – is also present. In this way a *BA* is created with a strong element of *MA* (the rhythms of physical/virtual, solo/collective, planned/serendipitous).

***MA* in Virtual Space** *MA* mastery does exist in some virtual technology. A few online learning providers such as Khan Academy have excelled at asynchronous learning modules, each lesson self-contained with exercises and immediate feedback. The material is arranged and weighed for ease of assimilation and skill building. The autonomous student sees when to proceed and when to repeat a lesson. The *MA* of the learning experience is delegated to the learner, who is certainly best placed to know what is comfortable. Game programmers are craft masters of *MA*: keep the game exciting, not too difficult but not too easy, always moving.

A Story of Effective *BA*, *WA*, and *MA* Adapted from a conversation with Richard Gabriel, a small group co-solutions a shared challenge: the unification and codification of the programming language *LISP*.

This project took eight years, was successful, resulting in a dictionary and a set of 'grammar rules' for a dialect of LISP we named Common Lisp. I was the instigator, went around to the groups in various countries working in LISP, argued for the need to harmonize efforts, and got everyone on board. The purpose (of the BA) was lean. I had engaged with the experts, the Big Boys in the field. (Right people in the group – BA) We had respect for each other (WA). We all came to the table with a genuine interest and we all had professional pride – nobody wanted to look like an intellectual slob in front of their peers. As the project evolved more junior people joined but the Big Boys held their feet to the fire. Anybody who did anything careless was 'flamed' – so people really paid attention to the quality of their contributions (BA and WA). We had occasional live meetings but most of the work was done by e-mail exchange. There was something significant in the juxtaposition of these two modes (MA). The e-mails were deliberate: carefully, slowly, mindfully prepared, formal. They were the backbone and contrasted with more informal spontaneous conversations and live meetings (Nonaka's axes). There was a recognizable something, a culture, an energy field, that grew and permeated everything (BA).

This project happened in the 1980s, before online chat platforms. Such a platform would probably have changed the speed and rhythm (MA) and the way disagreements were handled (WA). However, the critical success factor was the quality of the MA alternating solo, deliberate, and authored contributions with group solutioning. Regardless of the level of technology, the concerns of BA, WA, MA are the same.

A Story of Bad to Worse Jenny Quillien recalls faculty meetings.

The university had a main campus and smaller satellite campuses spread throughout the state. The structure itself engendered a number of classic organizational problems. A constant tug of war between dependence and autonomy, unfair allocation of resources, failure to take on board differences, status issues between main campus and satellites. All that sort of thing (poor BA and poor WA).

As everything went increasingly online, satellite faculty were allowed to digitally join the live main campus faculty meetings. For those who joined digitally, the view was from the back of the room. You could only see the back of heads so you guessed at identity and since they were speaking forward you couldn't always make out the words. If you signaled that you wanted to intervene and were recognized (rarely the case), the main campus faculty would turn around to look at the back of the room and see a face the size of a marble.

Nobody corrected the situation. It was a way to duck out. From our satellite perspective we had (per virtual session) been spared hours of driving plus a boring meeting. I would store up small tasks, like paying bills, to do while vaguely listening.

The digitalization of communication with satellite faculty was a further deterioration in MA which made the already poor WA and BA even worse. Situations that really called for focused solution seeking in small groups were allowed to fester. For example, student advisement. Student demographics in the satellites were different (students were older with a hodge-podge collection of previous classes *taken elsewhere). Which courses from another school could a student transfer? Had requirements for graduation been met? Tenured main campus faculty didn't want to relinquish control over these decisions but also didn't want to do the work. It all devolved into academic guerilla warfare and pulling punches. Embarrassingly bad. Technological advances did not make up for poor organizational leadership.*

Annex 2: Thought Experiment

To integrate various aspects of our discussion we conducted thought experiments organized around the process stages for collaborative solution-seeking. Imagine a consortium forms to deal with wicked societal challenges. The consortium is created on the basis of the quadruple helix, with participants from government, business, NGOs and the academic world. The consortium convenor, an NGO called the Global Lab for Societal Innovation, brings together people with relevant knowledge, expertise, creativity, and commitment to tackle border-spanning challenges. Typically, there are 120 participants coming from diverse countries. They work online, in heterogeneous groups of 12 people – each group a mix of 4-Helix partners – addressing questions like these:

How can we support the behavioral shift from 'green consumers' to 'green citizens?'

How can we change the medical profession's focus on treating and curing to a more systemic focus on prevention and health-aware lifestyles?

How can we learn the right lessons from the Covid-19 pandemic for whatever new crises may come?

There are no set answers to these questions. The groups must seek, define, and prototype conceivable solutions: combining relevant knowledge and skills, expertise, and experience, through an open, facilitated learning-by-doing approach. The initial sessions are set to last 3 days, so there is enough time to spend in each step of a nine-step process, after which the most promising solutions will be tested and improved in iterative real-world contexts with direct and indirect stakeholders.[18]

The thought experiment is about the process in one of the groups; it does not address how to combine insights or critical feedback from the other groups. Nor does it address the stage of testing and improving in the real-world. The assumption is that this will be a combination of virtual and physical activities, a true hybrid situation involving a different ecology of requisite spaces for each case.

Stage One. Understanding Who Is in the 'Room' and What They Can Contribute

[18] Similar nine-step processes, derived from different creative solution-seeking methodologies, have been used many times in physical face-to-face sessions like these. The present one is described in Rissola, Kune, and Martinez. 2017.

Essentially a plenary session where people talk about themselves, their experiences, motivations. Participants collectively discover what others can personally and professionally contribute, get a sense of resources available and information that needs to be captured. A common energy field (*BA*) emerges from developing empathic understanding of each other. Activities remain essentially person to person and tacit to tacit information sharing. The moderator is hosting, framing, providing documentation and exercises (perhaps playful ones) to foster the forming of the collective. This is the *Originating BA* with socialization and birthing of a *WA*. My space becomes our space. *KATA* guidelines include HEALTHY BA, NOT ACTING ALONE, LANGUAGE FOR EXPLORATION.

Current Technology is limited in Situational Awareness so awareness of the other is narrow (talking heads with no context). Future technology might involve playful multiple avatars.

Stage Two. Exploring Purpose

Mostly plenary and more heavily guided. What are we going to do in 3 days? What are we going to do for the project duration? Why? The immediate purpose is anchored in a larger context. It is established that different purposes can co-exist. The moderator is exploring the energy field for common ground, striking differences, unanswered questions, and also managing complexity, divergence, convergence, and consensus. The moderator will need to initiate *MA* for turn-taking, speech and pause for reflection, or smaller group conversations. This is the *Interacting BA* with externalization of information, peer-to-peer, and tacit to explicit. KATA includes PERSEVERE, HEALTHY BA, COMFORTABLY UNKNOWN, TALK AT THE BOUNDARY, BEAUTIFUL QUESTIONS.

Current Technology does not adequately support Stage Two which is a difficult stage. We end up force fitting non-linear processes into linear and clumsy turn taking. Difficult for the group to develop their own norms and Netiquette and *KATA* for self-organization. Lack of self-organization hinders ownership of results. Skills in recording, reviewing and searching group discussions for deeper exploitation of latent patterns are necessary. Agreement protocols for recording and exploitation are necessary. Future technologies would need to include faster turnaround to group members of their own production. Possibly see Organizational constellations (Hellinger Instituut, 2020) or Active Mission Control Service Center.

Stage Three. Framing the Questions

Plenary, then subgroups around core questions in breakout rooms. Iterative process with subgroup interaction. Examining & understanding the ‘challenge-as-given.’ What is the deeper problem, question, context, challenge? Reframing challenge to discover new perspectives not adequately addressed in the past. Presentation & discussion. Iterative process. Choices – these are leading for the rest of the workshop. Changing perspectives and perceptions. Internalizing the challenge context to understand issues behind the issues. This is the *Interacting BA, Externalization,* Peer-to-peer, Tacit-to-explicit, Framing, *MA, WA, KATA* for making choices. *KATA* guidelines include PERSEVERE, LANGUAGE FOR EXPLORATION, COURAGEOUS CONVERSATIONS, DEAD-END CONVERSATIONS, BEAUTIFUL QUESTIONS.

Current Technology. Framing Questions is difficult, but not because of the technology – going ‘beyond the obvious’ needs effective facilitation/coaching. Current technology includes the use of recording, accessible visual documentation, drawing, creating images = visible rendering (not just words). Future Technology could include intuitive avatars, fast turnaround of recorded material with usable summaries, accessible documentation, logically indexable resource bank.

Stage Four. Searching for and Exploring Leverageable Opportunities
Exploring the issues, searching for opportunities people have missed or not sufficiently exploited. Subgroups, then plenary. Presentation & discussion. The process is about exploring perspectives on opportunities resulting from reframed questions. Iterative search for emergent ontologies and meta-labels. *MA*, *Interacting BA, Externalization,* Peer-to-peer, Tacit-to-explicit, *KATA* guidelines include COMFORTABLY UNKNOWN, TALK AT THE BOUNDARY, LANGUAGE FOR EXPLORATION, BEAUTIFUL QUESTIONS. Breakout rooms alternating with plenary discussion.

Current technology includes Visual stimulation, Conceptual search, Fast visualization (image or drawing). Future technology would see accessible documentation, Active Mission Control Service Center organizing ideas and information for prototyping emerging ontologies.

Stage Five. Brainstorming for Ideas
Brainstorming Protocols. Plenary, then subgroups, Prioritize ideas, Cluster ideas, Choices: most interesting, most practical, wildest. Future technologies around co-creating a source library of possible inspiration and building blocks for possible solutions. *KATA*, Immersive images, Interacting *BA*, Externalization, Peer-to-peer, Tacit-to-explicit, *KATA* guidelines include TALK AT THE BOUNDARY, COMFORTABLY UNKNOWN, BEAUTIFUL QUESTIONS.

Current technology includes immersive images as visual stimulation, Fast visualization, accessible material, Ontologies and meta-labels. Future technologies include accessible documentation, Active Mission Control Service Center collecting, organizing, visualizing and feeding back ideas to the group.

Stage Six. Combinatoric Creativity: Enriching ideas
Subgroups then plenary. Here we have *KATA* requirements for cross-fertilization through presentations & discussions with different groups. Building more robust ideas. Enriching ideas with insights from other groups. *KATA, MA*, Emergence. Here is *Interacting BA*➔ *Cyber BA, Externalization* ➔ *Combination, Peer-to-peer* ➔ *Group-to-group, Tacit-to-explicit* ➔ *Explicit-to-explicit. KATA* guidelines include LANGUAGE FOR EXPLORATION, BEAUTIFUL QUESTIONS.

Current technology includes some gamification (SIM city, Farmville), Testing and refining ontologies and meta-labels. Future includes accessible documentation.

Stage Seven: Making Choices
Protocols. Setting criteria for decisions. Subgroups, then plenary. Unfolding *KATA* for making choices (decision-model to be determined by the group). Additional

thickening of idea-clusters and creative combinations. Consensus on promising ideas for potential solutions to work on. *KATA, MA*, Emergence.

Current technology includes simulation as reference point: e.g. 'What would the world look like in 3–5–10 years?' Forecasting tools & algorithms. Future includes better Simulation, Mapping.

Stage Eight: Prototypes: Making and Refining Them
Protocols for prototyping. Building initial prototypes using physical & digital attributes, images, video. Dry-run testing within the group. Dry-run testing with other groups within the larger workshop. Co-creating testable prototypes. Specifying target groups and methodology for testing/improving. Planning schedule for iterative testing and improvement. We see *KATA, WA, MA*, Emergence, *Interacting BA, Externalization,* Peer-to-peer, Tacit-to-explicit, *Cyber BA, Combination, Group-to-group, Explicit-to-explicit. KATA* guidelines include LANGUAGE FOR EXPLORATION, COURAGEOUS CONVERSATIONS, BEAUTIFUL QUESTIONS.

This stage is extremely difficult to do with existing technology. Future might include Access to image-bank, online video environment for collaborative manipulation of icons, photos, toys, Lego-blocks.

Stage Nine: Utilization: Testing and Improving Prototypes in Real-World Situations
Requiring complex systemic integration of diverse activities in hybrid environments. This involves diverse processes of *Combination* and *Internalization*, involving new sets of actors where – depending on the phase – both *Cyber BA* and *Exercising BA* are required. As such, it is too complicated for the scope of this essay.

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Creativity Flourishes Using Hybrid Space Patterns

Anat Mor-Avi and Lennie Scott-Webber

. . . .. Creativity emerges on the edge of chaos
while related to navigation between people, knowledge, and ideas.
Montuori and Donnelly (2013, p. 60)

Building a New Relationship Between Education and Architecture

Current architectural solutions are being challenged (Boys, 2011). Studies show that new, more active models for spatial solutions enhance engagement levels between all users and influence the culture of learning. After approximately 200 years of passive and controlling educational situations, active learning teaching methods have emerged, supported by similarly designed educational facilities. Looking back, ideas referring to space as a learning tool were developed through educational approaches, including classical examples led by Maria Montessori (1913) and Reggio Emilia (Malaguzzi, 1950). These two entities brought forth some unique architectural ideas, all of which remained mostly a local phenomenon.

One of the most influential architects, Herman Hertzberger (Dudek, 2000) from the Netherlands, was the first to connect the school's social values supporting learning with architectural qualities in the Montessori schools he designed in the1980s' in

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Amsterdam. The values, which his schools represented, were considered an example of significant historical development in school design. Herzberger demonstrated new methods of inviting social connections between the users by suggesting a unique organization and details advocated by the built forms (Dudek, 2000). This relationship created a potential for a friendly environment for the user and impacted the connection between form, social behavior, and the bond between the user's identity and the place. Hertzberger's famous statement, "We interpret form, but it also interprets us," (Hille, 2011, p. 11) explained his notion of the human connection to space.

Understanding how we learn (Ambrose et al., 2010), empowers the development of active and informal educational practices and the understanding of the learning processes. It challenges architecture to become more active and engaged holistically with the learning and the learner. These developments raised questions about how spaces influence the culture of learning and the learners' engagement and performances academically and socially. The COVID-19 pandemic has heightened our awareness of how we learn and teach, and expanded the meaning of the "where." The definition of space becomes broader and more hybrid (Mor-Avi et al., 2021). With this new understanding and the contemporary notion of collaborative creativity, this chapter adds to this text by (1) exploring the spatial design as a reflection of the culture of learning, (2) the multi-verse of creativity, and (3) the meaning of hybrid affordances. The chapter further offers a sampling of the findings from a Ph.D. dissertation on the connection between space and collaborative creativity explored by how hybrid spatial patterns may support the complexity of learning and creativity. This research study argued that space has the potential to empower learning by providing hybrid and contradictory architectural qualities, messages, and patterns to empower an innovative learning culture and creativity-"building cues."

Spatial Design as a Reflection of Culture

According to Seelig (2012), habitat is one of six important components supporting an innovative engine. Culture can be empowered by space when echoing the new culture conceptually but could hinder a new culture's success if not aligned with its conceptual ideas (Groves & Marlow, 2016). According to Groves and Marlow (2016), spaces reflect a place's culture through its architectural qualities, including: atmosphere, layouts, finishes, colores, thermal conditions, etc. For hundreds of years, traditional learning spaces were formal, private, and controlling educational experiences using rigid, closed, inverted, and fixed design solutions. Today, education is a more public domain, supporting informal, social, and emotional approaches, emphasizing soft skills (i.e., character and interpersonal skills) and freedom of choice. Accordingly, the spaces' cues and messages have become more flexible, open, human-centered, transparent, soft, movable, and support multiple options.

Space is an echo of culture and can support the desired learning behaviors needed for evolving new cultures of learning today. Architectural qualities and elements (called affordances) create cues and suggestions for behaviors and feelings. This term, architectural affordance, is related to an object's properties that show the possible actions users can take with it and was introduced in the study of cognition by the American psychologist James J. Gibson (1966). Therefore, affordances are a mechanism between users and objects (e.g., layouts, furniture, finishes, thermal conditions, etc.) (Mor-Avi et al., 2019). Studies exploring the influence of spatial affordances, messages, and cues on learning, learners, and faculty will be introduced next.

Space Does Matter

According to recent studies, there is a strong empowering connection between learning activities, behaviors, and spatial affordances, as paradigms shifts affect spatial solutions and move from a more teacher-centered focus to a learner-centered one, from formal- to informal- and passive- to active-teaching models (Scott-Webber, 2014; Scott-Webber et al., 2017a).

A literature review conducted by Talbert and Mor-Avi (2019), found several themes between spaces promoting learner-centered and active learning with informal learning. It then connected these models with evidence showing improved student learning outcomes, student engagement in several forms, and a positive connection with the instructor's practices and beliefs. Moreover, the interaction between the active learning approach and the spaces which invite students and faculty to be active by mobility, visibility through analog and digital tools have a significant, system-wide impact on schools' social and collaborative cultural patterns. The research highlights a growing understanding that space is the third component of effective learning experiences, complementing pedagogy and technology (Talbert & Mor-Avi, 2019).

The study introduced in this chapter aimed to explore specifically the influence of space on creativity. The next section shares the issues related to the complexity of creativity.

The Multi-Verse of Creativity

Social values (Scott-Webber, 2014) and collaborative creativity (Sawyer, 2007; Clapp, 2017) play essential roles in learning and teaching approaches for the twenty-first century. As a result, new teaching models and strategies enhance active learning with more "collective" (e.g., group settings and team project strategies). According to the World Economic Forum, in 2020 (Belsky, 2020), creativity becomes one of the three most desired skills along with critical thinking and complex problem-solving; all are keys to competing against Artificial Intelligence (AI) in the future workforce.

In 2006, Sir Ken Robinson, a British educator, drew attention to the need for creativity in the most-watched TEDTalk lecture ever – “Do Schools Kill Creativity?” He claimed that the world needs a creative and innovative society. Public and professional attention was irreversible, and the discussion about how to unleash the creative force of the students through introducing new educational approaches was and still is in developing stages” (Robinson & Aronica, 2015, pp. xix–xxvii). The issue of developing a creative culture and connecting to the creative child is not new and has been addressed as a desired value throughout the years. From the 1950s, creativity was connected with art and science educational institutions that expanded their facilities to create new places for artistic activities. Creativity was considered an act of the individual, and only at the beginning of the twenty-first century was contemporary creativity introduced as a collaborative process (Clapp, 2017). Today, creativity is considered a skill with the potential to empower economics (Robinson & Aronica, 2015).

The notion of creativity is dynamic, and as of the beginning of the twenty-first century, creativity’s concept was changing; reflected both as a concept and as a practice. Creativity, then, becomes part of everyday life performed by “everyday people” potentially everywhere, not related in particular to art or science courses. Creativity is connected to human relations and is recognized as a collaborative process. New research on innovation, group creativity, and the crowd’s wisdom all argue against the individual as genius (Montuori & Donnelly, 2013). Another concept related to creativity is dualism and is shared next.

Dualism (i.e., the division of something conceptually into two opposed or contrasted aspects) is part of our modern thinking and knowledge. “Social creativity,” which is a holistic way of examining today’s definition of a successful creative process, needs to be evaluated according to Montuori (2000) beyond the cultural divergence of individualism and collectivism. Montuori suggests looking at the term “social creativity,” which in the past was considered to be an Oxymoron, through several dual and hybrid lenses as self-society, creativity-conformity, and order-disorder. His suggestion aligns with the claim that this new era is marked by chaos, contradictions, and complexity (Bauman 2005, 2007). At one time, the world was defined by “solid” assumptions related to jobs, gender roles, genders, economic, and more, but it has become “liquid” and ever-changing (Bauman, 2005, 2007; Montuori & Donnelly, 2013). According to social theorists and demographers, the Western world as a whole is undergoing a generational shift from “I” to “WE” (Greenberg & Weber, 2008; Leadbeter, 2008; Howe & Strauss, 2009; Williams & Drew, 2012; Montuori & Donnelly, 2013). Therefore, the current notion of creativity represents a shift from the top-down culture to the participatory culture, which signifies the new relationship between “self and society.” This concept is evolving and represents the collaborative, distributed creativity (Glăveanu, 2013), and the issues of “I” and “WE” (Glăveanu, 2013).

Reflecting upon the above paragraph, cultural paradigm shifts may offer the current understanding that creativity flourishes through contradictory situations. As Montuori & Donnelly (2013) argue,

> *Creativity is fundamental . . . ..and evolving from contradictory as* ***order*** *and* ***disorder***, ***rigor*** *and* ***imagination***, ***hard work*** *and* ***play***, ***solitude*** *and* ***interactions***, *and* ***sharing***. *The critical tension between those contrasts suggests that* ***creativity emerges on the edge of chaos*** *while related to navigation between people, knowledge, and ideas (pp. 59–60).*

In addition to the idea that creativity is fundamental, it is as well a networked, ecological, relational emergent process that evolves from contradictory performances, as mentioned in the above citation (Montuori & Donnelly, 2013). Thus, it is suggested that creativity flourishes in hybrid patterns and, accordingly, contradictory spatial cultures and affordances. Since space may empower cultures and behaviors, as mentioned earlier, this study's goal was to investigate the ways architecture may offer cues to promote creativity in learning-driven environments. An overview of the methodology and the findings related to will be next.

Space, Creativity, and Some Findings

The dissertation explored the connection between creativity and space. It used a mixed-method research design to ensure bias was controlled. There were several techniques included: (a) content analysis of sixteen (16) architectural awarded designs of projects in the kindergarten to corporate learning areas, and (b) Post-Occupancy Evaluations (POE) incorporating (i) survey, (ii) interviews, and (iii) behavioral methods – onsite observation and photo traces. A convenience sample was used to gather the data.

The first technique was a content analysis of sixteen learning-driven, architecturally awarded environments. The range was from Kindergarten (K)-to-corporate settings. All of which had won major awards or significant recognition for innovative solutions. This technique's aim was to develop a collection of architectural attributes and patterns to create a coding system for analyzing photos consistently.

Analyzing these projects resulted in two major, clear, yet contrary patterns:

- Pattern One was defined as formal, closed, mostly with fixed solutions, hard barriers, teacher-led model, and suggested passive behaviors.
- Pattern Two was defined as informal, open, movable, with soft barriers, visual and audio connections, incorporating more student-led model, and suggested active behaviors (Fig. 1).

The second technique used Post Occupancy Evaluations (POE) incorporating ethnographic methods: (1) environment-behavior analysis through 18 (N = 18) interviews with closed and open questions, (2) twenty-five (N = 25) observations during 1 week in randomly selected times, and (3) surveys of faculty (N = 35), undergraduate (N = 95), and graduate students (N = 10). The American Institute

Fig. 1 Informal and open (aqua); formal and closed (blue) spatial patterns (Mor-Avi, 2020) © Anat Mor-Avi 2020. All rights reserved

for Architecture (AIA) awarded innovative building, Kaplan Institute, at the Illinois Institute of Technology in Chicago designed by architect John Ronan was the convenient sample. A sampling of the POE's findings relative to creativity is next.

One of Kaplan Institute's (the convenience sample as a designed building) design goals was to support a collaborative culture, and it has extensive visual and audio connections throughout the building. These attributes were to offer opportunities to discuss if and how space designed to promote an extensive collaborative culture could support creativity as well. Research questions focused on understanding the overall experience of the architectural qualities and elements that might enhance the collaboration and creative processes. In the surveys, the interviews, and the observations, two main issues related to creativity were dominant; the first was privacy, and the second was the balance between spaces inviting passive behaviors to those offering active behaviors. The survey had several aims. The first was to discern if there were perceived connections between a particular set of affordances representing building performance patterns and those supporting the creative process.

It was evident in the interviews that privacy is complex and has many meanings related to behaviors, the culture of a place, and space when learning is performed. Seventy percent (70%) of the interview participants mentioned the lack of privacy at least one time. The option to see and be seen through visual connections was appreciated, but 60% of the respondents found it a challenging influencer when no control was offered. Some expressions addressed by interviewees as influencing the perception of privacy included a sense of ownership and physical ownership, authenticity, intellectual and physical safety, confidentiality, physical proximity, and control on visual and auditory connections. Some of the responses were: "Transparency; bridge the trust between people.... but when no place to hide....you feel vulnerable." ...."I'm using headphones to create personal space – by students."

The second area for the questionnaire was regarding the influence on the learner when space performs in a passive cultural manner (e.g., activities being suggested by strong cues) or active culture (e.g., low cues with movable elements). Many interviewees were connecting a better collaboration experience with low cue affordances promoting a flexible and active culture. It was evident that the need for the learners' participation in creating and designing the space for their needs and the project needs is noteworthy. However, some users felt the need for those secured

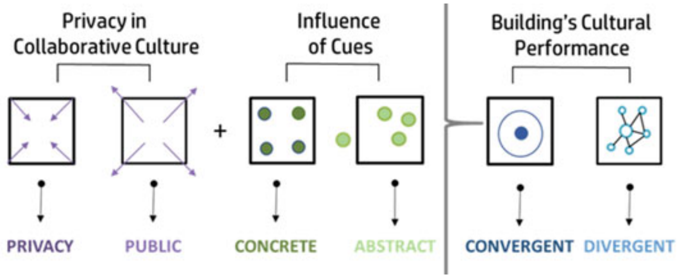

Fig. 2 Hybrid affordances (Mor-Avi, 2020) © Anat Mor-Avi 2020. All rights reserved

places that do not change at all. In the observation, it was evident that many of the movable writing partitions were used intensively, not only for writing but also for defining more personal space in the public areas.

In summary, findings from the surveys, interviews, and observations indicate that spatial affordances ranging from fixed-to-flexible and offering private and public settings are important affordances supporting the creative processes. To articulate these findings, a Taxonomy of Affordances was developed using three dichotomies: (1) privacy vs. public, (2) concrete for strong cue vs. abstract for low cues, and (3) a dichotomy reflecting the culture of convergence vs. the culture of divergence (see Fig. 2).

It may be argued that these contradictory affordances offer a hybrid experience. Contradictory cues that allow for both private and public, abstract and concrete settings – give a hybrid experience.

Hybrid Architectural Affordances - Details

This section provides more details on these contradictory architectural conditions, settings, and cultures.

Private Vs. Public Conditions

Affordances related to private spaces are considered those that separate, and public spaces are considered those which connect. Each has a range of visual and audio proximities for the main relevant qualities. Separating settings provide physical qualities, including partial or full-height walls, opaque boundaries, or transparent spaces with full curtains. These types of spaces offer individuals or teams a degree of quiet, full- or semi-isolation, confidentiality, and control over visual, auditory, and physical interventions (see Fig. 3).

Fig. 3 Private individual pod (left), semi-private pod (middle), and public setting (right) (Mor-Avi, 2020) © Anat Mor-Avi 2020.

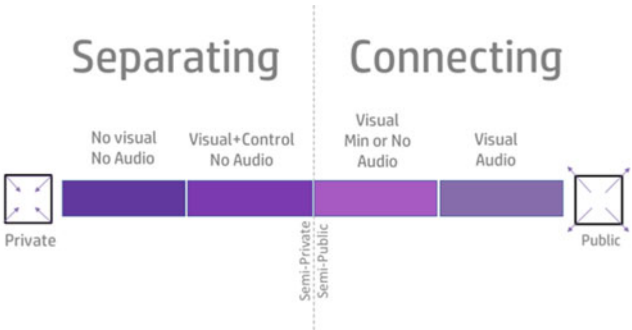

Fig. 4 Patterns from private and separating to public and connecting (Mor-Avi, 2020) © Anat Mor-Avi 2020.

Public space is often considered a social space and is generally open, accessible, and inclusive to all learners offering opportunities for academic content sharing. Public spaces provide audio and visual connections supporting both analog (i.e., non-digital means of communicating) and digital connectedness between users. These spatial types reflect the notion of education as a public domain. Examples from the interview quotes related to privacy and public are associated with closed, transparent, and exposed conditions were, "I need to use a closed classroom to make a phone call" (closed) . . . " I feel like a fish " . . . (transparent)" you feel more vulnerable" (exposed)..." no place to hide. – student" (transparent).

The findings show the need to include both qualities of separating and connecting with a range of semi-public and semi-private affordances with control over the visual and the audio, all to support different creative learning stages (see Fig. 4).

Concrete Vs. Abstract Settings

As described above, the influence of spatial qualities on passive and active behaviors was also dominant in the interview responses. Concrete affordances represented spaces that provide strong cues suggesting specific behaviors and were generally

Fig. 5 Kaplan Institute, IIT – concrete, and fixed (left images) vs. abstract and movable Settings (right images) (Mor-Avi, 2020) © Anat Mor-Avi 2020. All rights reserved

affiliated with passive and formal learning. The need for some ownership and authenticity, which may lead to self-actualization, were mentioned forty percent (40%) as supporting student success. It was clear that in pre-defined and fixed settings, where the learner is "invited" by the space to be a passive learner, ownership, authenticity, and spontaneous collaboration were not evoked. Part of these behavioral responses may be related to behavioral conditioned experiences caused by repeated situations over an extended period of time.

The images on the right, in Fig. 5, represent abstract, low cue settings informal, movable, and more ad-hoc activities and supported messy, dynamic, and active learning activities. They have movable writing boards and soft seating, which the users may define to provide a more intimate space for an individual or team activities. These attributes of low cues are decidedly different from those using strong cues. The images of strong cues include fixed seating stairs, the computer stands, and the kitchen table.

These solutions encouraged a "move to learn," and were defined by current users, mostly as "informal" spaces. Affordances for these spatial types are seen as being more user-centered solutions inviting the learner and the learning facilitator not to take the space layout as a given but to re-design the space according to the desired activities and needs (Mor-Avi et al., 2019).

The findings shown in this category suggest that all ranges between passive and active spaces with different degrees of flexibility and architectural qualities are important to support collaborative creativity among individuals and teams and provide more choices and control (see Fig. 6).

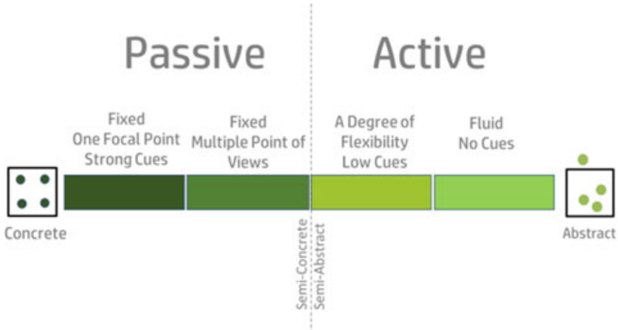

Fig. 6 Patterns from concrete and passive to abstract and active (Mor-Avi, 2020) © Anat Mor-Avi 2020. All rights reserved

Convergent Vs. Divergent Cultures

The third category of affordances was collected from the POE and is complementary to the two previous categories. This category represents opposite cultures and is related to spaces performing as anchors vs. spaces that act as a network system associated with current social and educational discussions (Ito et al., 2013).

This category comprises two patterns based on two situational cultures representing two very different modes of thinking. These are: (1) divergent and (2) convergent; both essential for creativity. These two situational cultures' needs should be reflected with intentional designs for spatial types. Situational Culture #1: Creative thoughts evolve when the brain is occupied with other activities simultaneously, allowing for divergent thinking. A divergent culture supports a network of creative and expanded connections between ideas, people, and knowledge. The divergent concept then is characterized by a networked setting, associated with a multidisciplinary approach, freedom to wander, and an appreciation of the learner's interests and needs. The affordances related to divergent culture might offer informal, ad-hoc, fluid, and changeable settings, inviting more just-in-time connections to happen, as well as messy activities. Situational Culture #2: Divergent patterns are contrary to convergent thinking, which benefits from having a clear mind and quiet surroundings. A convergent culture needs more anchoring and consolidating places to process creative thoughts. The affordances correlated with the converge culture represent a collecting concept symbolizing a congregation assembly, a centralized anchor. The assembly set represents a familiar protective place (see Fig. 7).

A decentralized network of affordances is characterized by multidirectional designs, flow, and soft connections between different affordances by a system of movable hard and soft partitions and furnishings (Mor-Avi, et al., 2019). Creativity and hybrid patterns are described next. There are multiple methods used to develop design solutions for particular places. This next section explores three: planned, unplanned, and hybrid as they relate to the creative process.

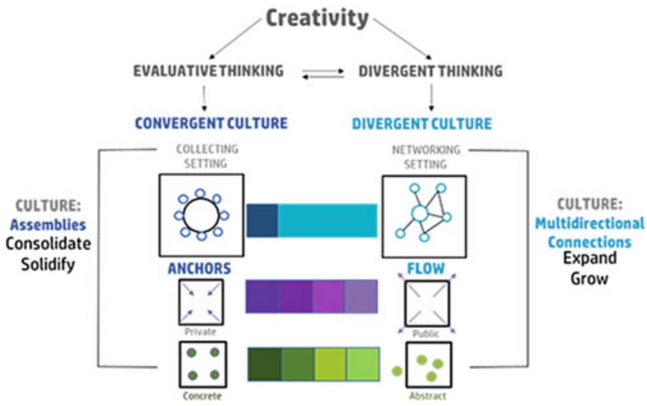

Fig. 7 Hybrid affordances empowering creativity (Mor-Avi, 2020) © Anat Mor-Avi 2020.

Creativity and Hybrid Patterns

As the fundamental concept of creativity, (which calls for creating new connections from the known to establish a novelty), space enhancing creativity should reflect the unknown emerging from the already known, defined in architectural terms – **planned and unplanned**. This section also introduces a new concept for the word 'hybrid' relative to the learning place. In this case, hybrid is operationally defined as an intentionally planned convergence of spatial types known to support creative endeavors.

The planned and unplanned concepts resonate with Wilson's (2009) structural model of the **teacher-led, didactic learning environment, passive setting,** and the self, or **learner-led, unstructured learning environment** as the **active setting** (Goodyear & Ellis, 2016). Planned and unplanned patterns echo with this research study's content analysis findings and were described as formal and informal learning spaces. These two spatial types invite a range of activities supporting both **didactic-learning in the formal spaces,** and **unstructured-learning in the informal spaces**.

The POE method reveals that students and faculty maybe empowered by contradictory affordance patterns when performing creative processes. Therefore, it is suggested that creativity flourishes in hybrid affordances of both private and public settings, concrete, and abstract conditions, complemented by convergent and divergent situational cultures. This suggestion connects with the contradictory performances of solitude and interactions, order vs. disorder, and rigor and imagination introduced by Montuori & Donnelly (2013) as the catalyst for creativity. It also resonates with the concept of Christopher Alexander's et al. (1977), which describes common design problems as arising from "conflicting forces," and proposes through the development of patterns a set of values connecting the built environment and the human essence with a purpose to guide the designer toward the best decision.

It is also suggested that the conflicting forces of the concrete, abstract, private, public, convergent, and divergent affordances, and the gradual range of the architectural qualities between these hybrid forces represents a pattern's values (refer back to Figs. 4 and 6). Therefore, situational Culture #3. Offering a system of hybrid networks connecting affordances supporting learning needs and productive collaborations is the foundation for some order in the complexity in which creativity flourishes (Mor-Avi, 2020).

Working from the suggestion by Montuori & Donnelly (2013), it is argued in this research study that space for collaborative creativity should also perform as a networked, dynamic, social emergent process to support the dynamic domain of education. Therefore, learning spaces should consider including:

– Planned CONVERGENT with CONCRETE attributes – familiar, fixed, passive anchors; with
– Unplanned, active, and organic, DIVERGENT cultures, with ABSTRACT settings ready to be changed according to the learning process and the learner's needs.

All of which are related to steering between a 'governed' process and a natural process among learners, knowledge, and ideas (see Fig. 8).

A divergent exploratory and insightful thinking for solving problems is the core of collaborative and creative culture. Therefore, it could be argued that spatial solutions supporting collaborative creativity should offer a *more* divergent culture and *less* convergent culture to allow for creativity to spark. Convergent cultural patterns supporting evaluative thinking should be complementary to the divergent culture patterns.

Hybrid and Dynamic– Learning-Driven Environments

Generating architectural solutions incorporating a hybrid, adaptive, and active system of patterns to empower innovative learning cultures and approaches is important. The constant cultural flux on innovative learning methods needs to be supported by a hybrid and dynamic system of spatial affordances; affordances supporting a wide range of learning activities that can be reconfigured every day in new ways and echo the needed agility in learning. A more "poetic way" to understand patterns is introduced by Leitner (2015). He argues that a simple word pattern is only the starting point of a new way in scientific thinking when dealing with complex systems and creative processes. Sets of patterns are used for collaborative forms of design and become a live system with its structural and functional complexity. Leitner (2015) refers to his idea when talking about 'alive,' but not the biological system with the German word *lebendig*, which is more abstract in its association. This point of view compares with using a pattern language when connecting architectural qualities to the dynamic domain of education.

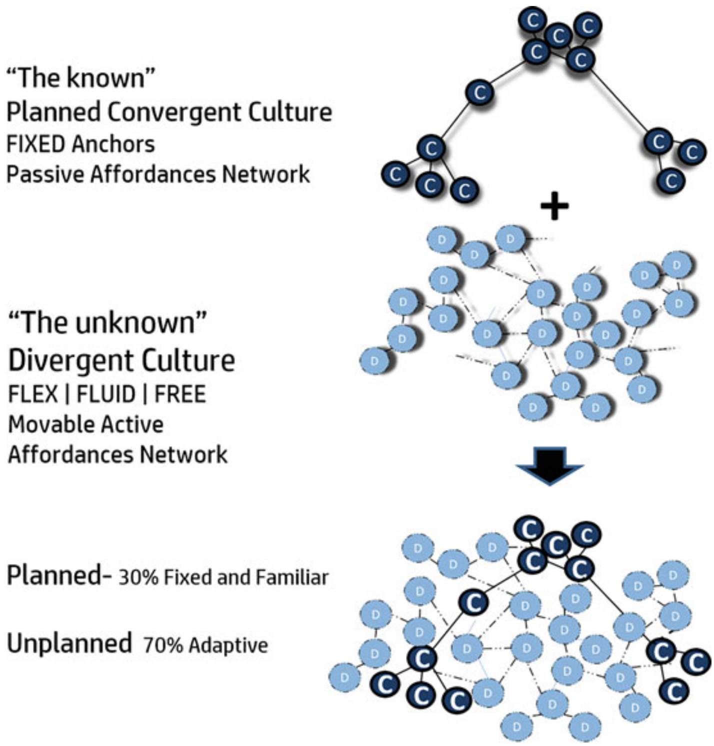

Fig. 8 Networks of hybrid culture patterns (Mor-Avi, 2020) © Anat Mor-Avi 2020. All rights reserved

The positive effects of space on learning may grow when spaces offer a range of affordances supporting different learning cultures and learning behaviors. The system of patterns then becomes a "tool" for teachers to address their curricula requirements. Space becomes part: of the curriculum, of the course, or the class when offering settings and conditions that enhance the needed behaviors. By offering the appropriate setting type for specific learning activities and behaviors, educators have the opportunity to express the expected behavior through space; it offers them the cues.

It is argued here that an adaptive system, like a "kit of parts," offers all users, faculty, and students to decide what attributes to promote, whether that be the: (1) culture, (2) behaviors, (3) emotions, and (4) architectural properties. Supporting users' emergent and creative needs, four types of design patterns important in empowering collaborative creativity are offered (see Fig. 9):

- Fixed Patterns - sets of anchors, assembling different groups or individuals mostly but not only to allow for maximum control regarding visual and audio connections for private conditions;

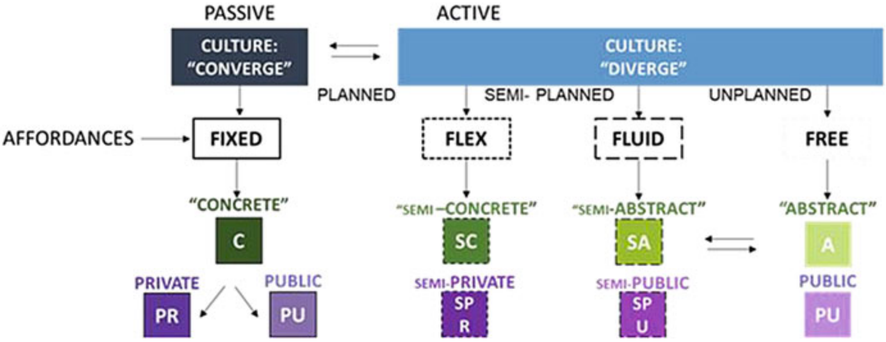

Fig. 9 Overview of the hybrid patterns (Mor-Avi, 2020)

- Flexible Patterns - a flexible system of affordance divisions allowing for semi-private and/or semi-public conditions with some control over visual and audio connections;
- Fluid Patterns - agile solutions by providing movable partitions for configuring and reconfiguring spaces at will, and as needed by the user providing semi-public conditions; and
- Free Patterns - open public spaces with full visual and audio, with only movable elements to empower connections for different engaging and spontaneous opportunities.

An example might help in understanding these ideas. Promoting active collaboration benefits from having a fluid or free-open public space with low cues allowing for spontaneous interactions, expressing and sharing visible learning with movable elements. Collaboration becomes more intuitive for the learners when supported by sensitive affordances promoting collaboration, connectedness, and creativity. The "where" becomes part of the behavioral system for learning. This organic system is complex and, at times, creates messes in spaces. However, since creativity emerges on the edge of chaos, spaces that emerge into the learning process should, to some degree, reflect this concept. Architects and educators should accept it as a positive characteristic of spaces supporting creativity.

Spaces with changeable, hybrid patterns with a range of conditions and an adaptive system of affordances, rather than final, fixed forms and linear solutions, offer more natural learning processes. It eliminates the perpetuation of the "one design fits all" mindset. Therefore, architects and educators might refer to spaces promoting collaborative creativity as an organic and agile product.

Final Thoughts

In summary, this chapter has taken the reader through innovative ideas including: (1) sharing the notion that spatial designs are a reflection of a situational culture, (2) that the collaborative process and the multi-verse of creativity are important concepts to consider, (3) space, behaviors, affect emotions, (4) some research findings from the Ph.D. dissertation were shared, (5) hybrid affordances were offered with details, (6) creativity was connected to new "hybrid" patterns, and (7) hybrid and adaptive spatial attributes were also shared.

This chapter offered design attributes that may permit the intentional support of a range of behaviors and cultural norms and may support the empowerment creativity, support motivated individuals, and fruitful collective and emergences into the intuitive learning process.

It is understood that in this era, designing for the learning process is a moving target, and designing for today's learning might be obsolete tomorrow. Space offering a dynamic, hybrid, active, and student-centered system of spaces could support the collaborative, creative learning needs for the twenty-first century and beyond. This chapter has introduced the reader to the process and some of the findings relative to the research work done on a Ph.D. dissertation. More information will be forthcoming in future publications.

This chapter was carried out as part of the first author's doctoral dissertation at Illinois Institute of Technology, College of Architecture, Chicago, USA, with devoted advising from Dr. Lennie Scott-Webber and IIT Professor Mimica Vedran. The chapter contains excerpts from the dissertation; intellectual property under IIT institutional copyright (Mor-Avi, 2020).

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Patterns for a Hybrid Campus

Christian Kohls, Dennis Dubbert, and Guido Münster

Introduction

Learning processes at universities are designed to enable students to organize their learning and collaboration independently. Universities must offer open, flexible and secure learning environments that stimulate learning activities and focus attention on the learning process. Learning spaces have a big impact on learning activities (Bligh & Pearshouse, 2011) and should provide affordances for a rich repertoire of activities and social interactions (Boys, 2011). Teaching and learning at university takes place mainly in buildings and their rooms, whereby certain forms such as lecture halls, seminar rooms, classrooms or laboratories have developed over centuries of tradition. However, such spaces are often isolated places as learning activities are rarely connected (Goodyear & Yang, 2009). Due to the possibilities of the internet, virtual rooms have significantly expanded the concept of learning space, and with augmented reality applications, the fusion of real and virtual space is a current educational technology trend that is attributed great potential for learning. Thus, hybrid use of physical and digital space is well established. Learning space is no longer limited to physical locations (Temple, 2008).

Universities are increasingly creating learning spaces for self-directed learning, spaces for informal learning and scope for the development of innovative forms of teaching and learning. Work or project spaces are therefore increasingly being expanded by media, e.g. by the university's own digital learning platforms, video conferencing systems or by external and collective data storage (clouds) and social media. In addition to the material project space, a virtual project space is also being created, which places new, specific demands on teaching and learning.

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Hybrid learning spaces support such scenarios. They are configurations that enable students to work, interact, collaborate, and to learn in a manner suitable to their needs: online/offline, on campus/off campus (Kohls & Köppe, 2017). Looking through the lens of hybridity allows us to get rid of a binary world view, and depart from planning learning in spaces in an either-or fashion. Rather, we encompass diversity, flexibility and ambiguity to let learners and teacher bring to life their own rich and personal learning environments.

The key questions we want to tackle in this chapter are:

- Which dimensions of hybridity exist?
- How can we empower learners and teachers to create their own hybrid spaces?
- How can we design learning spaces that have a high affordance for hybrid scenarios?

To answer these questions, we will first explore the ideas of hybrid pedagogy, blended spaces, and seamless learning. We will extract key dimensions for space design from these concepts. Then we will a) describe fictional design examples to show how the dimensions can be used as design variables, and b) discuss a case study to see how we used the dimensions to plan and transform existing spaces. In order to generalize our experiences and observations on other design solutions, we will introduce the concept of design patterns. Moreover, we describe our findings in one exemplary design pattern, "Hybrid Engineering Studio".

Hybridity

The term hybridity implies activities and learning spaces that depart from traditional dichotomies such as physical-digital, academic-nonacademic, online-offline, formal-informal, learning-teaching and individual-collective (Stommel 2012; Köppe et al., 2018b). In their work on assessment design, Köppe & Middelkoop (2020) have identified further dichotomies that could be overcome by a hybrid design: "Planning for Organization versus Planning for Learning" and "Synchronous versus Asynchronous Feedback" are timing dichotomies, "Teacher versus Student Grade Determination Responsibility" and "Formative versus Summative Assessment" are qualitative dichotomies. Boys (2011) discusses the problem of the formal-informal divide and points out that requirements of learning spaces are often more complex. A narrow view of informal and student-centered approaches implies that we need less formal lecture halls and rather informal, social learning spaces, often equipped with technology. Boys sees this dichotomy as a myth. Physical learning space is often idealized and based on wrong metaphors, such as colorful environments and bean bags that are supposed to automatically create a playful and informal learning setting. However, to consider the physical configuration alone is not enough. Rather, one has to explore the dynamic patterning of learning by analyzing both social and spatial practices as well as participant perceptions of space. One has to think about relationships beyond the campus as well as the non-defined zones, the spaces in-between. Hilli et al. (2019) point out that hybridity refers to cross-fertilization in which the duality of concepts remains yet something new emerges (see also chapter "Hyper-Hybrid Learning Spaces in Higher Education"). For example, instead of being either online or offline, students can be both. They can be in the classroom and at interesting learning places at the same time (Cohen et al., 2020).

Types of Spaces

Another form of hybridity is to move within different types of spaces. A good framework to discuss such overlapping of spaces is the blended space approach (Benyon, 2014). Hybridity in a blended space emerges when, for example, digital and physical areas are closely linked and overlap. The blended space approach can be found in various environments and applications, such as interactive tourist guides (Benyon, 2014), "Living History" areas in museums or Interactive Collaborative Environments (Benyon & Mival, 2016). Its origin can be linked to the blending theory of Fauconnier & Turner (2008), which is applied and further developed for blended spaces by Benyon (2014). Benyon & Mival (2015) show different spaces or areas of importance for the blended space approach. These include the physical space, the digital space, the informational space, the conceptual space, the navigational space, and finally the social space.

The number of spaces we can think of seems infinite (Ellis & Goodyear, 2016). As we are talking about knowledge spaces and knowledge domains, we can see that the content, the theories and practices of a field are also defining a space. That learners can move and progress in such a space is reflected in our everyday language when we speak of learning steps, transitions or reaching liminal spaces.

Seamless Learning

Seamless learning refers to the integration of learning experiences across formal and informal contexts, individual and social spaces, as well as face-to-face and online settings (Kuh, 1996; Wong et al., 2015). Wong & Looi (2011) identify several dimensions where such dichotomies exist and how to overcome them.

"Encompassing formal and informal learning": Learning spaces and resources can be accessed by learners to foster their "ongoing self- and co-construction of knowledge" (Milrad et al., 2013) instead just feeding them facts from textbooks and lectures. "Encompassing personalized and social learning": Students work individually on artefacts but can always share their resources with others. Individual and collaborative learning are not isolated activities but deeply intertwined (Kazmer, 2005). "Across time" and "Across locations": Being always online, students can learn anytime and anywhere without interruption when they move between different places (Chiu et al., 2008). Learning is blended at various locations and times, using heterogeneous technologies and diverse social settings (Sharples et al., 2012). “Ubiquitous access to learning resources”: Knowledge is available in different contexts, scenarios, places and at the right time depending on the various environments each students participates in (Hwang et al., 2008). “Encompassing physical and digital worlds”: Learning design should incorporate activities and experiences of life throughout the day with constant interaction of the physical and social world (Wong et al., 2015). “Combined use of multiple devices”. Social media is the means by which single devices connect to each other and enable the shared construction of knowledge and exchange of thoughts, comments and questions (Panke et al., 2016). “Seamless switching between multiple learning tasks”: Students should be able to co-create, re-contextualize and comment on knowledge resources. Seamless learning environments need to “connect, integrate and share learning resources in the right place at the right time by an interoperable, pervasive and seamless learning architecture” (Yang, 2006). “Encompassing multiple pedagogical and learning activity models”. Each learning spaces serves a diversity of goals and can be used in many different ways.

The goal of seamless learning is to bridge between the different spaces. The concept of hybrid spaces goes one step further as it questions dichotomies in general. Hybridity means that one occupies at least two spaces at the same time (Bhabha, 1994). Nevertheless, being aware of such dichotomies can help to overcome them.

Dimensions of Hybridity

Our first research question was to identify dimensions of hybridity. Dimensions can be derived from different frameworks such as hybrid pedagogy (e.g., physical-digital, academic-nonacademic, online-offline, formal-informal, learning-teaching and individual-collective), blended spaces (e.g., digital, informational, conceptual, navigational, social space), and seamless learning (e.g., formal-informal, individual-social, across time/location/devices, access to learning resources, physical-digital, switching between learning tasks, pedagogical and learning activity models). An overview is given in Table 1.

By understanding the distinct dimensions of spaces, we can make creative use of them. Instead of focussing on one dimension or space type only, e.g. only the physical space or only the social space, we can design solutions that are hybrid. Thus, a learning setup always happens in several spaces at the same time.

Designing and Planning New Hybrid Learning Spaces

Let us now consider how an understanding of the different dimensions can lead to novel ideas of hybrids spaces.

Table 1 Dimensions of hybrid spaces from different frameworks

Hybrid pedagogy	Blended spaces	Seamless learning
Physical-digital Academic-nonacademic Online-offline Formal-informal Learning-teaching Individual-collective Planning for organization-learning Synchronous- asynchronous feedback Teacher-student grading Formative-summative ...	Digital – Informational – Conceptual – Navigational – Social ...	Formal-informal Individual-social Across time Across location Across devices Access to learning resources Physical-digital Switching between learning tasks Pedagogical and learning activity models

When a student sits in a seminar room, a lecture hall or at home using educational videos, we can easily see multiple spaces involved. There is a physical location where the student sits and connects to; there is a social space with connection to the lecturer, surrounding students and buddy lists; there are online activities going on such as searching information, sending messages between students and making notes. Thus, we can see at least the physical, digital and social space and how they overlap. For the conceptual space we can further discuss which activities are performed, what kind of learning/teaching styles are at work hybridly at the same time. However, we may miss that there are some other spaces at work, such as the navigational and informational space. The navigational space is about where you are and how you can navigate to other places.

Hybrid Dimensions to Improve Learning Spaces

Let us first explore how the dimensions of hybridity can help in the design process by exploring fictional ideas for new learning spaces.

In the previous example we have seen that some space dimensions, such as navigational and informational, are often not accounted for. Let us see what happens if we deliberately explore options for these space dimensions.

Once we focus on the navigational space, we can see that the physical-conceptual-navigational space is often not in sync with the digital-informational-navigational space. For example, if a student uses a learning management system s/he has to navigate online to the resources that accompany the currently running course. If we connect the various spaces in a deeper and more meaningful way, the mobile devices of students could automatically adapt to the situation at hand. That is, when a student sits in a seminar room attending course ABC, then there should be a direct link that lets the student navigate to the online resources for ABC. Technically this could be achieved by a simple QR code, a link that is provided during the class or Bluetooth messages. While we often find direct links from courses in a learning management system to start online classes, the opposite connection is often missed. When we attend a live or recorded lecture, the delivered content is rarely linked to specific resources in an (additional) online space. Taking the navigational space explicitly into account makes us aware that physical spaces should be seamlessly linked to digital spaces.

Likewise, a hybrid connection of navigational-physical-digital-informational-social space inspires scenarios such as finding available rooms on campus, providing information where to find tutors, automatically form online learning groups with other students who attended the same seminar, list all available material tools on a mobile device, digitally highlight where to find tools in a room, start tutorial videos that explain how to use objects and machines in a physical lab etc.

The connection of physical-digital-informational-social can be illustrated by yet another example: Students can use their smartphones to vote on topics, send solutions, and discuss matters using a messenger client. Outcomes are then stored in the cloud and accessible for all students. All attendees of the lecture automatically join a virtual learning group that shares an online learning space with resources, blogs and bulletin boards. This would be an example of connecting physical-digital-social space. Moreover, students could be assigned to small groups, each group having their own online space. The grouping is done automatically based on spatial distance (e.g. students sitting next to each other, students meeting at the same site such as a café).

Using the dimensions time-locations-devices, one can think about another scenario: After sitting in a lecture hall or seminar room, a group continues their work off-campus in a café. The students put their tablets on the coffee table and connect them ad-hoc to create an interactive table-top. Learning spaces are created when and where they are needed. The group can structure and categorize the information using an unbound workspace on their tablets. Contributions are added from smartphones, digital pens and postings from other students who do research in the field. The results as well as the process are documented online in their project space and can be shared with a larger audience: blog posts, digital exhibition walls at public spaces, or a pop-up seminar in the urban neighborhood. At the same time students on-campus can join the same online workspace. Hence, the on-campus/off-campus dimension is also no longer a dichotomy.

These examples show several positive effects of a hybrid learning space. An open and student-centered learning space emerges. Students can connect with each other and learn in a collaborative community of inquiry. The learning process becomes more open and integrates real world experiences through expert and citizen participation. Learning spaces are created everywhere on demand. Hybrid learning spaces increase the mobility of students, foster interdisciplinary and international co-operations.

Chapter “How Co-design Can Contribute to the Ongoing Development of Hybrid Learning Spaces by Empowering the Users” of this book discusses how co-design can contribute to the ongoing development of hybrid learning spaces by empowering the users. Knowing the space dimensions and the different types of spaces allows practitioners to plan hybrid learning spaces, as an abundance of design variables are made explicit. Thus, we have shown how they can help to empower learners and teachers to create their own hybrid spaces. To further illustrate the process and see how such planning effects space design on a campus level, we will consider a case study.

Case Study on Hybrid Learning Spaces

In order to support hybrid learning spaces, university administrations have to provide learning spaces that have a high affordance for a variety of learning modes. At the computer science campus of TH Köln, we used design-based research (Reinmann, 2017) and a set of identified patterns to plan spaces for design thinking. We wanted to provide an ecosystem of workspaces (Quillien, 2012) and follow design principles for creative spaces (Kohlert & Cooper, 2017). A vivid work environment consists of interplaying spaces that serve different functions such as focused individual work, team work, informal collaboration and formal meetings. Kohlert & Cooper (2017) propose that creative spaces should foster wellbeing, collaboration, concentration, and rejuvenation. Hybrid spaces can support and increase creativity as Chapter "Creativity Flourishes Using Hybrid Space Patterns" illustrates.

In planning the various spaces, we used frameworks and patterns of good practice (see next section). To address the different phases of design thinking we created a planning space, a thinker space, an innovation space, a maker space and an open educational space (see Fig. 1).

To understand a domain, each space is equipped with interactive whiteboards to collect and aggregate research data. Storing information digitally allows a transfer between different spaces. In the phase of understanding and observation, the organization of data is critical. Hence, we have created a planning space that focusses on data collection and planning. It offers a large interactive wall to show, organize and map concepts and findings. Active ideation is supported in each of the spaces, however there is one innovation space that is equipped with hundreds of tools for idea generation. Next door to this space, we find a thinker space. This space is for incubation (ideation through relaxing) and reflection about current design states. Having another interactive whiteboard in this space allows to share results from the other spaces. The phase of prototyping and testing is supported by a maker space equipped with building materials, digital components, and 3D printers. All spaces are on the same floor. For early testing and feedback on prototypes we have installed an open educational space in a shopping mall that supports both co-creation and public presentation. Physical artifacts can be easily transferred from one space to another. Digital artifacts can be created, edited and shown in each of the spaces. The open educational space is in 5 min walking distance to the campus.

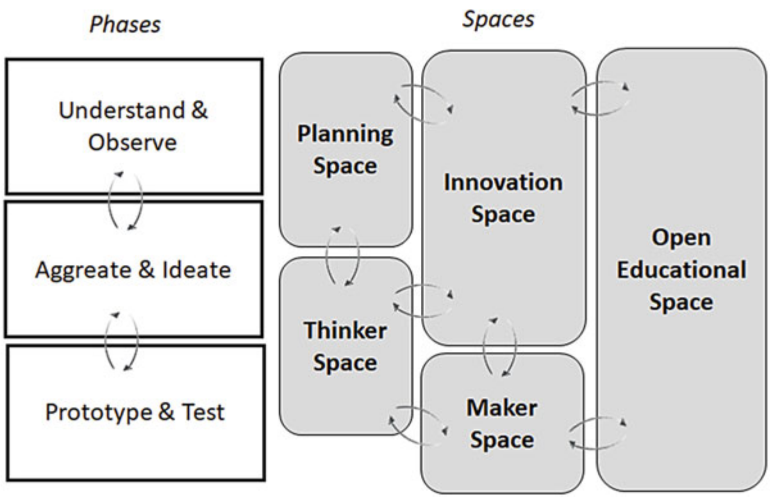

Fig. 1 Planning of an ecosystem of hybrid learning spaces for innovation

Fig. 2 Hybrid innovation space

Planning space: This space is best used for understanding and observing a problem domain. It has a bar table and a large interactive wall. The attached computer runs a cloud-based software for digital sticky notes. A team can add information such as data, pictures, sketches, findings, brainstorming items etc. both remotely and being on-campus. Thus, students can do field research and share their data on a large unbound work space. When they meet on campus they can compare, cluster and aggregate the information.

Innovation space: This space (Fig. 2) is at the core of design thinking. It can be used for all phases with a focus on ideation and prototyping. It provides a mixture of physical and digital tools, and supports different methods and social forms. At the center of the space is a large height-adjustable table. This table is the stage for new ideas and invites collaboration. One wall has an open cabinet with an abundance of work materials, Lego bricks, cardboard boxes, pens, stickers, idea cards and sticky notes. A table bar at the window front offers additional work space. There are two connected interactive whiteboards as well as three digital screens with apps for creative thinking. An arcade machine can be used to play and relax.

Thinker space: The thinker space can be used for discussions, decision making and incubation. It serves both ideation and testing phases. There are sofas, books, and an interactive whiteboard. The library of books offers inspirations. The space can also be used for break-out sessions or individual work.

Maker space: Prototyping and testing is essential to design thinking. To support this phase, the maker space contains several 3D printers, 3D scanners, whiteboards, workbenches and meeting tables. It also has VR equipment. This space is mainly used for prototyping and testing.

Open education space: This space is located in a shopping mall close to the campus. It can be used to present early prototypes in order to get feedback. The space can also be used for public co-creation sessions, for market research and project presentations. The space has a digital info display, a large interactive whiteboard, robots, and digital maker blocks such as Little Bits and Rasperry Pi. It also has workbenches, counters and stylish seating areas.

The different spaces we created were evaluated in interviews, written reports and observation. The findings, published in Kohls (2019), have helped to further improve the spaces. The learnings from our case study along with research on other existing spaces can help to design more learning spaces that have a high affordance for hybrid scenarios (more on pedagogical affordances in Chapter "An Analysis of Mobile Learning Tools in Terms of Pedagogical Affordances and Support to the Learning Activity Life Cycle"). Moreover, they helped to identify or refine patterns of good practice. Thus, we are now ready to describe such patterns in detail and hand them out to other campus developers. One of our newly identified patterns, "Hybrid Engineering Studio", is described in the next section.

Patterns for Hybrid Learning Spaces

The pattern approach is a way to capture proven solutions in a general way. The idea to capture balanced patterns of good design has its origin in the field of architecture. Christopher Alexander (1979) and his colleagues (Alexander et al., 1977) wanted to create a language which helps ordinary people to participate and express their wishes and demands in the design of towns, buildings and constructions (see also Chapter "Dialogic Teaching and the Architecture of Hybrid Learning Spaces: Alexander Meets Alexander"). The approach was adapted in many other fields, especially in the domains of software design (Gamma et al., 1995) and software education (Pedagogical Pattern Project). According to Alexander et al. (1977), "each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice".

Educational Patterns

As such, patterns capture the essence of recurrent good solutions. They describe both the solution form and the process to generate this form. Likewise, educational patterns capture the regularities of proven methods, scenarios and content, tools and media formats (Kohls & Wedekind, 2011). Patterns clearly state the design problem and design solution in a structured way and provide a "comprehensive set of design ideas" (Goodyear, 2005). They can be used to discuss different aspects of design expertise and "provide a lingua franca for joint course design" (Dimitriadis et al., 2009). The reflective analysis of patterns requires that a description of patterns discusses how and why a solution works. A form or intervention is neither good nor bad in itself but produces different consequences depending on the context. Patterns are never seen in isolation but capture the environments in which they work, often by relating to other patterns. Teaching is problemized and considered as a design science (Laurillard, 2012). Hybrid pedagogy patterns capture solutions forms that have been carefully designed to address pedagogical values. The first patterns on hybrid spaces had been mined a at 4-day workshop at EduPLoP 2016. A group of ten researchers had mined about 90 patterns of hybrid pedagogy. The group took a human-centered and empathic (Gagnon, 2014; Köppen & Meinel, 2015) approach to (designing for) hybrid education. In doing so, EduPLoP16 was structured in a way that bears some resemblance with the concept of value-based vision-driven educational design thinking (Aaen & Nørgård, 2016; Mor et al., 2016) where design patterns are formed on the ground of specific virtues and values and driven by value-based visions. The outcomes of this workshop have led to various publications on this subject (Köppe et al., 2018a; Pedersen et al., 2018; Köppe et al., 2018b; Kohls et al., 2017, 2018). More examples of patterns can be found in Chapter "Design for Balance: Addressing Challenges of Safety, Privacy and Identity Management in Online and Hybridised Learning and Teaching Spaces".

Pattern Mining for Hybrid Spaces

There are different approaches for pattern mining (Kohls & Panke, 2009). The approach taken here is a typical mix of methods of inductive and deductive research:

- Analysis of existing good practices for interior design
- Visits to tradeshows and exhibitions, browsing product brochures, explore existing rooms
- Testing of classic and digital tools
- Participatory design sessions with later users of the space (students, docents)
- Evaluation of the case study

In the process of identifying the general forms of the patterns, the findings from general frameworks can be considered as driving factors. Our patterns are based on the solutions developed in the case study as well as other recurring structures we found in different case studies of existing facilities, including i-Land (Streitz et al., 1999), ICE (Benyon & Mival, 2012), Maker Spaces (Forest et al., 2014) and iRoom (Johanson et al., 2002). The next section will illustrate one of our mined patterns in detail.

Hybrid Engineering Studio

The *Hybrid Engineering Studio* is a solution that applies to this context: Engineering students need to apply core skills and also build future skills such as reflective and creative thinking, planning and design. Experts and teams may be distributed among several campuses and external stakeholders need to be integrated in the creation process.

In such a context, the following problem often arises: When a team collaborates on creating artefacts, team members need to communicate with each other using more than voice and visual communication channels. Teams have to show and present each other what they are creating and what they are working on seamlessly. To address this problem, one needs to be aware of several forces.

Affordance of doing: Design and engineering students need to engage in creating and doing. Going into work mode needs to be seamless. Getting started must not be too time-intensive, quick setups are required.

Different skills and levels of expertise: Students start creating digital products with different levels of skills and experiences. Some have programming experiences, some have skills in electronics, others are skilled craftsmen.

See and hear each other: Collaborators at different locations need to hear all participants well. To use non-verbal communication, collaborators have to see each other full size.

Share what you have: As artefacts and prototypes are created at different locations, remote collaborators need to fully see (and maybe even experience) the outcomes of each team.

Point and discuss: Providing feedback to designs and prototypes is important. But pointing to specific details of a physical design is very difficult if done remotely.

Collect, discuss and capture: A distributed teams needs a shared space to collect information, capture the process and collaborative create sketches, structures, and concepts.

Inspire each other: The products and ideas of one team often inspires others.

Different types of prototypes: Prototypes are very important in engineering and designing. However, prototypes exist on many different levels: sketches, physical prototypes, minimal viable products, wizard of oz., and others. Moving from one level of prototyping to the next needs to be seamless.

Fig. 3 Hybrid design engineering studio

Visual collaboration: Prototypes and designs often require visualizations, and teams need visual collaboration channels.

To address these conflicting forces, the pattern captures this generalized solution: Create a large studio (80–140 qm^2) that offers building materials, immersive video technology, interactive walls, show case areas, capture & share areas and cameras for instant capturing and streaming.

The studio is a hybrid combination of a maker space, video conference room ("war room"), collaboration space, show case, workshop area, and living room (see Fig. 3). It has cabinets with working materials for different engineering activities. The materials should be abundant and address different levels of skills, e.g. non-technical building materials, maker blocks on an entry level (e.g., Little Bits), maker blocks for more sophisticated developers (e.g., Sam Coding or Rasperry Pi), maker blocks for experts (e.g., Fischertechnik), and raw materials for engineering. In addition, the studio has cabinets with design materials such as design cards, templates, sticky notes. Large interactive walls with infinitive workspaces (e.g. SMART Board and Miro, Microsoft Surface) allow to capture physical designs, collect ideas and research results. The content can be shared form remote participants from other hybrid studios or individual participants sitting at home.

One or more displays are available for immersive video conferencing. To see other participants in real size (to see all their gestures and facial expression), the studio has large displays or several small displays, where each display shows one participant. Video cameras should be installed, and users of the studio need to know which areas are captured. There should be a sharing area where artefacts can be placed and remote participants can immediately see what is placed there.

The studio also has *show case areas* where student teams can present their current progress or the project.

Conclusions and Outlook

Hybrid learning spaces have become a popular concept in the last few years. The Covid-19 pandemic has put the term "hybrid education" in a popular context. Unfortunately, this popularity is blurring its definition and very often goes hand in hand with a narrow view of online and offline phases. We understand hybridity as a new approach to consider learning spaces in richer and more diverse ways. In particular, the dichotomies of binary spaces will be resolved. In addition, we can see an overlap of different kind of spaces that lead to new and inspiring learning setups. Our case study has illustrated that the described approach can work successfully in shaping the campus of a university. However, this complexity can also lead to confusion. The pattern approach can help to organize the field into stable configurations without taking away the openness for new setups. Further research is need to back-up the identified patterns. Moreover, describing the patterns and making them available to other educational designers is an on-going process for the next years.

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Dialogic Teaching and the Architecture of Hybrid Learning Spaces: Alexander Meets Alexander

Alyson Simpson and Peter Goodyear

Introduction

When teachers plan for future lessons, they engage in mental time travel. They imagine and remember, consider possibilities and make commitments. In the middle of this, they think of students involved in learning activities. Implicitly or otherwise, they acknowledge that learning activity is *situated*: that what is being done, where and with whom are often important matters. What will the tasks actually entail? What tools, documents or other artefacts must be available? How will the classroom need to be arranged? Will students work alone, in groups, or as a whole class? Or will their activities flow back and forth between individual, group and collective forms? When teachers plan, they cannot think of all these things at once, so planning itself moves back and forth between the whole and its details, between more tightly and loosely-coupled relationships.

In this chapter, we consider teachers' thinking at the intersections between language and space. We focus on relationships between dialogical teaching and the places it needs. Intrigued by notions of hybridity, we have selected some examples that raise interesting questions about the nature and complexity of hybrid spaces, and how we might understand and speak about them.

As researchers, one of the challenges we all face when trying to work out how to create useful ways of understanding a new area (the sets of ideas, phenomena, relations, etc. involved in "hybrid learning spaces") is to get a sense of the geography of the novel intellectual terrain. This is non-trivial. It is not as simple as "carving nature at the joints" because the area we are researching does not exist as a fixed and objective thing, to which everyone interested has the same access. Nor is it entirely subjective, unique to each researcher – enabling each of us to compose it

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exactly as we wish. This is an inter-subjective enterprise. So questions we must ask, as researchers entering and making the field of "hybrid learning spaces" (HLS) include the following:

- What comes into focus when we consider something in spatial terms? What kinds of relations obtain between spatial qualities, such as dimension, direction, containment and perspective, and human activities and experiences?
- How should we think about the properties of the spaces we design and the experiences of their users?
- How do we discern and distinguish between what can (and should) be designed in advance, what is reconfigured in use and what then emerges?
- What relations exist between concrete (realised) and imagined spaces? Do our conceptions of "hybrid" extend beyond mixtures of the material and digital, to include imagined worlds?
- Are there significant differences between remembered and imagined spaces, and between memory, prior knowledge and conjectures about the future?

There are, of course, many other sets of meta-scientific and substantive questions that can be raised. In what follows, we use the recent teaching of one of us (Alyson Simpson) to reflect on some issues central to intellectual work on HLS. Alyson teaches pre-service school teachers (PST) to teach about English literature, language, writing and reading. Her position as a teacher educator introduces a recursive complexity: she has to think about how to help future teachers think about learning and teaching. Like the PST, she has to imagine future classrooms as well as unknown students and their needs and desires. Then, in a reflexive turn at the end of a semester, she critically examines the learning outcomes and makes plans to reconfigure actions for future iterations.

Alyson's approach is heavily influenced by Robin Alexander's ideas on dialogic teaching. Like many teachers in 2020, she found herself having to adapt rapidly, part-way through semester, to "teaching online". The rapid shift from teaching that was mostly face-to-face, on-campus, to teaching online has provided an opportunity to reflect upon relations between dialogue (teacher-student and student-student), the deliberative pedagogic design used to create different spaces in which dialogues unfold, and the movements of people and things between those spaces. In thinking together about these relationships, we have found it helpful to draw on another Alexander – the architect Christopher Alexander – and especially on some of his thoughts about collaborative vernacular design, recurrent design solutions and the ways in which successful built forms resolve tensions between competing demands.

The rest of this chapter falls into four main sections. Firstly we describe dialogic teaching and pedagogic design, with particular reference to the writings of Robin Alexander. After that, we introduce some ideas about (learning) spaces and design, drawing on Christopher Alexander. In the third and fourth sections we discuss some episodes from Alyson's recent work with PST who are preparing to teach English in primary schools. The first episode is intense, with activites running within a two hour teaching time frame. The second stretches across a semester, so the action appears to occur in slow motion across multiple weeks. In each of these episodes we connect dialogic activities to hybrid spaces. We identify some reusable design ideas relevant to the joint creation of congenial hybrid learning spaces. We raise some questions to draw out more imaginative and ambitious conceptions of hybrid learning spaces – and of how their design and occupation may be helped to flourish.

Dialogic Teaching: Robin Alexander

Dialogic teaching "is a pedagogy of the spoken word that harnesses the power of dialogue, thus defined, to stimulate and extend students' thinking, learning, knowing and understanding, and to enable them to discuss, reason and argue. It unites the oral, cognitive, social, epistemic and cultural, and therefore manifests frames of mind and value as well as ways of speaking and listening" (Alexander, 2020, p.128).

Robin Alexander proposes six principles to balance (resolve tensions between) social/emotional and intellectual components of dialogic teaching. The principles are criteria that can be used to inform the dialogic nature of interaction and judge its quality. Other researchers have employed the principles as analytic tools exploring classroom interactions (Jones & Hammond, 2016; Thwaite, Jones & Simpson, 2020). We have also adopted this method as we discuss our examples below.

> Collective: The classroom is a site of joint learning and enquiry, and, whether in groups or as a class, students and teachers are willing and able to address learning tasks together.
>
> Supportive: Students feel able to express ideas freely, without risk of embarrassment over contributions that are hesitant or tentative, or that might be judged "wrong", and they help each other to reach common understandings.
>
> Reciprocal: Participants listen to each other, share ideas, ask questions and consider alternative viewpoints; and teachers ensure that they have ample opportunities to do so.
>
> Deliberative: Participants discuss and seek to resolve different points of view, they present and evaluate arguments and they work towards reasoned positions and outcomes.
>
> Cumulative: Participants build on their own and each other's contributions and chain them into coherent lines of thinking and understanding.
>
> Purposeful: Classroom talk, though sometimes open-ended, is nevertheless structured with specific learning goals in view. (Alexander, 2020, p.127)

In his recent work, Robin Alexander speaks of *repertoires of talk* informed by the dialogic principles, which teachers draw on according to context. These repertoires are highly relevant to our discussion of designing interactions in the hybrid space of networked learning as they relate to manipulation of settings, forms, transactions and moves. The concept of talk repertoires encourages teachers to seek diverse solutions, acknowledging the complexity of responding to contextual challenges in teaching. It supports the concept of teaching as intellectual work depending on professional judgement and hence avoids the use of reductive teaching "scripts".

In her learning designs for initial teacher education Alyson aims to address the social and the intellectual challenge of keeping individual learners meaningfully engaged as well as the collective responsibility we share as teachers. Simultaneously, as her pre-service teachers learn about teaching English in the primary school, they also need to adopt the dialogic practices that scaffold their agency as learners. Through opportunities to talk about talk, the PST gain insights into principles of learning design that can influence how they teach in the future. To help position the language of the English curriculum as part of their pedagogic discourse (Alexander 2020, p.56), PST are required to critically reflect on their knowledge about that language. Through this work Alyson helps them develop a meta-language, which focuses their professional attention on the way dialogue shapes the classroom spaces they create and inhabit. As a result of working in the iterative, hybrid teaching sequence, PST become familiar with recognising how their strategic decisions impact on learning opportunities.

Learning Spaces and Vernacular Design: Christopher Alexander

The architect, mathematician and design theorist Christopher Alexander has played a very influential role in shaping ideas about the nature of built forms, and why people are drawn to certain kinds of places and things (Alexander, 1979, 2006). He shows us how to identify and work with recurrent patterns – at various scales, from cities and regions to buildings and rooms, to furniture and ornaments (Alexander et al., 1977). He also writes extensively about methods and challenges in collaborative vernacular design: including participatory design of complex learning spaces (Alexander et al., 1975, 2012. See also Goodyear & Retalis, 2010).

One of the many lessons we have learned from Christopher Alexander's early work is that common, successful built forms – forms which recur across time, space and cultures – succeed because of the ways in which they balance or resolve competing forces. A door, for example, resolves a tension between the need for security and the need for ease of passage.

Many of the built forms that we live and work among are so familiar that we barely notice them, or how they function. We may have some intuitions about things that work well or badly, but Christopher Alexander helps us see why things take the form they do, and to understand the forces they resolve and the limits on their applicability. Once we can explain these relations between forces and qualities of built forms, to ourselves or others, we are much better placed to reason about design and to discuss what works well, what may need to change, what is likely to fail or succeed, and so on. For instance, when entering a building we may not notice that a particular combination of elements succeeds in providing an appropriate transition between outside and inside, between public space and private space. Porches, stoops, thresholds, doorsteps, doorways, *noren*, curtains, antechambers, hallways, foyers and so on combine to make such transitions less abrupt. But their absence – too sharp a transition between outside and inside - can make arrival feel uncomfortable, even if one can't quite say why. Similar analyses can be applied to digital spaces and to spaces used for learning: the arrangement of their elements can be analysed such that one can find words to explain the tacit sense that something is wrong, or right, about a design. By extension, we propose that hybrid spaces which include material *and* digital elements are also open to analysis and explanation, and that a better and more articulate or explicit account of how they function is a contribution to our common fund of design knowledge.

Given the focus of this chapter on dialogic teaching, we restrict our treatment to relations between the built form of hybrid spaces and the desiderata for dialogue. We share two examples to draw out some important relations between the requirements of the forms of dialogue that we value and characteristics of the hybrid spaces used and imagined in Alyson's teaching. In each of the next two sections, descriptions of teaching are offered in the first person singular – in Alyson's voice – and are accompanied by figures visualising movement across spaces. These are followed by our joint analyses and commentaries, presented in the first person plural.

Dialogic Approaches to Iterative Pedagogies: Alyson's Description

In this part of the chapter, I describe the dialogic approach I took to designing the online learning experiences for my pre-service teachers, as they studied in their undergraduate initial teacher education program during the COVID-19 pandemic. Robin Alexander's work on dialogic teaching inspires my learning design because it encourages student and teacher agency through equitable practices. I planned to use synchronous and asynchronous activities to scaffold active listening, joint engagement, positive relationships, and opportunities to collaborate (Alexander, 2020).

The discipline knowledge of English formed the 'what' of our focus. In particular, the students were learning how to teach reading, writing, speaking and listening with children's literature. The pedagogic content knowledge - building knowledge of strategies used for teaching - formed the 'how' of our focus. The pedagogic values that informed my decisions aimed to create collective understanding through talk, build collaborations through shared projects, and establish a learning community through which participants gained agentic insight into their own learning. The students were given access to learning resources on the university's learning management system (LMS) so they could prepare for activities.

Prior to the move to teaching fully online, I was familiar with the use of LMS such as Canvas and had already set up our site for the semester using interactive resources such as Padlet, Quiz and Studio. I was using the multimodal potential of the platform to make connections from our university world to schools through

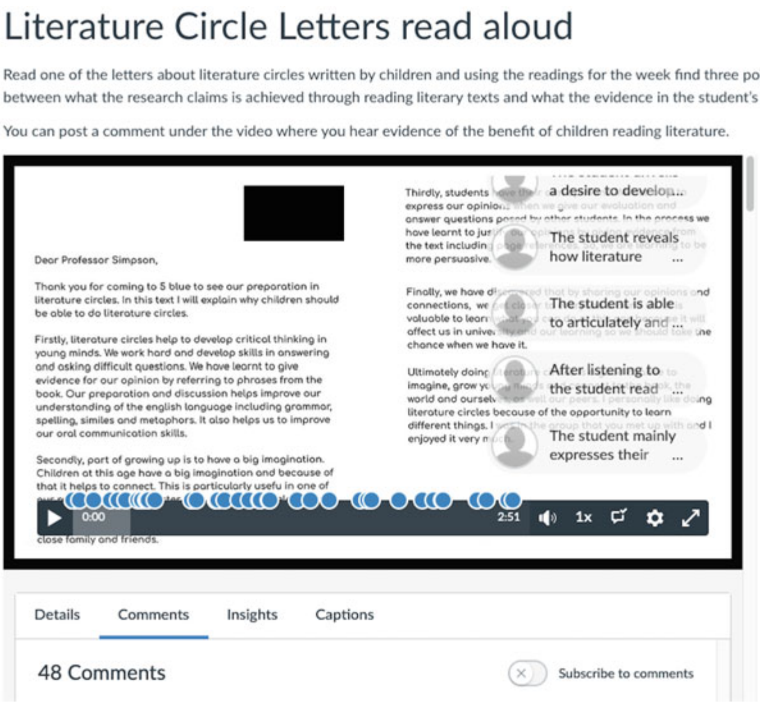


Fig. 1 Letters read aloud, with PST's annotations

the voices of children. For example, in the week 2 module, I created audio files of children reading letters out loud, sharing their opinions of how literature circles helped them develop critical reading skills. Prior to attending their face to face tutorial, the PST accessed these files and used the embedded commentary option in Studio to note three points of connection between what research claims is achieved through reading literary texts and what the evidence in the children's letter shows (see Fig. 1).

In our physical classroom space, PST sat in table groups and made notes on large sheets of paper that were hung on the walls for others to walk to and read. We used these shared materials, as well as the audio commentary online, as prompts to discuss, as a class, how listening to the letters being read gave us more insight into the children than mere written text could. This use of meta-talk as a pedagogical resource opened up a dialogic space for learning (Myhill et al., 2020, p. 7) in multiple layers. The switch from small group to whole class discussion set up opportunities for interaction, the movement from tables to wall and back again provided access to new information.

When all teaching moved online in week 3, like many others, I adopted Zoom as the platform through which I would provide for interactions in the forms of lectures and tutorials. I was familiar with Zoom from meetings but not for teaching. I wanted to hold on to the classroom culture we'd set up in the first two weeks: where students felt connected to their tutors and the learning that took place. I set out to experiment playfully with a brand new set of tools. The description that follows shows how our shared expertise built up over time, so that by week 9 students were familiar with the use of a wide range of pedagogic strategies and technological tools. In our online space, students logged in to the LMS from dispersed locations "arriving" at a Zoom portal, which made use of "Main" and "Breakout" rooms. The concept of Main Room was used to convey my expectation as a teacher that we would still work as a whole class informed by dialogic principles. That is, our interactions would be reciprocal, supportive, deliberative, etc. My use of Breakout Rooms was intended to create more student centred learning opportunities through increased interaction in small groups. Students knew that each of the activities used within a tutorial or across the semester would later be related back to the whole, as part of our cumulative approach to learning.

Example 1: Learning About Poetry (Allegretto)

The topic in week 9 was poetry. What to teach was used to inform how I taught as well as how the students learned. Taking a Bakhtinian persective on this kind of learning, it is possible to see dialogue as a "way of being as well as doing" (Alexander, 2020 p.45).

So, to complement the content located in modules in Canvas, I designed the inclusion of Breakout Rooms and branching choices in the LMS to create multiple dialogic interactive spaces and opportunities for the tutor to "drop in and out" of conversations to provide support. The two hour tutorial was broken into seven "chunks" to allow for breaks and shifts of pace and focus as we progressed cumulatively towards our collective purpose. Through varying iterative social and intellectual connections, students learned about aesthetic appreciation, wrote poetry types using language features and considered how their experiences revealed what they needed to learn more about. I started from what the students knew and led them through experiential learning to what they needed to know, using revision and application of knowledge to check their learning, and finished off with critical reflection and a resource bank for future use.

Figure 2 illustrates the flow of activity for the poetry tutorial. The principal spaces used for the activities are represented by the three columns. The vertical axis represents time. The number on each of the activities helps map to the brief explanations in the accompanying text. Arrows help follow the flow from one activity to the next.

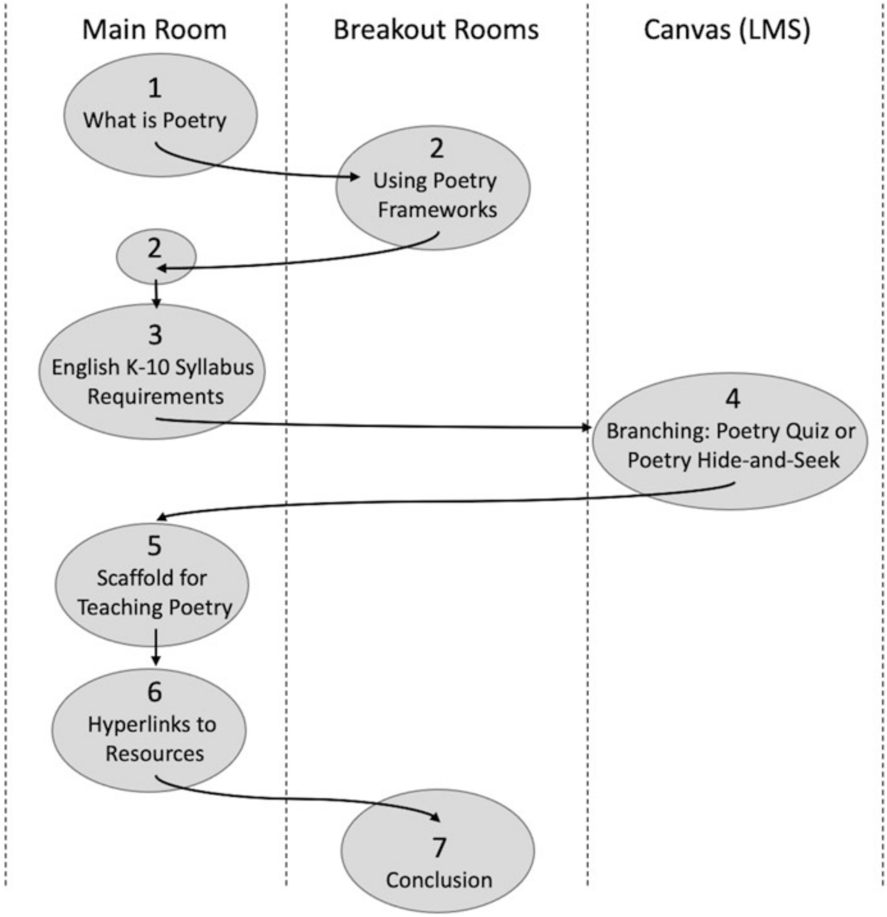


Fig. 2 Layering learning through movement across space and condensed time

Chunk 1 – Main Room
What is poetry – students brainstorm concepts about poetry, model guided writing using a worked example and share past experiences with poetry.

Chunk 2 – Breakout Rooms
Using poetry frameworks – students write poetry in small groups using scaffolded processes and address three questions: 1. What language features did you need to know about? 2. How did your vocabulary support what you were able to write? 3. What does that tell you about how to teach poetry writing?

Returning to the Main Room, groups shared poems they created for enjoyment. We then analysed how the collaborative metatalk during the composition prompted by the questions had contributed to learning.

Chunk 3 – Main Room
Australian Curriculum English and English K-10 Syllabus requirements – students discussed their responsibilities as teachers to understand content and pedagogy.

Chunk 4 – Branching
Poetry quiz or Poetry hide and seek - students were offered the choice of two activities, both focussed on technical terms about poetry. The students were not "present" in the main room or a break out room during these activities. The activities were time limited, and embedded in the main Canvas site through links or module activities, which allowed the students agency to direct their own learning pathway and a break from conversation. Option one was a matching definitions quiz and Option two prompted students to watch a video and comment on figurative language in the interactive time line underneath. As the comments made were visible to any student who logged in to this activity, a collective knowledge bank was built up in the shared LMS space.

Chunk 5 – Main Room
Creative Arts approach to teaching poetry – when students "came back" to the class after their independent work they were given a short overview of a step by step scaffold. This learning sequence was used to stimulate awareness of deliberative cumulative planning.

Chunk 6 – Main Room
Poetry resources – in the second last chunk of the tutorial we provided an overview of multiple hyperlinks for students to explore after class.

Conclusion – Breakout Rooms
Collaborative lesson planning - students discussed the relevance of what they'd learned. They used the "help" function to call tutors in to the room if they needed advice, which stimulated reciprocal, collective and supportive dialogue.

By the end of the tutorial the "through thread" of dialogic learning about poetry had been maintained as we layered up different ways of making meaning across multiple platforms. PST wrote to me in the chat line as we wound up the tutorial to say how much they'd enjoyed themselves and how richly engaged they'd felt across the entire time. In these times when distance is experienced physically and enforced technologically, we need to reconfigure our teaching spaces to enable human interaction in ways that join potentially disconnected "episodes" of learning together.

This quote from a PST reveals their explicit understanding of how the interplay between different spaces and joint activities operated in terms of pedagogic design to increase their engagement:

> "I think the way that the activities are scaffolded and how you go through everyone, forces us to be involved in each activity and to share. And you actually asked to see the work [from break out rooms in the main room] compared to just visiting the group chat and leaving it again".

It seems the interactive learning design connecting individual Breakout Room activity into Main Room discussion was positively regarded.

Example 2: The Travelling Letters (Andante Moderato)

Teaching about children's literature in pre-service teacher education is quite rare, even though research shows it is crucial for teachers to be good at teaching reading as well as being committed readers (Commeyras et al., 2003). Emphasis on the reading process can sideline the importance of talking about quality literature to engage students in reading (Simpson, 2016). In my teaching I deliberately embed discursive exploration of children's literature to help students "nurture and grow children who can read, who do read, and who love to read" (Dwyer, 2015 p. 73). I have reframed the role of talk about books as a core part of our undergraduate degree. In this way, the potential of the "fiction effect" to improve student engagement with reading (Jerrim & Moss, 2019) is fostered for my current students and their future pupils.

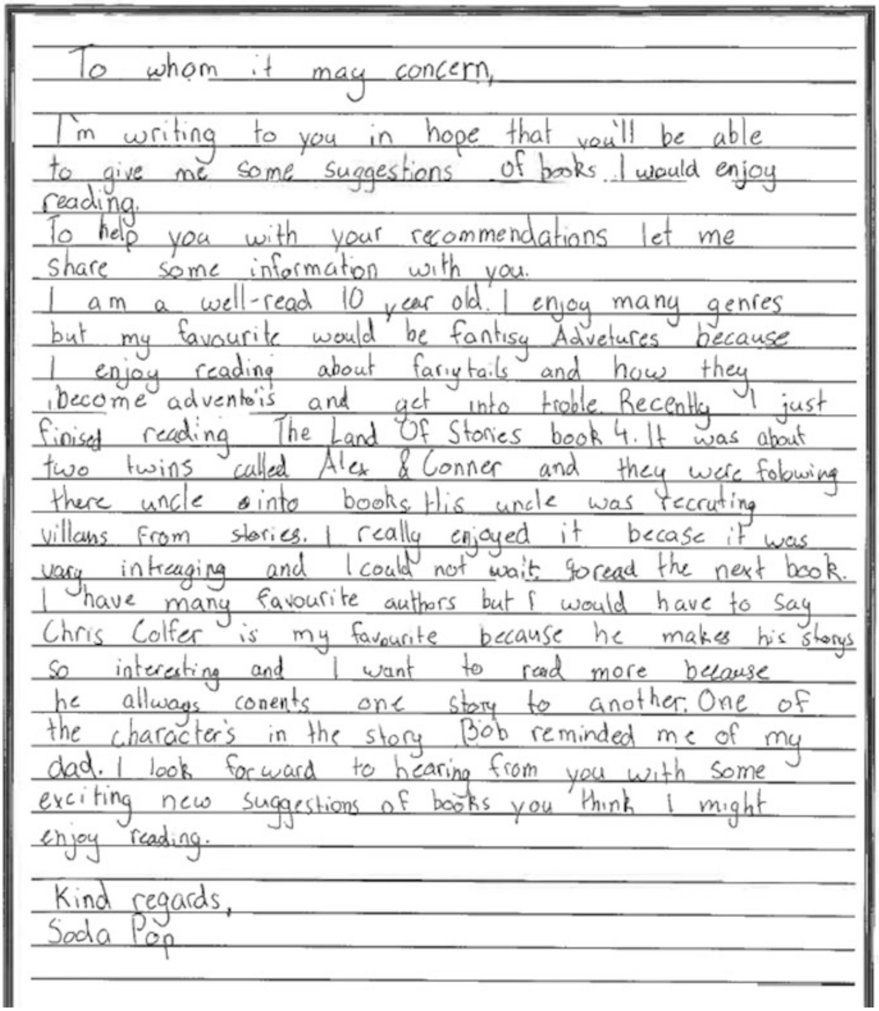
Example 2 describes how I set up partnerships with some local schools to create authentic interactions about children's literature through a program where university students received letters from primary school children in which they wrote about their reading preferences (see Fig. 3). These letters were shared with the PST students and embedded as core learning resources into the unit to scaffold students' developing knowledge of literacy pedagogy through different small group activities involving dialogue. As with the poetry example above, the letters informed purposeful discussions on numerous topics and the iterative use of the letters led to cumulative learning about the school students and how they might best be taught.

Figure 4 offers a visual depiction of the sequence of activities prompted by the letter exchange tasks, which went as follows.

Prior to semester start: Letters collected from schools and uploaded onto LMS for PSTs to read.

Week 2: Letter analysis 1 – individual PST downloaded 2 letters from the LMS and annotated them before coming to the tutorial, which was held on campus. During the tutorials, small groups of 4–5 PST discussed the book knowledge, literary preferences and opinions about reading revealed in the children's letters. Each small group created a shared data base of information writing on large wall posters that were digitally photographed for sharing across personal spaces. (See Fig. 5)

Week 6: Letter analysis 2 – individuals annotated their 2 letters before the tutorial for language features. In tutorials, which were held on Zoom, small groups of 4–5 PST discussed, graded and moderated the children's letters using syllabus indicators for writing. Each small group revised their shared data base.



To whom it may concern,

I'm writing to you in hope that you'll be able to give me some suggestions of books I would enjoy reading.
To help you with your recommendations let me share some information with you.
I am a well-read 10 year old. I enjoy many genres but my favourite would be fantisy Advetures because I enjoy reading about fariy tails and how they become adventoris and get into troble. Recently I just finised reading The Land Of Stories book 4. It was about two twins called Alex & Conner and they were folowing there uncle into books. His uncle was recruting villans from stories. I really enjoyed it becase it was vary intreaging and I could not wait to read the next book. I have many favourite authors but I would have to say Chris Colfer is my favourite because he makes his storys so interesting and I want to read more because he allways conents one story to another. One of the character's in the story Bob reminded me of my dad. I look forward to hearing from you with some exciting new suggestions of books you think I might enjoy reading.

Kind regards,
Soda Pop

Fig. 3 Initial letter from school student

Week 10: Letter writing – PST wrote back to the children with recommendations for books to read, matched to diverse children's needs and interests and suggestions to improve their writing. The letters were posted to the LMS (See Fig. 6.)

Weeks 9–11: Pedagogic rationale – Each small group used their data base of information to compare children's needs across a set of marked up texts. The shared knowledge was used as the basis of PST's collaborative lesson planning to teach writing. In Week 11 each small group met with their tutor on Zoom to discuss the pedagogic rationale behind their planning.

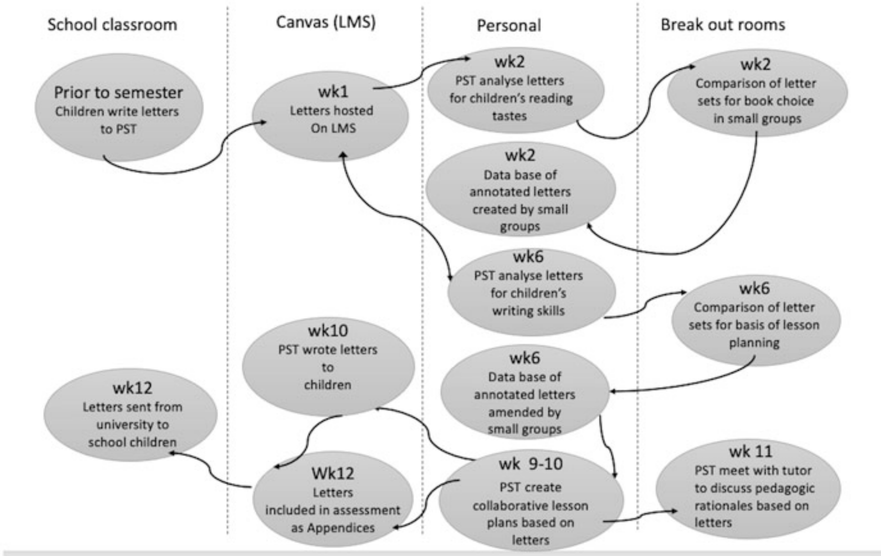


Fig. 4 Layering learning through movement across space and extended time

Week 12: A report based on the pedagogic rationale was submitted to the LMS as a group assessment. The lecturer cross checked letters for appropriate language and content and sent them back to the schools.

In Fig. 4 the main kinds of spaces used for the activities are represented by the four columns. Arrows show the movement of the material/digital letters across spaces and from one activity to another. Each activity is labelled with the week in which it occurred, to represent the temporal flow.

Across semester, the approach taken to use and re-use the letters for different purposes helped bind together our tutorial groups with their letter "buddies", stimulated the cohort to develop insights into learning to teach writing and gave them multiple opportunities to build coherent lines of shared understanding. Given the complexity of dialogic interaction necessary between tutorials, the reliance on personal engagement in hybrid spaces was higher in Example 2 than in Example 1. The highly deliberative pedagogic rationalisations were supported by appropriate technologies including Zoom meetings, screen sharing, break out room discussions, as well as upload of files through Canvas, Google docs etc. and discussions in privately curated spaces that took the place of in-class group work and handouts. Sadly, the letters written back this year weren't on brightly coloured paper sent in physical envelopes, but – as seen in the extract from a teacher's thank you letter below – the children and the classroom teachers were very excited to hear back from the university students.

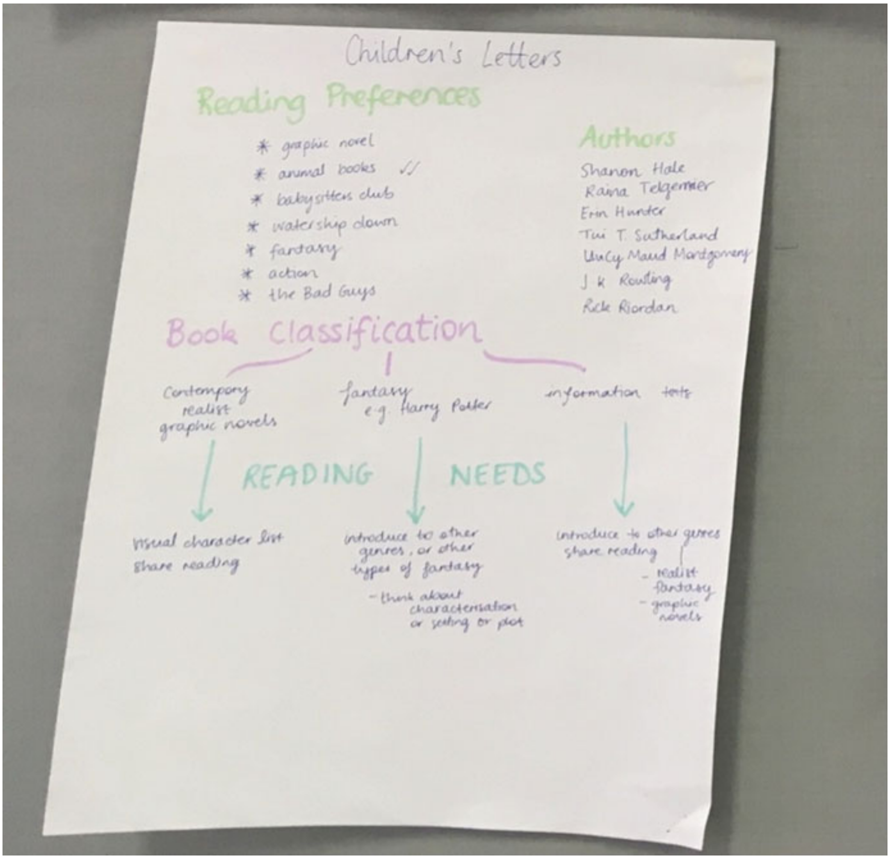
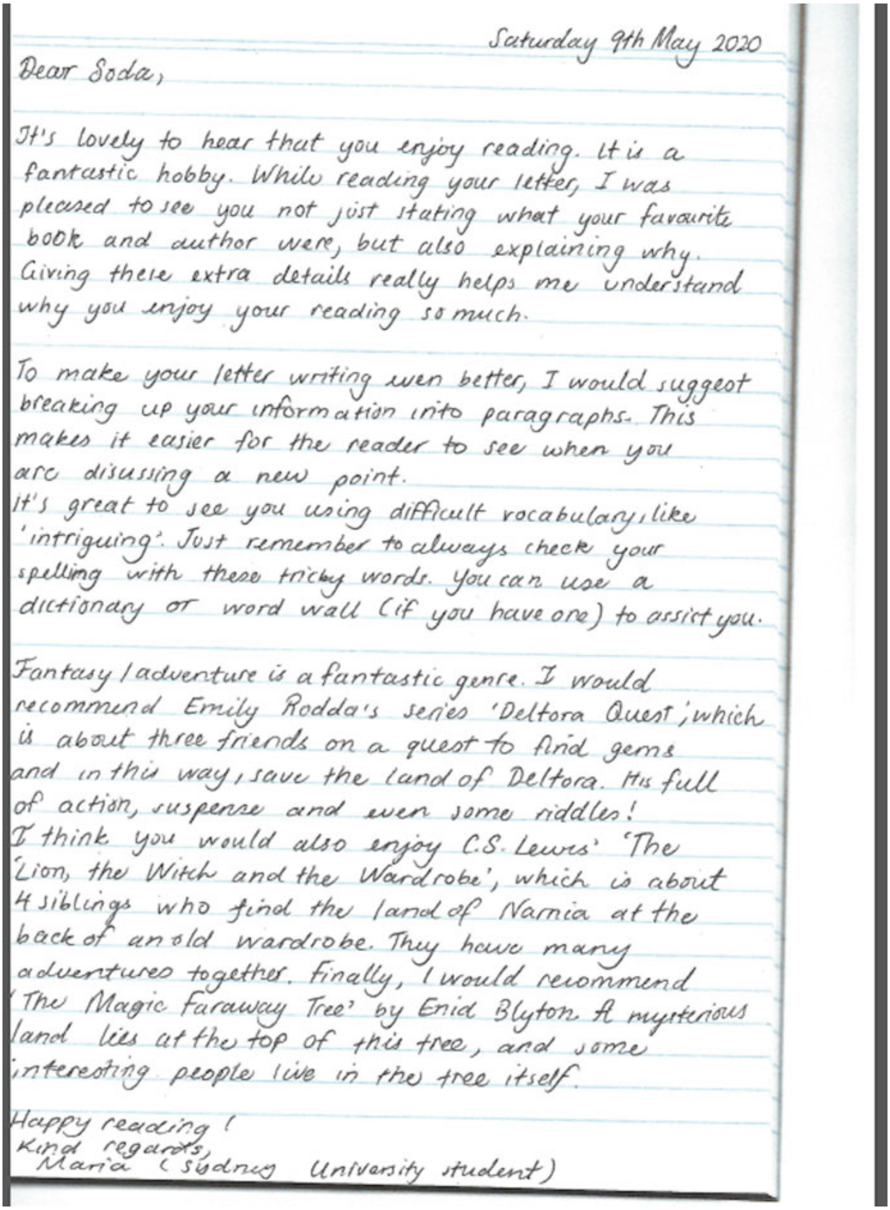


Fig. 5 Classroom wall chart with epistemic prompts for small group discussion

> Hi Alyson!
>
> The students absolutely loved receiving their letters!! Was very cute watching their excitement and engagement in reading what the Uni students had written to them!

The intent of this learning sequence was to teach PST to "enact ambitious teaching" (Kosnik et al., 2017, p. 60) as they learned how to teach reading with children's literature through a dialogic approach (Alexander, 2020). The iterative discussion of children's letters encouraged *habits of noticing* (Simpson et al., 2020) as pre-service teachers' learned about their students, learnt from their students, and took a more holistic view of the teaching of reading.



Saturday 9th May 2020

Dear Soda,

It's lovely to hear that you enjoy reading. It is a fantastic hobby. While reading your letter, I was pleased to see you not just stating what your favourite book and author were, but also explaining why. Giving these extra details really helps me understand why you enjoy your reading so much.

To make your letter writing even better, I would suggest breaking up your information into paragraphs. This makes it easier for the reader to see when you are disussing a new point.
It's great to see you using difficult vocabulary, like 'intriguing'. Just remember to always check your spelling with these tricky words. You can use a dictionary or word wall (if you have one) to assist you.

Fantasy/adventure is a fantastic genre. I would recommend Emily Rodda's series 'Deltora Quest', which is about three friends on a quest to find gems and in this way, save the land of Deltora. Its full of action, suspense and even some riddles!
I think you would also enjoy C.S. Lewis' 'The Lion, the Witch and the Wardrobe', which is about 4 siblings who find the land of Narnia at the back of an old wardrobe. They have many adventures together. Finally, I would recommend 'The Magic Faraway Tree' by Enid Blyton. A mysterious land lies at the top of this tree, and some interesting people live in the tree itself.

Happy reading!
Kind regards,
Maria (Sydney University student)

Fig. 6 Reply from PST

Hybrid Spaces and Dialogic Teaching: Our Joint Analysis

There is much that could be said about the educational activities just described, but we will focus on just four areas. We draw on the two Alexanders for some ideas about (i) the layering of dialogue(s) and the juxtaposition of modes and surfaces, (ii) shifts between dialogic activities in plenary, breakout and other kinds of spaces, (iii) negotiating boundaries and transitions between personal and shared spaces and (iv) the letters as both travelling artefacts and anchors.

The Extended Classroom Space

Though classrooms are not usually associated with choreography, the dynamic, iterative moves designed for use in the extended classroom space described above encourage this analogy to be developed. Settings for and forms of dialogic interaction were deliberately designed in with flexibility adopted as a contingent necessity (Michell & Sharpe, 2005) given the unknowns of teaching fully online. We have set out in Example 1 the use of chunking to illustrate the steps taken in one lesson and in Example 2 the use of travelling artefacts to illustrate complex movement across a semester. Here we will briefly outline how dialogue was layered up in these collective learning episodes through a wide variety of transactions that created hybrid learning spaces. The social aspects of Robin Alexander's Dialogic Principles (2020) - collectivity, support and reciprocity - were well scaffolded. The intellectual aspects – deliberative, purposeful and cumulative dialogue – were more difficult to establish, but traces can be found.

Face to face (f2f) teaching usually refers to situations where students and teachers are in the same physical space. With the rapid switch to Zoom, it strikes us that the definition needs revisiting: one manifestation of the teacher's presence in Zoom is as teaching "in your face". This consideration aside, the rationale for f2f discussions in the first few weeks of Alyson's teaching was to encourage students to share the individual impressions they each had of the letters from children. Dialogue was purposefully directed towards identification of writing support and a tally of student reading preferences. This initial conversation focussed largely on *physical* artefacts and previewed emerging tutorial activities and a major assessment task. It set the context through which students began to get to know the children's learning needs by reading their words and listening to their voices. Large pieces of paper served as epistemic prompts, curating ideas that emerged as students discussed sets of letters in person and incorporated comments written prior to the tutorial as annotations on individual letters (Fig. 5).

After the shift to the Zoom classroom, students found other ways to share learning artefacts including creation of Google docs, chat recordings, and screen shots. Dialogue was prompted through interaction that relied on interpolation of theoretical literature, curriculum documentation, professional standards, literary resources as well as activity templates. By working with all these different online prompts, students shifted dialogic perspectives from novice to expert, from peer to professional colleague. Students worked through experiential learning and critical reflection dialogically. In one activity, they were discussing the rhyming scheme of poems as they wrote them, and in the next, their awareness of syllabus requirements for teaching poetry in primary schools. Each shift of focus led them to deeper cycles of consideration so that by the end of the semester the cumulative benefit of learning in this manner was visible in the students' capacity to defend their pedagogic rationales in writing and in small group interviews.

Christopher Alexander talks about *design patterns* as solutions to recurrent problems and a *pattern language* as a way of representing an assemblage of patterns, brought together to tackle some larger problem (Alexander et al., 1977). The discussion above leads us towards a conception of a pattern language to represent a classroom configured for a certain kind of dialogic learning and teaching. The classroom provides common ground for dialogical activity, in which a group of students, with or without teachers, comes together for a time, to work quite intensively. The classroom is furnished with digital and material artefacts that play crucial roles in the activity (e.g. as shown in Figs. 1, 3 and 5). These artefacts can stand in different productive relationships to the dialogue, and have (multimodal) affordances that prompt and support different aspects of the dialogic activity. They may act as shared points of reference – as inputs to, or anchors for, the discussion. They may be transformed as the dialogue unfolds. As the image in Fig. 1 reveals, some of the artefacts accessed in the classroom themselves have quite complicated spatial characteristics and affordances, such that they merit the epithet "hybrid". The PST's annotations in Fig. 1 connect segments of an audio recording of a child talking about literature with theoretical ideas encountered elsewhere in the PST's curriculum. The annotations are depicted on a horizontal timeline, but can also be browsed, read and discussed in other ways. The children themselves cannot be present, but a trace of their talk furnishes the classroom and enables the PST to weave together language and ideas that connect real children's voices to theory, to future teaching practice and to imagined future classrooms. The unexpected shift to Zoom classrooms is, in part, enabled by the way that patterns within the pattern language cling together, and can migrate together, into a different landscape.

Hall and Side Rooms

The combination of a plenary "hall" (the Main Room) and adjacent side rooms (Breakout Rooms) is familiar – from educational architecture and from the layout of conference facilities. In Alexander's terms, each of these two kinds of spaces is itself the resolution of some shaping forces, and so is the combination of the two.

A plenary space allows and affords dialogic activities in which, for example, all the participants have the chance to know they are partaking of the same dialogue, a teacher can economically address all the students about important matters (guidance for the next task; recapping on the task just completed), group rapporteurs can share outcomes with the whole community, and so on. In the Main Room spaces, which are supposed to encourage collective, supportive and reciprocal dialogue, students often speak less frequently than in Breakout Rooms. Therefore, there is more evidence of the teacher adopting purposeful, cumulative and deliberative moves in the Main Room to scaffold interaction towards intellectual exchange.

By contrast, the nature of Breakout Rooms - created as multiple smaller spaces - offers richer dialogic affordances for individuals working in groups. Somehow, even though the physicality of the student's "home" location does not change from Main Room to Breakout Room, a sense of reduced space is created by the increased intimacy of fewer people - fewer faces and/or log in screens - being simultaneously visible. This altered social grouping encourages students to "come out of hiding" (or turn their cameras on) as hierarchical power relations between teacher and student are reduced and interactions are set up as more equal: peers are speaking to peers. Smaller groups allow more people to contribute, speak, lead, suggest ideas, and so on. This also helps students learn to listen to a multiplicity of voices. Therefore, there is more evidence in the Breakout Rooms of collective, supportive and reciprocal dialogue as peers help each other work towards the knowledge construction set up by tasks.

It's not just the qualities of these two kinds of spaces that are important, but also the ease and speed of movement between such spaces. In the Zoom sessions in Alyson's poetry tutorial example, transitions between spaces are virtually instantaneous. In contrast, shifts between physical spaces are often so time-consuming and disruptive that teachers will organise small-group tasks within a plenary space. This disadvantages students who have soft voices as well as those who are hard of hearing. But Zoom also cuts out those special opportunities for serendipitous talk that come when walking between physical spaces. That said, we note that students are learning to invent novel communicative practices and to adapt formally-provided and other spaces to suit their own needs. When students are given access to social and intellectual tools and provided with opportunities to interact dialogically, they are enabled to co-construct knowledge in unexpected interstices.

Negotiating Visibility and Privacy: The Adjustable Width/Opacity of Zoom Windows

Christopher Alexander has much to say about boundaries, transitions and relationships between adjacent spaces. He draws attention to the need to reconcile privacy and conviviality, personal and public, secret and open. His analyses help us understand the functioning of a "private terrace on the street", alcoves off a shared living space, "half-private offices", welcoming reception rooms and "child caves", to name just a few examples (Alexander et al., 1977). Consider how this can play out in Zoom. Depending on protocols, preferences and bandwidth, a student participant in a Zoom-based class might:

1. Contribute only through a text-based chat
2. Mute their microphone and listen but not speak
3. Use their microphone but keep their camera switched off, and show a name or pseudonym on the shared screen
4. Use their microphone but keep their camera switched off, and show a photo – of themself or something they like or something that represents them or how they feel on the day, or that has some other connotations relevant to the course
5. Turn their camera on, and use an artificial background (which may or may not represent some other place, that may or may not be important to them in some way)
6. Turn their camera on, to reveal the room in which they are working – which may be specially furnished and arranged for this purpose and closed off from the rest of their flat, house or building.
7. Turn their camera on, to reveal the room in which they are working and any other spaces, people or pets that happen to come into view.

Crook (2002), Gallagher et al. (2017) and Gourlay & Oliver (2018) report detailed investigations of how university students reconfigure their home study spaces when they are participating in networked learning. Practices and preferences vary considerably, and for many are heavily constrained by the needs of other people with whom they live. The success with which a personal study space can be assembled and (at least temporarily) defended is likely to have strong implications for students choosing options 6 or 7 from the list above.

Thinking now from the points of view of others participating in the course, each of these seven options alters the world from their perspective. Each decision about how visibly present to be is made manifest on other people's screens. In smaller and larger ways, each person's actions reconfigure the hybrid space(s) in which they are working. There is a lot of heated debate, at present, about whether or not students should be required to turn their cameras on in Zoom-based classes. There can be very strong arguments, and strong feelings, concerning issues of privacy and surveillance. We do not want to comment on those arguments here, but we do want to make the point that the configurations of these shared spaces can be consequential – for shared sense-making and relationship building. Spatial configurations rarely determine what can be done, but they can influence what is done, sometimes in subtle ways that are not noticed. Spatial configurations can make it easier or harder to enact each of Robin Alexander's six principles. For example, Breakout Rooms enhanced reciprocal learning but could have worked against shared understanding across the whole cohort, without deliberate planning for cumulative impact. In the case of the poetry writing, nine small groups worked with one poem template each but because a communal Google document was created and subsequently discussed, every student gained knowledge of all formats.

Synchronous, group-based audio and video communication across the Internet is still in its early days. The tools that help us create different kinds of spaces, and our ways of making and inhabiting these spaces, will doubtless change quite quickly, altering beyond recognition. And yet it feels important to develop a sharper sense of what is at stake, when the tools and spaces change. As human animals evolving in material worlds, we have developed senses and sensitivities that are important in understanding social interactions and relations between places, people and ideas. Much of this is tacit – we recognise something is different when interactions break down, and it may take a while to appreciate spatial qualities – such as position and perspective - that make a difference. The poet, Alexandra Teague expresses a similar point this way:

> "But what I learned most of all—so foundationally, I didn't even know I was learning it until years later—was about *inhabiting perspective*: knowing I was in a room with other people and a certain heat of their opinions, and their voices, and my body and my words, and maybe a bookshelf to my left, and a door that opened to a hallway, and all the doors inside us that opened to personal and collective pasts and other places. ... I mean perspective in the visual-art sense of shared space in which objects reside, of lines that rely on a vanishing point; perspective that, if we're paying attention, makes us aware of where we're situated and where we are looking and why." (Teague, 2020, 1–2, emphasis added. Teague is reflecting on the Stegner Workshops on creative writing, run at Stanford by the poet Eaven Boland.)

Letters as Learning Artefacts That Both Travel and Anchor

We make two further complementary points, raised by the use of the letters across the semester. The first concerns the role of the letters themselves in connecting and enriching learning spaces. The second emerges from the *contents* of the letters, which we use as a springboard to talk a little about imagined fictive worlds and their real representations: a topic which takes us back to the broad "questions for the HLD research field" that we sketched at the start of the chapter.

The letters can be interpreted as *traveling artefacts* – moving between spaces, connecting different spaces through time and helping constitute an extended, hybrid learning space. We can also think of them as *anchors* – such that the PST's thinking and discussions were thereby tethered to another, or a wider, reality.

At a minimum, there's an extended hybrid space to account for – one that involves:

- the children's schools and classrooms - in which they write the letters, read books, are guided by their teachers, etc.
- their homes - in which they also read
- the spaces in which the PST are reading, considering and discussing the letters
- imagined worlds – in the books the children mention; PST's future classrooms, etc.

The letters written by the children to the PST, and later by the PST back to the children, create an extended hybrid learning space that functions, in part, because of the way it resolves two competing sets of forces. These forces are endemic, and widely recognised, in education for the professions. One set arises from "the world of work" and the other from academia.

One approach to teacher education is to learn "on the job" – through observation and "pitching in", through apprenticeship and mimesis (Rogoff, 2014; Billett, 2014). Following such a model, PST spend little if any time in discussion with university academics or their peers in other schools. An underpinning assumption is that the knowledge of most value to PST is already located in the school in which they are apprenticed. The approach taken at the Sydney School of Education and Social Work is different. It involves an interleaving of university-based and school-based experiences. For the discussions of children's writing, and of the books they like, PST *might* take time out to visit schools, discuss examples with children and their teachers, and return to the university to share what they have learned. But the children's letters, as described in Alyson's text above, make this unnecessary – the letters travel from (multiple) schools to the university, connecting those diverse places and enabling discussion of children's writing and their reading preferences. Moreover, electronic copies of the letters allow discussion to continue, even after the rapid unanticipated shift to online.

Space also affects *what* gets discussed. To make a provocative point briefly, we turn to books the children and PST wrote to each other about. Some such books bring to life rich imagined worlds and supplement the author's prose with maps. One thinks, for example, of Tolkien's books, and maps, of Middle Earth – and of Arthur Ransome's stories set in mildly rearranged versions of the English Lake District and Norfolk Broads, or the Hundred Acre Wood, in Winnie the Pooh (Bushell, 2020; Sheeky Bird, 2014). The letters that the young children wrote referred to current literary places such as The Land of Stories, whereas the PST more often shared their own childhood reference points - such as lands at the top of The Magic Faraway Tree, the fantasy land of the Deltora Quest or C.S. Lewis's land of Narnia, accessed through the back of the wardrobe. As each of these stories relies on the reader moving imaginatively into a new, fictional place, not only were the letter writers connecting their lived educative realities about school through their exchanges but they were also making sense of learning by creating connections through shared interpretations of literary landscapes.

Maps in fiction serve a number of functions, including an assertion that geography is important – challenges in the narrative depend, in part, on spatial relations and/or the qualities of a place. When children, PST and other adults talk about stories, books and the worlds they bring to life, *shared mental maps* play a part in anchoring or scaffolding the dialogue. Real maps of fictional worlds can scaffold shared acts of remembering and speculation. So we suggest that imagined places need to be acknowledged as candidate components of hybrid learning spaces. And, thinking back to Christopher Alexander's methods for collective vernacular design – marking out and walking among imagined buildings on their real (material) intended sites – we step further and suggest that dialogues about future teaching can benefit from grounding in shared representations of imagined future learning spaces.

We have room to simply note three corollaries. First, in opposition to those who decry escapist fantasy and ersatz nostalgia, we point out that imagination is an emancipatory resource. We can escape *to* better imagined future worlds. There *are* alternatives. Second, imagined worlds allow readers to position themselves differently, to learn to look at things from altered perspectives, and to develop capacities for empathy. Thirdly, memory and imagination are brought into closer relation. Both involve mental time travel. This raises some interesting ontological questions about hybrid learning spaces – extensively conceived – and about the boundaries of shared and personal knowledge.

Concluding Points – There and Back Again In this chapter we have combined some ideas from the work of two people who have had a deep influence on the ways we think about teaching, learning spaces and design: Robin Alexander and Christopher Alexander. From Robin Alexander, we take the theory and practice of dialogic teaching. We note the teacher's intention to create dialogic spaces for students to share their thinking depended greatly on opportunities for productive interaction that necessarily incorporated the kinds of exchange (social, material and intellectual), which hybrid learning spaces made possible. From Christopher Alexander we take ideas about built forms, patterns and design solutions as embodying the reconciliation of competing forces. We also adopt his commitment to vernacular, participatory design – a set of practices that also require shared design constructs and language. Combining their ideas about language, space and learning helps us identify some valuable characteristics of hybrid spaces that afford dialogical activities and some reusable design ideas. We see how an understanding of the patterns constituting a dialogic classroom may be of practical help when the classroom itself undergoes sudden, unexpected transformation. As we stated at the beginning of the chapter, teachers must both predict learning outcomes and "by design" strategically plan for learning experiences. The capacity to reconfigure plans in response to changing tensions - brought about by student needs and situational demands - involves sharp professional vision: an acuity that can be developed with insights into the dynamic interplay of space, time and human activity. As the new teaching semester begins, Alyson is revisiting the learning design and considering adaptations to the learning spaces. In Tolkein's words – she has gone 'there and back again". This recursive turn is made possible by our identification and close examination of the architectural configurations that were at play. Our chapter has offered some lived "hybrid" educational experiences, which may now be explored by others, in a dialogue informed by practice and theory. We encourage colleagues to continue to imagine: what next, and where?

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Design for Balance: Addressing Challenges of Safety, Privacy and Identity Management in Online and Hybridised Learning and Teaching Spaces

Steven Warburton and Mark Perry

Introduction

Hybridised Learning Spaces continue to evolve and have undergone a generation of change over the March to October 2020 period following the exigent requirement for educational responses to the COVID19 pandemic. Primarily these have seen the use of online services to deliver the learning experience to replace face-2-face experiences. Although networked learning is not a new concept (see Hodgson et al., 2014) this has brought to the fore, especially for those learners who have been primarily engaged with in-person classes, some of the issues that are inherent in an online environment. Here we focus on privacy, safety and identity, and offer five design patterns that speak to reducing concerns and improve approaches to managing these three challenging areas that are highlighted as we transition from one type of space to another. Where many previous papers have dealt with the crossovers between space design and pedagogy (Ellis & Goodyear, 2016; Kohls, 2017; Köppe, 2015, 2017) this chapter privileges the importance of the online space for learning and the role that identity construction, privacy and safety play in grounding effective teaching and the notion of digital placemaking.

The value of using patterns to consolidate approaches to design solutions was popularised in the mid-1970s, in particular by Christopher Alexander where he developed the first pattern language for architectural design. Each pattern is stated as a problem, and is in a standardised form, made up of the title, problem statement, context and solution (Alexander, 1977). In the mid-1990s the software developer community started to adopt the Alexander style to portray the themes that reappear in different domains and for multiple software design instances. Software patterns and pattern languages became a vital force in software design solutions, and a

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series of Pattern Languages of Programming conferences continue today.[1] It was not long afterwards that the usefulness of patterns in the educational domain was recognised, and several key publications have become standards, especially in the area of hybrid learning environments and where technology is a key feature. For example, Goodyear & Retalis, 2010; Mor et al., 2014.

Background Concepts

This section explores and unpacks a number of the key concepts that form recurring themes throughout this chapter. They also underpin the shape and direction of the forces that the design patterns address in the later core section.

Place and Space

The concept of place has traditionally been grounded in geography and generally defined as location plus meaning. In our modern hyperconnected modern world the notion of both space and place have become disrupted. The previously recognisable boundary between virtual and real has become increasingly blurred, for example in the increasing sophistication of new technologies with Augmented Reality, where three-dimensional real world has an additional virtual computer-generated overlay, as well as eXtended Reality platforms (Schmeizer, 2020), and three-dimensional computer enhancements of static objects. Examples include Pokémon Go for gaming, systems for military combatants; see (Chong, 2018), (Champney, 2016), (Fillios, 2021). Space is often treated as undifferentiated and only becomes a 'place' as we get to know it and in that familiarity endow it with value (Yi-Fu Tuan, 2001). Of particular interest here is the crossover between digital and physical space and the opportunity this affords for digital placemaking as a sense of place is developed (Vali, 2014). Here, hybrid space exists as a conceptual instrument and becomes the location where digital placemaking happens: where people's attention is on the fusion of the physical and digital worlds. In turn, hybrid space brings together the physical and digital worlds to enhance the experiential value of both. It blends different concepts of space, such as physical and digital, and enables hybrid pedagogical approaches. Finally, to define or make visible space one must be able to move from one place to another (Yi-Fu Tuan, 2001).

[1] For example, Mark Perry contributed to the 2002 PLoP conference at Allerton Park University of Illinois at Urbana-Champaign, https://www.hillside.net/plop/plop2002/proceedings.html, and the 28th PLoP conference scheduled for 2021.

Privacy

The attention paid to privacy has developed rapidly over the last fifty years, but historically it was slow in developing as a protectable concept of its own, but ideas of the “home as private space” emerged occasionally in the jurisprudence. In the eighteenth century, Lord Camden, Chief Justice in England, pronounced “We can safely say there is no law in this country to justify the defendants in what they have done; if there was, it would destroy all the comforts of society, for papers are often the dearest property any man can have”.[2] At the end of the nineteenth century privacy was famously summarised as “the right to be let alone”,[3] a concept that continues to today as a summary of the rights protected in the Constitution of the United States of America.[4] Since the widespread introduction of data storage in digital devices by the state (1960s), corporations (1970s) and now even individuals (1980s), more focus is being brought to bear on restraints on the use of personal information with regulation being introduced at national and international levels. Some nations were slow to embody concepts of privacy into their laws, but recent moves have been aimed at controlling what are seen as the excesses of use of digital information.[5] International treaties and conventions will often have statements such as “No one shall be subjected to arbitrary interference with his privacy, family, home or correspondence, nor to attacks upon his honour and reputation. Everyone has the right to the protection of the law against such interference or attacks”.[6] Today the majority of nations have their own privacy legislation that aims to shield individuals from unwanted interference in their ‘personal matters’.[7]

In learning environments, the change from physical places to virtual spaces has had a strong impact upon the concepts of privacy for the individual. In pre-internet ages, for example, it was common for universities to put up a list of exam results with the names of the students and their mark on a notice board. This was not considered a problem, but the distribution of that information was physically limited to those on campus at that posting site. Even in such physical distributions, which are now rare, an appreciation of the value to the individual of identity and information has shifted, with anonymised list becoming the norm.

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[2] Entick v. Carrington, 1558–1774 All E.R. Rep. 45.

[3] The Right to Privacy, Warren and Brandeis Harvard Law Review. Vol. IV December 15, 1890, No. 5

[4] “The Constitution of the United States”, Section 2, Article III.

[5] Such as in the General Data Protection Regulation, European Parliament and Council of European Union (2016) Regulation (EU) 2016/679. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32016R0679&from=EN

[6] United Nations UDHR 1948 Article 12.

[7] In 1980 the Organization for Economic Cooperation and development, issued “Recommendations of the Council Concerning Guidelines Governing the Protection of Privacy and Trans-Border Flows of Personal Data” which offers a set of principles, not enforceable, but that have been enacted into many different jurisdictions.

Sometimes one of the key standards for the development of new digitally based systems, whether using learning management systems, assessments driven by the need for invigilation, and pursuing interactivity has been either forgotten or lost in the rush to accommodate the need for non-physical learning spaces. The need for 'privacy by design' in engineered systems became a popular development model in the 2000s,[8] suggesting that measures for ensuring the privacy of those interacting with the system should be internalised as part of the design rather than being seen as a post-development compliance with external requirements. However, this is easier to proclaim than ensure as there is always a dichotomy between trying to ensure privacy and confirm identity, for example, how can the provider of a learning environment ensure that their interactions are with the desired parties? The pandemic year, 2020, forced many changes in organisations as they attempt to rapidly adapt to a non-physical learning environment, taking on more hybridisation of learning systems, and concomitantly dealing with challenges to the modern conception of privacy.

The need to disclose private information in an online learning environment has been illustrated emphatically in the online invigilated assessment realm. There are organisations that provide invigilation of exams in real-time, so the examinee has to have a video camera watching them engage with the test, whilst the organisation collects some biometric data, from photos to key stroke analysis that examines a typing rhythm and is the keyboard equivalent of the fingerprint. Clearly such technologies which are used to ensure the integrity of the exam are also highly intrusive. Often these exams will be taken in the home of the examinee, and there is the risk that more information than that required to ensure the identity of the individual is ascertained.

Privacy laws have a role to play here, and there are some baseline requirements that are common to most jurisdictions. The 'subject' should give informed consent for the data to be collected and should be made aware of how long their data is held before deletion. There should be the opportunity for the student to 'opt-out'. This is sometimes a hard balance, because it may be that some accreditation agency is insisting on an invigilated exam, in which case the student that has opted out may not be able to proceed in her or his programme to the satisfaction of the accrediting body. There needs to be assurance that any collected data is held at a level of security proportionate to the type of information recorded. Biometric data is a particularly sensitive area, and many students worry about the use of facial recognition systems in these circumstances, despite their increasingly widespread use.[9] Also, the level of private information collected should be proportionate to the need.

[8] The Information and Privacy Commissioner of Ontario, Ann Cavoukian developed a framework in the mid 1990s with the Dutch Data Protection Authority, and the path for better systems was discussed in detail at Conference on Computers, Freedom & Privacy (Toronto, 2000), http://www.cfp2000.org/

[9] However, the use in exams is a very small incidence of such use. For example, many borders use facial recognition and passport scanning. The Australian Government is investing $250 million in upgrading its online systems to include facial recognition when accessing government services.

Safety

Having a safe hybrid learning environment, a safe space in a safe place, is also not a trivial task for those organisations that wish to deploy learning management systems for online programmes. Here, the challenge is in ensuring the ability for the students to engage safely in a meaningful and interactive manner, but without the normal physical cues that often act to dampen unsuitable behaviour (Davis, 2002). These challenges of have been explored in more detail in the design pattern language for online teaching (Warburton & Perry, 2020) where several of the patterns address the balancing of rules versus freedom within the online teaching setting. Getting to a place that balances the subjective feeling of safety with that of open exchange of ideas and information is difficult, and will vary from space to space.

Identity

Identity is a central concept in any socio-cultural account of learning. The notion of identity is closely interwoven with these ideas of safety, privacy, space and place. Many of the fears expressed in relation, for example, to the participation in online supervised examinations (see above) revolve around questions of data capture and identity. The role of identity in relation to academic achievement is also important. Murrell's (2007) situated-mediated identity theory provides an in-depth articulation of how identity is related to achievement and makes a significant connection between achievement and success as being mediated both by beliefs in capability as well as by the quality of experiences and social interactions. Indeed, learner identity develops over time in an often-complicated interaction between the discipline, environment and the teacher, for example through the way in which communities of practice are played out (Solomon, 2007; Wenger, 1998).

Design Patterns Overview

The design patterns (Table 1) described in this section have been generated in response to the critical themes that have emerged in the unpacking of the challenges (described above) that hybrid and online learning spaces pose in terms of privacy, safety and identity. The form of these patterns follows a typical Alexandrian style with a problem – solution pair framed by a context and the forces that are in tension in a particular problem space that are resolved within the solution statement. The pattern form has been extended to include consequences and where available case study notes. The mapping and methodological approach are both detailed in the sections below.

Table 1 Summary of the five design core patterns

	Name	Synopsis	Core Domain/s
1	Privacy by design	Internalise global privacy principles and norms for local jurisdiction when designing a general process or computing system to ensure privacy of participants, without detracting from its' efficacy.	Privacy
2	Permissioned aggregation	Take a defensive approach to managing your online personal data and when aggregating the personal data of others respect their rights to have some control of how their data is used and displayed.	Safety, Identity
3	Identity Placemaking	Manage your online identity by controlling social application settings to manage gradients of intimacy that determine who can access what in socially meaningful ways.	Identity
4	Safe spaces	Create a bounded space for social interaction that allows for participants to meaningfully co-create a respectful and productive environment for learning	Safety, Privacy
5	Social climate	Create a bounded space for social interaction that allows for participants to meaningfully co-create a respectful and productive environment for learning.	Identity, Privacy

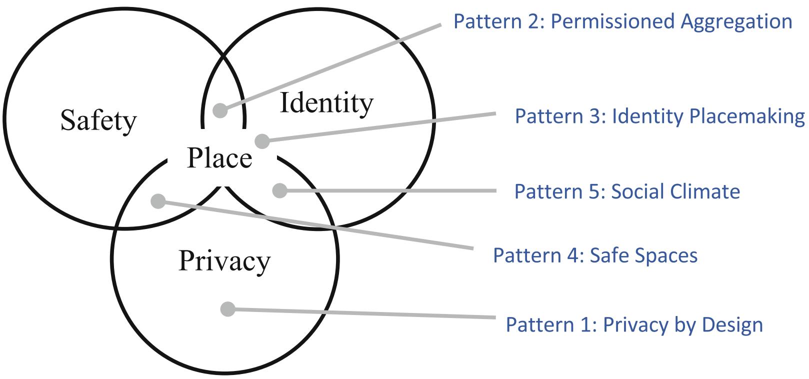

Fig. 1 The central concept of place within the overlapping elements of safety, privacy and identity as a mechanism to frame the interrelationship between design patterns

Model for Framing the Design Patterns

The relationship and mapping of the design patterns to the challenges identified is shown here with the notion of place taking a central cohering position (Fig. 1).

Methods

These patterns have been selected following two approaches. First, through the review of relevant unpublished identity patterns from previous work that have been updated to the framework above (Design Patterns 2 and 3). Second, via published literature and drawn from the experience of the authors as academics working in the tertiary education, through a series of exploratory pattern mining sessions (Design Patterns 1, 4 and 5). Following the pattern refinement protocols, these alpha state patterns have been exposed to small group workshops to validate, refactor and finalise as detailed below.

1. **Step 1:** Literature review: practice-based papers, theoretical works etc.; Explore grey literature; Mine for patterns; Outcome: An iterated a set of proto-patterns (pattern sketches).
2. **Step 2:** Workshop with expert practitioners; Use rule of three for validation; Outcome: A collection of real-life examples from the workshop participants.
3. **Step 3:** Iterate patterns from alpha (first draft) to beta (release) form; Refactor where necessary; Outcome: Linked patterns that form a basic pattern language.

Design Patterns

In this section the five design patterns are described in detail. As previously indicated, the patterns follow a defined and consistent form:

Synopsis: A short summary of the design pattern (see Table 1).
Domain: Where this pattern is located in relation to others within the framing model (Fig. 1).
Context: The outline of the particular area in which this pattern in situated, defining the scope.
Problem: Statement of the challenge that this particular pattern addresses.
Forces: Detail on the forces (issues) that are in tension within the problem space.
Solution: The measures that can be taken to resolve the forces and bring harmony to the problem
Watch out for: What are implementation issues that need to be accounted for successful resolution. What are the liabilities within the pattern?
Examples or Case Study (optional): A short summary of particular cases where the design pattern has been applied and/or would support the use of this particular design approach.
Related Patterns (optional): The patterns that are identified within and/or related patterns languages.

Pattern 1: Privacy by Design

Domain	This pattern offers insights that directly speak to matters of privacy at a general system designer level.
Context	You are designing a general process or computing system.
Problem	You want to ensure privacy of participants, without detracting from efficacy of (system).
Forces	• Restricted access to system by identity. • The level of privacy suitable for the context must be compliant with regulation. • Permissions and other data must be managed securely. • Membership constraints. • Legitimate users need to control release of their own data, but some minimum required.
Solution	Internalise global privacy principles. Internalise privacy norms for local jurisdiction. This ensures compliance with regulation (host's jurisdiction) and avoids attempts at forcing compliance on computing systems, which tend to be procrustean.
Watch out for	Complex to build in all principles and legislative requirements. System needs for information from users vary and has varying levels.
Related	Many privacy-by-design patterns at multiple levels of abstraction can be seen at https://privacypatterns.eu/ and https://privacypatterns.org/

Case Study

An example of a particular issue, highlighted within this pandemic year, was the requirement to rapidly deploy all examinations in online mode. This raised the need for 'invigilated exams' for two reasons. The first is that this was the closest mirror for the usual 'exam room' place that is setup for many students, and the other that for some accredited courses an invigilated exam is a requirement.

Providers of invigilated exams seem to have approached this issue primarily from the perspective of ensuring that the identity of the person who is sitting the exam, or a series of exams, is the person who should be sitting the exam, and provide some form off live proctoring to eliminate external 'help' for the exam sitter. The obvious solution to authenticate the exam sitter is to get students to register with the exam provider, giving some forms of identification, for example a student identity card and a driving licence with photographs embedded. The provider can then use these photos with facial identification software with a video camera for the exam.

Other biometric information can be tied to these identification points for further authentication, such as analysing the typing pattern which is individual to each person, where keystroke analysis of the hold time (the time a key is pressed) and the flight time (the hut time between keys) can be used as the 'typing fingerprint'. The provider may elect to record, save and archive such identification data that raises potential privacy concerns, which typically can then be treated as 'personal information' and subject to a security blanket and perimeter defences. This is a technological approach to the identification, authentication problem in a learning assessment environment.

This is not the best approach. A better way would be to think of the problem as one of framework. How can we ensure that examinees have protection of personal information but be identified, authenticated and 'watched' for an exam purpose? (another solution would be to design the assessment framework that doesn't require the exam setting, but nonetheless ensuring identity and veracity of submission). Perhaps using some common well proven patterns that allow for identification and authentication whilst *minimising* the storage of an individual's data that could be misapplied by bad actors.

Facial ID systems, for example, do not need the id data to be shared with the service provider, but can be kept local (e.g., Apple Pay). Other deployments such as Zero Knowledge Proofs (described over three decades ago), have been used in blockchain deployments and ensure the privacy of the payer and even the amount paid in distributed ledger interactions. Such frameworks have not been well deployed in educational assessments as yet.

There are other solutions to privacy and safety issues that arise in the educational space that have not been well adopted. Many of these relate to trust. Mostly students trust their educational institutions (EI), and most issues arise when the institutions uses another external party (EP) to provide an educational instance, whether a learning management system or assessment process. One solution would be for the EI not to use such external bodies, but it has been seen to be cost effective in budget constrained times, and sometimes the only means to deploy a resource in a matter of days. A way around this may be to adopt the Requestor/Provider/Broker model as in Fig. 2 (Aljazzaf, Z.M. et al., 2010) but empowering the EI as the Broker, with direction to the Requestor (student) to use the Provider. EIs have often failed to see themselves in the hybrid provision of services as players in a Service Orientated Architecture, but this has become clear in the COVID years.

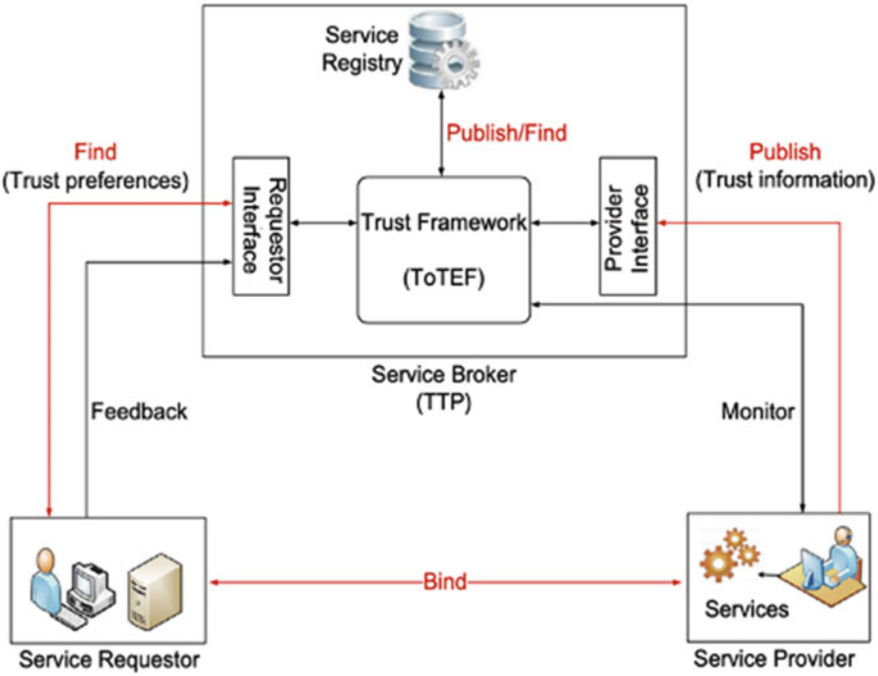

Fig. 2 Trust-based SOA

Pattern 2: Permissioned Aggregation

Domain	This pattern highlights the design requirements in addressing safety and identity concerns in the control of online personal data across systems (including learning platforms).
Context	This pattern is relevant in the context of building content-rich contact lists, social network aggregators, feeds for learning management systems, event management tools, travel planning tools and any other application where personal data is a vital component and where that personal data has been aggregated using an automated or semi-automated software process. It focuses primarily on the 'ethical' rights of the person about whom information from different sources is being aggregated. Although there are relatively solid legal frameworks in place in this area, they vary greatly by jurisdiction. The use of social networks typically takes place in a global space, and sometimes the applicability of such frameworks is unclear, which means that this pattern is concerned more with our 'norms of behaviour' than it is with the legality, or otherwise, of particular actions.

(continued)

Problem	The growth of the social web has made it easy to aggregate and publish personal content that relates to others, but we still need to manage data in ethically responsible ways, particularly when we are in trusted environments with a potential power imbalance such as in any learning and teaching setting (Abruzzo, 2009). Personal data, defined both as data created by a person about themselves and data about that person created by others, is typically dispersed across the Web and is often aggregated, either for personal use e.g., centralising an address book or for public display by those such as social network aggregators. Where such aggregation is set up by an individual and happens in an automated or semi-automated way (by using some form of software robot) the subjects of that data need to retain some influence over the use to which it is put. Any significant loss of influence may result in data that was perfectly acceptable in its original form being displayed to unintended audiences in an unanticipated context, leading to unwanted and undesirable results. Appropriate use of the data needs to be sensitive to both the context and the legal and moral rights of the user, the creator/owner and the subject.
Forces	• The commercial and/or community-driven desire to build compelling social networks based on rich and open personal data. • The commercial and/or community-driven desire to build compelling personal and public tools based on the aggregation of personal data. • The desire to protect the privacy of users of social networks and other tools (including the desire to protect users from their own actions). • The desire to help educate the users of social networks and other tools about the consequences of their actions where personal data is concerned. • The legal 'data protection' framework constraining the uses to which personal data may be put. • The (weak) legal 'intellectual property rights' framework, constraining who controls rights of usage over personal data. • The legal 'privacy' framework, constraining the conditions under which personal data can be used. • The desire to undertake social activities in close collaboration with others (e.g., a shared blog) where it may subsequently be difficult to determine how items of personal data relate to individuals.
Solution	Take a defensive approach to managing your online personal data and when aggregating the personal data of others respect their rights to have some control of how their data is used and displayed. There are two broad approaches to respecting the wishes of the person about whom personal data from different sources is being aggregated: • Respecting any attribution or licensing markers associated with the personal data being aggregated (these are usually only available in a human-readable form e.g., as text or graphics on an HTML page); • Asking permission to re-use personal data manually. Neither approach is wholly satisfactory since the first largely relies on human-readable information and the second usually relies on a manual process (though it could be automated in some cases). Both, therefore, have a rather poor fit within an automated or semi-automated aggregation environment that includes a number of well-established and widely adopted technical approaches: • Aggregating multiple RSS feeds, e.g., using freely available software/services such as a Yahoo pipe;

(continued)

	• Obtaining 'friend' information through ad hoc APIs and screen-scraping; • Sharing contact lists based on vCard and/or HTML microformats; • Searching Google for latest contact detail; As a result, the person about whom information is being aggregated must adopt defensive strategies to their personal data: • Adopting a cautious approach to personal data from the outset. Taking time to consider the consequences of personal data becoming public (e.g., being seen by colleagues, friends or family) before making it available, even within restricted environments; • Monitoring of personal data usage, either manually or in a semi-automated way, through search engine tools such as Google and twitter; • Complaining about mis-use of personal data to data owners and application developers/providers; • Blocking access to certain users (where systems allow this); • Adding licensing and attribution details to their data, (e.g., using the Creative Commons licences), and embedding where possible (e.g., in photographs). People who share personal data about others should adopt similar approaches. Note that the use of licensing-based approaches, such as Creative Commons, for the permissioned aggregation of personal data is less than ideal because the desire of the data subject is often only to restrict certain kinds of privacy-related data sharing, not a blanket prevention of re-use for other purposes. Furthermore, licences relate the data creator/owner and the data user, but do not usually refer to the data subject.
Watch out for	How others aggregate personal data about you is important because changes of context between the source location and the aggregation may result in a change in meaning of the information being shared. For example, data created in the context of a person's private life may surface in their professional life or vice versa. The situation is complicated by two factors. Firstly, while some personal data is made available directly by the subject of that information themselves, other data may be available from other sources (e.g., photographs of people taken by others and made available on Flickr) and over which the subject has less control (and possibly less legal rights). Secondly, some personal data may be generated in the context of collaborative activities, e.g. a shared blog, in such a way that dis-aggregating content by and about different people ("who said what about whom?") may be difficult. Clearly one needs to think carefully before exposing personal data about oneself on the Internet. "How would I feel if this information was to be taken and used in some other context?" is a sensible question to ask oneself on a regular basis. The Cambridge Analytica scandal provides a clear example of bad actors. Taking care of your own data is especially true before pushing personal data into a service using a shared account because disaggregating content back out may be difficult. Exposing personal data about other people deserves the same consideration. Whilst the technical mechanisms for aggregating personal information are relatively well established and widely used, the methods by which the usage of such data can be controlled are much less well defined, softer, and ultimately may not work well in all situations. Although many social networking tools have mechanisms for adjusting privacy settings, these are not foolproof, are often not even engaged, and the shared knowledge and conventions about the acceptable use of personal data typically have to be maintained outside of the particular technology in use. Furthermore, the trust required to ensure that things don't go wrong relies on both the goodwill and good practice of the creator, subject and aggregator of the personal data.

Pattern 3: Identity Placemaking

Domain	This pattern provides design insights into personal identity management in online social (including learning) spaces.
Context	This pattern is of relevance to individuals who are in the process of building their identity using multiple online social spaces. It is valuable to anyone who already maintains their online identity across distributed social (including educational) sites and feels the need to architect the way in which personal data is organised. This pattern is relevant to social application designers, for example collaborative learning platforms.
Problem	In the relatively uncontrolled and distributed content spaces of the Internet it is difficult to maintain a single sense of self. Users of the digital domain's socially networked spaces contribute to their online identity. However, current life-streaming sites such as Twitter, Facebook, Flickr result in a communication pattern that is relatively uncontrolled. How can one extend a sense of agency within the digital domain while contributing to an open approach to sharing and communicating?
Forces	• Desire to open personal data to different selected groups, such as in a discussion forum, while maintaining some control over the level of access; • Opening profiles and displaying activity across multiple sites to participate in community activities resulting in a sense of confusion and lost sense of agency as data proliferates in disconnected and sometimes contradictory ways.
Solution	Creators of online profiles must be able to control the social application settings to manage gradients of intimacy that determine who can access what in socially meaningful ways. To allow for what we term 'identity placemaking' across the internet then we need to address it in a similar framework as one might design a home; each room signifying either public or private space with gradients of intimacy attributed to each space. This concept aligns with Christopher Alexander's research on 'Intimacy Gradients'. He discusses that 'unless the spaces in a building are arranged in a sequence which correspond to their degrees of privateness, the visits made by strangers, friends, guests, clients, family, will always be a little awkward.' His method of resolution is to 'lay out the spaces of a building so that they create a sequence which begins with the entrance and the most public parts of the building, then leads into the slightly more private areas, and finally to the most private domains.' (Alexander, 1978) For the above to occur, the profile holder must be able to control the social application settings to manage gradients of intimacy. This currently can be achieved to some degree in a number of programmes, in Facebook this is in the privacy settings. By setting privacy levels the profile owner can restrict access to content within their contact lists. In Flickr, privacy settings can be attributed to images through grouping contacts as well. If the other social applications used do not allow for actions similar to favouriting or commenting to be turned off then the user may only have the choices of allowing information about them to circulate, to cancel their account, or to censor/tailor the status updates.

(continued)

	Coming back to the Alexander-type metaphor of the online home, contributing to status updates, retweeting, and commenting on blogs may increase a list of followers or improve a public network in the most public arena of one's home. This could be seen as a porch; a socially engaged space that accepts exchange between the public and the profile holder. By hosting and engaging in the space where the conversation is taking shape the identity placeholder is openly contributing to the web and adding to their profile identity. In this case it is via engagement with a public on one's own blog, Facebook page, or Flickr site, that the sense of agency develops and is nurtured. Furthermore, it is an asset in open identity placing to develop a core network of supporters. These are the people who will boost a profile regardless of situation through good or bad. They are the contacts that a user may wish to move further into the home as well, guided by gradients of trust set by the profile holder. An example of this would be a core research group who may work inside the online office space. They have access and can contribute to the porch area but they also can converse privately amongst each other. Another general example would be of a group of core contacts that has access to the online living room where games are played and small talk takes place.
Watch out for	It is in contributing and engaging with the public that the sense of agency is honed as all one's maintained identities come under one roof demonstrating a persons' interests past and present. A single person depending on the number of networks they operate within can have several gradients of intimacy moving from public to the private space within their online home. Once in the public domain it is difficult to control followers. Perhaps the best approach is to start by reading the agreement clauses in social applications in order to understand how user content is owned and distributed, to try to know your public, and to place status updates within frameworks that allow for gradients of intimacy. Thinking of how to construct the personality that you want to display before engaging in the space helps. Within the digital domain though, it is likely that someone is following my status and movement, at least occasionally from time to time. I see this act of following, with geo-graphical freedom, as a constructive method for maintaining social groups and support networks, for strengthening cultural traditions, languages, and among other things retaining a core network.

Case Study As noted in the solution above, those that create the online profiles need to control intimacy gradients within the application's framework, essentially involving control of access to various levels of online information. This is an analogy for identity placemaking, thinking of the nature of a home, which parts of the home are private spaces, and which of them are open for public access. This matches the conceptualisation behind Christopher Alexander's 'Intimacy Gradients' within a building. The conceptualisation of privacy within buildings can be managed by organising space, and thus rooms, with reference to how 'privateness' is attributed to the particular space.

In online systems this type of ranking is managed at the establishment of the settings for the particular application. This is often during the setup of online access to a specific site, although this will often be modified as the needs of users, and the desires of platform holders, change over time. It is also typical that host sites will have a privacy document, that may be updated from time to time, spelling out the various constraints on privacy. For example Flickr currently (Jan 2022 at https://www.flickr.com/help/privacy) gives a number of actions as well as jurisdiction based limitations on their policies and suggests: "you can control who is able to see different parts of your profile, including email address, IM names, real name, and current city. If you choose to use your real name (or include any identifying information as part of your 'screen name') that information will be publicly displayed through the Services. Therefore, please use caution in determining how you wish to be identified in using the Services." Other online spaces have variations on similar themes, and although it is important that users understand the limitations on their privacy in social media sites, they rarely read the privacy documentation.

The analogy of the Alexander home provides a useful perspective for some online environments, particularly with social media where the posting of personal news, tweets, comments, thoughts and pictures of people's cats often are seen as means of communicating to the public, or a large group of 'friends'. Such communications can also increase the interactions with others and generate interest and followings in the poster's networks. These are essentially public engagements where sharing is the primary purpose of the site's tools, are akin to the porch of the home, a place for generating engagement with the public. The generation of a sense of agency is a key feature of social networks, so the posters use their porches to expand public interactions. Depending on the motives and understanding of the poster these can foment positive or negative outcomes with others, and sometimes controversial postings are like an undesirable flag on the porch - just there to grab attention. There are also opportunities, as with the Alexander home, to have graduated entry into more private online realms, often based on trust and filtering by the poster - for example a space for do-it-yourself enthusiast that would be akin to the work shed, or gardening sites for those with like-minded interests.

Taking such perspectives on social sites gives a viewpoint for understanding where privacy can fit. What are the layers of entry that posters are willing to think about and maintain, and whether social media sites employ useful tools for that purpose.

Pattern 4: Safe Spaces

Domain	This pattern draws on a design approach to identity and privacy management in online social (including learning) space from an educator perspective.
Context	As an online educator it is likely that you are working with a heterogenous group of learners, mixed ages, backgrounds and abilities. It is imperative that within the learning space there is a strong element of trust and a feeling of safety to allow participants to take risks and speak to advance knowledge and learning.
Problem	Meaningful learning cannot occur in an environment where there is a lack of trust or a sense that one can safely express oneself and one's ideas frankly and freely.

(continued)

Forces	• You may have vulnerable learners in the teaching space who need extra care and attention. • Online education is often an attractive solution for non-traditional learner groups. • You may have an eclectic group in your setting based on the ease of access to online compared to in-person settings.
Solution	Therefore, use a space that allows control over who has been granted permission to enter that space. Provide discreet mechanisms that allow learners to flag discomfort so that this can be dealt with quickly. It is important that students can reflect issues to the teacher in real-time. Ensure that you have set the [GROUND RULES] (Warburton and Perry, 2020). Have a clear group agreed etiquette and agreement on the consequences of breaking that agreed ground rules of engagement e.g., banning from future sessions or being barred from a course.
Watch out for	Over policing. Avoid constraining the environment with too many rules and regulations that distract from creating the desired space for effective learning.

Case Study Students must feel they are in a safe space for a strong sense of social presence to be developed (Kreijns et al., 2003). Most online learning environment provide the functionality to bar or block users. Many environments provide a private message facility that can be used to contact the teacher. For example, the popular video conferencing software Zoom allows a high degree of flexibility in the use of chat.[10] See https://support.zoom.us/hc/en-us/articles/203650445-In-Meeting-Chat

Pattern 5: Social Climate

Domain	This pattern draws on a design approach to identity and privacy management in online social (including learning) space from an educator perspective.
Context	You are designing your learning environment to cross both physical and virtual spaces. Learning and teaching does not exist in a vacuum, rather it is situated in the meaningful interactions between teachers, students, and peers.
Problem	A successful learning experience is often formed through a series of coherent and connected sessions that build positive communities over time. Disconnected and punctuated experiences, for example that move form virtual to physical and vice-versa, do not allow individuals to build their relationships and identity and can subdue meaningful learner interactions.
Forces	• Participants will bring their own sense into both physical and online identity into the space, perhaps derived from activity across other social media platforms. • The symbolic cultural artefacts that might be present in normal in-person teaching settings (places) are not present as reminders of place and role in the online setting.

(continued)

[10] Zoom states that private chats are not recordable by the host unless the host is a party to the private chat.

Solution	Enable consistent and sustained spaces in which learners meet and enjoy their learning and teaching experiences by purposefully promoting conversation around people's surroundings or personal objects as an [ICEBREAKER] (Warburton and Perry, 2020). Ensure that space, time, and prompts for this social (non-teaching) interaction are clearly demarcated and their purpose understood. Build a repository of social memory to lay the scaffolding for continued interaction and the setting for digital placemaking.
Watch out for	Always maintain an awareness of privacy and ensure sensitivity to learner's needs accordingly.

Case Study It is important to provide spaces that support social interaction in a meaningful manner. This covers the social interactions that occur, the established group culture, the beliefs and rules that develop, the ideals. Social presence is an important precursor to collaboration and fruitful discussion (Garrison & Anderson, 2003). Learners need to feel a link with others if they are to genuinely share ideas and exchange views. This does not mean that the focus is on social interaction or 'niceness' at the expense of intellectual exchanges; it means that learners develop trust and respect for each other, and for the ideas of others:

> [. . .] social presence does not mean supporting a 'pathological politeness' where students will not be sceptical or critical of ideas expressed for fear that they might hurt somebody's feelings and damage a relationship. Social presence means creating a climate that supports and encourages probing questions, scepticism and the contribution of more explanatory ideas. (Garrison & Anderson, 2003, p. 50)

Discussion and Conclusions The design patterns presented in this chapter have been specifically chosen to highlight differing perspectives on the complicated and multi-layered nature and role of learning and teaching spaces. And the challenges that this presents to learners, teachers and designers alike. Together they emphasis elements that are problematic when learning and teaching is hybridised and, in particular, the need to consider designs that address the challenges posed to privacy, safety and identity management. It is particularly in the virtual space where these are more acutely experienced and this perspective has been privileged in the accounts and examples presented here. Attending to each aspect is vitally important when design learning and teaching environments that incorporate a hybridised setting. In addition, with an increasingly critical focus on the spread of 'datafication' – more readily recognised in the commercial world as the representation of social and environmental worlds in machine readable format – to education (Williamson, 2020a,b; Jarke & Breiter, 2019) there is a need for design solutions that allow for pragmatic solutions to the controversial domains of, for example, the use of facial recognition (see Privacy by Design case study above) and predictive analytics with hidden algorithms that flag failure and with questionable ethics police the resulting human intervention/s (Ifenthaler, 2016).

This chapter has also raised important challenges to the traditional conceptualisation of 'space' as neutral and suggests that hybrid learning spaces can be re-conceptualised as 'places' as they become imbued with value. Here, 'place' is authentic and always socially constructed, in other words somewhere that is emotionally and personally significant. By using place as the term to replace space, it allows learning designers to access relational, emotional and comparative thinking in their designs. For example, helping to make visible those design considerations that may create places that provoke anxiety and dread versus those places in which a learner may feel comfortable and trusting.

Therefore, how do we shift from Hybrid Learning Spaces to Hybridised Placemaking for Learning and Teaching? Digital placemaking is often concerned with the harnessing of technology to deepen connections between physical locations and people (Foth, 2017; Morrison, 2020). It is an approach that offers much potential value when we consider how hybridised placemaking might function. The key ingredients of leadership, strategy, creativity, technology, collaboration, community, context and approach all combine to build an idea of the meaning of a space, and a sense of belonging for the communities who use it (Morrison, 2020) and these tropes are equally exploitable as we consider the design of our hybrid learning places.

As we open up the possibilities of placemaking it is then possible to return to key themes within the design patterns that have been presented. For example, safety and comfort can be afforded through design considerations that address what can be called spaces for lurking (Warburton, 2013). Using a related theory on landscapes called "Refuge and Prospect" (Appleton, 1975) it is possible to consider the value of design actions that create spaces that allow quiet observation before participation.

> In 1975, Jay Appleton proposed a novel theory to explain why landscape has such an aesthetic impact and has recently provided a supplementary. He argues that, due to evolutionary circumstances, human beings spontaneously experience the landscape in terms of the opportunities it offers for them to 'see without being seen'. A deep-seated behavioural mechanism has been inherited, underlying superficial tastes and preferences, that enables humans to find pleasure in distinguishing landscape features that provide points of vantage — prospect — and those that furnish security — refuge — from various hazards that threaten life, limb and comfort. In the modern world prospect, refuge and, in particular, hazard may often be symbolic rather than real. For example, features in the landscape may sometimes convey the idea of danger, without posing an actual threat to safety. (Clamp and Powell, 1982)

With these additional observations it is possible to advance the original pattern framing model presented earlier to one that becomes more refined (Fig. 3).

Finally, a consideration only indirectly addressed in the patterns here and in the notion of hybridised spaces is time. The effects of asynchronous and synchronous modes of learning and teaching will have specific and particular effects on how a hybridised space (or place) is conceived and experienced. For example, at an institution that is predominantly teaching at a distance but runs a regular intensive face-to-face 'summer school' will have a nuanced time-based relationship between online and physical interactions and consequently the development of learner identity (Parkes, 2014). This offers an important future lens for incorporation into any pattern language in this domain.

In conclusion. All of the patterns presented here form differing perspectives on the potential challenges to successful creation of hybrid learning spaces. The need for awareness and balance in such spaces is not 'natural' as it is (usually) in physical

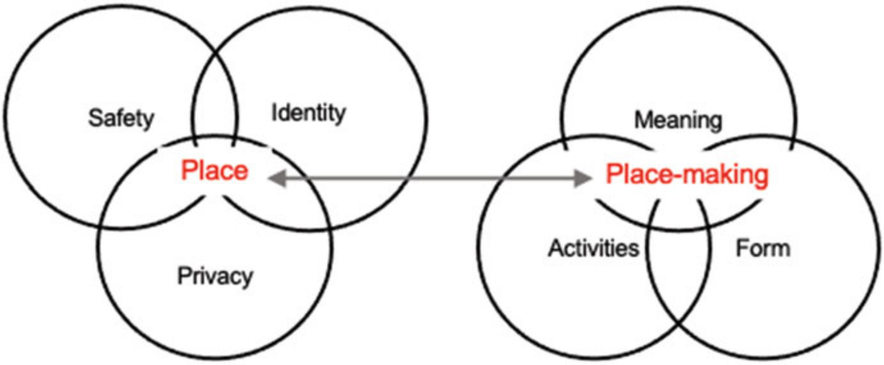

Fig. 3 The hybridised learning space reconceptualised as founded on place and placemaking. Here placemaking is acknowledged as arising from a combination of meaning (social and cultural characteristics), form (virtual and physical) and activities (transactions and flows). (See also Carmona, 2014)

engagements. The patterns here provide a thought provoking re-assessment of whether place and placemaking are the ultimate design goal for successful learning and teaching spaces to be realised and provide a productive entry point to resolving the challenges of privacy, safety and identity concerns.

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Part V
Concluding

Forward Looking: Predictions for the Future of Hybrid Learning Spaces

Yishay Mor, Einat Gil, Yannis Dimitriadis, and Christian Köppe

Introduction

The chapters of this book explore the theme of Hybrid Learning Spaces from diverse perspectives: epistemic, pedagogical, technological, architectural, ethical and organisational. They report on state-of-the-art research and practice. As is often the case in such publications, many readers might find themselves wondering what the concrete implications of these insights are, in the short, medium and long term. Are these idiosyncratic exemplars, reflecting radical research agendas, or are they harbingers of the future mainstream reality of education?

This chapter makes an initial attempt to answer this question. Given the short timeframe between the acceptance of the other chapters and the publication of the book, we adopted an agile research methodology. Admittedly, this fact questions the validity of our findings, and calls for further research. Nevertheless, we find the insights garnered in this process interesting – and believe they are worth sharing.

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The approach we applied is a “quasi-Delphi study”. The Delphi method (Hsu & Sandford, 2007) was developed at the RAND Corporation during the cold war as a method of forecasting technological developments (Rescher, 1998). It has since been used in a wide variety of domains for forecasting, policy and consensus analysis. The Delphi method is designed to elicit sound practical insights by pooling the knowledge of domain experts. In a Delphi study, a panel of experts is selected based on a set of pre-defined criteria. They are presented with a set of statements regarding the future, on which they comment and evaluate their likelihood. The facilitators define an apriori consensus threshold (typically 75–80%). When the ratio of agreements to a statement is above the threshold, it is accepted as representing the common judgment of the group. When the ratio is below the threshold, the statement is refined in view of the comments and re-evaluated. Further rounds might present the experts with additional statements, elaborating or corollary to the previous round.

Our study adopted the general gist of the Delphi method, but did not follow the protocol strictly due to logistic constraints. As an expert group, we selected the authors of the chapters of this book. We derived a set of predictions from the core claims and insights in the chapters and presented them to the expert group. The responses were interesting – both for the statements for which we achieved consensus, and for those where we did not. We therefore decided to present all these statements and their evaluations here.

Method

The authors of this chapter, who are the editors of this book, reviewed all the other chapters and elicited from them 11 predictive statements. These were presented as a survey to the other authors. An open copy of this survey is available here: https://forms.gle/AM3eGMBw9PGK1o4w5. For each statement, the respondents used a 5 point Likert scale to evaluate its likelihood, impact, timeframe (from near to far future) and their confidence in their responses. They were prompted to suggest references (both book chapters and other publications) which support / relate to the statement and offer any comment and suggestions they might have.

21 authors (61% of all non-editor authors) responded to our survey. Based on the responses, the next step should be a refinement of the statements and circulation of a second round for evaluation by the experts. This remains the subject of future work.

Findings

Our analysis of the chapters yielded 11 predictive statements. When presented for evaluation by the expert panel, 5 of these statements received a likelihood rating of 4/5 from more than 70% of the respondents, and 10 from more than 50%. In terms

Table 1 Summary of expert evaluations. Numbers indicate the ratio of experts who responded 4 or 5

Prediction	Likelihood	Impact	Confidence
1: The new normal, the new super-normal	0.90	0.71	0.62
2: Synchronous hybrid teaching practices	0.57	0.62	0.43
3: Learning design partnerships	0.62	0.67	0.57
4: Learning design and learning analytics for hybrid learning	0.71	0.62	0.38
5: Design principles for hybrid seamless learning	0.57	0.67	0.71
6: Pedagogical success of hybrid learning will need an enculturation process	0.62	0.76	0.57
7: Design for privacy, safety and identity in hybrid spaces	0.71	0.67	0.67
8: Death of the lecture hall	0.76	0.67	0.71
9: Classroom oriented sensors, digital traces and analytics	0.38	0.43	0.38
10: Adaptive/adaptable learning spaces	0.81	0.86	0.67
11: Situational awareness	0.62	0.52	0.38
> 0.7	5 (/ 11)	3	2
> 0.5	10	10	7
Min	0.38	0.43	0.38
Max	0.90	0.86	0.71

of impact, only 3 received a rating of 4/5 from more than 70% of the respondents, but 10 received a high rating from 50% (see Table 1). Note that we also asked the experts to estimate the timeframe for the realization of the predictions. However, methodologically we found it hard to provide aggregate measures for this variable and thought it would be more reasonable to present its distribution per prediction.

Considering these outcomes, at first we were inclined to present only the statements with a high rating. If we would have applied a full Delphi protocol, we would have tried to refine the other statements and re-evaluate them. However, we see value is sharing not just the conclusive findings but also the points of controversy. Academic literature is affected by publication bias and a preference for novelty. These can potentially create a tension between the academic discourse and the practical one. Trends and attitudes that might be common among researchers may be less appealing or convincing for practitioners, whether for substantial reasons or for mundane ones. With this in mind, we argue that when reviewing predictions derived from a body of literature (in our case the chapters of this book) it is worthwhile noting not only those that are accepted as high in likelihood and impact, but also those that are perceived as more speculative or esoteric.

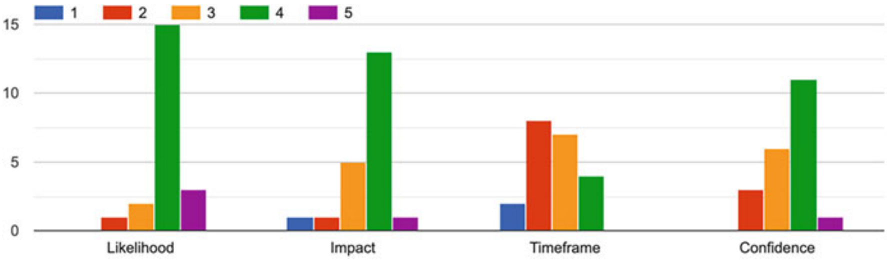

Fig. 1 Evaluation for Prediction 1: The new normal, the new super-normal

Prediction 1: The New Normal, the New Super-Normal

Likelihood 0.90, Impact 0.71, Confidence 0.62 (Fig. 1)

Hybridity has become the standard in post-COVID19 educational systems, but in the narrow sense of blended / HyFlex (dual mode, hybrid synchronous instruction) classrooms. As such, it is destined to pass through the usual stages of the Gartner hype cycle: inflated expectations, disillusionment, enlightenment, productivity. Finally, we will stop using the adjective hybrid to describe what we see as obvious and transparent. The normalisation of hybridity in the base sense of blended will open the door to hybridity in the synergetic / merged and the fluid sense - where dichotomies of formal-informal, academic-work etc. are blurred. While these more radical interpretations of hybridity (or hyper-hybridity) will never become mainstream, they will nonetheless become more common and the place for students' motivation might play a more central role in the learning process.

References: Beardsley, Albó, Aragón & Hernández-Leo (2021); Cook, Mor & Santos (2020); Eyal & Gil (2022); Fawns (2019); Fawns, Markauskaite, Carvalho & Goodyear (2021, 2022); Fleischmann (2020); Moreno-Oliver & Hernández-Leo (2020); Nørgård & Hilli (2022); Velamazán, M., Santos, P., & Hernández-Leo, D. (2022).

Interpretation and Commentary

Support for this prediction is close to unanimous among the experts. Hybridity is here to stay, and not only in the base scenario where students alternately meet at home or on campus or professors open their physical class to distant participants. Rather most experts agree with the multi-faceted hybridity in its future fluid manifestation. In contrast to the 0.91 likelihood estimate – the predicted impact is a bit more moderate (0.71), either reflecting a conviction that the impact is already present ("the new normal") or expressing skepticism regarding the prospect of alternative forms of hybridity.

Some important comments were offered by the experts. The main issue that came up related not to whether the prediction will actually happen (it will), but rather how it will be utilized in academic institutions pedagogically and structurally e.g.: How will it affect teaching and learning? What changes will transpire at the micro level, for the single teacher/lecturer/class, who see the changes and might decide to respond by integrating novel methods of teaching in her class; and at the macro level – as institutions establish centers for 'teaching innovation' and organizing spaces according to different possibilities (Mor-Avi et al., 2021). Further to that, two experts related to the motivational aspect, pointing at the balance needed to support the students (and the lecturers) well-being.

Last, one expert pointed out the limitations of Gartner's model of the hype cycle, suggesting looking at additional tools that can support innovation. Such tools might use design methodologies for co-design to support leading a change in teaching and learning in its new hybrid normal.

Prediction 2: Synchronous Hybrid Teaching Practices

Likelihood 0.57, Impact 0.62, Confidence 0.43 (Fig. 2)

Synchronous hybrid teaching practices will evolve to support students and teachers effectively in diverse scenarios. These will be articulated through representations (design patterns, activity recipes, etc.), class management tools, and creative activities that engage both present and remote participants. Educational institutions (schools and higher education) will require a deliberate organisational effort to integrate these practices into their organisational culture - with proper hardware, software, training of academic staff and curriculum adaptation. Once they complete the transition, they will open up opportunities for populations denied access to education, due to geographic or other constraints, in times of crisis (such as the COVID pandemic) as well as in normal times.

References: Bülow (2022); Morris & Stommel (2018); Gupta et al. (2021); Cook, Mor & Santos (2020)

Interpretation and Commentary

The experts' opinions on the likelihood of this prediction were more evenly spread, resulting in an overall score of 0.57. Surprisingly, the estimate of impact was significantly higher - with 12 out of 21 experts assigning a value of 4 or 5 (resulting in an overall score of 0.62).

While some institutions have been successfully incorporating synchronous hybrid teaching and learning for some time, these practices have been mainstreamed globally in the last year due to the COVID pandemic.

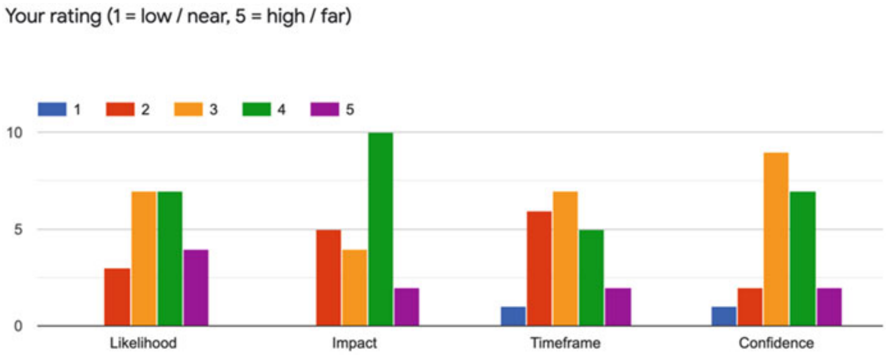

Fig. 2 Evaluation for Prediction 2: Synchronous hybrid teaching practices

However, many of the newcomers appear to be disillusioned, realising that if not implemented properly, synchronous hybrid learning is “the worst of both worlds” – synergising the limitations of both online and onsite teaching; On one hand, the teacher is constrained in utilising collaborative and active learning approaches that utilise the affordances of physical (or virtual) interaction. On the other, the need to be present simultaneously in the classroom and in a virtual environment creates a challenging cognitive load for the teacher. In light of these observations, some experts were adamant that synchronous hybrid teaching will return to its pre-COVID niche.

Nevertheless, other experts noted that this approach is aligned with an Open Education philosophy, and echoes values of equity and increasing access to education. Some suggested linking it to a “University 4.0” framework. This requires institutional, and possibly national, commitment - in terms of infrastructure and resources as well as explicit forefronting of the underlying ethics. At the base level, this depends on the availability of solid infrastructure to ensure connectivity – an issue that might be challenging at times in developed countries, not to mention underdeveloped. Thus, equality of resources might play a major role at its assimilation.

The experts voiced a strong concern regarding the pedagogical support both lecturers and students need to perform in this environment. Specifically, coherent and rigorous designs for learning in such conditions are essential, but common models are still rare. This is due to the complex, ill-structured and unpredictable conditions that hybrid synchronous teaching & learning present, the variable physical-technological-pedagogical and content knowledge to support the more/less skilled teacher. Lecturers are challenged to orchestrate dual-mode participants (from a distance and in class), and design patterns that work for small classes may be inadequate for larger ones. Finally, one expert noted the need for appropriate techno-physical spaces - and their scarcity in many institutions. Thus, the place of space regains its own importance in this form of teaching.

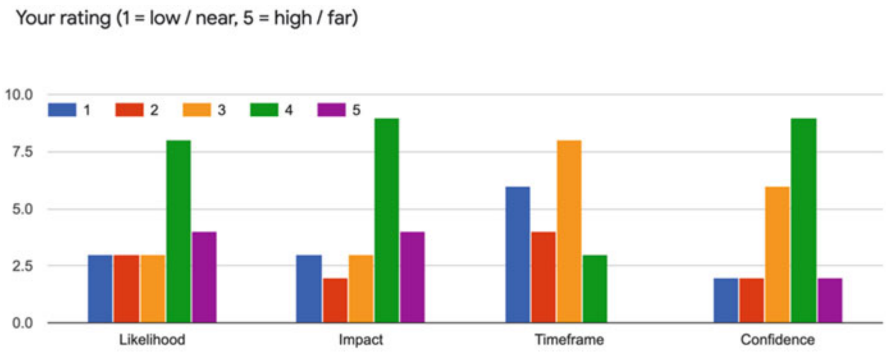

Fig. 3 Evaluation for Prediction 3: Learning design partnerships

Prediction 3: Learning Design Partnerships

Likelihood 0.62, Impact 0.67, Confidence 0.57 (Fig. 3)

The affordances of hybrid learning spaces open up vast possibilities for innovation in teaching and learning. Utilising the full potential of these possibilities requires bold experimentation and collaborative design, evaluation and re-design. Admittedly, the mainstream of any educational system will always be risk-averse and reluctant to experiment, but the margins of innovation will strengthen and in these margins we will see teacher-learner design partnerships exploring the interplay between space, technology, and educational practice.

References: Bøjer & Brøns (2022); Fawns, Markauskaite, Carvalho & Goodyear (2021, 2022); Kohls, Dubbert & Münster (2022); Greenhalgh et al. (2005)

Interpretation and Commentary

This prediction scored in the mid-range for both likelihood (0.62) and impact (0.67). While there is no debate regarding the value of learning design partnerships, the experts expressed cautious skepticism as to their viability in the current institutional atmosphere. Among the reasons for these doubts are concerns whether universities will sustain investment in good design(ers) and the fact that higher education had access to distance/hybrid learning for decades and failed to define normative practices or ethos. Some experts recognize the changes driven by the Covid-19 pandemic, raising awareness to the value of design. But these changes were imposed by the circumstances.

Others pointed out growing collaborative design activities involving teachers and students, e.g., in the Scandinavian context. But even if teachers and students acquire new digital competences that enable novel hybrid learning scenarios, there still is doubt if these competences really lead to new social and pedagogical classroom dynamics. Finally, students and teachers are limited in the innovation they can realise without the collaboration of ed-tech providers and researchers.

Prediction 4: Learning Design and Learning Analytics for Hybrid Learning

Likelihood 0.71, Impact 0.62, Confidence 0.38 (Fig. 4)

Hybrid learning occurs in multiple spaces (digital and physical), settings (formal and informal) or contexts (indoors and outdoor, in-classroom and out-of-classroom), extending the current view of mobile and ubiquitous learning. These emergent new integrated dimensions of hybrid learning pose significant challenges for the involved stakeholders, especially the instructional designers and educators. Collecting learning analytics from multiple spaces, settings and contexts will be especially relevant in order to have an integrated view of the evolution of students' learning. Such analytics may inform the learning (re)design of such complex situations, while the learning design may make the analytics meaningful to the stakeholders. The mutual interdependence and integration of learning analytics and learning design will play a major role in the upcoming hybrid learning environments. On the other hand, the power of such technologies raises complex ethical issues. Thus, academic institutions, researchers and practitioners should enable multimodal learning analytics through multiple spaces, settings and contexts, so that the integrated use of learning design and learning analytics can be made possible and reinforced in the hybrid learning spaces, while maintaining an open conversation on the ethical considerations.

References: Pishtari & Rodríguez-Triana (2022); Beardsley et al. (2020); Vujovic et al. (2020); Yilmaz & Yilmaz (2020); Wong & Looi (2022)

Interpretation and Commentary

There is a quite high consensus among the experts that a stronger alignment between learning design and learning analytics will be manifested in emerging hybrid learning spaces. Multimodal and multispace data will be collected, analysed and displayed, informing effective (re)design of teaching and learning, while addressing the associated ethical challenges. The expected impact seems to be reasonably high but in a rather long term. That said, it is worth noting the low confidence score for this prediction, suggesting that many of the experts feel less informed on this topic, or that they have a feeling that "the jury is still out on this".

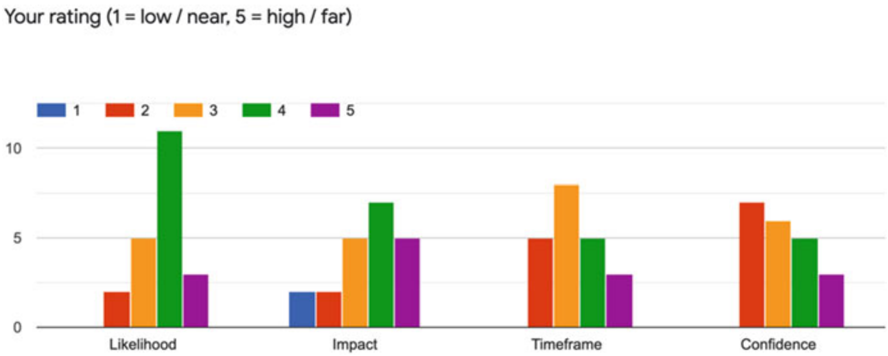

Fig. 4 Evaluation for Prediction 4: Learning design and learning analytics for hybrid learning

Experts have expressed, as with several other principles, that policy makers and administrators will play a major role in promoting and funding the corresponding initiatives. Although there are some reservations regarding the excessive dependence on technological possibilities and the eventual negative impact to creativity and innovation, there is significant consensus that such evidence-based approaches are both necessary and potentially useful. Notably, one expert suggested that providing data-based metacognitive feedback may be effective in guiding researchers, teachers and instructional designers (Yilmaz & Yilmaz, 2020). This suggestion is based on studies that have shown that such feedback results in enhanced transactional distance and motivation of learners.

Finally, several experts pointed out the "bad press" regarding multiple cases of inappropriate use of data analytics, resulting in public sensitivity to threats on privacy in all fields of our hybrid life, including education. This finding is also confirmed by the experts' high acceptance of prediction #7 regarding the need for design for privacy, safety and identity in hybrid learning spaces. However, there are also some hints that top-down policies and effective use of consent forms may enable a safe use of learning analytics.

Prediction 5: Design Principles for Hybrid Seamless Learning

Likelihood 0.60, Impact 0.76, Confidence 0.57 (Fig. 5)

Although several research studies have been recently published regarding hybrid seamless learning, both in terms of theory and case studies, robust and evidence-based design principles for implementation in the real world are necessary. Given the complexity of hybrid learning and its multiple dimensions, the research community should formulate such design principles systematically and evaluate them in longitudinal studies in authentic contexts. The trend of a wider adoption of

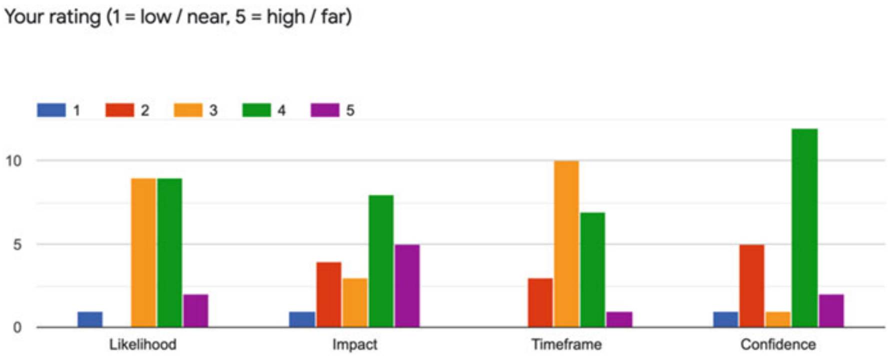

Fig. 5 Evaluation for Prediction 5: Design principles for hybrid seamless learning

Design-Based Research and the urgent need for dealing with the complexity of hybrid learning will eventually put design evidence-based design principles in the foreground.

References: Cook, Mor & Santos (2020); Cook & Holley (2022); Kohls, Dubbert & Münster (2022); Wong & Looi (2022); Velamazán, M., Santos, P., & Hernández-Leo, D. (2022).

Interpretation and Commentary

This prediction was strongly contested by our experts. While there is a general agreement regarding the necessity of evidence-based practice, and the need to share design knowledge, the experts expressed significant skepticism regarding the viability of the above proposal.

Davies (1999) issued a passionate call for evidence-based education over 20 years ago. Indeed, some of our experts have personally been pursuing this goal for as many years and more. And yet it is far from mainstreamed. Some argue that the cause is the nature of professional knowledge in education, which is much more idiosyncratic. Others argue that the evidence needs to be grounded in practitioners' lived experiences. Yet the barriers may be systemic: educational institutions are perhaps more resistant to change by nature of their structures and cultures.

Regarding design principles and patterns, as encoding of design knowledge, some experts suggested searching outside the educational system. Many systems (work, government, leisure) are undergoing rapid hybridization. Some of these are more flexible and error-tolerant than educational ones. Instead of "growing" their own design knowledge, educational institutions might benefit from adopting patterns and principles from other domains. As an analogy, consider the technological tools most prevalent in education. These are predominantly productivity suites, designed and developed for the corporate world.

Finally, some experts questioned the quest for seamless hybridity. Instead, they argued, we should be candid and "seamfull" (Fawns et al., 2021, 2022) about the ways we use technology.

Prediction 6: Pedagogical Success of Hybrid Learning Will Need an Enculturation Process

Likelihood 0.57, Impact 0.67, Confidence 0.71 (Fig. 6)

Existing studies in hybrid seamless learning show that adoption and pedagogical success of the new evolving paradigm will need a complex enculturation process for teachers, learners, parents, instructional designers and institutional stakeholders. This process is necessary, since for example, meaningful and effective hybrid learning activities might occur across contexts, not only in a single context; individual, collaborative and community learning should be merged; inquiry and personalized learning should be supported in a rather fluid environment; while activities and resources in informal settings should be strongly reinforced beyond formal education. The recognition of this need is growing, among researchers, practitioners, leaders and policymakers. We expect it to evolve and mature, setting the ground for a wide adoption of hybrid learning.

References: Wong & Looi (2022); Fawns, Mulherin, Hounsell & Aitken (2021)

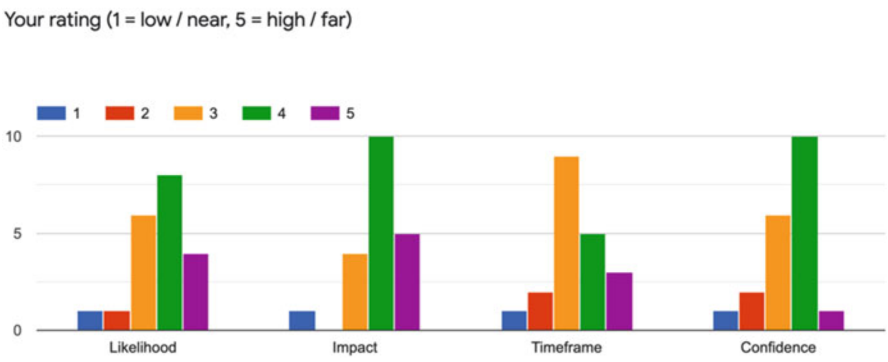

Fig. 6 Evaluation for Prediction 6: Pedagogical success of hybrid learning will need an enculturation process

Interpretation and Commentary

The need for the enculturation process regarding effective design an use of hybrid learning spaces was broadly accepted by the experts. They expressed a rather high confidence in this prediction and its eventual high impact. At the same time the experts highlighted the complexity and difficulty of mobilizing such processes.

The experts expect that this process will most probably take some time to bring tangible results, since changes in culture in hybrid contexts are complex and ask for a consensus among multiple agents that even go beyond the direct educational stakeholders (e.g., municipalities).

It is expected that the communities involved will need to find the balance between competing challenges and needs in this new complex context, as e.g., to find out when online learning is necessary, convenient or more effective from a learning point of view. Thus, as one expert suggests, “this prediction is a normalisation of certain kinds of practices & expectations across societies (especially technology-rich segments of such societies)”.

Prediction 7: Design for Privacy, Safety and Identity in Hybrid Spaces

Likelihood 0.71, Impact 0.67, Confidence 0.67 (Fig. 7)

Hybrid learning spaces will progressively involve informal learning and out-of-class activities, thereby integrating multiple facets of the life or learners. However, such a holistic view on the learning trajectory of individuals and groups asks for a shift to a strong attention to a balanced view of effectiveness, efficiency, identity, privacy, safety. This concern has been already expressed and partially addressed by institutions, legislating bodies and companies. Designing for such a balanced view will become an integral and essential feature of any R&D initiative in hybrid learning spaces.

References: Warburton & Perry (2022); Cook, Mor & Santos, P. (2020). Mor-Avi & Scott-Webber (2022); Hakami & Hernandez-Leo (2021)

Interpretation and Commentary

Most experts see this prediction as likely happening and having a larger impact. The importance of identity, privacy and safety as well as digital well-being is agreed on and already featured in some R&D initiatives. Including these aspects in design is key, but as these aspects differ they should also be mapped and developed into a

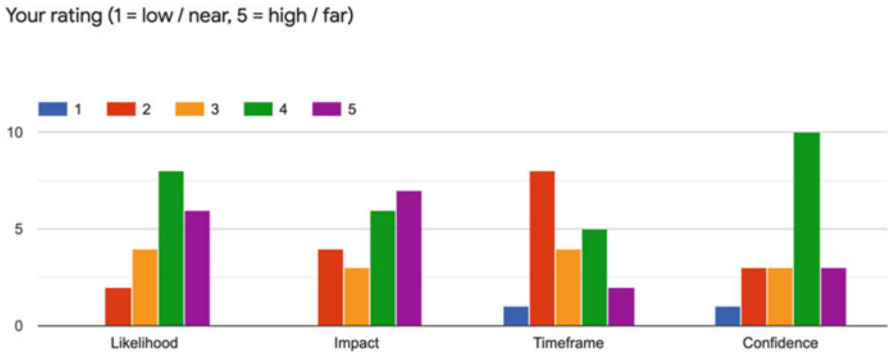

Fig. 7 Evaluation for Prediction 7: Design for privacy, safety and identity in hybrid spaces

framework. There was some disparity regarding the timeframe, potentially because of the difference between the need of addressing these issues now (also triggered by current broader socio-technical trends) and the current difficulties of taking these issues into account when designing hybrid learning spaces. An example given with a project using Google Glass makes this point clear: even though this technology offers nice opportunities for hybrid learning activities, it also was very obvious that too much data was collected without any relation to the actual project, prompting student concerns.

Prediction 8: Death of the Lecture Hall

Likelihood 0.76, Impact 0.67, Confidence 0.71 (Fig. 8)

Hybrid classrooms, which support remote, synchronous and asynchronous student participation will become the norm. A significant portion of small courses (under 50 students) will be taught in this format. Large courses (over 200 students) will be taught predominantly online, with a mix of asynchronous content delivery and synchronous interaction, combining different spaces into one larger classroom. Plenary rooms and adjacent side rooms (both physical and digital) are included as well as homes and public spaces, connecting the classrooms also more with the participants' environments. Kohls et al. suggest hybrid connections of navigational-physical-digital-informational-social spaces.

References: Kohls, Dubbert & Münster (2022); Simpson & Goodyear (2022); Zydney, McKimmy, Lindberg & Schmidt (2019); Association for Learning Technology Community Resources https://www.alt.ac.uk/communityResources

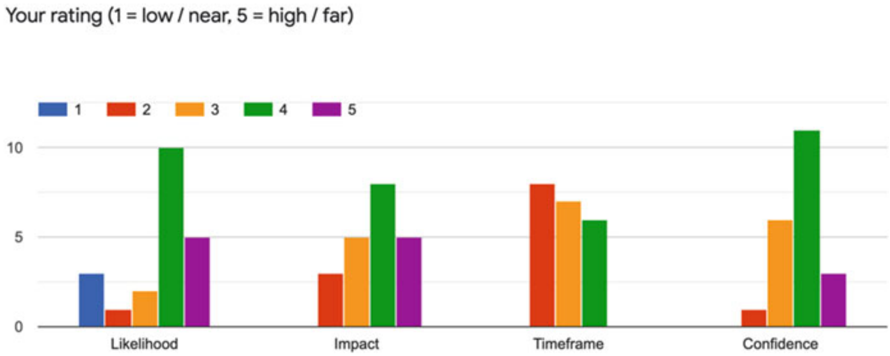

Fig. 8 Evaluation for Prediction 8: Death of the lecture hall

Interpretation and Commentary

While overall our experts have expressed their support for this prediction, they have also raised some reservations. First, they warn about confusing evidence-based prediction with wishful thinking; many education visionaries have prophesied the death of the lecture hall, and yet new halls are being designed and built as we write this text. Second, the new classrooms we envision are resource intensive, both on the institutional side and on the learners' side. While we can expect to see their proliferation in developed countries with a strong economy and government backed universal education, they will take much longer to arrive in other parts of the world. Finally, we should not discount the social value of meeting fellow students and ensure the new designs (educational and architectural) we promote consider and provision for that.

Prediction 9: Classroom Oriented Sensors, Digital Traces and Analytics

Likelihood 0.38, Impact 0.43, Confidence 0.38 (Fig. 9)

Classroom face-to-face activities will still play a major role in future hybrid learning spaces. Interactions between students and teachers, and with physical and digital artifacts within a classroom are currently recorded only through observations that are costly, non-scalable, and not easily transferable across contexts. Digital traces of classroom interactions may provide useful analytics to teachers and learners in real-time during the classroom activities, in near-time among activities across spaces and contexts, or in far-time in terms of reshaping the learning designs and spaces. Also, such classroom digital traces and analytics may contribute in bridging different modalities of in-class and out-of-class learning activities. Cur-

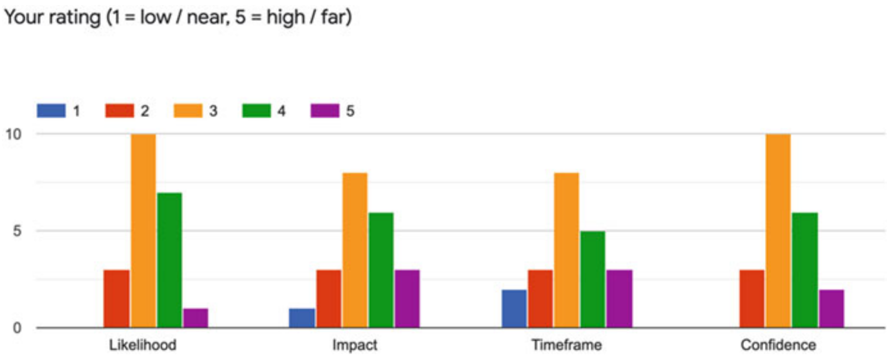

Fig. 9 Evaluation for Prediction 9: Classroom oriented sensors, digital traces and analytics

rently, hybrid classes are instrumented with a wealth of "speaking" and "showing" technology: cameras, microphones and screens which help instructors communicate with participants. In the future, these will be augmented with "listening" and "seeing" technology: sensors and analytical dashboards that help instructors observe learners and adapt to their needs, while taking care of privacy, trust and safety.

References: Martínez-Maldonado et al. (2022); Warburton & Perry (2022); Cook, Mor & Santos (2020); Amarasinghe et al. (2020)

Interpretation and Commentary

The prediction regarding the use of sensors in a physical classroom has not received a high consensus among the experts. While they consider that it is likely that sensors will enable the collection of traces and the production of useful indicators, they expect the impact to be realised in the mid-long term. Some noted that health-related sensors are already widespread, and they will be probably relevant for medical education.

A recurring issue raised by experts are privacy concerns due to the increased use of sensors, and the need for a responsible use of learning analytics drawn from sensor data. Several experts expressed concerns regarding overload of technology in the physical classroom and whether these sensors address real needs of teaching and learning practice. Further research is required to reduce the orchestration load (Amarasinghe et al., 2020) of teachers in these overly complex technology-rich ecosystems. Alongside (or perhaps before) the pedagogical challenges, multiple ergonomic and usability issues still need to be resolved.

Despite the low scores for this prediction, we still find it worth consideration. The low confidence score suggests that more research is required in the technical as well as the organisational, ethical and pedagogical aspects of this theme. Theoretically,

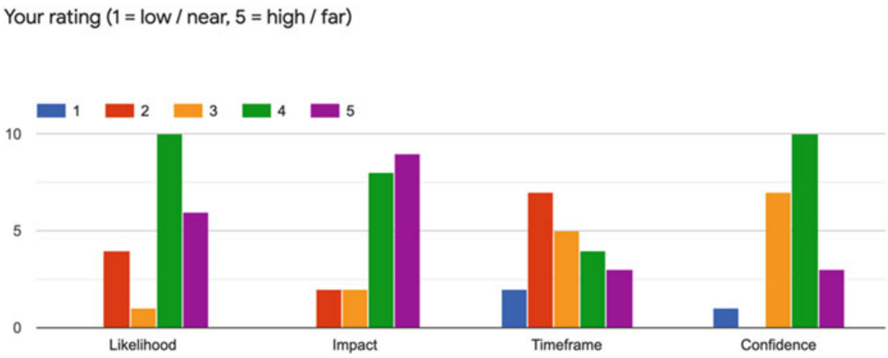

Fig. 10 Evaluation for Prediction 10: Adaptive/adaptable learning spaces

there is a huge potential for analytics in virtual, classroom and hybrid learning environments. How this potential can be realised is still a tantalising open question.

Prediction 10: Adaptive/Adaptable Learning Spaces

Likelihood 0.81, Impact 0.86, Confidence 0.67 (Fig. 10)

Hybridity also includes a shift from passive to active learners, in order to facilitate active learning in hybrid spaces, a fixed architectural configuration is not appropriate anymore. New learning spaces will therefore offer easy ways of re-designing them and giving the control about these designs to both learners and teachers (as co-configurators) so that they can fit them to their needs and desired conditions.

References: Mor-Avi & Scott-Webber (2022); Kohls, Dubbert & Münster (2022); Martinez-Maldonado et al. (2022); Bøjer & Brøns (2022); WEF (2016); Lackney (2008); Martin (2009); Kali et al. (2019)

Interpretation and Commentary

Alongside prediction 1, this statement received the highest scores for likelihood (0.81), impact (0.86) and confidence (0.67). Awareness and acceptance of Adaptive/adaptable Learning Spaces, akin to Active Learning Classrooms/Future Learning Spaces (ALC/FLS), has been on the rise in the past 20 years. Evidently, space design will need to facilitate active learning in hybrid spaces. New spaces will be flexible, empowering learners and teachers to optimize them for diverse scenarios by re-designing and re-configuring them.

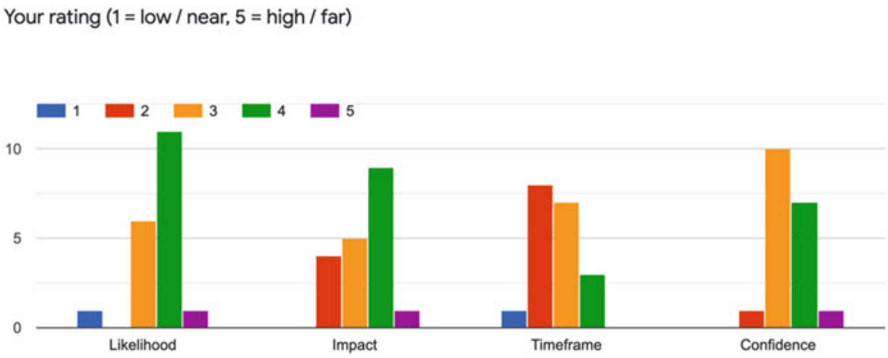

Fig. 11 Evaluation for Prediction 11: Situational awareness

Alongside the consensus regarding the need to establish such flexibility an user control as a standard, the experts stressed the need to promote teachers' ability to utilise this flexibility. Teacher training must emphasise the development of spatial / environmental competences needed for active learning (Bøjer & Brøns, 2022; Martin, 2009; Kali et al. 2019; Lackney, 2008).

Other comments noted the potential, and necessity, of teaching in hybrid spaces to bridge and connect between vocational and more 'academic' studies. Finally, one commentator linked adaptive spaces to adaptive and personalised learning, but warned that such approaches require dedicated attention from a teacher or an AI, both entailing high costs.

Prediction 11: Situational Awareness

Likelihood 0.62, Impact 0.52, Confidence 0.38 (Fig. 11)

Situational awareness plays an important role in physical/analog environments, it enables us to be aware of what is going on. Virtual meeting platforms (such as Zoom, Google Meet and MS Teams) have become a key component in hybrid learning spaces. Some are starting to integrate important aspects of situational awareness (like the gallery view or in platforms such as wonder.me or gathertown, where participants also are positioned in space and can move around by themselves), but in order to be valuable alternatives to physical meetings, these will be strengthened in terms of the richness of experience, the associated learning designs, and the utilisation by analytics.

References: Kune & Quillien (2022); Martinez-Maldonado et al. (2022); Bülow (2022)

Interpretation and Commentary

This prediction was rated in the mid-range in terms of likelihood (0.62) but, alongside prediction 9, received the lowest marks for impact (0.52) and confidence (0.38). Although some experts noted it as “interesting” overall the response was very low: 5 comments compared to 8–12 for all other predictions. One possibility is that this is due to methodological flaws - this prediction was the last in our survey, where experts have already exhausted their time and energy on the previous ones. It is perhaps presented in less detail and clarity. Alternatively, or perhaps complementary, it may be that the concept of Situational Awareness (as also described by Kune & Quillien in their chapter) is new to the discourse on hybrid learning spaces, and more work is required to raise recognition to its importance.

Discussion

The “quasi-Delphi” study we conducted yielded interesting results, some of which surprised even us. This method was born out of pragmatic constraints, but nevertheless deserves some attention. We have been involved in editing collected volumes in the past - journal special issues, books and conference proceedings. We have often wondered, in retrospect, about the practical implications of such works and the robustness of their messages. Admittedly, the scientific validity of our method is debatable (that is not to say that it is invalid, only that it deserves debate). Nevertheless, it allowed us to give an honest answer to the questions above. In that respect, the expert evaluations should not be seen as a judgment of the truth of the predictions, but rather as a means to differentiate between insights which have clear and immediate practical implications, and those that require further consideration and research. With this in mind, the comments that the experts provided are no less important than the numeric rating. In several cases, they noted that the predictions are more normative than descriptive, i.e. portraying the world as we would like it to be, not as it is. In such cases, the question that emanates is: how do we make this happen? The quintessential design research question. In other cases, they indicated that the prediction itself was too vague or unclear to judge. In such cases, it is clear that further conceptual work is required to enable informed conversation.

Consequently, we identify several directions for further work (practical and research):

- The predictions we identified should be communicated to the professional and research communities. Those with high scores as a basis for decision making, those with lower scores as a research agenda.
- To enhance the validity of our findings, we need to refine the predictions in light of the experts’ comments, and submit them to further rounds of evaluation. It might be worthwhile to adopt a dual strategy - on one hand, complete the

Delphi protocol. On the other hand - open them for public scrutiny by the wider community.

- Each prediction points at a valuable research direction; The high-scoring ones should be validated by empirical research (i.e., formulating them as hypotheses and collecting data to refute / confirm them). The "aspirational" statements (those which describe reality as we would like it to be) should be rephrased as design research questions, and the "obscure" statements call for conceptual refinement.

Finally, we asked our experts to suggest additional predictions and observations we had overlooked. We briefly note some of the insights they offered.

We need to move beyond the technical focus on hybridity, and ask ourselves: Where does learning occur? And then, how might we best design for those multiple experiences addressing the needs of the layers of players within the academic community? We need to recognize there is a Time/Space Continuum from onsite to online; asynchronous to synchronous. Each area is rich with possible solutions, expectations and experiences. Each can be and should be designed at scale. We need to return to the discussion on situated learning (Brown et al., 1989; Lave & Wenger, 1991), situated cognition (Lemke, 1997) and embodiment (Núñez, Edwards & Matos, 1999; Ziemke, 2003) and reconsider the relations between body, self, others, environment and learning. Hybridity is no longer a property of the learning environments we construct, perhaps it has not been for a long time: we have inadvertently become hybrid creatures, cyborgs, operating simultaneously in multiple physical and virtual spaces. We need to re-construct our understanding of knowledge (ontology) and the ways in which it is constructed and communicated (epistemology) by hybrid creatures in hybrid spaces, and then build design frameworks based on these understandings.

Yet another dimension of hybridity concerns social roles and rules. We are all simultaneously "learners", "teachers", "designers", "audiences", "performers", "workers" and "customers". How do we contain and reconcile these multiple facets? Do we want to reinstate the old structures, establish and consolidate new ones, or learn to accept a fluidity? How do we balance the power of agile and adaptive hybrid structures with the requirements of formal institutional systems? How can we leverage hybridity to open up educational systems, allowing learners (and teachers) more ownership and control, allowing them to become designers of their learning trajectories? The flexibility that starts in enabling learners to join a course "anytime, anywhere" continues in allowing them to combine qualifications and credentials from multiple educational providers and construct "DIY qualifications". Yet despite such ideas circulating for several years, we have yet to see them implemented at scale. Their realisation requires regulatory and organisational innovations, but no less - it relies on providing learners the tools and skills to navigate and plan their paths within such complex landscapes.

Finally, no discussion of techno-pedagogical innovation can avoid the ethical dimension. Increasing learner autonomy raises questions of the prevalence of "bad" learning - misinformation, defamation and hate. If learners are free to set their agenda and form their world view how do we protect them from harmful influences? The power of data science, in the physical as well as the virtual world, raises questions of surveillance cultures, abuse by governments, corporates and institutions, and the biases programmers project into the technologies they create.

The Covid-19 pandemic has pushed the issues explored in this book from the fringes to the mainstream. Will they remain there? Should they? How do we "not waste a good crisis" and leverage the circumstances to emerge with stronger, more effective, equitable and opportune educational systems?

Conclusions

When considering the predictions we formulated, four stand out as conclusive:

- **Hybrid, in the blended sense, is the new normal, and in so it enables richer forms of hybridity to emerge as the new "super-normal"**. Institutions have adapted to provide most of their curriculum in hybrid formats. We will see some retraction, but hybridity is here to stay. The normalisation of base forms of hybridity will enable more complex forms to emerge on the fringes. These forms will not become mainstream, but they will nevertheless have an impact on educational ecosystems.
- **New frameworks for privacy, safety and identity**. In singular (non-hybrid) environments, there is a clear line between "in" and "out" - who has access to what data, content, interactions. The current ethical, logistic, and legal frameworks for protecting participants privacy, safety and identity rely on these boundaries. Hybridity breaks them down, and new frameworks will need to be developed.
- **Death of the lecture hall**. Conducting courses in large halls is expensive - in real estate, maintenance, transportation, and coordination. In large classes which are predominantly delivery-oriented, co-presence has little or no advantage. Online courses, on the other hand, allow students to set their own pace and see the lecturer up close. The pandemic has made these insights common knowledge, and now there is no going back. Institutions will simply stop building lecture halls.
- **Adaptive/adaptable learning spaces**. This is, in a way, the flip side of the previous observation. If passive learning shifts online, then on-site learning should become more active and diverse. Lecturers will learn to use the physical space in surprising ways, and the space design itself will need to facilitate their freedom to innovate.

Additional issues were identified as having high potential, but requiring regulatory and institutional adaptations to utilise this potential: learning design partnerships, the acculturation of staff to "think hybrid", and the synergy of learning design and learning analytics for hybrid learning spaces.

Alongside these, several themes for future research and development stand out: data collection from physical, hybrid and external spaces to facilitate holistic learning analytics, and understanding and utilising situational awareness in learning design and orchestration.

It is important to note the limitations of this study. Our quasi-Delphi experiment involved a somewhat self-selected sample of experts, and only engaged them in one round of evaluation. Nevertheless, we are confident that the findings have value, if only in identifying hypotheses and questions for future research. Overall, we stipulate the following conclusions:

- Hybrid learning spaces hold a great potential for enhancing and democritising higher education. The understanding of this potential is still in its infancy, and will require continued efforts in research and practice.
- As this understanding evolves, so will the language we use to describe and argue about hybrid learning spaces. This linguistic evolution will clarify the relationships to other conceptualisations (e.g. seamless, connected and networked learning) as well as elucidate the nuances within the hybrid landscape, through concepts such as fluidity, hyper-hybridity and situational awareness.
- The ethical and data security dimensions are still poorly understood and inadequately addressed, and will require careful attention.

Finally, we found the quasi-Delphi methodology useful in consolidating the insights from a large group of experts and distilling from these practical implications and predictions. We highly recommend that others explore this method further.

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