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Transforming the space-time of learning through interactive whiteboards: the case of a knowledge creation collaborative task.

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Abstract
The present article aims at qualitatively exploring the emergent space-time configurations of Interactive Whiteboard (IWB) usage within a collaborative media design task at a university of applied sciences. During this course, the students had an opportunity to use the IWB technology to support the collaborative learning process within small groups of 4-5 members. It is argued that research on the space-time transformations enabled by digital technology, carried out by adopting the dialogical concept of chronotope, is useful to improve the understanding of learning in technology rich settings. Participant observation was conducted on two groups of students. Video-audio records of the students' activity and of group interviews were collected and qualitatively analyzed. The findings reveal that the IWB was only partially integrated within the students' activity. Most of the IWB usage took place during the first phase of the course. The IWB use was characterized by specific space-time configurations that allow to examine how the students attempted to integrate the IWB in their learning space. The students' reflections during the group interview allow to advance our understanding concerning the emergence of the space-time configurations identified by the researcher, as well as the students' perception of the learning environment. It is concluded that the usage of IWB and the effectiveness of the emergent space-time configurations are both strictly dependent on the nature of the learning task and the pedagogical approach adopted.

Keywords: interactive whiteboard; chronotope; knowledge creation; higher education; educational technology

1. Introduction

In many countries there have been large investments to provide educational institutions with Interactive WhiteBoards (IWB). In many schools and universities, IWBs are part of the normal technological toolset available for teachers and students. Some research suggests that the features of the IWB technology are well fit for supporting teaching and learning processes (Al-Qirim, 2016).
Previous research on the integration and use of Interactive whiteboards (IWB) in higher education teaching revealed that often the most advanced features of this technology are not used or used in a very limited way (Al-Qirim, 2011). Indeed, typically the IWB is used as a presentation tool, which does not allow deploying the whole range of functionalities offered by the technology (Sad & Ozhan, 2012). Accordingly, research on IWB largely focused on student-teacher interaction while studies on students' use of this technology for collaborative work are quite rare (Warwick, Mercer, Kershner, & Staarman, 2010).
Among a few exceptions, the study by Gursul and Tozmaz (2010) shows that the students' use of IWB was limited to activities that could be carried out on normal boards and for explaining things through animation. Nevertheless, the affordances provided by the IWB, including "visibility, provisionality, stability, direct manipulation, multimodality, and re-usability, potentially offer strong support for cumulative, collaborative, and recursive learning" (Hennessy, 2011, p. 483).
In particular, the literature supports the idea that one key advantage of IWB is the improved visibility of content displayed, in particular for multimedia and interactive content (see Al-Qirim, 2016). Thus, it is expected that the IWB might contribute to generate a novel space-time configuration of the learning process, where interactive content is easily displayed, visualized and interactively manipulated by all students through the use of the virtual space displayed on the IWB. An in-depth understanding of if and how the interactive features of this technology are actually exploited by students in collaborative learning tasks is still missing in the literature.
The present explorative study contributes to address this research problem by examining the integration of the IWB within a collaborative media design task at a university of applied sciences in southern Finland. During this course, the students had an opportunity to use the IWB technology in order to support the collaborative learning process within small groups of 4-5 members.

2. Theoretical framework

In this investigation, the analytic interest is on the potential new space-time configurations of collaborative and interactive usage of IWB. Indeed, as mentioned above, the literature suggests that the features of this technology lend themselves well for transforming the way in which students collaborate and interact with learning content. For this purpose, this study is based on the concept of chronotope (Bakhtin, 1981), which emphasises the space-time dimension of learning.
The rationale for the use of this concept is that a specific aspect of the introduction of new technology in learning practices is related to the transformation of space-time. These transformations involve, for example, the emergence and use of pervading virtual spaces (such as the shared virtual space displayed through the IWB). Some researchers have argued that the research on the space-time transformations that are enabled by digital technology is essential for our understanding of thinking and learning in technology rich settings (Carvalho, Goodyear, & de Laat, 2017; Ritella & Ligorio, 2016). The basic idea on which this type of investigations is grounded is that a better understanding of how students and teachers re-organize the space and time of their learning might reveal new insights on how learning takes place in contemporary education and how participants to learning activities integrate multiple digital tools in a spatially distributed and temporally layered process.
In sum, here chronotope is used as a conceptual tool to analyze how the IWB technology is integrated in the learning space throughout the duration of a project course (the temporal dimension).

Chronotopes are defined as socially emergent configurations of space-time, where both discursive and material aspects of space-time relations are considered and seen as mutually interdependent. Chronotopic analysis is contributing to research on a wide range of educationally relevant topics, such as students' interpretation of tasks (Ritella, Ligorio, & Hakkarainen, 2019), learning across multiple online and offline contexts (Kumpulainen, Mikkola, & Jaatinen, 2014), teachers' allocation of classroom time to different students in response to testing arrangements (Renshaw, 2014), the exploration and appropriation of educational technology (Ritella, Ligorio, & Hakkarainen, 2016) and emergent opportunities for literacy learning in classroom interactions (Bloome, Beierle, Grigorenko, & Goldman, 2009).

As an analytical tool, chronotope allows to make visible the temporally layered process through which the learning space is transformed when new tools are introduced, thus it allows to trace the development of learning across physical-material, virtual and social spaces. Of course, the transformations of contemporary education are not related to technology alone. Digital tools do not automatically have an impact educational practices, nor affect learning by themselves (Säljö, 2016). The effects of technology on education also depend on the pedagogical approaches adopted, which are characterized by specific ways of organizing space and time (see Ritella, 2018).

In the present article, the analysis focuses on a particular genre of pedagogical practices, that is, knowledge creation (Paavola, Lipponen, & Hakkarainen, 2004). This pedagogical approach conceptualizes learning as a collaborative effort directed toward developing artifacts, broadly defined as including knowledge, ideas, practices, and material or conceptual ones. It involves the design of authentic tasks in which learners are required to collaboratively develop, transform, or create shared objects of activity (such as conceptual artifacts, practices, products, diagrams) in a systematic fashion. These types of complex and open-ended tasks usually require complex instrumental ensembles that need to be orchestrated across multiple sessions of learning, going beyond the typical space-time setting of traditional school lessons. The knowledge creation approach thus aims at triggering the spatially-distributed and temporally-layered creation and development of shared objects of activity, which are expected to lead to the growth of students' knowledge and skills.

3. Aims and Research questions

The main aim of the present investigation is to analyze the space-time configurations through which two groups of students used the IWB during a knowledge creation task. In addition, the study examines students' post-hoc reflection concerning the use of the IWB in this type of task. The research questions can be summarized as follows:

1) What space-time configurations of IWB usage emerge at different phases of the students learning activity?
2) Are there specific configurations of space-time which allow to exploit the improved visibility and manipulability of content enabled by the IWB technology?
3) How do the students perceive the presence of the IWB technology within their learning space-time?

4. Context and participants

This study is part of a larger research project involving an interdisciplinary design course, at the Bachelor's level, held at Metropolia University of Applied Sciences in Helsinki. This was a "blended" course (Ligorio, Loperfido, Sansone, & Spadaro, 2011) planned according to the principles of the knowledge creation approach discussed above. The course involved eight small groups, each attended by four or five students. On the first day of the course, representatives of partner companies – who

acted as customers for the groups – presented authentic business problems, and each group was asked to design a product or service that addressed one of them.
The course lasted 16 weeks, and the students worked for 10 hours per week in a technologically rich environment involving IWBs, tablets, notebooks and desktop computers. The features of the IWB were enhanced by the presence of tablets that were wirelessly connected to the IWB allowing all the students to interact in real time with the content displayed on the IWB without having to physically reach the IWB touchscreen. In particular, the software allowed the students to contribute to shared concept maps visualized on the IWB by means of tablets.
During the first session the teachers' assistants briefly introduced the IWB technology and showed to the students how to use it. During this session the students were explicitly invited by the teachers to use the IWB. For the continuation of the course, the students were told that the IWB was available, but they were free to decide if, when and how to use it.
The author of this article presented the research to the students and asked them to volunteer as participants. Two groups volunteered and signed an informed consent. The first group had five members (2 females; 3 males); the second group had four members (3 females, 1 male). Both were intercultural groups: the first group was composed by three Finnish and two international students; the second group was composed by four international students. As this was an interdisciplinary course, students came from different bachelor's degree programs: marketing, nursing, media engineering, industrial management and IT studies.
Each observed group worked on a business problem presented by a representative of an international humanitarian institution, namely: 1) the difficulty of convincing people to wash their hands carefully and frequently in order to prevent the spread of contagious diseases, 2) the challenge to entertain children while their parents donate blood. Besides working in groups, the students had a steering group meeting every week with the teachers and their customer, and attended some lectures and plenary meetings. The students were able to organize their group work with a certain degree of autonomy, so the organization of space-time was a relevant dimension of their joint activity.

5. Data collection

For the data collection, participant observation, with audio and video recordings (Goodwin, 2000) was carried out. In order to follow the potential transformations in the space-time throughout the course, data were collected during the two first weeks of the collaborative activity, during two weeks in the middle of the activity and, finally, during the last two weeks. Only the sessions in which the students worked in groups were considered; the teachers' lecturing was excluded. In total, nine sessions per each group were included in the corpus.
To keep track of the online activity, the video records also included the IWB screen records, whenever it was used, which were synchronized with the video-audio recording for a joint analysis. During the second and the last week of observation two video stimulated recall group interviews were conducted to collect students' reflections. In addition, four of the participants filled in a daily diary for the whole duration of the course, where they specified for each session of collaborative work the following information: date and time, place, technologies used and activities carried out. Finally, the researcher had access to a wiki page and a Dropbox folder where information and the artefacts were uploaded and updated by the students.

6. Data analysis

In this study a qualitative approach inspired by ethnography (Hammersley & Atkinson, 2007) is adopted. The choice of a qualitative approach is due mainly to two reasons. First, space-time frames work as an often implicit and invisible ground for activity (Morson & Emerson, 1990) that is not easy to observe with traditional methods. Second, there are not yet clear guidelines for analysing space-time relations (Leander et al., 2010; Ritella, Rajala, & Renshaw, 2020). This implies that the analysis is still largely explorative.

The main data of this study were the students' diaries and the audio-video recordings of both the students' interaction (33 hours) and the group interviews (4 hours). The other data sources were used to clarify and enrich the interpretation of the videos. The main data were catalogued and organized in collections using Transana, a software specifically developed for video analysis. The analysis involves a sequence of actions.

First, the diaries and fieldnotes were used to create an overview of the main activities, learning contexts (where the activities were carried out) and tools used during the course and to identify the sessions when the IWB was used by the students. Second, video data were explored to define the criteria for selecting the relevant events for in-depth analysis. Concerning the recordings of students' group work, only the records including actual usage of the IWB were selected for further analysis. The analytical focus was on the so-called changes in the configuration of participation, i.e. the moments when the participants physically changed their positions in the room, or changed the set of material and/or digital tools used to accomplish the learning task (Ritella, Ligorio, & Hakkarainen, 2016). It was expected that these changes can reveal information concerning how and why the students enact different types of space-time configurations, allowing to trace their genesis and development. Thus, the emergence of new configurations allowing to exploit the features of the IWB can be traced. Concerning the group interviews, the focus was on all the text concerning the usage of the IWB and the students' reflection concerning their learning environment.

Third, searches in the data were repeated to systematically find the relevant clips displaying 1) changes of space-time configurations in the group work data and 2) speech concerning IWB usage in the interview data. One researcher conducted the searches of the data and showed the selected video clips to another researcher to discuss the significance of each clip.

Finally, the episodes that were considered significant were transcribed and qualitatively analyzed. Nicknames were used to protect the identity of the participants.

Discourse analysis (Gee, 2014) offers useful conceptual tools for the analysis of the space and time dimension that is crucial for chronotopic analysis. Such analysis involves inferring space-time relations from discourse by considering linguistic features such as the tense, aspect and modality of verbs; adverbials; conjunctions that mark temporal relations; and phrases that mark location. In addition, gestures, especially deictic gestures such as pointing (Goodwin, 2003), gaze and body positions, as well as the changes in content visualized on the IWB allow to detect a multiplicity of space-time configurations.

7. Findings and discussion

The chronotopic analysis presented below examines the fine-grained details of students' collaborative activity and their perceptions related to the learning space-time in this course. This allows an in-depth discussion of the evolving collaboration and of the integration of the IWB within the space-time of learning.

At a general level, out of a total of 33 hours of recorded interaction, less than 4 hours involved the actual use of the IWB. Moreover, the analysis of the diaries shows that all of the IWB usage took place during the first phase of the course. No usage of the IWB was reported after the third week of the collaborative activity. When it was included in the activity, the IWB was used for a limited range of aims by the students. In particular, Group 1 used the IWB for a) drawing a shared mindmap, b) visualizing learning content provided by the teachers and c) taking notes during a brainstorming; Group 2 used the IWB only for d) creating and editing a shared artifact composed of the picture of a paper mindmap previously drafted and a list resulting from a brainstorming.

In order to address research questions 1 and 2, all the configurations of IWB use were traced in the video data. Even though the IWB was not consistently used in the different phases of the course, the data allow to detect multiple space-time configurations. Table 1 summarizes the main space-time configurations and scenarios of IWB usage. Each new line of the table denotes a change in the configuration. For example, in configuration A1 (see Figure 1), one of the students, Carl, was standing in front of the IWB, while the other students sat in a semicircle, visualizing the contents and using tablets. After 10 minutes, a new configuration emerged (A2). In A2, Carl moved to sit down on a desk, and used a notebook to visualize his own writings and the tablets to interact with the IWB. This change from A1 to A2 marked a restructuring of the space-time of the collaborative activity, since the focus was not anymore centralized on the shared screen of the IWB. The wireless technology allowed a synchronization between the individual virtual space on each tablet and the shared space on the IWB. In configuration A4, later on, the wireless technology enabled the students to experience and test a novel configuration of participation (Figure 1). In this configuration, all the students were sitting in a semicircle, and their gaze was periodically shifting between a) the individual virtual space on the tablet, b) the shared virtual space on the IWB and c) the social space of collective verbal interaction. This configuration of space-time allows each student to contribute to the shared artifacts with a higher degree of independency, and seldom is a coordinator role required. In its prototypical form, this configuration of space-time can be considered as the embodiment of a de-centralized system (Resnink, 1997), which is a self-organizing system where the collective activity does not require a central coordinator or a leader.
At a first sight this configuration seems very promising because it allows to exploit both the improved visibility enabled by the IWB and the improved manipulability of content by all group members enabled through the wireless connection of the tablets. When the tablets were not used, usually one student was standing in front of the IWB screen and manipulated the content on the IWB, while the other members made suggestions without the possibility of directly manipulating the content. Thus, in the latter configuration, the improved visibility of the IWB is exploited, but the manipulation of content is centralized since only one student at a time can interact with it. Often, the student who interacted with the whiteboard enacted temporarily the role of coordinator, defining the agenda of the activity.

Figure 1. On the left, snapshot of configuration A1; in the middle, snapshot of A2; on the right, snapshot of configuration A4.

Table 1. Summary of usage scenarios and configurations of participation detected in the data

Group	Session	Duration (min.)	Usage scenario	Space-time configuration	Description
1	I	10	creation of a mindmap	A1	Carl operates on the IWB screen, the others visualize content on the IWB and use tablets
		5		A2	Carl alternates between paper notebook and tablet, the others visualize IWB and use tablets to contribute to the mindmap
		4		A3	Carl draws on the IWB, the other students visualize the IWB, and use tablets
		6		A2	Carl alternates between notebook and tablet, the others visualize the IWB, and use tablets
		18		A4	All students sit in circle and use tablets to contribute to the mindmap. For 5 times Jack moves toward the IWB screen to interact with the mindmap for a few seconds.
		4		A3	Carl draws on the IWB, the others visualize the IWB, and at times contribute using tablets
		2		A4	All students sit in circle and use tablets to contribute to the mindmap
	III	15	Visualizing learning content	B1	Jack navigates content on the IWB, the others visualize and talk. Ivy writes on her laptop
		12		B2	Jack draws on the IWB; the others visualize and verbally discuss. Ivy writes on her laptop
		15	Taking notes / brainstorming	B3	Jack navigates content on the IWB, the others visualize and talk. Ivy writes on her laptop
		72	Visualizing content	B4	Ivy writes on laptop results of discussion, the others use tablets; IWB for visualizing content
2	I	3	Writing of a shared artifact (picture of mindmap + list resulting from a brainstorming)	C1	Carla interacts with the IWB while the other students visualize the content and use tablets
		12		C2	Paola interacts with the IWB while the other students visualize the content and use tablets
		2		C3	Paola, Ursula and Ken interact with the IWB; the others visualize the content and use tablets
		15		C4	Ursula interacts with the IWB while the other students visualize the content and use tablets
		8		C5	Ken interacts with the IWB while the others visualize the content and use tablets
		2		C6	Ken and Paola interact with the IWB while the others visualize the content and use tablets
		8		C5	Ken interacts with the IWB, the others visualize the content and use tablets
		2		C7	All students around the table talking to each other; no interaction with IWB
		1		C9	Ken and Paola interact with the IWB, the others use their own laptop at a different table

1	C10	Two subgroups are temporarily formed: Ken and Paola collaborate at one table while Ursula and Carla sit at a different table
3	C11	The group reunites, sitting at a table in front of the IWB, visualizing content and using tablets

This first set of findings allows to conclude that the usage of IWB allows the emergence of some provisional configurations of participation that fruitfully exploit the features of the IWB. However, the data show that these configurations are not maintained or further developed throughout the course. In both groups, it seems that the students did not find a way for working with the IWB that was suitable on the long term and thus they quit using it. Nevertheless, the data show that the students, especially Group 1, appreciated the possibility of using it. Indeed, during the interviews they claim that through the IWB "it's easier to see the big picture", "you see the ideas from the other team members", "everyone can take part in [the collaborative process]", etc. In addition, some of the students particularly liked the possibility to interact with the contents displayed on the IWB through the use of tablets. For example, one student said: "I think that the thought process is more fun as well that we were tititi ((gesture indicating the writing on the tablet))".
In contrast, when the students did not use the IWB, sometimes they became disengaged from the task. During the interview, they attributed their disengagement to the lack of a shared screen for the whole group. In particular, during the first stimulated recall interview, the students were asked to comment on what was happening during a videoclip previously recorded (second week of the course). In the videoclip, they were not using the IWB, but they were apparently working on the task: three of them (Carl, Lenny and Jack) were using tablets and two (Ivy and Rachelle) were collaborating on the writing of a document required by the teachers on a laptop. Carl and Jack reported that they were actually off task in that moment due to the fact that they could not see what was happening on the laptop screen: "I was sitting over there and I didn't feel part of it"; "you can't focus on the thing if you don't see it". Although this might be a post-hoc reconstruction of the situation which might not correspond to the students' lived experience, it is interesting that the students mentioned the improved visibility of content as a positive improvement of the collaborative process and the lack of visibility as a constraint. Thus, on the one hand, the students seem to recognize the potentialities of the IWB for improving visibility and enhancing equal participation. On the other hand, none of the groups was able to successfully enact stable configurations of spacetime that could take advantage of these potentialities in the long term. In future research, role taking might be considered as a strategy to model students' collaborative process toward stable configurations of technology usage able to prompt enhanced participation (Spadaro, Sansone, & Ligorio, 2009; Sansone, Ligorio, & Buglass, 2018).

These mixed findings can have a threefold interpretation:

a) The students did not fully "appropriate" (Overdijk & van Diggelen, 2008; Ritella & Hakkarainen, 2012) the technology, which was not essential for the accomplishment of the task. Indeed, in a few occasions the students asked for help from the teaching assistants to solve technical problems when using the smartboard. In addition, some of the students mentioned that they quit using the IWB because it was slowing down the accomplishment of the task, probably because time and effort were needed to learn how to use the IWB and the software associated with the wireless connection of the tablets. In particular, the students explained that in a few occasions they switched from the IWB to the laptop because they "had a deadline for it", "it was a way to make work faster". Finally, one student explicitly said the he was "technologically challenged", having troubles in learning to use the novel technology;
b) The features of the IWB where not well suited for some of the subtasks carried out by the students during the second and third phase of the course. Indeed, the diaries show that in the

middle and at the end of the course, the students carried out primarily individual work, for which a shared screen was not needed. This is related to the features of the knowledge creation approach, which seems to require 1) a division of labor between the students, 2) an alternation between individual and collective activity; 3) a need for different types of tools in different phases of the process. The implication of this argument is that technology such as the IWB might be useful in the initial phase of the knowledge creation process to support brainstorming and shared discussion, but might be less useful subsequently;

c) The experimental software was not fully developed, so that the functionalities were limited only to the contribution to the shared concept map and the students experienced some bugs and technical issues. Indeed, during the interview, some of them mentioned that they did not like the user interface of the software.

The findings of this study suggest that the space-time configurations can reveal new insights on the collaborative usage of IWB. The set of space-time configurations that were detected for each group correspond to the embodiment of strategies that each group uses to integrate the IWB in the learning space and to use it appropriately for the accomplishment of the learning task. However, none of the space-time configurations involving the advanced features of the IWB revealed to be fruitful in the long term.

In sum, the features of the IWB were perceived as a useful aid for discussion and participation by the students, especially at the beginning of the course. However, even if the students willingly explored the features of the technology, they did not find a way to organize the space-time of the activity that allowed to exploit them fruitfully.

8. Conclusions

Al-Qirim and colleagues (2017) discussed seven scenarios of usage of the IWB within a higher education institution. The possible interactive usage of IWB by groups of students in a collaborative project task was not considered in their study. However, they agreed with Salinas (2008) that a synergy is needed between learner-centered and collaborative pedagogical models and educational technologies. More generally, the improved visibility of content together with the features of the IWB is often expected to generate effective space-time configurations for collaborative learning (Hennessy, 2011). The course analyzed in this article was potentially a good site to examine how this synergy can emerge in practice as students cooperate on an open-ended design task using the IWB. The analysis shows that the students could experience innovative and potentially fruitful space-time configurations of IWB usage, which were enabled by the improved visibility of the IWB and by the wireless connection of tablets. However, the integration of the IWB in the learning process faced a multiplicity of challenges in this context. Indeed, such potentially effective configuration of space-time for carrying out the collaborative task emerged only for relatively short periods of time (a few minutes) and were not maintained or replicated over time. The findings suggest that the development of novel and effective configurations of IWB usage in this case study was dependent on the nature of the learning task and the pedagogical approach adopted. Indeed, the interactive features of IWB were appreciated by students but were not essential for the accomplishment of the knowledge creation task during the second and third phase of the course, when individual work was prioritized. The implication is that instructional designers and teachers should consider the features of the chronotope of knowledge creation and design learning environments able to flexibly support the students' engagement in each phase of the accomplishment of the task. For example, a learning environment might include the IWB at the beginning of the course for the generation of ideas and for reaching a shared understanding, but provide also other tools essential for the individual work carried out in later phases. Furthermore, the temporal constraints of the activity did not allow a full appropriation of the

technology, and the students claimed to quit using the technology when a deadline was approaching, since its usage slowed down the accomplishment of the task. This is also related, in the case analyzed here, to the existence of bugs and technical problems, which did not allow a smooth accomplishment of the task, fragmenting the activity with frequent interruptions.
The present investigation has some limitations since it is carried out only by observing two small groups of students and the findings might not be easily generalized. The discussion of the findings is not aimed at drawing generalizable knowledge, but on obtaining a thick description and a detailed discussion of the case study and on the development of hypotheses to be further examined in future research programs. Nevertheless, it is argued that the findings open up new directions of research concerning the design of learning environments able to effectively support students in successfully accomplishing knowledge creation tasks.

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