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Riis, Marianne; Dirckinck-Holmfeld, Lone

Published in:
Mobility, Data, and Learner Agency in Networked Learning

DOI (link to publication from Publisher):
10.1007/978-3-030-36911-8_10

Publication date:
2020

Chapter 10
Boundary Practices and the Use of Boundary Objects in Collaborative Networked Learning

Marianne Riis and Lone Dirckinck-Holmfeld

10.1 Introduction

All learning involves boundaries, and in networked learning where information and communications technology (ICT) is used to promote connections, action, and interaction, discussions on boundaries and boundary practices are always prevalent (Ryberg and Sinclair 2016). In general, learning and collaborating at the boundaries is complex due to lack of shared vocabulary, habits, routines, worldview, etc. (Dirckinck-Holmfeld 2006), and in ICT-mediated contexts technology itself adds to the complexity due to decontextualization (Gourlay and Oliver 2016) and changing space-time configurations (Timmis and Williams 2016).

In practice studies, the concept of boundary objects has been proposed as a way of talking about certain objects that mediate knowledge, actions, and relations in and between practices (Carlile 2002, 2004; Wenger 1998; Star and Griesemer 1989). As seen from a social learning perspective (Wenger-Trayner et al. 2017), the challenge in networked learning is to create possibilities for learners to participate in meaningful ways while transcending different types of boundaries by way of using boundary objects to mediate the ongoing negotiation of meaning, identity, learning, and knowledgeability in communities of practice. Following Wenger-Trayner this paper researches into how students use boundary objects to facilitate collaborative networked learning with a focus on how the materiality of the boundary object, the pedagogical design, and the discursive practices afford engagement, imagination, and alignment.

M. Riis (✉)
The Danish Evaluation Institute, Copenhagen, Denmark
e-mail: mri@eva.dk

L. Dirckinck-Holmfeld
Department of Communication and Psychology, Aalborg University, Aalborg, Denmark

N. Bonderup Dohn et al. (eds.), *Mobility, Data and Learner Agency in Networked Learning*, Research in Networked Learning,
https://doi.org/10.1007/978-3-030-36911-8_10

10.2 Method and Context of the Study

In this paper, we use findings from two different studies (Dirckinck-Holmfeld 2006; Riis 2016) conducted at the Danish master programme for professionals on ICT and learning (MIL). The MIL programme is inspired by the concept of communities of practice and founded on the principles of problem- and project-based learning. Students are not only distributed in time and space, but as MIL is a mutual and equal collaboration between four Danish universities—Aalborg University, Aarhus University, Copenhagen Business School, and Roskilde University—also faculty and the administrative secretary are distributed across time-space and institutional boundaries (Dirckinck-Holmfeld 2006; Dirckinck-Homfeld 2002; Fibiger et al. 2005). Essential for MIL is the use of a virtual learning environment (VLE) and additional digital technologies to mediate the participation and activities. Since the program's establishment in 2000, the use of these technologies as infrastructure, tools, and analytical objects has changed in line with the general technology development (Riis 2016).

10.2.1 MIL as Context for Studying Boundary Practices and Boundary Objects

As a context for studying boundary practices and boundary objects MIL is exemplary.

The basic principles of MIL's learning environment are based on problem-based learning, dialogue, collaboration, and learning in communities of practice, not only between students, but also in its setup with teachers and the secretary. This makes MIL an exemplary empirical setting for studying cross-boundary work. Further, as the program was established in 2000, it is a mature case environment. Finally, as a primarily virtual environment mediated by a digital learning platform, MIL provides a rich opportunity for doing virtual ethnography and enables a closer look into the traces of the student activities and dialogues as well as provides a shared environment for students and teachers to work closely together to explore new educational tools and settings. Hence, we expect that by using MIL as the empirical base for exploring and theorizing on boundary objects and boundary practices, we can provide new detailed insights in these processes.

The paper builds on two case studies as point of departure for the further exploration of boundary objects in boundary practices. The first study (study I) took place in 2003–2004 (Dirckinck-Holmfeld 2006) and explored the role of boundary objects used by MIL students to coordinate, collaborate on, and challenge their construction of knowledge and meaning. The virtual learning environment in MIL at that time was supported by a system called Virtual U, which was a 2D asynchronous learning

environment. The formal learning activities and the students' communication and collaboration took place as primarily asynchronous discussions in for a supported by four physical seminars and a shared examination day.

The other study (study II) took place from 2007 to 2011 (Riis 2016) and was especially focusing on how the use of avatars mediate the students' collaboration in one of the courses dedicated to the exploration of 3D learning environments. The course predominantly took place in a 3D learning environment called Second Life. For students and teachers to enter the 3D learning environment, they had to use an avatar. In the course, the use of the avatar was a shared phenomenon of study for the students as well as the researcher and teacher.

10.2.2 Methods

We are not doing a comparative study; however, we use the two studies to throw light on certain aspects of boundary objects and boundary crossing work in two different digital contexts. In a Danish setting the two case studies illustrate the historical opportunities for mainstreaming teaching and learning in virtual environments. The aim is to come closer to an understanding of how different boundary objects support teaching and learning and to throw light on the material aspects of boundary objects. Both cases are based on an explorative approach and inspired by virtual ethnography. Study I had a more traditional design looking into the practice of a course group in a shorter time span, whereas study II was organized as an action learning project exploring Second Life as part of a PhD project.

Traditional ethnography and virtual ethnography share an anthropological past; however, virtual ethnography transcends the traditional grounded research in several ways. One of them is about the site to study. In a traditional anthropological case, the researcher will engage in long-term, face-to-face fieldwork in one *geographic* site, while virtual ethnography includes different types of sites. Hine (2015) describes this as a multisited form of research that may span spatial and temporal boundaries online, offline, or as a combination of the two. Hine (ibid.) further explains that as field sites increasingly become networks, virtual worlds, and a combination of virtual and physical spaces, it raises new questions on what a "space" is, how to engage in observations, how to select a field site, and how to follow up with interviews and interventions (online and offline). As participants in digital environments leave digital traces, such as posts in the communication fora they use, and what, when, and with whom they communicate, this gives the researchers new ways to get insights into the black box of, e.g., a group learning environment. The virtual nature of the learning environment expands the opportunities for the researcher to participate in real time as well as to recall the communication and the activities, which have taken place.

10.3 Study I (2003–2004): Studying 2D Boundary Objects in Problem-Oriented Project Pedagogy

MIL provides a very rich set of data for exploring how collaboration takes place in a digital asynchronous learning environment. MIL is a "multisited" space, crossing spatial and temporal as well as physical and digital boundaries. In Virtual U (at that time), there were a little less than 300 asynchronous, 2D fora per year, which contained almost all of the interaction among the participants in the virtual periods (2-year groups of 50 students).

In study I, we are looking closer into one course group of five students (four men and a woman). The work took place as the first assignment the students had to do together. The course was dealing with cognition and values and was part of a module on human-computer interaction (HCI). The group worked together for 8 days, and they had to produce a shared, written project report within that period and deliver it for assessment.

10.3.1 Collecting and Analyzing Data

The data was collected based on a selection of the MIL fora, which were used by the group (five fora overall). The selection of the group and the fora was done by one of the authors based on purposive sampling. The selected group was the most active using the fora. As most of the teaching, collaboration, and learning activities took place in Virtual U, traces of these activities were accessible to the researcher. The analysis of the data was based on the students' fora.

First, all the fora of the course group were read in order to get an immediate insight into the collaboration process and to explore the boundary objects being used. The fora were read one by one. The mode for the readings was: all messages sorted by date—focusing on breakdowns/successes in the group work and identifying possible boundary objects. Based on the reading—and controlling search in the material—a draft "rich picture" (Fjuk 1998) of the process and the use of boundary objects was constructed. In the first iteration, one rich picture with all the activities was constructed. Based on the first reading, a simple coding system was constructed in order to identify and clarify categories of boundary objects (see Table 10.1). This coding system was inspired by the boundary object types suggested by Star and Griesemer (1989) and focused on object repositories, standards (self-regulated and MIL/teacher-regulated), products (ideal types), and communication tools.

This system was used in a second reading of the materials in order to clarify details and a revision of the rich picture took place, and three rich pictures were elaborated presenting all the used boundary objects, the problem formulation phase, and the finalizing project phase. Finally, a "thick description" (Geertz 1973) was written up around the data. The "thick description" had two narrator perspectives, which were interchanging, one of the students and one of the researchers.

Table 10.1 coding system to identify boundary objects

Coding system for boundary objects
Self-regulated standards: S1 = group collaboration agreement, S2 = group calendar, S3 = rules for communication, C4 = formative work evaluation criteria, C5 = scientific work methods, C6 = mail and telephone list, C7 = rules for referencing
MIL/teacher guidelines: G1 = assignment text, G2 = tutoring, G3 = teacher comments, G4 = evaluation criteria, G5 = teacher notes, G6 = technical help, G7 = inspiration from seminar *Products:* P1 = problem formulation, P2 = project outline, P3 = parts of project P4 = draft project, P5 = final project, P6 = list of references, P7 = layout, P8 = chat documents
Object repository: R1 = tutor conferences, R2 = teachers' conference, R3 = literature course 2, R4 = literature course 1, R5: World Wide Web, R6 = workplace, R7 = other MIL conferences
Communication tools: C1 = VUK3, 1–7; C2 = Messenger, C3 = VU Chat, C4 = video conference, C5 = telephone, C5 = face2face

Names were used to make the story livelier but did not represent the participants. The "thick description" and the figures were sent to the participants for discussions, clarification, and further elaboration.

10.4 Study II (2010–2011): Studying 3D Boundary Objects in Problem-Oriented Project Pedagogy

Study II was based on research-led action research, AR (McKay and Marshall 2001), which is characterized by a research interest that precedes and possibly initiates the search for the occurrence of a real-life problem (Riis 2016). The project was organized through four AR cycles with different MIL students—each of the cycles investigating both research issues and problem-solving interests.

This paper draws especially on the insights from the fourth AR research cycle, which was conducted in the winter 2010/2011, and the research interest was to further the study of Second Life as a VLE, different activities, and a synchronous assessment method. Furthermore, there was a specific interest in changing the overall communication mode from asynchronous to synchronous by making Second Life a learning objective in itself (Riis 2016 p. 204). In particular, the students' use of avatars and their experiences and reflections were a shared focus for the teaching and learning experiment.

The virtual and participating ethnography took place in an elective course module, which ran for 8 weeks. The study was a multisited study as the study activities were situated in four different locations: at a face-to-face the seminar, at the students' workplaces, in the students' private settings, and as inworld activities that took place between 8 and 10 PM, except for Fridays and Sundays between 3 and 5 PM.

Ten MIL students participated in this fourth cycle; however, one student fell ill and was therefore not included in the data. All participants came from the educational sector. The students were a combination of first- and second-year MIL

students, meaning that the teacher could not expect the same theoretical background knowledge. All, but one participant, were considered to match the profile of being relatively tech-confident; however, only two of the students were familiar with Second Life before entering the course. The virtual learning environment was a combination of First Class and Second Life, with the latter being in focus in this paper.

The author characterized her positionality in the project as being that of "insider in collaboration with other insiders" (Herr and Anderson 2005 cited in Riis 2016 p. 89.) having deep insights into the practice of MIL—both as a former student of MIL, a PhD student in relation to MIL, and as a teacher in MIL. To support the research, the author generated a data archive (Rapley 2007) collecting a large corpus of materials of texts, screen dumps, pictures, etc. The analytical approach was content analysis inspired by grounded theory (Riis 2016).

10.4.1 Theoretical Background

At the MIL programme, arguments for collaborative networked learning have primarily been based on a sociocultural perspective on learning, with the ideas of Lave and Wenger (1991), Wenger (2010, 1998), and Wenger-Trayner and Wenger-Trayner (2015) on situated, social learning as main inspiration. At the ontological level, sociocultural theories suggest that learning is constructed, social, situated, mediated, distributed, and a matter of coming to be (Riis 2016). At the pedagogical design level, the teaching and learning processes are realized through the inherent need for collaboration in problem-oriented project pedagogy (Dirckinck-Homfeld 2002). In problem-oriented project pedagogy learning, the starting point is directed by the students' interests, and the students define and "own" the problems derived from their different professional "landscapes of practice" (Dirckinck-Holmfeld et al. 2009). According to Wenger-Trayner and Wenger-Trayner (2015), the "body of knowledge" of any given profession is best understood as:

> [a] landscape of practice' consisting of a complex system of communities of practice and the boundaries between them. (ibid., p. 13)

Further, such a landscape of practice forms "a complex texture of distinction and association, possibilities and impossibilities, opening and closing, limits and latitude, gates and entries, participation and non-participation" (Wenger 1998, p. 121). As seen above, the design of the learning infrastructure at MIL is supported by ICT as a way of connecting and creating interdependencies between the participants and their different landscapes of practice, in line with the tradition of networked learning (Dirckinck-Holmfeld 2016).

10.4.2 Knowledgeability and Modes of Identification in Landscapes of Practice

Knowledgeability has been put forward as a way of describing the body of knowledge and complex relations that people build and maintain between intersecting practices, and the formation of identity is modulated in and across the boundaries of such practices through different modes of identification[1] (Wenger-Trayner and Wenger-Trayner 2015; Wenger 1998). In a landscape of practice, knowledgeability is shaped by the participants' personal and communal, intersecting trajectories of learning. Therefore, a learning trajectory in a social landscape is not merely a matter of knowledge acquisition, but of coming to be. The participants inhabit the landscape with different identities that over time shape the "accumulated memories, competencies, key performative events, stories and relationships to people and places" (Wenger-Trayner and Wenger-Trayner 2015, p. 19). In return, the landscape shapes the participants' identities through different modes of identification or dis-identification:

- *Engagement*—a way of talking about participants' active involvement in mutual processes of negotiation of meaning
- *Imagination*—a way of talking about participants' creation of images of the world and seeing connections through time and space
- *Alignment*—a way of talking about participants' coordination of energy and activities to fit within broader structures and contributions to broader enterprises (Wenger 1998)

All three modes of identification are ways to make sense of the landscape through positioning, and the relationships of either identification or dis-identification function both within and across the boundaries of the landscape. In our study, these modes are detectable in both MIL cases, albeit to varying degrees and mediated by different boundary objects.

10.4.3 Boundaries and Boundary Objects in Learning

The concept of boundary practice has been studied in various research domains where it has been used to describe a wide variety of phenomena, including professional identity, symbolic capital, politics, and knowledge sharing in and between intersecting practices (Lindberg et al. 2017; Lee 2007; Wenger 1998).

Based on an extensive review of boundary research within the educational field, Akkerman and Bakker (2011) defined a boundary as any *sociocultural difference* leading to discontinuity in action or interaction. In educational research, boundaries are typically identified in and between domains, practices, and contexts. However,

[1] The modes were called "modes of belonging" in Wenger (1998).

as stated by Akkerman and Bakker (2011, p. 22), "a boundary is not a static and predefined distinction," rather boundaries are experienced subjectively and contextually. Experienced boundaries can easily remain implicit during interactions, and the learning potential or opportunity is only realized when people identify boundaries through dialogical and collaborative engagement and negotiation. Furthermore, the authors found that the research interest in boundaries over the past decades has been linked to an attempt to reconceptualize the notion of (knowledge) transfer based on an appreciation of differences and diversity as potentials for learning (ibid.). In fact, as Wenger-Trayner et al. (2017) argue, boundaries should be regarded as learning assets, and when designing for learning, "the principle is to systematically make boundaries a learning focus" (p. 18).

When boundaries become a focal point of a design for learning, boundary objects come into play. Star and Griesemer (1989) introduced the concept of boundary object to describe an object that serves to mediate several intersecting social worlds while simultaneously satisfying the informational requirements of each of them. Originally, Star and Griesemer (1989, p. 410–411) proposed four categories of boundary objects (repositories, ideal types, coincident boundaries, and standardized forms), and Carlile (2002, 2004) further extended the notion of "effective" boundary objects into a hierarchical classification based on three levels of knowledge boundaries:

- A syntactic boundary, which potentially leads to *transfer of knowledge* through the use of representation objects (e.g., repositories)
- A semantic boundary, which potentially leads to *translation of knowledge* through the use of learning objects (e.g., standardized forms and methods)
- A pragmatic boundary, which potentially leads to *transforming knowledge* through the use of transformation objects (e.g., models and maps)

10.5 Boundary Objects in a 2D VLE (Study I)

In the first study, Dirckinck-Holmfeld (2006) explored how boundary objects serve as resources to support students' collaboration and learning in a networked learning arena organized as problem- and project-based learning, the MIL programme. Based on a case study of a course group's work, the study identified four different types of boundary objects, which the groups were using to support their work:

- Group products
- Ideal types of frameworks, concepts, models
- Standards and guidelines
- Communication infrastructure (ibid. p. 2)

These types of boundary objects share similarities with the proposal from Star and Griesemer (1989); however, the study also identify new objects, which served the course groups in their ongoing process of negotiation of meaning, knowledgeability, learning, and identity.

Among these objects, the study found that the *group products* were most important as a boundary object with the problem formulation and the outline as the most challenging, but also the ones promoting boundary crossing and horizontal learning opportunities. In the process of problem formulation and making the outline of the project, different kinds of learning and collaboration took place: (1) Learning about (assimilating knowledge): sharing experience from practice, introducing new theories, concepts, methods, and worldviews. (2) Transforming knowledge (accommodating knowledge): students transform their knowledge base struggling with the new concepts, references and frameworks and get novel insights about meaning, relations, application, and design. This process is both an individual and a group process. The individual student is struggling with the different kinds of input, while the process is pushed forward by their shared responsibility for the group work. Furthermore, the peers use the group as a community of practice, "thinking aloud," updating each other on new insights, and sharing references on literature, tools, exiting innovation projects, etc.

Using Wenger's framework (1998), the product becomes the shared enterprise of the group and the nexus for negotiation of perspectives. Especially the problem formulation phase, where the group of students has to develop a shared problem statement and research questions, afforded the enactment of students' experiences and different practices. The other phases of the course group work, writing the different parts of the assignment and finalizing the assignment, also facilitated boundary crossing. However, this kind of learning is of a consolidating character, mixed up with pragmatic reactions to the situation. In this phase, the goal became to submit the assignment on time and to pass.

Writing up a shared course project acted in the MIL context as a transformative boundary object for the group of students coming from different sectoral backgrounds. *Ideal types* such as theories, models, and concepts further supported the establishment of a shared repertoire among the students and functioned as a shared boundary object, where the students tried out their interpretations and reflections not only as a theoretical discussion, however, linking to their different experiences from practice. *Standards and guidelines*, such as the group agreement, the calendar, and the communication rules, supported the students in doing the work, and finally the *communication infrastructure* in Virtual U, such as the discussion fora, the layout and pedagogical design of the course template, and the Messenger unit (Virtual-U chat), was instrumental for the collaboration to take place.

Based on her study of MIL students' collaborative learning in the 2D arena, Dirckinck-Holmfeld (2006) found that all categories of boundary objects can mediate knowledge on different levels, and "what determines the 'efficiency' of a boundary object is *relational* to the situation, and to the objectives" (ibid, p. 7), thus adding to Carlile's (2004) relational understanding of knowledge and power.

When a boundary object supports the collaborative process on the routine level, it functions at the syntactic level and the participants share the syntax; however, when there is a breakdown, the participants will have to go to the level of semantics or pragmatics in order to "repair" the knowledge boundary. As the focus in problem- and project-based learning is on transformative learning (and paradigmatic changes in worldviews), it is vital that the students use the boundary objects that are in focus

in the collaborative learning process, such as the group products and the ideal types to go beyond syntax and semantics, and challenge each other at the pragmatic level.

If we take the standardized forms as an example, i.e., *the group agreement*, it has worked on all levels. When the group constructed the agreement on the seminar, they were working on the semantic and pragmatic level. Some of them for sure had never thought about working together in a virtual universe, and they were negotiating and altering their ideas and experiences for group working to fit this new context. However, when they in the following phase were using the standard they developed, it was used on the syntactic level—or the routine level. Only if there was a breakdown in the group communication, e.g., if the others did not respond because for them no response was "we agree," then because of the different interpretation, they would have to return to the semantic and pragmatic level and renegotiate the group agreement, and the group did so.

The same could be said about their repositories. A repository can be used if the students know the syntax; however; if there is a breakdown, they have to understand the way it is organized and categorized on a semantic level, e.g., how to label the conferences in order for other MIL project groups to use their conferences to find the relevant documents.

We would therefore propose that all three of Carlile's knowledge forms could be seen as related to the different kinds of boundary objects. When a boundary object is supporting the collaborative process on the routine level, it is functioning at the syntactic level; however, when there is a breakdown, then the participants will have to go to the level of semantics or pragmatics in order to "repair" the knowledge boundary. However, we also agree with Carlile that the different kinds of boundary objects do not serve equally important roles in the collaboration process. In a virtual learning environment, standards serve as subsidiaries for the collaboration on the shared product, which are in focus. Consequently, we will suggest a relational view on boundary objects. What determines the "efficiency" of a boundary object is *relational* to the situation and to the objectives. In a shared collaborative learning process and a networked learning environment characterized by strong ties, the construction of the shared product and the problem formulation is the strongest boundary object. However, in the case which Star and Grisemer was referring to, which was a loosed coupled "network of practices," the shared repository was maybe the strongest boundary object in the sense that all groups could contribute to this. Further, more the aim was different. In the MIL learning case, the enacting of transformative knowledge has the highest priority, while in the Star and Grisemer case, the intention was not to transform the knowledge boundary; it was more likely to broaden the knowledge base in the repository. Furthermore, the boundary objects may function at different knowledge levels—from syntactic to pragmatic—but there is a dynamic relation between the different levels. When collaboration is smooth, it acts on the syntactic level (routine level); however, when there is a breakdown, it prerequisites interchanges at the semantic or pragmatic level.

10.6 Boundary Objects in a 3D VLE (Study II)

The second study, which also was conducted at the MIL programme, was based on a multiple case study involving 53 students over a vast period in four consecutive action research cycles and did not initially focus on boundaries and boundary objects (Riis 2016). However, after reviewing and analyzing the data anew, we have identified the same types of boundary objects as in study II. One type of boundary object, namely, the *ideal types of frameworks, concepts, and models* as exemplified in compulsory literature, seemed to function in similar ways. In both studies, the literature represented a domain-practice alignment, meaning that in study I, the literature reflected discursive, online collaboration, whereas the literature in study II focused on embodied, online collaboration. As an example, in study II, the students stressed the possibility of experiencing and performing concepts such as immersion, embodiment, and presence in a grounded manner via their avatars, leading to a deeper understanding and a more critical stance towards the concepts. Our analysis also shows how the three other types of boundary objects—*group products, standards and guidelines, and communication structure*—were present, but differed due to their more manifest materiality.

In study II, the *group products* were also very strong boundary objects. Contrary to the written report in study I, these students had to do an analysis of the 3D virtual world as learning arena, build a reflected example of such learning arena in their designated sandboxes, and finally present their theoretical arguments and demonstrate (with required peer interaction) their environment in synchronous sessions. The manner in which the students were able to reify their collaborative work through material products and embodied processes inworld was underlined as one of the major benefits of this type of learning arena. Further, the performative nature of the presentations was typically enhanced by dressing up the avatars in—for the presentation theme—appropriate clothes and by using props (e.g., wheelchairs when the theme was nurse education). Figure 10.1 illustrates examples of the students' presentations of their group products.

As for *the standards and guidelines* boundary objects, in study II, the students initially struggled with the extra task of getting to know, understand, and practice the distinct 3D virtual world culture, which by all accounts constituted an ontological challenge. In study II, the students spent considerable amounts of time on avatar acclimatization and general enculturation. As well as the students in study I, these students needed to focus on the MIL culture, which seemed to change considerably from what they were used to from previous courses and modules in the MIL programme. The students emphasized the more informal and playful tone concerning interaction with both their peers and the teacher. On the other hand, the students also pointed to the difference in meeting other people/avatars in the learning arena, especially in terms of meeting strangers. In such cases, the students were left quite perplexed until they learned to "crack the cultural code" (ibid., p. 253). Meeting strangers, typically educators from around the world, was also a deliberate design decision throughout the research cycles, and in hindsight, these meetings illustrated exemplary boundary practices.

Fig. 10.1 Students' presentations of group products (Riis 2016)

In study II, one of the most remarkable boundary objects was the *communication infrastructure*. The students were all accustomed to the asynchronous conference discussions, when they first entered the 3D virtual world. In many accounts, the students highlighted the possibility of communicating synchronously and via material objects inworld (the avatar itself included). As found in study I, online students appreciate synchronous communication as a means of quick clarification and consolidation in negotiation processes, and in study II, the synchronous way of teaching and learning was often described as being "emancipating" in comparison to what the students were used to (ibid., p. 219). Besides differences in communication frequency, the students also pointed to another aspect of the communication infrastructure, which has to do with the materiality of the learning arena. The rich possibilities in terms of multimodality, and especially the possibility of visualizing, creating, and performing their processes and products of learning, were generally highly appreciated.

Finally, in study II, we identified a new type of boundary object, the 3D avatar, which turned out to be the most powerful boundary object given that it was through the avatar that the students experienced and participated in the inworld teaching and learning activities. The majority of the students became deeply involved in customizing the avatar in terms of its appearance and adjusting to its behavioral traits and possibilities. Through this boundary practice, the students were often challenged by boundaries between their own personal preferences and the technological affordances, and as such, the avatar represented the materialization of continuous identity struggles, oscillating between playful and carefree learners and goal-oriented and reflected students. In general, the avatar was a highly "effective" boundary object with regards to both collaboration and knowledge sharing.

However, for a few students in this study, the avatar became an impenetrable boundary, an object of obstruction rather than progression, as expressed by this student:

> Whether people want to play with paper dolls or if they have a need to make virtual social relations must be their choice. (Student quote from Riis 2016, p. 264)

For this student, the use of the 3D avatar clearly resulted in dis-identification and no sense of belonging to the community. In summary, our analysis of study II has shown how the different materialities of the boundary objects and consequently the boundary practices as well, as compared to study I, provided the students with new possibilities for knowledge sharing and identity work, but also it invited for a cheerful and experimenting learning environment embodying and promoting new performative actions. However, it also should be noted that not all students wanted to invest themselves in this social experimentation and could not see this as part of an academic learning agenda.

10.6.1 Differences Between the VLEs in Study I and Study II

Table 10.2 describes the dominant features of the two different settings for study I and study II. According to one of the developers, Virtual U was one of the first online, asynchronous environments designed with a specific pedagogical vision and framework in mind (Harasim 2017). The Virtual U focused on "discursive spaces" designed to facilitate collaborative learning and knowledge construction in an educational institution, and it was based on a campus metaphor, e.g., with course templates, conferences (for discussions), and personal workspaces (ibid., p. 127–128). Second Life, on the other hand, was designed as a shared simulated 3D space with no

Table 10.2 Dominant features in two settings for ICT-based networked learning (adapted from Riis 2016)

	The 2D VLE in study I Virtual U	The 3D VLE in study II Second Life
Purpose	Developer-determined • Teach, study	Self-determined • Multipurpose
Environment metaphor	Campus workspace Nonfictional	Mirror or fantasy world Nonfictional/fictional
User representation	2D profile, username (icon) Disembodied Pseudonyms not allowed	3D avatar, avatar name Embodied Pseudonyms are default
Communication modalities	Vision, writing	Audition, vision, proprioception, writing
Dominant interaction frequency	Asynchronous	Synchronous
Content creation	User-created	User-created

predefined purpose in mind other than socializing and promoting the users' freedom "to create their own fictions and communities, imbuing them with meaning through interaction" (Ondrejka 2008, p. 231).

Each learning environment offers many distinct features or affordances that are both functional and relational. As such, the purpose of the different arenas can be challenged. The 2D environment was purposely designed with teaching and learning in mind and was solely used as such. The 3D environment, however, was designed as an open social space in which users could choose to engage in a number of activities. Nonetheless, for the majority of the MIL students, the 3D environment was also primarily used as a space for teaching and learning. Only a few students engaged in extracurricular or private activities, and when asked about this, the students pointed to time restraints, leaving no or little time to use the environment for anything other than educational obligations (Riis 2016).

Furthermore, as pointed out by Hutchby (2001), some affordances are complex and need to be learned over the course of longer periods, and in our study, this holds true especially in terms of the perceived embodiment in the 3D arena. As an example, the sense of proprioception (e.g., experienced by seeing one's nose or limbs when moving), which in the 3D environment depends on the user's chosen point of view, became a distinct boundary between the user's "I" in the real and the virtual world—thus providing an opportunity to reflect, negotiate, and learn, both individually and collaboratively.

10.7 Discussion

In both studies, we have identified and analyzed "effective" boundary practice and boundary objects that can mediate knowledge creation and sharing on all proposed levels and thus promote both transfer, translation, and transformation of knowledge (Carlile 2002, 2004). Further, the 3D avatar as boundary object added new dimensions to the academic learning environment providing space and tools for identity work, cheerfulness, design, play, and explorations. Table 10.3 provides an overview of the dominant boundary objects in the two studies.

The identified boundary objects mediate not only in and between different types of knowledge or domains, but also in and between different practices. Essentially the students in both cases met boundaries between their prior knowledge and their professional practices and the new knowledge and new practices of MIL. In both studies, the students were challenged; however, in study II the challenges also seemed to arise from the 3D environment and its particular affordances in itself.

Through collaborative building and synchronous presentation of their findings via their avatars, the students in study II were forced to reflect and negotiate boundaries pertaining to the domain, the academic practice, their relationships, *and* their own identities as learners and as professionals.

Table 10.3 Overview of boundary objects in the two studies

	Boundary objects in study I	Boundary objects in study II
Group products	Written project report	Oral project presentation and design products
Ideal types of frameworks, concept, and models	Exemplary literature in terms of domain-practice alignment	
Standards and guidelines	Reflecting the MIL culture and that of the group	Reflecting the Second Life culture, the MIL culture, and that of the groups
Communication infrastructure	Asynchronous conferences, incl. the group's own conferences (synchronous chat)	Synchronous space, incl. the groups' own sandboxes (asynchronous conferences)
Student representation	Logo and name	Avatar and pseudonym

In terms of student representation, we noted that the 3D learning arena and the avatar as boundary objects facilitated identification through what one might call "actionable imagination" in a way not possible in the 2D arena. Precisely because this space afforded more than discursive action and let the students reify their thoughts, ideas, etc. in a materialized manner, the students were challenged in their "creation of images of the world" (cf. Wenger 1998).

Combined with the change in the course dissemination (the group project), the boundary objects in the 3D arena seemed to facilitate abundant opportunities of boundary crossing, which for the most parts of the students lead to identification and a strong sense of belonging. This sense of belonging to the MIL community was also seen in the students' choice of names. During the project period, Second Life did not allow users to name their avatars with real-life names. Instead, new users were asked to pick names from predefined lists. Only 14% of the students chose names that resembled their real-life names (Riis 2016, p. 244). The rest chose names indicating some sort of affiliation with their personal interests and six students chose names indicating they were MIL students (e.g., Miling, Milo, Milano, and Milena).

In study I, Dirckinck-Holmfeld (2006) pointed out new relational dependencies of boundary objects, and based on our current analysis of study II, we observe how the 3D learning arena, with avatars and other virtual objects, functions as proxy for the material in ways not possible in the 2D learning arena, supporting that not only differences in, but dependencies of, the *materiality of the technology* also play an important role in ICT-based networked learning.

Moreover, based on our analysis of the findings from both case studies, we propose to extend the relational view on boundaries and boundary object to the ontological level of learning and knowledge sharing, suggesting that a socio-material perspective might be beneficial to understanding the phenomenon. According to several authors (Gourlay and Oliver 2016; Johiri 2014, 2011; Fenwick et al. 2011; Edwards 2011), socio-materiality points to the inseparability of the social and the material, and a study of technology in practice therefore needs to address this. A socio-material approach may provide new insights on knowledgeability, given that:

> [The] question of producing knowledge and learning shifts from a representational idiom, mapping and understanding a world that is out there, to a view that the world is doing things, full of agency. Not only humans act, because non-humans act on and with humans. (Fenwick et al. 2011, p. 3)

As such, in a socio-material perspective, the body of knowledge and complex relations would be more attentive towards the entanglement of material artifacts and the bodily performances of the learners, which still would be entwined with discourse. In a socio-material perspective, the avatar could be seen as the materialization of the students' identity struggles and as a medium of agency and performance. While the 3D learning arena has directed our attention to this materiality, it is important to point out that a stronger focus on the materiality of the 2D learning arena could be just as relevant in terms of finding and designing for new ICT-based networked learning opportunities.

Furthermore, a socio-material perspective would provide new insights into different modes of identification in terms of either disembodied or embodied engagement, imagination, and alignment (cf. Wenger-Trayner and Wenger-Trayner 2015; Wenger 1998). Relationships with other and self are always a matter of negotiation at and with the boundaries of practice, and a socio-material approach could uncover unexpected potentials for learning.

As described earlier, Akkerman and Bakker (2011) found that boundaries could be defined as *sociocultural* differences that lead to discontinuity in action or interaction based on a review of 181 previous studies. Based on our analyses, we therefore propose to extend the definition of boundaries to include a material perspective and enhancing the focus on agents (both human and nonhuman) as those who act and interact. In doing so, modes of identification through engagement, imagination, or alignment can be emphasized as important factors of boundary crossing and boundary work.

Nonetheless, in both studies the strongest dependency between learners and boundary objects occurred in relation to the situational and collaborative fabric of the learning designs, calling for a continued focus on the social aspects of design for learning in problem-oriented and problem-based networked learning.

References

S.F. Akkerman, A. Bakker, Boundary crossing and boundary objects. Rev. Educ. Res. **81**(2), 132–169 (2011)

P.R. Carlile, A pragmatic view of knowledge and boundaries: boundary objects in new product development. Organ. Sci. **13**(4), 442–455 (2002)

P.R. Carlile, Transferring, translating, and transforming: an integrative framework for managing knowledge across boundaries. Organ. Sci. **15**(5), 555–568 (2004)

L. Dirckinck-Holmfeld, Designing for collaboration and mutual negotiation of meaning: boundary objects in networked learning, ed. by S. Banks, V. Hodgson, C. Jones, B. Kemp, McConnell (eds.). *Proceedings of the fifth international conference on networked learning 2006: Symposium: Relations in networks and networked learning*, organised by Chris Jones. Lancaster University, p. 1–8, 2006

L. Dirckinck-Holmfeld, Networked learning and problem and project based learning – how they complement each other. *Proceedings of the 10th International Conference on Networked Learning 2016*, ed. by S Cranmer, N.B. Dohn, M. de Laat, T. Ryberg, J.A. Sime JA, Lancaster University, 2016

L. Dirckinck-Holmfeld, C. Jones, B. Lindström (eds.), *Analysing Networked Learning Practices in Higher Education and Continuing Professional Development*, Technology Enhanced Learning, vol 4 (Brill | Sense, Rotterdam, The Netherlands, 2009)

L. Dirckinck-Homfeld, Designing virtual learning environments based on problem oriented project pedagogy, in *Learning in Virtual Environments*, ed. by L. Dirckinck-Holmfeld, B. Fibiger, (Samfundslitteratur, Frederiksberg, 2002), pp. 31–54

A. Edwards, Building common knowledge at the boundaries between professional practices: relational agency and relational expertise in systems of distributed expertise. Int. J. Educ. Res. **50**(2011), 33–39 (2011)

T. Fenwick, R. Edwards, P. Sawchuk, *Emerging Approaches to Educational Research. Tracing the Sociomaterial* (Routledge, Abington, 2011)

B. Fibiger, J. Nielsen, M. Riis, E.K. Sorensen, L. Dirckinck-Holmfeld, O. Danielsen, B.H. Sørensen,. Master in ICT and learning – project pedagogy and collaboration in virtual e-learning. Contribution to the 3rd European Conference on e-learning. Paris, November 2004, 2005, ISBN: 9547096-7-5

A. Fjuk, Computer Support for Distributed Collaborative Learning. Exploring a Complex Problem Area. Dr. Scient. Thesis 5. Dep. of informatics. University of Oslo, 1998

C. Geertz, *The interpretation of cultures. Selected Essays* (Basic Books, Inc., Publishers, New York, 1973)

L. Gourlay, M. Oliver, It's not all about the learner: reframing students' digital literacy as sociomaterial practice, in *Research, Boundaries and Policy in Networked Learning*, ed. by T. Ryberg, C. Sinclair, S. Bayne, M. de Laat, (Springer, New York, 2016), pp. 77–92

L. Harasim, *Learning Theory and Online Technologies*, 2nd edn. (Routledge, Abington, 2017)

K. Herr, G.L. Anderson, *The Action Research Dissertation* (Sage, Thousand Oaks, 2005)

C. Hine, *Ethnography for the Internet: Embedded, Embodied and Everyday* (Bloomsbury, London, 2015)

I. Hutchby, Technologies, texts and affordances. Sociology **35**(2), 441–456 (2001)

A. Johiri, The socio-materiality of learning practices and implications for the field of learning technology. Res. Learn. Technol. **19**(3), 207–217 (2011)

A. Johiri, Engineering knowing in the digital workplace: aligning materiality and sociality through action, in *Reconceptualising Professional Learning. Sociomaterial Knowledges, Practices and Responsibilities*, ed. by T. Fenwick, M. Nerland, (Routledge, Abington, 2014), pp. 112–124

J. Lave, E. Wenger, *Situated Learning. Legitimate Peripheral Participation* (Cambridge University Press, Cambridge, 1991)

C.P. Lee, Boundary negotiating artifacts: unbinding the routine of boundary objects and embracing chaos in collaborative work. Comput. Supported Coop. Work **16**, 307–339 (2007)

K. Lindberg, L. Walter, E. Raviola, Performing boundary work: the emergence of a new practice in a hybrid operating room. Soc. Sci. Med. **182**(2017), 81–88 (2017)

J. McKay, P. Marshall, The dual imperative of action research. Inf. Technol. People **14**(1), 46–59 (2001)

C. Ondrejka, Education unleashed: participatory culture, education and innovation in second life, in *The Ecology of Games: Connecting Youth, Games, and Learning*, ed. by K. Salen, (The MIT Press, Cambridge, 2008), pp. 229–252

T. Rapley, Doing conversation, discourse and Document analysis, in *The SAGE Qualitative Research Kit*, (SAGE Publications, Cambridge, 2007)

M. Riis, *Avatar-mediation and transformation of practice in a 3D virtual world. Meaning, identity, and learning*. Ph.D. dissertation. Aalborg University Press, 2016

T. Ryberg, C. Sinclair, The relationship between policy, boundaries and research in networked learning, in *Research, Boundaries and Policy in Networked Learning*, ed. by T. Ryberg, C. Sinclair, S. Bayne, M. de Laat, (Springer, New York, 2016), pp. 1–21

S.L. Star, J.R. Griesemer, Institutional ecology, 'translations' and boundary objects: amateurs and professionals in Berkeley's museum of vertebrate zoology, 1907-39. Soc. Stud. **19**(1989), 387–420 (1989)

S. Timmis, J. Williams, Transitioning across networked, workplace and educational boundaries: shifting identities and chronotopic movements, in *Research, Boundaries and Policy in Networked Learning*, ed. by T. Ryberg, C. Sinclair, S. Bayne, M. de Laat, (Springer, New York, 2016), pp. 111–124

E. Wenger, *Communities of Practice. Learning, Meaning, and Identity* (Cambridge University Press, Cambridge, 1998)

E. Wenger, Communities of practice and social learning systems: the career of a concept, in *Social Learning Systems and Communities of Practice*, ed. by C. Blackmore, (Springer, London, 2010)

E. Wenger-Trayner, B. Wenger-Trayner, Learning in a landscape of practice. A framework, in *Learning in Landscapes of Practice. Boundaries, Identity, and Knowledgeability in Practice-based Learning*, ed. by E. Wenger-Trayner, M. Fenton-O'Creevy, S. Hutchinson, C. Kubiak, B. Wenger-Trayner, (Routledge, Abington, 2015), pp. 13–29

B. Wenger-Trayner, E. Wenger-Trayner, J. Cameron, S. Eryigit-Madzwamuse, A. Hart, Boundaries and boundary objects: an evaluation framework for mixed methods research. J. Mixed Methods Res., 1–18 (2017). https://doi.org/10.1177/1558689817732225