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Learning to work between IT infrastructures

Emily Winter †

† Institute for Social Research, Swinburne University of Technology, Mail H53, PO Box 218, Hawthorn, Victoria 3122, Australia

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Abstract

Introduction. This study investigates the implications of the interplay of multiple information infrastructures to learning and conducting work and to its related information work practices, and how the materialities of work and its infrastructures play into their intermingling.
Method. The present study is based on an ethnography of a week-long archaeological teaching excavation conducted by the author. The excavation took place on a stone-age site in a Nordic country in Spring 2016.
Analysis. The analysis of the ethnographic data was based on constant comparative method and close reading.
Results. Four major information infrastructures were identified in the empirical setting. They and their diverging materialities were intimately linked to how information work was conducted at the excavation. The presence of two infrastructures designed for the same purposes of documenting the site and excavation process caused problems with scheduling and managing the work, but did at the same time make their associated premises and infrastructural obligations visible for the participants of the excavation. The older of these two infrastructures played a potentially important role as an infrastructural stalwart, an infrastructure that stabilised another infrastructure.
Conclusion. The presence of parallel, overlapping information infrastructures makes them visible and potentially less effective but also unveils their underpinnings for learning and insights in their role in information work.

Introduction

Learning a new job is seldom as simple as mastering the use a single set of tools and one individual procedure. There tends to be a plethora of intermingled visible and implicit practices to learn and in most cases, there are not only multiple tools but several partly overlapping, complementary and conflicting infrastructures to master before the work really gets under one's skin. People use multiple parallel information infrastructures to communicate with each other (Cameron and Webster, 2005), to seek information (Jokela, Ojala and Olsson 2015) and to support the work with different parts of individual tasks (Munkejord, 2007). On a societal level, the existence of parallel infrastructures tends to have both positive and negative effects, positive through increased competition and negative through duplication of efforts (Höffler, 2007). The longevity of legacy infrastructures adds another layer to the issue. Their embeddedness in routinised practices makes them long-lived (Robertson, 1997). Earlier

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studies have noted, for instance, that issues such as the lack of trust on digital systems can keep paper-based legacy approaches live as backups (Björk, 2006). Similarly, they can survive as parallel infrastructures to support specific aspects of the work such as fulfilling the legal obligations of keeping archival records (Haux, 2006).

There is an increasing body of literature on the effects and implications of information infrastructures for work (e.g., Irani, 2014; Winter, Berente, Howison and Butler 2014), and factors affecting their use and perceived usefulness (e.g., Faniel, Kansa, Whitcher Kansa, Barrera-Gomez and Yakel 2013; Borgman, 2007). In general, with the exception of high-risk environments (e.g., Singer, 2012), the maintenance of parallel systems is often considered counter-productive because of, for instance, the associated costs (Haux, 2006; Bird and Dhooge, 2011) and negative impact on the well-being of employees (Franssila, Okkonen and Savolainen, 2016). There is, however, relatively little research on how people in practice navigate parallel information infrastructures and how the simultaneous presence of multiple informational substructures affect the learning of work practices – with certain exceptions. Of these, the work of Blomberg, Suchman and Trigg on lawyers parallel use of electronic and paper-based files (Blomberg, Suchman andTrigg, 1996), and, for instance, Østerlund's (Østerlund, 2008) study of the documentary aspects of medical work are well-known examples.

The aim of this article is to provide insights into how the presence and interplay of multiple information infrastructures influence the learning and conducting of work and its related information work practices. More precisely, this study asks how the compatibilities and incompatibilities, and different materialities of parallel information infrastructures affect the process. The present article draws from an ethnographical investigation of a week long archaeological teaching excavation in a Nordic country conducted in Spring 2016. During that week, a group of undergraduate and graduate archaeology students were set to learn archaeological fieldwork and its related information and documentation practices. Undergraduates were learning the basics of archaeological field documentation using a traditional paper-based for documentation approach (i.e., infrastructure). Graduate students familiarised themselves with a new digital photo-documentation based approach (i.e., infrastructure) developed by two senior archaeologists who participated in the excavation. The empirical work provided in-depth insights into the conflicts and compatibilities of the two documentation infrastructures and other infrastructures of archaeological fieldwork, and the implications of these frictions and affinities for mastering archaeological information work. In a more general sense, the fieldwork provided possible cues to how co-existing infrastructures influence each other and the implications of their parallel impact in the evolution of work practices at a workplace.

Literature review

During the last couple of decades, there has been a growing interest in infrastructures both in information studies (e.g., Huvila, 2009; Sundin and Carlsson, 2016; Carter, 2016) and in other fields such as science and technology studies (e.g., Parmiggiani and Monteiro, 2016; Wyatt, Harris and Kelly, 2016), computer supported cooperative work (e.g., Monteiro, Pollock, Hanseth and Williams, 2012), geography (Graham and McFarlane, 2014a), anthropology (Hubert, 2015), education (e.g., Guribye and Lindström, 2009) and sociology (e.g., Camic, Gross, and Lamont, 2011; Mongili and Pellegrino, 2014b). The focus in much of the earlier research has been partly on how to construct and develop infrastructures for supporting various types of activities and especially later on, with an increasing emphasis on developing a line of inquiry for studying existing and emerging infrastructures and their implications (Bowker, Baker, Millerand and Ribes, 2010). As Bowker (2010) and colleagues stress, the evolving infrastructures have an impact on social conduct. Tools, techniques and infrastructures do not merely support actions people are about to do but they do steer these activities to new directions as plenty of studies have demonstrated in diverse contexts from science (Pickering, 1995) to legal profession (Riles, 2011) and architecture (Belardi, 2014).

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Much of the earlier archaeology related research on infrastructures has focused on the first mentioned line of research, on developing and laying ground for developing e-science infrastructures for archaeological research (e.g., Vatanen, 2004; Kintigh, 2006; Kansa, Kansa and Watrall, 2011; Löwenborg, 2014). There is, however, an emerging body of literature of studies on existing infrastructures and their adoption and use. Goodwin's (1994) ethnographic study of archaeological fieldwork and its constituents precedes much of the contemporary infrastructures related research. In a brief review of the work of, among others, Svensson (2015), Huggett (2016) underlines the necessity of similar infrastructural introspection in archaeology as the proponents of infrastructure studies (Edwards, Bowker, Jackson and Williams, 2009; Bowker et al., 2010) have suggested on a general level. De Roo, Bourgeois and De Maeyer (2016) have studied archaeological information processes and infrastructure use in Flanders noting that non-digital documentation practices are still prevailing and the development of documentation practices is slowed down by the lack of incentives to in-depth analysis of data. In Sweden, Huvila has studied archaeological information flows and the use and non-use infrastructures (e.g., Huvila, 2016a,2016b). He notes that the acceptance of new information artefacts as valid carriers (i.e., an infrastructure) of archaeological information can be hampered by a lack of mutual understanding of each others priorities among the different stakeholders of archaeological activities (Huvila, 2016a). Faniel and colleagues have investigated the reuse of archaeological research data in the US (Faniel et al., 2013; Kriesberg, Frank, Faniel and Yakel, 2013). They noted that the existing information infrastructures tend to lack necessary contextual information that would enable archaeologists to effectively reuse existing resources. Repositories should give adequate information on data collection procedures and the reputation and scholarly affiliation of the archaeologists responsible for the original field studies (Faniel et al., 2013).

Theoretical framework

The interest of the present study lies in how (as purported) legacy and novel (information) infrastructures with different materialities affect learning (information) work when they are installed in a single context. The theoretical underpinnings of this work are in Stengersian (Stengers, 2010) reading of information infrastructure studies (Bowker et al., 2010), materiality (Miller, 2005b) and situated learning theory (Lave and Wenger, 1991). This lens allows the study to bring infrastructures and their materiality, and the social conduct of their users together in a process of mutual becoming. The approach provides means to articulate how infrastructures and human actors are influencing each other without essentialising infrastructures, human-beings or their relations, or being hopelessly vague about what is happening when they are brought together.

Materiality and information infrastructures

The concept of information infrastructure is generally used to refer to informational structures or structural premises underpinning different types of activities and processes. This article draws from the multidisciplinary literature on information infrastructures (sometimes also knowledge infrastructures, e.g., Karasti, Millerand, Hine and Bowker, 2016) and an emerging branches of scholarship called infrastructure (Edwards et al., 2009; Ribes et al., 2012) and information infrastructure studies (Bowker et al., 2010). Similarly to how (information) infrastructures are described in the particular branch of literature, also in this study the term is used to refer to 'shared, evolving, open, standardized and heterogeneous installed base[s]' (Hanseth, 2010) that allow, facilitate and shape our surroundings and their conditions, and form an invisible substrate for activities. According to now famous enumeration of the dimensions of an infrastructure by Star and Ruhleder (1996), they are characterised by embeddedness, transparency, their reach or scope beyond a single event of practice, that they are learned as a part of membership, they link with conventions of practice, they are embodiments of standards, built upon an installed base, and as noted, they become visible upon breakdown. Moreover, different things can act infrastructures at different times, and essentially, it is more relevant to ask when is an infrastructure rather than what it is and for whom, as information infrastructures are generally characterised by their openness for multiple (types of) users (Monteiro et al., 2012, p. 576).

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A general understanding of information infrastructures is that they should not to be considered as information carriers (Star and Ruhleder, 1996) or information artefacts (Mongili and Pellegrino, 2014a). They are rather to be thought about as relational entities (Star and Lampland, 2009), which are capable of traversing the great divide of human and non-human (Latour, 2004), or following Whitehead (as for Whitehead, 1978), as entities that play an integral part in the process of, perhaps an equally great, but non-divided becoming. Using the metaphor introduced by Orlikowski (2006), infrastructures provide, together with other objects and contexts (which may or may not be infrastructural as well), scaffolding (i.e., a temporary platform to provide support) for knowledgeable human action. Even if the materialities of the things underpinning an infrastructure have significance (whether physical, digital, e.g., Leonardi and Barley, 2010; Kallinikos, Aaltonen and Marton, 2010, tangible or intangible, Schleifer, 2009), information infrastructures are not a dimension of technology as they are of the everyday life (Appadurai, 2014). Their implications lie not as much in their physical (or nearly physical) layout but in how the infrastructure is made experienceable (in tangible form, or e.g., as speech, see Beynon-Davies, 2015), how it is experienced, and how it mediates and influences human activities (Graham and McFarlane, 2014b). The materiality of information infrastructures extends beyond physicality (cf. e.g., Dant, 1999), it has agency and it is a constellation of scales of many different types of materialities rather than a binary (material/immaterial) attribute of an object (Miller, 2005a). Also the rapport of different types of materialities tends to be more complex than a question of mere contradiction or complementarity. Even if certain types of materialities can be, to a degree, non-autonomous (e.g., digital materiality, as it requires physically material hardware to sustain, Malpas, 2009), the dependence of materialities has been observed to be deeper than that and explained in terms of, for instance, hybridisation (Svahn, Henfridsson and Yoo, 2009) and as dialectics of mutual becoming of multiple forms of materialities (Magaudda, 2011).

There is also another sense in which infrastructures are tied to materiality. In addition to supporting and facilitating information work, information infrastructures also shape what is recognised as information or knowledge (Bowker, 2005) and how it can be acted upon indexically (Day, 2014). The shared commitment to infrastructures (Bowker, 2005) is generative of not only objects and forms but also on the level of ontology (Olsen, 2012). Naming things changes how they are called but also how they are perceived and acted upon, and eventually, what they are in a particular moment. As such, information infrastructures are both materialisations of practices, and scenes for autonomous becomings, and as Simone (2014) suggests, materialisations of anticipation when to act. When this is contextualised in Stengersian understanding of practices as obligations (Stengers, 2010), infrastructures appear not only as mere expectations but as materialisations of shared obligations and anticipations of these imperatives, making the scaffolding also anticipatory of the future action rather than merely as a support for action at the present.

Learning and information infrastructures

A focus on infrastructural experience, (material) ontological implications of infrastructures, and infrastructures as materialisations of anticipations and obligations has somewhat different repercussions to learning than mechanistic perspective to infrastructures as technologies, that in a very literal sense, support and facilitate activities. Instead of learning to use or exploit an infrastructure, whether informational or other, the principal question is how to master it in a sense of becoming capable of coping and living a life (as in Ek and Widén-Wulff, 2008) mediated by it (Graham and McFarlane, 2014b) in an on-going process of mutual becoming (Stengers, 1994). An infrastructure appears as a part of the landscape of practice (Wenger-Trayner et al., 2014), a materialisation of anticipations and obligations to act (Stengers, 2010; Simone, 2014) in particular ways that participants need to learn in order to be able to become proficient in the infrastructure, or at least, cope with it in a satisfactory manner. The learning of the infrastructure is situated (as in Lave and Wenger, 1991) and is premised by the mastering of particular practices that give an individual access and ability to act within a specific

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community of practice (Wenger, 1998; Wenger-Trayner et al., 2014), or in a broader sociomaterial sense, to participate in a particular dance of agency (Pickering, 1995). Simultaneously, as the current empirical study demonstrates, infrastructures are not only objects that are awaiting to be mastered. Similarly to technologies in general (Stengers, 1997), they are tightly intertwined with the general course of activities. People put them to work to change (i.e., teach) social conduct and the infrastructures themselves regulate and set norms (i.e., teach) to how human agents (should learn how they) should and can act.

This specific type of concern on learning and infrastructures applies to all types of 'installed bases' (Hanseth, 2010) indifferent of their orientation. The perspective differs from how infrastructures and learning are framed in the context of the infrastructures for learning (Guribye and Lindström, 2009) as facilitators of learning or 'resources and arrangements that support a certain learning practice' (Guribye and Lindström, 2009). Infrastructures for learning have their place also within the broader concern for learning infrastructures but rather than in focusing on them in an instrumental sense, the emphasis is on how even these infrastructures are mastered in practice.

Material and methods

The present study is based on an ethnography of a week-long (5 days from Monday to Friday) archaeological teaching excavation conducted by the author. The excavation took place on a stone-age site in a Nordic country in Spring 2016. The excavation team (Table 1, all participants were assigned false names for reporting purposes) consisted of Horatio, the director of the excavation, senior archaeologist Edward (working with the new digital documentation infrastructure on the site) and his assistant Matthews, and another senior Archie who worked as a finds officer being responsible for cataloguing, cleaning and processing of the finds collected at the excavation. In addition, the team consisted of eleven undergraduate and graduate archaeology students, a part of which came from the country where the excavation took place and a part from other European countries.

The ethnographic observation was conducted as a non-intrusive participant observation (Hammersley and Atkinson, 1995). The author participated and observed the work of the team throughout the entire duration of the excavation taking written and audio-recorded notes and photographs. In order to capture the situation as naturalistic as possible, the author tried to avoid interfering with the work and discussions of the observees. The non-intrusive approach was deemed possible, because the author had previous first-hand experience of participating and working on several archaeological excavations. This experience reduced the need to ask the observees to explain everything they did in detail and provided a point of comparison to what was generic and particular at a specific excavation. Even if explicit interviewing was kept to minimum, the archaeologists and students were asked clarifying questions whenever needed. However, even if the author was trying to be non-intrusive, especially the archaeologists and increasingly towards the end of the week, also the students came to talk to her, telling about their work and asking their own questions that contributed significantly to the richness of the material and provided opportunities for informal interviews without intervening in the observed work. When travelling to and from the excavation, the author had also a possibility to discuss with one of the archaeologists (Edward) about the work at the site for approximately one hour every day.

The approach for analysing ethnographic data was based on constant comparative method (Glaser and Strauss, 1967) and close reading (DuBois, 2003). Finally, after a preliminary analysis was complete, the material was revisited using negative case-analysis (Lincoln and Guba, 1985, 309-313) with the specific purpose of finding contradictory evidence (as e.g., in Zach, 2005) that would decrease the reliability of the conclusions.

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Participant	Role at the excavation
Horatio	Director of the excavation, expert of mesolithic archaeology
Edward	Archaeologist, director of the work with the development of photo-documentation method
Archie	Finds officer, responsible for physical materials retrieved, expert of mesolithic archaeology
Matthews	Archaeologist working with the development of photo-documentation method
Styles	Student
William	Student
Jack	Student
Oldroyd	Student
Hammond	Student
Clive	Student
Mason	Student
Hobbs	Student
Wolfe	Student
Finch	Student
Bowles	Student

Table 1:Participants of the excavation.

The empirical approach has some obvious limitations. Findings are based on a case study of a single, relatively short excavation that limits the possibilities to generalise the expressed views. In order to control for the over-expression of individual opinions, the analysis places a special emphasis on views expressed by multiple individuals and recurring activities. Bearing the aim of the present study to explore the dynamics of infrastructures, information work and learning in mind, the possible inability to generalise findings of the specific aspects of the particular excavation is not considered to be a major issue. Another source of bias is that the observed activity was a teaching excavation. The internal dynamics of a project involving only experienced archaeologists would have undoubtedly been different. However, the specific benefit of observing a teaching excavation was that there was more to observe. All participants, both learners and their teachers needed to be more more explicit about articulating and making visible (cf. Star and Strauss, 1999) what they were doing, and what was important and why, in what was happening, than when professionals are quietly engaged in their routines.

Findings

Parallel infrastructures and their parallel materialities

An archaeological excavation opens up as an illustrative example of a thick (cf. Pickering, 1995) of intertwined infrastructures and their users. People participating in an excavation with their earlier knowledge and experiences, tools and environment with their constraints and affordances, and their intermingling constitute an excavation as an assemblage-in-becoming. Borrowing from Checkland (1981), this amalgam of social and material things in making can be conceptualised as a soft system, or leaning to Pickering (1995), as a mangle of practice, or by combining their perspectives, as a tangle of them both.

Instead of attempting to provide a comprehensive account of all possible infrastructures that pertain to an archaeological excavation, this study focuses on the explicitly archaeological elements of this infrastructural mangle. However, even if the infrastructural landscape of an archaeological excavation is empathetically archaeological in that archaeology is the common denominator of its individual elements, not all of the infrastructures of this assemblage were archaeology-specific. The studied excavation was located at the edge of a sub-urban residential area that meant easy access to the site (no need to stay overnight and fewer problems with transportation of equipment), access to water and (what was crucial for the use of digital documentation methods) electricity. Edward noted that their computers run much slower on batteries that had slowed down their documentation work at another excavation site the year before.

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Archaeological stratum

In addition to the generic infrastructures, four archaeology specific installed bases were identified during the fieldwork. There was no question that the most fundamental structural underpinning of the excavation was the archaeological stratum i.e., the soil that was excavated at the site. Quite obviously, without the stratum, there would have not been archaeological activities or information work happening on the site. Further, even if the working of archaeologists was heavily underpinned by their earlier experiences and expectations, the actual stratum at the site with a particular set of layers of soil with different colours and textures, natural and man-made artefacts, played a central role in how the work could proceed, and what archaeologists and students considered interesting to document and what they documented in practice.

At the time of the excavation, the materiality of the archaeological-stratum-as-infrastructure is decidedly tangible and physical (to become much less so after the fieldwork, cf. e.g., Olsen, 2012). The hard clay soil (which was arduous to excavate) and all buried physical artefacts and features had a very direct and tangible impact on the archaeological endeavour. In addition, such factors as the proximity of the site to the seashore (which gave, among other things, indications of the possible age of the site), the location and distance between two trenches that were opened at the site (which provided two physically separate entries to the stratum) and the deep plowing of the field located at the site in the early 20th century (which had mixed the topsoil of the stratum), all set conditions (or norms) that facilitated and resisted archaeologists' attempts to learn and pursue their work.

Project group

The physicality of the materiality of archaeological stratum was in stark contrast to the less tangible materialities of other archaeological infrastructures at the site. In addition to the predominantly non-human infrastructure of archaeological stratum, the project group formed the principal, emphatically human, information arrangement that could be identified during the empirical fieldwork. Students were assigned to mixed teams consisting of undergraduates and more experienced graduate students. Each of the teams were assigned with their own areas to excavate in one of the two trenches. The pivotal nature of the project group and the teams as a key information infrastructure became apparent in that very little information seeking from outside occurred during the week. First when they were explicitly asked, the students became aware of their lack of information seeking beyond asking his fellow students and teachers. Surprised of his behaviour by himself, Styles noted that '[i]t hasn't really come to my mind to do so'. Instead, the senior archaeologists came together several times a day to discuss finds, excavation strategies, and to compare earlier experiences both without and together with students. This happened both casually when they met by chance and by explicitly going to a colleague to ask a question. After being somewhat reserved on Monday morning, the students began to follow a similar pattern of casual talking while working, and when having specific questions to ask, going to a fellow student or an archaeologist for an answer or confirmation.

Much of the infrastructural materiality of the project group was connected to the bodily aspects of archaeological work and its underpinnings in the physical materiality of the archaeological stratum. The layout of the excavation with two separate trenches structured not only the access to the stratum but also how the students and archaeologists worked, moved and communicated with each other. The three groups working close to each other at a larger trench number 1 communicated much more with each other (partly because it was possible, partly because they had to coordinate the work between the teams) while the fourth group at the trench number 2 kept it more to themselves.

Documentation infrastructures

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From the perspective of the aims of the present study, of the interplay of infrastructures and its implications, the most interesting pair of underlying structures identified during the fieldwork, were the two documentation approaches used at the excavation. They formed two parallel, partly dialectical and partly intertwingular (to use the term coined by Nelson in his 1974 book ComputerLib), predominantly social arrangements that enabled archaeologists to collect and inscribe (i.e., document) their observations and the work at the site. Even if the physical and social materialities of the site and the participants of the excavation played a significant role in shaping how the site was documented, there was no doubt that the two documentation infrastructures and their respective constellations of bodily, physical, digital and social materialities were pivotal to the shaping of the documentation. The use of two complete parallel systems for producing double documentation of a site is not typical for an archaeological excavation, but as the empirical data gathering for this study demonstrated, it opened a rather unusual perspective to study the mangle of two parallel infrastructures.

The infrastructural capacity of pen-and-paper documentation to convey archaeological information relied heavily on the tools of the trade: measurement tapes, pens, paper, drawing boards, plans and section drawings, and how well the documenters mastered them. Even if both the students and archaeologists explained that the documentation was not an artistic exercise, the perceived quality of the resulting documentation was dependent on how well the drawers could bend their tools to help them in their pursuit. It was necessary to go and stay very close to the stratum, scratch the surface of the soil to see and feel the boundaries of different features, measure, sketch, erase, redraw and compare the drawing to what could be seen in the trench. The plan and section drawings were complemented by taking written notes and photographs of specific features and parts of the trench. The proximity of the documenter and stratum during the making of the documentation, and its diagrammatic results were in sharp contrast to each other.

In comparison to the pen and paper documentation, the infrastructural capacity of photo-documentation relied on a very different set of materialities. Instead of using pen and paper to draw plans and sections of the layers and features in each trench, the photo-documentation approach was based on constructing a series of photogrammetric three-dimensional models of them. Instead of the skills of using pen and paper, the outcomes of photo-documentation were dependent on how well the documenter could exploit such physical (material) objects as digital cameras and computers, and digital (material) objects like digital images, database tables and photogrammetry software. In both pen-and-paper and digital documentation, it was important to decide how much to dig, what features to expose, what features were features, and what to document. However, in contrast to the pen-and-paper approach, photo-documentation placed even more emphasis on the need to clean up the trench and make it 'look nice' (Edward) i.e., to make sure that all interesting features were clearly visible in the photographs. It was necessary to take the photographs fast directly after cleaning the trench before the dirt dried too much and its colour turned to uniform grey.

Even if the two documentation infrastructures were intermingled with each other and the socio-material process of engagement with the archaeological stratum at the site, there were notable differences in their rhythms and respective takes on the process. The time spent at the trench taking photographs for photo-documentation was remarkably short. Much of the thinking, selecting and interpreting done at the trench by a pen-and-paper-documenter, was done in a site hut when the photographs were processed and turned to a three-dimensional photogrammetric model. When features were documented using pen and paper, the trench was the source of reference. In contrast, when working with photo-documentation, Matthews, Edward and Horatio run in several occasions eagerly between the site hut and the trench carrying a portable computer and checking whether a feature they had detected in the photo-model could be seen and felt in the trench, much like the seamen compared figures, calculations and observations in Hutchins study of shipboard navigation (Hutchins, 2006). This turned the referent-reference relationship and the order of precedence between the physical and digital materialities effectively upside down. Using photo-documentation, it was also possible to combine photo models from different excavation seasons to

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create and show larger models on screen, or as Matthews explained, to open large 'virtual trenches' that were never exposed in the field at any one time. Further, as Matthews and Edward noted, with photo-documentation, the documenters could do virtual pen-and-paper work using a digital surrogate of the trench by drawing plans directly on the photo model long time after the excavation had ended. It is also easier to reinterpret the features that are visible in the photo model than in a schematic drawing. Presenting another reading of features documented in a diagrammatic hand-drawn plan is much more difficult, if not impossible. Even if the documenters were undeniably exposed to the materiality of the stratum for an extended period of time when drawing with pen and paper, the digital approach allowed a larger group of archaeologists both at the site and, more significantly, after the fieldwork period had ended, to be exposed to a reasonably high-resolution digital surrogates of the stratum long after the stratum itself had been lost forever.

It was also apparent that capturing data with pen and paper was slower than by taking photographs, even if a part of the slowness was compensated for by the amount of time needed to turn the photographs to a three-dimensional model in the site hut. In practice, because it was possible to document faster, it was possible to do it more often. This was an advantage, which Edward and Matthews emphasised and tried to put in practice. A part of the slowness of drawing by hand could be explained by the inexperience of the undergraduate students who were learning the method. Edward, especially, complained that the slowness of the pen-and-paper documentation slowed down the whole excavation process. The need to keep measurement tapes (which should not be visible in photographs) in the trench as visual aids for drawing, and the similar need to walk around the trench (which messed and left footprints in the cleaned soil) made it impossible to take photographs while someone was drawing a plan. Ideally, photo-documentation could and should be done very fast in the whole trench at once to get a series of photographs in as constant lightning conditions as possible, with the soil as similarly moist in all images as possible, and without any footprints or interventions made in the stratum between taking the photographs.

The main reason, as explained by Horatio, for the rather untypical approach of using two documentation methods at one excavation in parallel was that the undergraduate students needed to learn the basics of archaeological documentation (i.e., the pen-and-paper method). At the same time, Horatio was clearly interested and enthusiastic about digital photo-documentation. He had agreed that Edward and Matthews could test and develop the approach at the excavation and teach the graduate students to use it. Horatio, Edward and Matthews were convinced that the new approach was faster and 'better' than the older one, and saw a lot of potential in the photo-modelling as a basis (i.e., infrastructure) for advancing archaeological scholarship. Archie did not seem to disagree per se but was more reserved and, as the finds officer, focussed on teaching students how to identify and process finds rather than on working with the documentation of the site as a whole. The students seemed to have somewhat conflicting feelings about the digital approach and considered that drawing by hand, even they complained that it was an arduous task, was somehow safer and more comfortable. It seemed that they considered partly, that learning to draw by hand felt more like archaeology, and partly, that learning to take good quality photographs for photo-modelling and to use the photogrammetry software were difficult. Some of the students were clearly more enthusiastic about photo-documentation asking questions, presenting theories and seeking the company of especially the somewhat calmer Matthews who was apparently perceived to be more easier to approach than Edward, his highly energetic senior colleague.

Also, in contrast to archaeologists who had the overall responsibility for the site as a whole, and who also in practice seemed to consider it in its entirety as their site of work, it was very apparent that the students felt a strong direct responsibility of the practical work at their (assigned) trench and considered that the trench was their principal site of the work. A part of the attachment can be explained by the very apparent enjoyment of digging that was noticeable with many of the students, and partly with their relative lack of experience (applied all) and self-certainty (especially apparent with some students like William and Jack) that lead them to check and double-check their observations and conceivably, to

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consider that a longer time spent by the trench would improve the quality of their observations and conclusions. This type of a felt sense of intimacy with the object of research is common in the field sciences (O'Reilly, 2016) and has been associated with a fear of being drawn away from the field (Kohler, 2002a). Also in this study, the students were clearly concerned of being kept away from the trench in the site hut while processing photographs and turning them into photogrammetric models. Even if the fear cannot be characterised as being perfectly rational, it was not entirely unfounded. In a sense, apart from affecting the topology of archaeological information work, the photo-documentation also shifted archaeological work at the site from being a relatively pure field exercise to incorporate elements of laboratory practice with its associated conventions of trust, credibility and reproducibility (cf. Kohler, 2002b).

Material intertwingularity

However, even if the four major information infrastructures came with their distinctive constellations of materiality, they were also dependent on each other. The physical layout of the excavation with two trenches, one smaller and one larger, affected the evolution of the social infrastructure but also how and when the documentation was conducted using pen and paper, and digitally. The smaller trench could be documented, in general, faster and the team working there could plan their own process more independently. They could excavate, draw and take photographs according to their own schedule. In contrast, the teams working at the larger trench were always dependent on how the work of the adjacent team progressed. It was impossible to clean and photograph the layers if the adjacent team was working close to the edge of it messing up the soil and literally standing in the way. Teams did also have to negotiate on who could use which tools and when.

Even if the reliance of human infrastructures on the physical archaeological stratum was more explicit than vice versa, the fieldwork showed that the infrastructural capability of the archaeological stratum was equally dependent on social practices: what types of tools archaeologists chose to use to excavate it, how archaeologists touched the soil, and how it was documented. Horatio explained that in the particular Nordic country where the study was conducted, it is conventional to use trowels and not shovels and pickaxes at lithic sites to 'increase the precision' of excavation. In this country the soil is also often lose and not hard, as it is, for instance, in many Mediterranean countries. Therefore, it is generally unaccepted to use a brush to clean soil (Edward), a convention that especially the foreign students participating in the excavation had difficult to understand. Even if it was not formally approved, some of the students and archaeologists did occasionally brush the soil using a glove or their hand because it was much easier to smooth and level the soil by brushing than by scraping, especially if there were a lot of stones in the feature. The perceived importance of the sensitivity to the soil was apparent also in how Edward criticised (making sure that no one else than the author heard) the use of hoes. According to him, with a hoe, it was impossible to feel the differences between soil types similarly to how it was possible with a trowel. Another example of how the infrastructural capacity of the stratum was dependent on human touch was the practice of tasting the soil documented already in earlier studies (Olsson, 2016; Goodwin, 1994). At the studied excavation, the archaeologists were not equally bashful of their tasting and feeling of artefacts and even soil with their teeth (which are more sensitive than skin, as Archie instructed the students) as at the excavation studied by Olsson (2016). Horatio did, however, remark after Archie had demonstrated how to distinguish clay and silt using his teeth, that the students should be somewhat restrictive about putting soil in their mouth in order to avoid getting ill.

Although a large part of the material considerations relating to the stratum were not directly dependent on the documentation method, it was possible to observe differences in how the materialities of the archaeological stratum played out in the work with digital and pen-and-paper infrastructures. Even if direct sunlight and dryness of the soil made documentation difficult in general, it was especially problematic with photo-documentation. Using pen and paper, it was possible to find features by scraping the soil with a trowel, mark them using nails and string, or by drawing in the dirt (similarly to the

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archaeologists studied by Goodwin, 1994), and draw them later on whereas the features that were invisible in the photographs in the first place could not be made visible afterwards. In contrast, if the photo model was based on high-quality photographs, it contained potentially much more visual information than a schematic plan. In Goodwin's terms, they were both documentary methods of interpretation (Goodwin, 1994), approaches of interpreting a particular snapshot of a stratum by naming its features either using a diagrammatic drawing consisting of schematic units or a photogrammetric model created at a specific point-of-time. Also, even if the two documentation approaches used at the excavation were theoretically parallel to each other, even their respective materialities interfered with each other in the differences in how well the trench should be cleaned, how it was possible to draw a plan gradually while another part of the trench was still being excavated, and how fast the capturing of the data needed to be done.

Learning the ropes

Similarly to how the four information infrastructures and their materialities, also the ways of how students learned to engage with them were simultaneously distinct, overlapping and intertwined to each other. The fast progress of learning to work with the infrastructures could be easily discerned in how the movements, questions and body language of the students changed from being somewhat wary to became increasingly casual, confident and planned during the week. Towards the end of the week, the students moved faster, became more goal oriented in their actions, worked more independently and had more confidence to make suggestions rather than to merely ask questions. They became increasingly assured with using different tools, in preparing the features for drawing and taking photographs, producing appropriate documentation by hand and by using computers, and in planning how they worked and exploited the existing infrastructures to get their work done. For instance, in trench number 2, the students used a long time in the beginning of the week to negotiate with each other in which order they should excavate, take photographs and draw. By the end of the week, they had developed a routine how to coordinate the work with each other (using the social infrastructure to negotiate their order of work) and how to work with the stratum (as an infrastructure) to make it ready for documentation, first by taking photographs of the cleaned layers, and directly afterwards, to start drawing the exposed features using pen and paper while the graduate students were working in the site hut with the photo model. Their relation with the stratum began to emerge as more systematic and formalised (as for Toll and Mazmanian, 2016) than in the beginning. The students had started to learn how to discern points of interest in the stratum that are particular to archaeology and as Goodwin (1994) emphasise, of being an archaeologist.

Even if the students learned surprisingly well to cope with the partly conflicting requirements of documenting by hand and using photogrammetry, the discrepancy between the two was an apparent issue throughout the week. There was no similar conflict between the other two infrastructures even if the way how the documentation was done had an impact on how the stratum and the social infrastructure worked with and for the participants of the excavation. The archaeologists, Horatio, Matthews and Edward, used two primary arguments to explain why students needed to learn to draw by hand. Even if some of the students discussed the benefits and disadvantages of the different approaches together, in the presence and absence of the archaeologists, and together with them, the discussion was rather one-sided. Edward, Matthews and Horatio explained why doing the both was important whereas the students were mostly expressing their anxieties and doubts about a specific phase of work, or being enthusiastic with their mentors. Of the arguments of Horatio, Matthews and Edward, the first one was that the traditional skill of pen-and-paper documentation is still used (if not very often) at archaeological excavations.

The second, not entirely uncontested argument made by Horatio and largely, if not quite wholeheartedly, seconded by Edward and Matthews, was that students need to draw by hand to learn about archaeological work and archaeological thinking. It seems that the archaeologists considered mastering the pen and paper, measuring and drawing, making decisions about were to draw a line between two

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features, and being together with the physical infrastructure, cleaning the trench and being very close to the soil as essential facets of archaeological competence. What seemed to put doubt on this second argument was that the major asset of the photo-modelling approach is that it changed much in the archaeological documentation and analysis process, and how archaeologists interacted with each other (infrastructure) and the trench (infrastructure). The capability of photo-modelling to change archaeological work was explicitly acknowledged and commended by Horatio, Edward and Matthews, and was also apparent in the practices the students and archaeologists were engaged in the field. The differences in the central aspects and tasks of the documentation work, its spatial distribution on the site at the trench and in the site hut, and the focus on producing two different types of documentary artefacts with distinct materialities all underlined the disparity of the two infrastructures. Moreover, it also evinced of the presence of two different types of archaeologies, two distinct processes of learning how to pursue archaeological work and to make the social collective (infrastructure) and the physical stratum work together. Even if the basis of the both approaches was in detecting and making visible archaeologically interesting features, it was rather doubtful if learning the one truly complemented the other.

Discussion

Infrastructures at an archaeological excavation

In spite of its evident limitations, the present study has provided insights into the understanding of the impact of engaging with multiple information infrastructures when people learn and engage in information work. A common aspect of all of the studied infrastructures was that they were relative to each other at a particular time in a particular place. They were embedded in the (information) work of the participating archaeologists and students, they were transparent (as long as they did not break down, which was partly the case with the two parallel documentation infrastructures), they were both spatial and temporal, learned as part of membership, linked with the conventions of archaeological work, embodiments of an assemblage of explicit and implicit standards, and built on an 'installed base' (Star and Ruhleder, 1996) of the conventions of archeological work. Even if they all were intertwined to each other in the process of conducting archaeological fieldwork, they were not directly overlapping or complementary to each other but provided different entry points to perform archaeology.

Similarly to how Graham and McFarlane (2014a) suggest of infrastructures in general, it would not have been correct to characterise the studied infrastructures as artefacts. They were sets of processes, or perhaps even more so, from the perspective of work, sets of practices with both human and non-human constituents, and physical and non-physical materialities. In the context of an archaeological excavation, the layers of soil were not infrastructural and material only as (physical) soil but in relation to what was being done with it, similarly to how the documentation infrastructures were infrastructural and material in relation to a particular set of artefacts used together with other artefacts and infrastructures, rather than as sets of independent artefacts or infrastructural things. Similarly, the photo-modelling based documentation infrastructure was a complex mangle of human actors and their practices, digital (camera, computers, software) and non-digital (trench, site hut) artefacts, all with their distinct forms of materialities. In photo-documentation, the trench materialised as a visual model whereas the pen-and-paper approach was in a very tangible sense rooted in schematisation of what was seen, felt and even tasted at one time in the field.

This was especially apparent in how the interpretation of a trench emerged in a long-term engagement with the physical stratum when drawing with pen and paper, whereas photo-modelling was based on taking a literal snapshot of it and producing an interpretation in a long-term engagement with a surrogate. In essence, the photo-documentation shifted archaeology a few steps from being a field science to become a laboratory enterprise (cf. Kohler, 2002a). The photographs based approach was not more objective than the pen-and-paper-based one, and with both infrastructures, the archaeologists are dependent on each other (as in Goodwin, 1994), they need to trust on that interpretations, choices and

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measurements made by their colleagues are archaeological. The impact of the infrastructures on each other was not, however, only unilateral. As the need to either to clean or feel the dirt in a particular way shows, also the stratum steered the infrastructural capabilities of documentation approaches. The processual nature of infrastructures was the most apparent with the social infrastructure that lived and evolved together with the other substructures of work at the excavation from the impact of the physical layout of the trenches, and working in the site hut or close to the stratum, to how the emerging collaborations influenced information exchange at the site.

It was also apparent that the different infrastructures had different 'rhythms' (as in Shaw, 2014). The infrastructures and the scaffolding (as for Orlikowski, 2006) they provided evolved, interfered with and supported each other, and conditioned and enabled (information) work by shifting focus from physical artefacts to how and when the different artefacts and their materialities participated in the mangle in different rhythms. On a macroscopic level, the stratum, people and the two documentational approaches functioned in parallel to each other at the particular excavation during the specific week, to lose their infrastructural function after the work had ended, and possibly, to regain it in a different constellation of infrastructures in the future. Similarly to how Star and Ruhleder (1996) suggest, it is more appropriate to ask when the infrastructure (e.g., during a particular excavation) happened instead of asking what it was. On a microscopic level, the slower and faster rhythms of excavating harder and loser soil with different tools, the fastness of photo-documenting in field and slowness in the site hut, and the slower pace of documenting using pen and paper in field played into each other. Understanding the processual rhythms can help to know 'when to act and when not to act, and in what ways' (Graham and McFarlane, 2014b, p. 5) with an infrastructure. Documentation with pen and paper was equally little a mere question of using pen and paper than to spend time at the trench and producing a diagrammatic interpretation of features than photo-documentation was only about operating a digital camera or computer. The patterns of how documentation, and the interactions with the stratum and fellow students and archaeologists followed and were linked to each other, and how the speed of taking photographs is contrasted with the slowness of drawing and the time spent by the trench to the time spent in the site hut were all parts of a larger process on much longer temporal continuum.

Taken further, the entanglements of artefacts and their use-in-situation reminds of the ontology of becoming of Stengers (based on Whitehead, see Stengers, 1994) and the 'social materiality' of Dale (2005). Being inseparable, the material and social aspects of infrastructures are both a part of the control structure that regulates the obligations embedded in the infrastructures, how things should be done and are being done in practice. In an ethnomethodological sense, the infrastructural social-material practices are orders of how things are done and much of the discrepancy between working with two infrastructures and learning them in parallel can be traced back to the different materialities of the infrastructures and how they participate in the control of human practices. As Dale (2005) writes, the 'locus of control is much more difficult to see' when the (social) ideologies become embedded and embodied in the social materiality. Stretching this observation further to a Stengersian direction, the embeddedness and embodiedness of infrastructures not only interweaves the social and technological priorities and make it difficult to distinguish them, but denies the possibility and relevance of attempting to do so. The different material outcomes of using and not using particular tools for cleaning layers (i.e., interacting with the physical infrastructure), and of taking photographs of moist or dry soil become indistinguishable parts of the social conduct rather than an external justification for engaging in particular practices.

The inseparability of the human and non-human in the studied infrastructures does not mean, however, that the two would have had an identical modus operandi. They both had agency but as Pickering (1995) has noted on material objects and, for instance, Cooren (2004) on texts and Stengers (1997) on technologies, their agencies are not symmetrical. Seconding Stengers (1997), the archaeologists exercised agency by putting the infrastructures to work to steer and regulate the work at the site, and the infrastructures were engaged in another type of agency in putting archaeologists and students to work

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by providing norms and limits to how the excavation could proceed. Edward and Matthews were explicit about their intention of putting the photo-modelling approach to work to improve fieldwork practices and the quality of documentation but similar aspirations to use the physical layout of the stratum, putting students to groups consisting of undergraduate and graduate students and pen-and-paper-based infrastructures to either implicitly or explicitly to regulate how the students were working could be observed throughout the week. At the same time, the two documentation infrastructures (their composition and functioning) and their materialities (how they were tangible both in literal and metaphorical sense, how their materialities related to materialities of tools and of the trench) together with the archaeological stratum and the social infrastructure all pushed the archaeologists and students to work according to their respective standards. These attempts were not always aligned with each other as the anxieties with the different temporalities, requirements and work flows related to the different infrastructures revealed.

The friction was most apparent with the two documentation infrastructures, which were largely supposed to serve an identical purpose of documenting the site but it was equally apparent that they were not there alone and the friction both influenced and was influenced by the infrastructural engagement of the stratum and the social conduct of those present at the excavation. The presence of parallel infrastructures shifted the material conditions of archaeological thinking and simultaneously revealed not only the invisible aspects of documentation work (as in Carter, 2015) but also helped to articulate their practical and theoretical underpinnings. It made the 'seen but unnoticed' seen and noticed (Garfinkel, 1967) upon the (relative) breakdown of the hegemony of one infrastructure. Sundin and Carlsson (2016) second Bowker (2005) in that infrastructures function better the less we think about them. In case of obviously parallel overlapping infrastructures, it becomes difficult, if not impossible, not think about them. This applies equally to competing documentation approaches at an archaeological excavation as to search engines, healthcare systems and information sources. Even if thinking about infrastructures would make them less effective and would undermine them as achievements (Rao, 2014) over the complexity of the natural and social worlds, the observation of the work at the excavation site showed that the contrast can also open them for necessary criticism and a possibility to develop new infrastructures.

In spite of the relative antagonism between documenting by using a digital camera, and pen and paper, it would still be wrong to say that one of two the parallel infrastructures would have been meaningless in the presence of the other. Similarly to how Heuvel (2007) underlined earlier in the context of analysing business processes, it was apparent that also in the studied case of archaeological work, legacy systems (here, a legacy infrastructure) did 'contain genuine value' and its alignment with the work at the site should be taken seriously. At the studied excavation, it seems that apart from the (relative) continuing relevance of being able to conduct archaeological documentation by using pen and paper described by Horatio, the legacy infrastructure was used and useful in providing a (relatively) stable point of comparison for appreciating and framing the digital infrastructure used at the studied site, and in a broader sense, digital archaeological methods in general. The latter use of the legacy infrastructure was undoubtedly partly intentional (i.e., how the archaeologists referred to the significance of learning archaeological thinking, in practice, archaeological work according to the pen-and-paper model) but as the relative vagueness of these statements suggests, it seems that it was also, to a degree, unintentional and definitely, unarticulated and untheorised.

The diversity of archaeological documentation and work practices and how archaeologists attempt to increase trust in their work by adhering to specific infrastructures and infrastructural practices have been documented in the earlier literature (e.g., Huvila, 2016a). The presence of such a foundational infrastructure seemed to have a capability to suppress potential volatilities caused by an abrupt shift from one infrastructure to another and the emergence of several competing archaeologies and (in plural) archaeological information works. The role of the legacy infrastructure can be described in terms of an infrastructural stalwart, a sort of a scaffold of a scaffold (using the term of Orlikowski, 2006), with an

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aim of stabilising infrastructural processes rather than specific material or immaterial objects. This type of backup differs from the earlier documented uses of paper-based infrastructures as literal backups to unreliable digital systems (e.g., Björk, 2006). As an infrastructural stalwart, the resilience of the legacy infrastructure depends on its conceived relevance for stabilising, and maintaining and contributing to the 'formalisation' (as for Toll and Mazmanian, 2016) of archaeological disciplinary practices rather than on its technical or practical capability to document and preserve something that cannot be done to a reasonably reliable extent by using the new digital infrastructure. All this confirms earlier urges to see legacy systems not only as technological but comprehensive organisational issues (Brooke and Ramage, 2001).

The power of a legacy infrastructure to function as an infrastructural stalwart is in the capability of infrastructures to produce 'everyday normality' (Graham and McFarlane, 2014a), and seconding Shaw (2014), to be constitutive of the life and to sustain it for longer periods of time as far as the infrastructures are complementary rather than antagonistic to each other. The social infrastructure supported and was knitted together with the rhythms of the archaeological stratum and both of the documentation infrastructures drew from physical and social organisation of archaeological work. The presence of parallel competing infrastructures did, however, seem to end up with the dissolution of the (relative) balance and, to a degree, break the infrastructures and their invisibility by offering two different ideas of everyday normality (ref. Graham and McFarlane, 2014a) with their distinct materialities i.e., of how things should be done and documented, and on a fundamental level, of what lies in the focus of an archaeological excavation. The relative breakdown did not limit to the two parallel and explicitly competing infrastructures. By their links to and emphasis of partly conflicting standards and conventions, they affected also how the archaeological stratum and group functioned (e.g., by making a part of the students to wait the others to complete their documentation and how the stratum should be prepared for documentation), to quote Hanseth's (Hanseth, 2010) definition, as 'a shared, evolving, open, standardized, and heterogeneous installed base'.

Learning infrastructures

As theorised in the beginning of this article, the convergence of learning field archaeology and its infrastructures followed the trajectory of mastering (as in Ek and Widén-Wulff, 2008) the infrastructure and its related dance of agency (Pickering, 1995), and of gaining access to a particular community of practice (Wenger, 1998; Wenger-Trayner, Fenton-O'Creevy, Hutchinson, Kubiak and Wenger-Trayner, 2014) rather than as an instrumental process of using a particular infrastructure as a tool for learning or teaching. The presence of four parallel infrastructures that played out in the documentation work meant, however, that the situatedness of learning had a double-bind. There was not only one 'installed base' (Hanseth, 2010) or a stack of largely compatible infrastructures with mutually fitting materialities to be mastered. In the presence of a physical and social, and two overlapping documentation infrastructures with their distinct anticipations and obligations to act (Stengers, 2010; Simone, 2014), the infrastructural mangle incorporated two parallel dances of social-material agency to live with. The contrast between the two documentation approaches was emphasised by the seeming complementarity of the two other infrastructures and how they individually linked together with the both foiling ones.

During the week-long observation of archaeologists and students working and learning together, it was apparent that the students were learning as much to work with an archaeological stratum as they were learning to work together as archaeologists. The essence of learning and doing archaeological work at the site for the students was to help them to infrastructuralise the trench and the archaeological community (of practice) at the site in order to help them to do the same for other stratums and the archaeological community in general in the future at any archaeological site. From the perspective of learning, the two parallel documentation infrastructures had a rather instrumental role of providing and mediating access between the social and physical substructures of archaeological work. Simultaneously, however, because of their parallel instrumentality to the two other infrastructures and mutual discord,

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their presence at the excavation had a effect of disclosing some of the central tenets of archaeological work to its participants and spectators.

The argument that the students needed to learn the pen-and-paper method was intriguing from the perspective of infrastructures and their relation to learning. On a practical level, learning the two documentation approaches seemed to be a question of learning to interact and work with and within two different types of infrastructures. On a more profound level, the question is, however, how the two infrastructures and their materialities are related to archaeological work, archaeological knowing and their materialities (i.e., as in Evans and Daly, 2006), and how learning to interact with and within them affects learning archaeology and the archaeology that is being learned. A short and somewhat superficial answer could be that the two documentation infrastructures interfered with each other rather than helped the students to aim for one goal. This seems as a reasonable conclusion especially if the enthusiasm of Matthew and Edward on the capabilities of the digital infrastructure to revolutionise archaeological thinking is taken by its face value. Even if all senior archaeologists on the site were very explicit about the necessity to master the physical materiality of the archaeological stratum, Edward and Matthews seemed to be less confident that learning the pen-and-paper based infrastructure was a necessary precondition for achieving it. However, if the thesis put forward by Horatio, that the students need to learn how to draw by hand to learn about archaeological thinking is taken seriously, the legacy infrastructure becomes an epistemological infrastructure for the digital infrastructure, a lens through which the digital documentation practices, its outcomes and rapport with the archaeological stratum (as infrastructure) are interpreted, measured and evaluated.

The proposition has obvious similarities with the critique of replacing non-digital tools with digital ones in other domains, for instance, Belardi's emphasis of the importance of 'thinking by hand' in architecture (Belardi, 2014). Further, a part of the conviction can be explained in terms of apprenticeship, and by a desire to help students get archaeology 'under their skin' (Herzig, 2005) and to learn them some of the ethos and hardships of field archaeology (cf. e.g., Holtorf, 2006; Moser, 2007) as they were experienced by earlier generations. Perceiving the mastery of the pen-and-paper approach as a prerequisite of archaeological work puts the two infrastructures in a continuum with archaeological-stratum-as-infrastructure. In this continuum, a part of the material, processual and social aspects of the legacy infrastructure are reinvented and remediated in the new infrastructure, not merely 'shifted from analog to digital' (Roosevelt, Cobb, Moss, Olson and Ünlüsoy, 2015, p. 339). The necessity of this remediation and assuming the pen-and-paper infrastructure as a benchmark of photo-modelling can be challenged, as Edward and Matthews somewhat cautiously appeared to do, but only with obvious, yet unforeseeable consequences to the relationship of archaeological documentation and the archaeological stratum. Even if the contrast between preparing a trench for drawing and for taking photographs may appear minimal, it emanates from a very fundamental differences in how a specific documentation infrastructure and its materialities (as is and as they are acted upon) are related to the materiality of the archaeological stratum.

Even if the obvious points of disconnect between the new and legacy infrastructures do not render the propounded order of succession of the infrastructures invalid, it does undermine any uncritical takes on the rationale of their epistemic succession. In contrast, the earlier observations of the consequences of an increased visibility of infrastructures provide an alternative take on understanding how the succession of infrastructures and learning a legacy infrastructure can support the learning of its successors. As an infrastructural stalwart, the pen-and-paper documentation made learning photo-documentation more difficult both because of the need to intellectually accommodate for and in practice conduct parallel work and to socialise in two communities of practice instead of one. However, at the same time, it also made archaeological work more learnable. If the presence of competing infrastructures make them more visible and consequently, decrease their effectiveness (Sundin and Carlsson, 2016; Bowker, 2005), the discord can make them and archaeological thinking easier to master. By making each other visible, the conflicting infrastructures provide each other a benchmark and force both students and archaeologists to reflect upon their differences and to make an active choice of how to proceed with their work.

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Divesting one hegemonic infrastructure of its invisibility, gives an opportunity to be more explicit and critical about its infrastructural obligations, how practices and infrastructures together shape (and not only perpetuate, as the critics of situated learning theory have warned, e.g., Contu and Willmott, 2003), paraphrasing Wenger-Trayner and colleagues (2014), the landscape of practice.

Learning through conflicting infrastructures is perhaps not an approach that automatically leads to radical and conscious transformative experiences assumed in the transformative learning theory (Cranton, 2013) but its potential outcomes do undoubtedly reach beyond mere transaction (Miller and Seller, 1985) or iteration of old practices and power structures (Contu and Willmott, 2003). At the studied excavation, even if the most of the students were not actively advocating for either of the documentation methods, they were not merely mimicking the mechanics of how the archaeologists were interacting with the two infrastructures and their materialities. This is also where infrastructural stalwarts differ from infrastructures that are complementary to legacy structures. Whereas an infrastructure that acts as a stalwart forms a point of reference can be removed at will, complementary infrastructures are dependent on the substructures they are augmenting. Installing additional infrastructures leads to a duplication of effort and longevity of legacy procedures whereas an infrastructural stalwart holds a promise of sustaining selected practices in a different infrastructural landscape. Increasing the exhaustiveness of self-documentation and collection of personal reflections using audio and video is an illustrative example of an effort to erect a complementary infrastructure that is useful for reflecting on-going infrastructural practices. It is a method that has been employed to encourage reflexivity of archaeological fieldwork (Hodder, 1997; Berggren et al., 2015), but if it is used in the absence of alternative infrastructures to support archaeological work, it has limited potential to bring about change. The tenacity of paper-based infrastructures in the management of archaeological information (Huvila, 2016a,2016b) provides another example of the co-existence of two parallel but only partly functionally overlapping infrastructures. Even if the traditional paper-based information management could function also in this context as an infrastructural stalwart, from the perspective of the management and use of the archived archaeological documentation, the current digital workflow does not provide a comprehensive enough alternative that would allow the legacy structures to be replaced.

Conclusions

The aim of this article was investigate the impact of the interplay of the parallel presence of new and legacy information infrastructures to learning new work and its related information work practices. More precisely, this study set to ask how the compatibilities and incompatibilities, and different materialities of two information infrastructures can affect the learning of work and its related information work. Firstly, the analysis shows how different infrastructures of work and their materialities can be complementary and conflicting to each other. Four infrastructures of information work could be identified at the studied archaeological excavation, including the (physical) archaeological stratum, the (social) project group, and pen-and-paper and photo-modelling based documentation infrastructures. These infrastructures are intimately linked to each other. The actual (as they are acted upon) and perceived (as they are conceptualised) links between them and their materialities are a key to understanding the configurations of information work at the excavation.

It seems that the presence of conflicting infrastructures make them visible, causing frictions, volatility and loss of a sense of normality with a tendency of making the infrastructures less effective. At the same time, however, in the present study the visibility of infrastructures made their underpinnings discernible and forced archaeologists to explain the rationale of the novel take on documentation in relation to the legacy system. From this perspective, the legacy infrastructure played a potentially important stabilising role as an infrastructural stalwart, an infrastructure that stabilised another infrastructure. It provided a baseline for understanding how the new infrastructure works and does not work, and how it held together the two versions of archaeologies and archaeological works associated with the two documentation

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infrastructures. In this sense, making infrastructures visible gives an opportunity to spell out how practices and infrastructures shape the landscape of practice (as Wenger-Trayner and colleagues would phrase it, Wenger-Trayner et al., 2014) and, citing Bowker (2005), how the infrastructures themselves participate in knowledge making. Even if learning through conflicting infrastructures would not be a shortcut to in-depth insights, it can help learners to contextualise their situation in hand and become aware of its constituents.

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