

Cross-Use of Digital Learning Environments in Higher Education: A Conceptual Analysis Grounded in Common Information Spaces

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Abstract—This paper addresses the cross-use of different Digital Learning Environments (DLE) in Higher Education (HE). The paper aims to analyze DLEs and their use in a HE organizational entity through the lens of Common Information Spaces (CIS), a concept grounded in Computer Supported Cooperative Work (CSCW). In general, CSCW literature focuses on individual systems regarded as CIS. Moreover, the research shows that DLEs are often analyzed from an educational perspective, and less from a *cooperative work* perspective. However, a teaching/learning context can be viewed as a co-dependent cooperative work arrangement, where the exchange of information and knowledge is performed *through-* and *with* the help of DLEs. In this way, DLEs should be rather viewed as being part of a complex cooperative ensemble rather than analyzed as individual CIS. This paper sheds light on such complex information spaces, where the information spaces are formed through clusters of DLEs, rather than individual DLE units. Finally, the contribution of the paper consists of addressing the cross-use of DLEs from a CIS perspective, moving beyond looking at DLEs just through an educational perspective.

Keywords-Digital Learning Environments (DLE); Higher Education (HE); Computer-Supported Cooperative Work (CSCW); Common Information Spaces (CIS); information spaces.

I. INTRODUCTION

This paper presents the cross-use of different Digital Learning Environments (DLE) in a Higher Education (HE) organizational entity. DLEs are defined here as digital platforms, websites or specific webpages used by course instructors and students in a course for exchanging information or knowledge, relevant for their learning, respectively teaching, within the frame of the course. In a course, a course instructor can use one or more such DLEs: for instance, the course instructor can use both a dedicated Learning Management System (LMS), the email system, the HE website, and a social media platform or channel dedicated to the course. Each of these is considered individually as a DLE when they are used for the purpose of teaching/learning. We will call in this paper the individual DLE as a DLE unit. Therefore the terminology used here is not LMS but rather DLEs. They all together form a Common Information Space (CIS) in that specific course, for the course attendees, and the course instructor. However, the complexity of understanding these information spaces increase when each of the course instructors start using sever-

al DLEs in their courses, some of them being officially the HE institutions' DLEs, whereas some of them are not.

Nevertheless, students may attend several such courses, where each of the course instructors may have their own set of dedicated DLEs. The students usually have very little power regarding the decision on what DLEs to use. At the same time, there are cases when the course attendees themselves suggest to the course instructors to use some *new* web platforms or the *latest* social media platform, in the course. Through this paper, we wish to understand the complexities that come along with this dynamic use of DLEs. Specifically, we want to understand: *what challenges do they set for the students, respectively for the course instructors; how do DLE translate as CIS: what type of CIS are they, how are those represented, and used in a HE setting?* Specifically, the paper discusses and analyzes DLEs through the lenses of Common Information Spaces (CIS) (*compare to* Communication Spaces [1]).

The rest of this paper is organized as follows. We continue with the background of this study in Section II. Section III posits this paper on a theoretical level, elaborating on the concept of Common Information Spaces (CIS), giving a detailed account of the existent literature discussing CIS, including relevant definitions, examples, and characteristics. We continue then by introducing the methods in Section IV. Section V summarizes the findings, whereas Section VI discusses them through the lens of CIS. Finally, Section VII concludes the paper and gives directions for further work. The acknowledgments close the article.

II. BACKGROUND

DLEs are often analyzed from an educational perspective, and less from a cooperative or collaborative perspective. Analyzing DLE in a HE organizational entity through the concept of CIS is interesting because it challenges the traditional view on DLE as educational platforms and less as cooperative or collaborative platforms. This perspective is grounded on several arguments.

First, we argue that DLE should be seen as cooperative platforms and as CIS since multiple stakeholders usually use them: Course Instructors (CI), Students (S), administrative staff (ADM), junior and senior researchers, and nevertheless by the IT department (IT) for maintaining, securing or updating them. There are many cases when one individual in an organization takes multiple roles: CI are asked to take

courses at the same HE institution, students work part-time as teaching or research- assistants, or senior CI are both researchers using various research platforms and at the same time teaching personnel.

Second, a HE organization usually has its own official DLEs that were either bought through a formal agreement or built in-house for many years. These can cover a range from LMS to web publishing systems, to examination systems, or submission systems. Some of these DLEs official systems to the HE organization might also be official at a national level, not only at a local level. The official DLE's are required by the Norwegian law to be universally designed [2][3]. However, although there are official DLEs that are usually used by multiple internal stakeholders (CI, S, ADM, IT), there are also non-official DLEs, i.e., DLEs that are not quality ensured, secured, maintained, or tracked by the organization itself, but by external stakeholders, such as privately-owned companies, perhaps located in another country. One such example is social media platforms owned by private companies. In this case, the platforms are not primarily LMSs. However, these can be used by a HE organizational entity as DLEs to support communication, exchange files, knowledge, and information.

Third, etymologically, teaching can be defined as showing something to someone by informing or instructing, directing, guiding, sharing, delivering, or making someone aware of some specific knowledge, communicating or informing someone about something [4], while learning refers to acquiring knowledge or skill(s) through teaching, an exchange of experiences, or as a result of studying [5]. Learning is strongly connected to teaching and the individual's experience.

Fourth, although much focus is on teaching and learning in HE institutions, these entities are after all public organizations with their own procedures, rules, regulations, dedicated laws, own organizational structures, and employees. They are workplaces similar to other public institutions: The Tax Office, Public Hospitals, or National Employment Agency. In the Nordic countries, many of these institutions' procedures and ways of interaction with their "clients" are very much automated, digitalized, or in the process of automation and digitalization. Along the same lines, HE processes and ways of interaction between different stakeholders are aimed to be automated and digitalized. For instance, in Sweden, the application process to universities is done through an online website [6], where the prospective students can apply online to educational programs or extra curriculum courses, at least twice a year, with some standards deadlines (April, 15th and October, 15th). The website functions as a national database where any citizen can apply to any university programs or courses, as long as they fulfill the requirements. The whole process is smooth. In Norway, an almost similar digital platform exists [7].

Nevertheless, once accepted to a program or a course, being it campus-, distance-, or Internet-based, the students will be asked to use new digital platforms. Moreover, in

Sweden and Norway, much of the teaching, even the campus-based one, make use of various DLEs. Nevertheless, employees at these institutions will use additional human resources platforms, the type of Enterprise Resource Planning (ERP) systems to plan their resources (teaching staff, courses, budget), such as SAP [8], Microsoft Sharepoint [9] or Box [10]; time schedule systems that have to be synchronized with teaching staff, courses, class-, laboratory- or group rooms; or in some cases digital examination platforms, that have to be secured, and limit the individuals taking the exam to navigate the web or reach to other external resources during the examination time. Moreover, email is usually extensively used for communication within and outside of these organizational entities.

As such, HE institutions are more than educational entities that *produce* or prepare individuals for taking part in the workforce, but as complex and dynamic cooperative assemblages, where interactions, different negotiations amongst various stakeholders, communication, and cooperative work arrangements take place. Computer Supported Cooperative Work (CSCW) emerged from the need to study group work and office automation [11]. As indicated by Schmidt and Bannon [12], CSCW is conceived as "*an endeavor to understand the nature and requirements of cooperative work to design computer based technologies for cooperative work arrangements*" (emphasis in original). A subfield of CSCW is Computer-Supported Collaborative Learning (CSCL). As shown in a CSCL study, information technology, such as DLEs, can support collaborative learning; however, the users need to overcome some challenges that come along with the use of these technologies [13].

Nevertheless, these information technologies also change the behaviors and practices of learners and teachers [13]. However, CSCL focuses in general on mediated communication technology between teachers and students, and not on seeing DLEs as part of large organizations, where DLEs can be seen as information spaces. Moreover, seeing learning/teaching as a form of *cooperative work* is interesting because, according to Schmidt [14], cooperative work refers to co-dependent work that has to be done by an ensemble of people together, (either for achieving a product or a service), which otherwise would not be able to be achieved by individual persons. *Cooperative work*, (comp. to *collaborative work* which is positively laden [12]), refers to the interdependent relations that develop due to the manifested practices that take place, which very often require some form of *coordination* as well, e.g., so-called *coordinative practices* [15]. At the same time, a learning/teaching relation in a HE context is usually a co-dependent one: the teacher's responsibility is to provide relevant knowledge in a course that the students can learn; at the same time, the students need to deliver assignments, take exams or in some form show that they have achieved the learning outcomes. In this way, such a setting can be regarded as a cooperative setting.

Finally, the paper emphasizes the use of multiple systems and how these are viewed as clusters of CIS, rather than individual systems. All in all, HE organizational entities viewed through the lens of cooperative work helps us in seeing beyond educational setting and reflecting on the complexity of the use of multiple virtual information spaces used in HE organizational entities, and on the need of coordinative practices for enabling a successful cooperative work, i.e., a successful exchange of knowledge in teaching/learning context.

III. LITERATURE REVIEW: ON CIS

This section gives an extensive overview of CIS, by defining the concept, grounding it in examples, illustrating the specific characteristics, and explaining how the concept will be later used in the paper.

A. Defining CIS

The concept of CIS was first used in Schmidt, and Bannon’s [12] work on “Taking CSCW seriously.” The authors used the terminology along with the definition of articulation work, saying that CIS is one of the aspects supporting articulation work, together with workflow [12]. According to them, a CIS is necessary for distributed cooperative work, to maintain some form of ‘shared’ and locally and temporarily created understanding about the objects in the CIS. Usually, such a CIS is actively created, accessed, maintained, manipulated, and shared at various degrees, amongst multiple actors or stakeholders.

A CIS has the aim to allow the members of a cooperative ensemble to cooperate and interact without formal constraints, such as procedures or conventions [12]. A CIS also aims to bring “people and information together, through artifacts (...) and interpersonal communication, and they help ensure uniformity of information” [16].

Moreover, CIS “indicate spaces that support distributed cooperative work as an alternative to procedural or workflow type arrangements” [18]. A CIS goes beyond a personal information space, where the individual producer of an object is also the ‘consumer’ of an object, i.e., the meaning that an individual attributed to an object is interpreted by the same individual [12].

A CIS also includes a common developed vocabulary [12]. CIS are containers and carriers of information [19]. Finally, Bossen [17] developed and formulated seven parameters of CIS. He argued that CIS is too loosely defined and that the proposed parameters can be used as an analytical framework for CIS [17]. These are represented in Table I.

B. Examples of CIS

A shared database is not necessarily a CIS, following [12]. The objects represented in a database are “carriers of representations,” and not objects *per se* [12] if the actors do not have direct access to the material objects as artifacts. For instance, if the actors have access to a product X, or to a file Y, both outside of the database system, then they can build a common and shared understanding of how these objects should be represented in a database system. In other words, the actors can give a *common* interpretation of the material objects. Hence, a CIS embeds a coherent and interpretative aspect of the material objects represented in a database, compared to database objects that are rather “carriers of representations” [12].

A clear example of a CIS given by the authors is a whiteboard, where several members of the cooperative ensemble jointly scribble, modify, draw, or erase things written on the whiteboard [12]. Each member of the cooperative ensemble interprets the objects on the whiteboard individually. However, the scope is to achieve a common and shared meaning.

An excellent example of a CIS is when a department develops its own “set of meanings for key terms” (Savage, 1987, p. 6) in [12]. For instance, in a HE institution, the meaning of a *seminar* or *laboratory assignment* may be different based on different educational departments or courses. A laboratory assignment in a programming course means perhaps the development of a program by coding in an ordinary classroom environment, while laboratory assignment in biology or chemistry can possibly mean a form of experimenting in a specially dedicated lab, where specific tools and instruments are available. In this sense, CIS has a physical character.

Other examples of CIS are documents and artifacts used in an organization, supporting the cooperation between the cooperative ensemble members [12].

However, we have seen that lately, with the advanced web or software solutions available, these documents or artifacts can be represented virtually: virtual post-its or virtual dash-boards shared between members of an organization. Trello, Microsoft Team, Slack, or Google Drive are a

TABLE I. SEVEN CIS PARAMETERS FROM BOSSEN [17]

#	CIS Parameter	Explanation
1	degree of distribution	physical distribution of the cooperative work;
2	the multiplicity of the web of significance	several webs of significance are included in CIS;
3	degree of the needed articulation work	articulation work may vary depending on the character of the cooperative work;
4	multiplicity and intensity of means of communication	face to face communication, but also other communication means available and/or necessary during the cooperative work;
5	web of artifacts	all the artifacts included in the cooperative work;
6	immaterial means of interaction	habits, procedures, the structure of the organization, division of labor, etc. that decrease the need for coordination;
7	need for precision and promptness of interpretation, in the cooperative work.	the need for precision for the available information; this parameter is especially important in time- or safe-critical situations;

few examples of CIS where objects of a CIS are co-created by several members of the cooperative ensemble. Such a system should: “in addition to services facilitating the creation, modification, transmission, etc. of messages, provide services supporting the cross-referencing, cataloging and indexing of the accumulating stock of messages”, but they should also support the inclusion of external items [12].

A more extreme example of CIS is the web (www), where some pages are produced by several entities that do not necessarily are tangential to each other, however, a heterogeneous group of consumers of the CIS access information produced by several of them [19]. According to the study, this is a paradox example of CIS, which is both *internally closed* to the producers, however *open and accessible* for many.

C. Characteristics of CIS

Besides the seven parameters of CIS identified by Bossen [17], the literature has identified a couple of other parameters of characteristics specific to CIS. We briefly illustrate each of those, as follows.

1) Dialectic Nature of CIS

Bannon and Bødker [19] argue that putting information in common and interpreting it was not sufficiently discussed [19]. Their paper argues for a dialectical nature of CIS: CIS is both *open* and *closed*, and they are often both *portable* and *immutable*, containing *malleable information items* while *supporting the cooperative work*”.

2) Hybrid Information Spaces: In-between Private and Common

CISs are also characterized by some sort of malleability: “open for some yet closure for others” [19]. Such an example of *hybrid* information spaces is illustrated in [18]. These are framed as information spaces that are in-between private and common [18]. Such an example is the Personal Health Records (PHR) studied in MyBook and MyHealth Norwegian projects [18]. PHR are considered to be *hybrid information spaces*, partially because the patients have to input and track their personal health data, but some of this data is also shared with medical staff [18]. Hence, they can be shared across roles and boundaries [18]. This can trigger dilemmas along how and with whom the information is shared, who owns it, in which ways it is accessible and for whom, and how these are regulated amongst the patient and the medical staff [18]. The authors recommend the regionalization of hybrid information spaces, such that the systems are designed in such a way that they can both be private and preserve the user’s autonomy and control, but also shared (hybrid), with the aim of cooperative work [18].

Nevertheless, CIS should be mediated by human mediators, that support both those members of the cooperative ensemble who create, modify, or develop (*producers*) the common information, and those that use this information (*consumers*) [19].

3) Scalability and Multiplicity of CIS

One study added to Bossen’s CIS parameters, the following ones: collaboration’s scalability and information spaces’ multiplicity [17]. Collaboration scalability includes the number of participants involved, and the phases necessary for achieving the collaborative work [17]. The information spaces’ multiplicity refers to the number of entities and artifacts that intersect in the collaborative work and form the CIS [17].

4) Multiple Centers, Peripheries and Overlapping Areas

Information always belongs to a place, although the place does not necessarily need to be geographically fixed [20]. Following [20], CIS is described as having both *multiple centers* and *peripheries* but also *overlapping areas*.

5) CIS Objects Re-producing Fragmentation

Rolland et al. conceptualizing CIS across heterogeneous contexts [21]. They presented the idea of CIS as malleable and open objects, which are achieved in practice [21]. They also emphasized the idea of large scale CIS reproducing fragmentation [21]. One of the earlier studies [22] (*forthcoming*) also proves this fragmentation.

6) Temporality of CIS

CIS distributed across time and space is characterized by physical separation of cooperative members, limited access and control over the shared material, and more strict division of tasks [19].

A study investigated CIS across distributed medical teams in *emergency, time-critical, episodic, and heterogeneous cooperative situations* [23]. Having a shared understanding of these emergency cooperative settings is necessary. Munkvold and Ellingsen [24] talk about CIS use in a hospital ward while they introduce the temporal dimension of CIS, when several users are involved with their own trajectories, and intersected trajectories. Moreover, Bertelsen and Bødker [20] problematized cooperation and CIS in *massively distributed information spaces*, a case on a wastewater plant. The authors challenge the idea of CIS that provides access to *everything everywhere* [20].

7) Physical Aspects

The study from [16] investigated the physical aspects of objects part of a physical CIS in emergencies. The CIS part of the emergency rooms is artifacts, including electronic records, equipment, or whiteboards, supporting the staff work [16]. However, the study stresses that the information available on these CIS’s is determined not only on the quality of the information, or how timely it is disposed of but also how easy it is for the staff to interact with it [16]. For instance, the study illustrated that the height and the place where the displays in the hospital are placed determines the coordination work the staff, and how much they engage with each other. Bossen [17] presented a similar case from a hospital ward. Another study that explored distributed information spaces in a hospital setting from Mexico city is the study presented in [25]. Specifically, the authors explore the physical mobility, moving beyond the desktop metaphor [26].

CIS in a shared workspace is characterized by the physical co-location of the cooperative ensemble' members, real-time sharing of resources, and sometimes ad-hoc co-handling tasks [19]. However, cooperative work does not always take place in the same shared location: the *cooperative work might exceed the temporal and local boundaries* [19]. This also puts additional requirements and changes in the design of a CIS. The information shared in a distributed CIS has to be packaged and belong to a context [19].

8) Communication Means in CIS

Hjelle [27] illustrates an example of information spaces used in an oil and gas company. He analyzes the case through Bossen's seven parameters of CIS [17]. The author points out that the best interaction is done through face to face communication [27]. The study concludes that not all of the seven parameters [17] are equally significant. However, many tools seem to be used to facilitate the cooperation, although they are not always cooperation tools, communication tools used to facilitate the cooperation when face to face meetings are not possible [27].

Sometimes, information technologies used in organizational settings are discussed as *communication spaces* instead. However, CIS and communication spaces are different, although they might have some similarities in common [1][28]. While communication spaces focus very much on the communication takes place across distributed or non-distributed spaces, CIS focus instead on how information is created, shared, maintained, and achieved. At the same time, CIS may include various communication spaces.

D. CIS in This Study

The CIS literature covers, in general, a few studies from hospital wards (see [14][17][21][22]), and in organizations, such as oil and gas companies [27], or wastewater plants [20]. However, many of these studies focused very much on the physical CIS, except for the study from [18], who focused on the hybrid and mobile information spaces. To our knowledge, it seems that CIS was not so far studied in HE institutions and that DLEs were much more often regarded from an educational perspective rather than a CSCW perspective. This study aims to bring new insights on both DLEs seen through the lens of CIS and CSCW literature, but also to the CSCW community on how DLEs can be regarded as CIS and the complexity of analyzing those as such. We continue in the next section with the method, and after that, we present the findings before we discuss those.

IV. METHOD

A. Participants and Setting

We have interviewed several experts, with an area of expertise in pedagogics and universal design. We define experts as senior researchers, with an area of knowledge in either pedagogics or universal design and a subdomain of informatics, such as human-computer interaction, interaction design, computer-supported cooperative work, or com-

puter-supported collaborative learning. All of the participants had several years of experience of being course instructors. We will use, therefore, interchangeably the notions of experts, course instructors, or teachers, referring to the same participants.

The interviews were performed in several stages of the study. In this paper, we illustrate some findings from the interviews conducted with the interviewees having their background in pedagogics (n=3). However, similar findings are also presented in the rest of the interviews (see [22], [29]).

Finally, the interviewees were recruited through personal contact. The author had no relation to the participants since before.

B. Data Collection and Analysis

The interviews lasted about one hour- one hour and fifteen minutes each. These were transcribed verbatim by the author (SD). The data were analyzed in several steps, as recommended by [30]. Some photos were also taken during the interviews, on artifacts shown by the participants. These did not contain any personal or sensitive data.

The analysis was done through systematic text condensation [30]. 12 Excel spreadsheets were used for documenting all the steps throughout the process. The analysis was done in four steps: (step 1) the data was fully read to get a sense of what the data was talking about (themes: $n_1=6$, prioritized themes $n_1=4$); (step 2) identifying and categorizing meaning units (codes $n_1=130$ for the first theme, $n_2=124$ for the second theme, $n_3=125$ for the third theme, and $n_4=39$ for the fourth theme); (step 3) condensing the codes into meanings ($n_1=23$, $n_2=13$, $n_3=25$, and $n_4=9$); these subcategories were then organized in categories ($n_1=7$); (step 4) finally, during the last step, the author has synthesized the condensates into concepts ($n_1=3$). The resulted concepts were: cross-platform use of DLE, user diversity in Higher Education, universal design, and organizational tensions. This paper focuses solely on the cross-platform use of DLEs. However, the theme of user diversity and universal design were covered in [29].

C. Ethical Considerations

All the participants were given detailed information about the study, the possibility to ask questions prior- and during the study, and they could withdraw at any time without providing any explanation and without any consequences for them. The participation was based on free will. All the participants were willing to participate in the study signed informed consent before taking part in the study. The study follows the ethical guidelines from the Norwegian Center for Research Data (NSD) ref. Nr: 55087). This work was performed on the Tjenster for Sensitive Data (TSD) facilities, owned by the University of Oslo, Norway, operated and developed by the TSD service group at the University of Oslo, IT-Department (USIT) (project number: p400).

V. FINDINGS

The participants mentioned 23 DLEs. The minimum number of DLEs used by the participants was 5, whereas the maximum was 16 out of 23. It seems that the youngest of the interviewee was more prone to use digital technology in class, together with her students. The same interviewee used social media platforms and considering using instant messenger in her communication with students, arguing that these were the preferred communication channels by the students.

The official publishing system was used by two out of three participants. However, one of the interviewees used it only for information related to her area of work, research, and publications, but not in a teaching/learning context. The interviewee considered the HE’s official web publishing system more as an administrative tool rather than being a dedicated tool for teaching/learning.

Moreover, only two participants used the official examination system, whereas the third participant was aware of it, but did not find it appropriate to use it together with its course-takers. However, email and the new official DLEs introduced at the HE institution were used by all interviewees.

Further, one of the interviewees used three simulation environments, as the leading DLE platforms, in his teaching, although another DLE was the official institutional platform. These simulation environments were mandatory to be used by the students during the course. While some of the students were against using these external simulation tools, some felt motivated in using real-world scenarios in simulated environments. Teaching specific and generic skills by using these external simulations environments and DLEs was the main argument for using those. However, the students were required to make their submissions in the official DLEs, across the semester. But a final official examination at the end of the semester was required to be done in a third system, i.e., in the official examination system.

Two of the interviewees were using two other digital systems each in their teaching. Only one participant used cloud-based storage. The same participant also used additional plug-ins in the official DLEs.

Further, one of the participants expressed the need for a participatory tool and keeping track of things in a DLE. Therefore, she chose a publicly available database system-like online tool for recording each years’ course participants’ entries.

Table II gives an overview of the systems in use, as described by the participants. Another inventory of DLEs used by other participants taking part in the same study was done in our earlier published work (see more in [22], forthcoming).

TABLE II. OVERVIEW OVER THE DIGITAL LEARNING ENVIRONMENTS AND TOOLS

#	Participant (CI)	#1	#2	#3
	Systems used in a HE Organizational Entity			
1	Publishing system		X	X
2	Internally and externally used submission and assessment system	X		X
3	External quiz and input system 1			X
4	External quiz and input system 2			X
5	External quiz and input system 3			X
6	Email	X	X	X
7	New DLE system	X	X	X
8	Third-party application			X
9	Social media platform 1			X
10	Web service for forum discussions and wikis		X	
11	MOOC or MOOC like platform		X	
12	Examination platform	X		X
13	Virtual game environment 1	X		
14	Virtual game environment 2	X		
15	Virtual game environment 3	X		
16	Learning Analytics	X		X
17	Specialized analysis software 1	X		
18	Specialized analysis software 2	X		
19	Specialized video analysis software 1			X
20	Specialized video analysis software 2			X
21	Cloud-based storage			X
22	Different variants of messenger applications			X
23	The third-party plugin used in the official DLE system			X

The official DLE was described by one of the participants as being an administrative tool rather than supporting learning. The system was also described as not being user-friendly and being cumbersome; however, it was also described as being easy to access and manipulate if one is familiar with such tools. At the same time, it seems to be a complex system to navigate, and that many of the student users complained about navigation issues. She also mentioned that non-regular students, i.e., older employees at the HE who are asked to use the official DLE, have a hard time using it. She described how the systems are nowadays designed as dashboards. According to the participant, these are often seen by international students that lack digital skills as a “dump place,” where the course instructor “dumps” course material and information rather than as a DLE that provides opportunities for learning.

“(...) for some of the students, they were not used to it, and they were not introduced to it in the way I would like to do it, it was just like a., sort of a repository, like a "dump place," where all this information about the course, slides, whatever the material teachers wanted to use, it was kind of thrown into that, in an organized way - which is good. For them, this was not a discussion platform; it was not a place where they could express their views or interact with the materials where they would say: okay, I would want it in

this way, or I would post my idea or view in an idea or knowledge in a discussion. They did not perceive technology as something that offers them the possibility to express, learn, engage, and be an active participant in this case in a learning activity. And I think it is an important function of the technology, to provide a platform, for those that either does not have a possibility or the attitude to do this face-to-face in plenary, for various reasons, or for those that are at a distance. So this is an opportunity. I think it is a missed opportunity if we do not present it and use it as teachers, or those who introduce it in the right way.” (Participant, Interview)

Finally, one participant was pledging for digital natives being prone to like dynamic DLE than others, and therefore they might find the official web publishing system as being out of date. However, she was complaining that there are (perhaps too) many functionalities available in the official DLE, that there are anomalies in these functionalities, i.e., a chat functionality available in the system for all class, but not inside the groups, that the system is characterized of high complexity, that it can be perceived as overwhelming at times, that it is rich in functionalities, and has a U.S. based design geared towards assessment. She mentioned that the system requires to have a pedagogical rationale when planning a course to be able to make the most use of it.

“It’s often that the students, like the natives, they come to the University, first-year students and they know they will be using learning platform, digital learning platforms, because most of them have used it in high school, or even in lower grades, while students coming from other parts of the world, don’t have this ingrained experience, or simply experience of using the technology in this way. And I think there is always a gap there that often creates difficulties for the other group, not because they are not good performers, or good learners, or interest or motivated, because they simply need, a different encounter- start encounter with technology.” (Participant, Interview)

VI. DISCUSSION

This section presents a regionalization of DLEs units in categories and clusters of information spaces. Based on our findings, shown earlier in Table II, DLEs are re-grouped in this section into official systems, third-party applications, and specialized software applications, quiz input systems, virtual games environments, and social media platforms. The classification is made based on each DLE unit’s own primary purpose. The reason for regionalizing DLEs in these categories is to illustrate that the majority of the DLEs in use are non-official systems, but also to showcase their distribution across different domains requiring a different set of skills for using those. After that, a discussion on DLEs as information spaces follows.

A. Regionalization of the DLEs Units in Categories and Clusters of Information Spaces

Information always belongs to a *place*, or for that matter, to *space*, as it was also proved in the illustrated examples [20]. In line with [20], this study also proves that information can belong to some *overlapped areas* and *multiple centers*, i.e., see for instance the information distributed or

shared through the official systems; or to *peripheries*, such as the information belonging to the quiz input systems, social media, virtual game environments, or specific specialized software systems that are used solely in particular courses. Such regionalization is needed to show the high use of non-official systems and the cross-use distribution amongst official and non-official DLEs.

Figure 1 shows a heat-map on the regionalization of DLEs from Table II. The black line distinguishes between the official systems, i.e., the system that is official to the HE organizational entity, such that they are proposed, indicated, maintained, and secured by the HE organization itself. We organized the DLEs units used by the participants in six categories: official systems (dark green), third party applications (pink), social media (blue), quiz input systems (yellow), virtual games environments (orange), and specialized software applications (light green).

The set of official DLEs {#1, #2, #6, #7, #12} is represented by five DLEs. However, we can observe that only five out of 23 DLEs in use are official systems, whereas the majority of the systems, precisely 18 of them, are not official ones, i.e., neither maintained nor secured by the HE organization personnel. Next, we can observe that six DLEs used to subscribe to the *third-party applications* category. Examples of these are the use of a third-party application (#8), web service for forum discussions and wikis (#10), MOOC or MOOC like platform (#11), learning analytics (#16), cloud-based storage (#21), and third party plugin used in the official DLE system (#23). Several specialized software applications were used – the set represented by {#17, #18, #19, #20}. Virtual game environments were used in a number of three: the set composed of {#13, #14, #15}, as well as quiz input systems – the set represented by {#3, #4, #5}. Finally, only two social media platforms were mentioned as used by the participants in their students-teaching/learning HE context, the set composed of {#9, #22}.

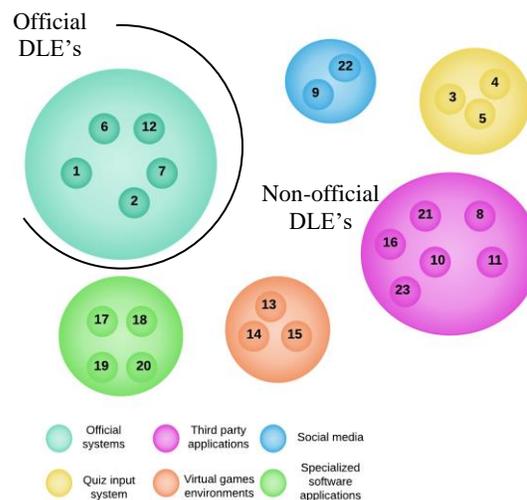


Figure 1. Heat-map over the types of DLEs used.

Further, Figure 2 illustrates a heat-map over the DLEs handled by each of the interviewees, including their types, which is color-coded. It indicates a regionalization of DLEs units based on an *individual regionalization* for each of the participants.

We can observe from Figure 2 that participant #3 used all five official systems, participant #2 used only three of them, whereas participant #1 used four of them. However, it seems that only participant #3 used social media and quiz input systems, and only participant #1 used virtual games environments. Participant #3 was also the youngest amongst the interviewees, which can perhaps be one of the reasons for being more prone to adopt DLEs. However, this is less important. More interesting is to look at the variation of the range itself, because it means that if a student takes all three courses, at the same time, from these three course instructors, the students will have slightly different CIS clusters for each of the courses (Figure 2). Such a situation may take place since all of the participants belonged to the same HE organizational entity.

At the same time, we can observe that each course’s CIS is formed out of at least two DLEs units, and a maximum of five. This means that the student’s virtual information space is not solely formed out of a single DLE unit, but of at least two. As many as DLE units are included in the information space, as more fragmented, the information space becomes. Nevertheless, once with the fragmentation, more coordinative practices are also needed: the student, as well as the course instructor, needs perhaps to have an account on each of these information spaces, to log in, to log out, to download or upload course material, to share, read or write information to space, etc. This may contribute to fragmented information awareness [22].

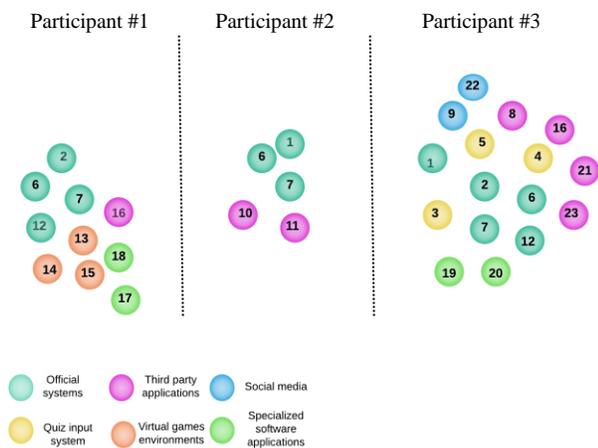


Figure 2. Heat-map over each of the participants’ DLEs units used.

B. DLEs as Information Spaces

This subsection analyzes DLEs as information spaces, based on the Bossen’s seven parameters [17] of CIS and the CIS’s characteristics (Section III).

The physical distribution of the cooperative work (parameter #1 in [17]) across space and time calls for the need of a number of DLEs, both common and hybrid information spaces. However, what is essential to do is not to disregard the amount of *articulation work*, which is a “supra-type of work” (see [12], [31]–[33]) that comes once an information technology or system is introduced in an organization, to facilitate the work. In the examples presented earlier in the previous sub-section, it seems that often the CI is the decision-maker on what DLEs units are to be used in the course as CIS. Thus, the CI is often the decision-maker of the information spaces to be used by students. In some cases, students also suggest some new channels of communication as DLEs units to be included in the course’s CIS. However, as the literature shows, it seems that it is very much overlooked or underestimated the disadvantages of adopting specific interfaces, the decision is mostly based on intuition, rather than on a thorough or elaborated process [34]. Nevertheless, according to Bossen’s parameter #3 on articulation work, this depends on the character of cooperative work [17]. We argue that the amount of articulation work required by information spaces is given not only by the cooperative work but also by the number of DLEs units included in an information space, being it *hybrid of common*.

A *hybrid* information space composed by DLEs units refers to the information space created by both the private or peer group notes of a course attendant or course instructor and the information that is put in common in such an information space. For instance, the CIS that participant #3 is using is, in fact, a cluster of DLEs units, or individual hybrid information spaces, such as social media platforms. A social media platform used both as a DLE unit and as a CIS is a hybrid information space, in this sense. The cluster of information spaces used by participant #3, together with her students, is hence a hybrid one.

Further, the information spaces’ multiplicity [17] is given by the number of entities or artifacts that intersect in the collaborative work and form the CIS. In the illustrated examples on the cross-use of DLEs, we can say that the students’ or course instructors’ information spaces’ multiplicity is given by the number of DLEs units used in a course. However, while this number of DLE unit types (e.g., official systems, third party applications, social media, etc.), varies between 2 and 5, for the students or course attendants taking courses from all the three course instructors, the number of DLE units in use may vary up to 23.

Moreover, multiplicity is also given by the multiple webs of significances (parameter #2 in [17]) of the users: students and by the course instructors, each having different backgrounds, skills, different levels in digital literacy, etc. The web of significance is given by the number of users (students, CI) and the context the DLE units are used within. The multiplicity and intensity of the means of communication (parameter #4 in [17]) are illustrated by the majority of DLEs units, as many of them include some form of communication channels, especially the official systems and social

media. Moreover, the web of artifacts (parameter #5 in [17]) distributed across different DLEs units form the students' respectively, the course instructors' information space. The web of artifacts is also given by all the resources provided by the CI, and by all assignments or submissions provided by the students.

The immaterial means of interaction (parameter #6 in [17]) consists of all the habits, procedures, and division of labor shared amongst the stakeholders. When these routines are well known to all of the stakeholders, the coordinative work will decrease [17]. However, as shown in [35], the lack of procedures and rules around a newly adopted groupware system puts particular demands on the quality control of the data gathered, the privacy of the organization and the individuals' using the system, and it can become a liability to the organization, rather than an asset. Similarly, in the case of students that do not know how to use DLEs as their common or hybrid information space, the articulation work for making the work *work* will most likely increase on the teacher's side. Specifically, one of the participants explained how she had to do some coordinative work in the form of articulation work when students with a lower digital literacy did not know how to use or navigate the information spaces, although she explained during class where the web of artifacts is available and how to use those. As one of the participants specified, "*students coming from other parts of the world, don't have this ingrained experience, or simply experience of using the technology in this way.*" (Participant, Interview).

In terms of needs of precision (parameter #7 in [17]), the participants did not express any concern regarding time- or safe critical issues for the availability of information. Perhaps the *deadlines* can be regarded as such, but other than that, there are not such critical time aspects. However, compared to physical information spaces, such as a whiteboard during a class filled with notes co-created through discussion by students and CI, that's is dynamic, momentary, and transitory, in a way – it will be deleted by the end of the class, virtual information spaces are seemingly slightly different. Virtual CIS and their objects seem to have a more extended temporality, i.e., the course material objects are available online over a more extended period of time throughout the semester, rather than only for one hour during the class. Moreover, virtual information spaces, such as DLEs units forming clusters of information spaces, seem to be more malleable and plastic than the physical ones: while they still keep their constant variable over time, they can yet be changed, updated, modified, deleted, and re-created. However, they are still present in the system. Their temporality, in this sense, can, in a way, be episodic.

Finally, the dialectic nature of DLEs clusters forming the hybrid or CIS is given by the openness and closeness of the DLEs units. For instance, we can notice the dialectic feature for the DLEs used by participant #1 and #3. The findings show that both participants use both official systems, being those closed (e.g., system #7, #9) or open (e.g., system #1),

and other external systems – they also closed (e.g., #9, #13) or open (e.g., #3, #4, #10).

C. Cross-use of DLEs

Each of the DLE units can be considered as CIS or hybrid information spaces, based on two conditions: 1) the functionalities they provide, and 2) the perspective from which they are analyzed (student/CI). The clusters of information spaces, as shown in the figures (Figure 1 and 2), are indicated based on the data collected from the CI. However, for the students, the information spaces may cross different information spaces regions, depending on which courses they take, and the DLEs CI use in their teaching.

Several studies from the existent literature showed (see, for example, [35]-[36]), the introduction or integration of information technology or information technology devices in various organizations with the purpose of office automation [11] challenges the respective organizations their local procedures, rules, habituated practices, and coordinative practices. Similarly, our study shows some of the challenges posed when un-official DLEs are used: the information becomes fragmented across different information spaces, the distribution of DLEs may cross different information spaces regions, for the students; the degree of articulation work increases with the number of DLEs in use; the multiplicity and intensity of the means of interactions depends on the type and number of DLEs used, as well as on the number of users;

Finally, using such complex information spaces that are formed out of DLE units and clusters of DLEs give some freedom and flexibility to its users, but it also puts some responsibilities or expectations on them, such as collective expectations on one's availability at all the time, everywhere, increased commitment in communication, changed practices and norms, or experiencing an intensified communication, similarly to the findings from [37].

VII. CONCLUSION AND FUTURE WORK

This paper has presented DLEs viewed through the lens of CIS. The research question addressed was: *what challenges do they set for the students, respectively, for the course instructors; how do DLE translate as CIS: what type of CIS are they, how are those represented, and used in a HE setting?* Specifically, the article has focused on how DLEs can be designated as complex information spaces. DLEs are often seen, analyzed, and discussed about as educational environments. Moreover, it seems that CIS addressed in educational settings seem not commonly explored. The contribution of the paper consists of discussing the cross-use of DLEs from a CIS perspective, moving beyond looking at DLEs just through an educational perspective. This makes the contribution of the article interesting and relevant. As future work, it would be interesting to investigate the articulation work necessary to be performed when large DLEs clusters are in use, and how these affect the work and performance of CI and students. Moreover,

addressing these information spaces from a universal design perspective would be both interesting, relevant, and timely.

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