Use-Oriented Information and Knowledge Management

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USE-ORIENTED INFORMATION AND KNOWLEDGE MANAGEMENT: INFORMATION PRODUCTION AND USE PRACTICES AS AN ELEMENT OF THE VALUE AND IMPACT OF INFORMATION

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There is a broad consensus that better models for assessing the impact of information efforts are needed to inform information and knowledge management and digital preservation. In contrast to measuring the quality of information, less attention has been directed to the assessment of knowledge and information processes as its constituent. Using archaeology and archaeological information as a sample context, the aim of this conceptual article is to probe in to the evaluation of the impact and usefulness of information by taking into account the practices of how it is produced, managed and used. On a basis of a review and discussion of earlier literature on the impact of information and evaluation and management of information in archaeology, it is proposed that a better understanding of how the impact of information unfolds as a part of its production, management and use could contribute to the development of infrastructures, repositories and procedures for the management of the preservation and use of these resources.

1. Introduction

Considering the volume of investments in creating technologies, infrastructures and standards for the production, sharing, capturing, preservation and dissemination of information, there is conspicuously little comprehensive research on the impact and implications of the efforts and especially, of the outcomes of the information itself (Case & Given, 2016). Much of the current evidence of the goodness of information is either anecdotal, based on calculating visits, searches or downloads, or on an assumption of the existence of a golden standard for what is good or bad (cf. Shen et al., 2013; Aloia et al., 2017). The problem is that in spite of the effort to analyse and find measures, we know relatively little how information impacts everyday work practices in different fields and how 'good' information unfolds when information is being made or used. Consequently, there is a risk that the efforts to manage information and knowledge focus on stuff that happens to be out there, appears acceptable, but is not especially useful in practice. At the opposite end of the spectrum, there is a similar risk to focus on explicit user needs, wants and desires that are impossible to meet because preferred kind of information does not exist or is too difficult to produce.

These problems are not limited to any specific field and they apply to many areas of professional work. This includes archaeology, which is used in the present study as a sample context to discuss the question of impact and especially the issue of outcomes-in-use of information. Being a field working with a large and growing body of heterogenous information makes archaeology an interesting case with a potential to provide insights far beyond its conventional boundaries. Archaeology works with a broad range of multidisciplinary sources, including historical, geographical, geophysical, documentary, close and long-range observational data, and the implications of archaeology spread across the society from cultural heritage and education to land use and infrastructural planning. As a whole, even if there are clearly archaeology-specific issues with the value (e.g. Lafrenz Samuels, 2008; Niklasson, 2013; Querol et al., 1995; Gillman, 2010) and management of archaeological information (Kintigh, 2006), many of the challenges enumerated in the archaeology-related literature are far from being exclusive to that particular field (Borgman, 2015; Bruseker et al., 2017).

The aim of this conceptual article is to probe in to the evaluation of the impact and usefulness of information by considering the practices of how it is produced, managed and used, and how this understanding can inform future work in information and knowledge management. Rather than proposing new quality measures for the information itself, which has been a common approach in earlier proposals (e.g. Lee et al., 2002; Lee, 1996), this article investigates the problem identified in earlier research that besides enforcing quality standards, it is necessary to investigate the usefulness and outcomes of information (e.g. Dawes, 2010) in the context of its making and use. As Huggett (2016) has remarked in the context of archaeology, the problem is not necessarily that particular information could not be represented. Instead, the challenge is how to capture the information that is useful and make it usable – and further, how to assess its usefulness and usability. On a basis of a

review and discussion of earlier literature on the impact of information and evaluation and management of information in archaeology, it is proposed that a better understanding of how the impact of information unfolds as a part of its production, management and use could contribute to the development of infrastructures, repositories and procedures for the management of the preservation and use of these resources. Finally, a tentative framework for probing into the constituents of creation and use-centric value is proposed to inform the development of future impact evaluation schemes.

2. Theoretical considerations

The theoretical rationale of this study draws from the ecological approach to information work studies (Huvila, 2008a) and Pickering's theorising on the relation of material entities and human practices (Pickering, 1995). According to Huvila's model of the ecology of information work, information and knowledge organisation systems (or in general, information infrastructures) *warrant* working with information in particular ways whereas specific ways of working with information *afford* the emergence and usefulness of certain types information infrastructures and *constrains* some others (Huvila, 2009). This forms a spiral-like cycle where information infrastructures influence information practices that for their part influence infrastructures. The approach draws on the concept of warrant (Beghtol, 1986; Hulme, 1911-1912) in knowledge organisation literature and Gibson's ecological approach with its notions of affordances and constraints (Gibson, 1977)

The notion of warrant was first introduced as a part of the concept of literary warrant, which refers to the principle that the criteria of organising knowledge in any specific manner needs to be present in the literature (Hulme, 1911-1912). After the seminal work of Hulme, a number of additional warrants have been instituted to refer to other bases of organising knowledge (e.g. Beghtol, 2002; Smiraglia, 2009).

In contrast to warrants, the central assumption of Gibson's theorising of affordances and constraints is that the environment privilege (afford, provide cues) or resist (constrain, provide opposite cues) certain actions (Gibson, 1977). The two notions have become popular especially in human-computer interaction research and practice (Kaptelinin & Nardi, 2012) as conceptual means to refer to possibilities and impossibilities offered by various types of artefacts. Information infrastructures in the model of the ecology of information work (Huvila, 2009) are an example of such an 'artefact', or in terms coming closer to Gibson's original work (Gibson, 1977), features in the environment of information workers.

When the model of the ecology of information work is complemented with sociomaterial theorising of Pickering (1995), the oscillation of influence between infrastructures (or in this study, information itself as a part of infrastructures) and human actors can be seen as form of a *dance of agency*. Pickering uses this metaphorical notion to refer to a reciprocation of human and non-human influence in a sociomaterial practice. Pickering's approach has affinities with other strands of sociomaterial theorising, including Actor-Network Theory (Latour, 2005) and practice theory (Gherardi, 2017), but also with the Giddensian notion of structuration (Giddens, 1984), which has had a major influence on contemporary thinking on human-non-human relations. Pickering's approach is more symmetrical in comparison to human-centric approaches (including the structuration theory), even if in contrast to, for instance, Actor-Network Theory (ANT) (Latour, 2005), Pickering maintains that human agency differs *a priori* from non-human agency. In this article, the focus of referring to Pickering is on explicating the oscillation of agency in the sociomaterial nexus rather than attempting to fathom the complexity of sociomaterial configurations. The dance of agency is put to fore to elucidate the shifts of how, when and by whom the impact and value of information is perceived from the perspective of different human and non-human actors.

3. Impact of information

The difficulty to assess information is a well-known problem. It is symptomatic that even if Glazer (1993) underlined the importance of measuring the value of information rather than merely of technology already in 1993, and Menou (1995a) proposed a research agenda for the study of the impact of information only a couple of years later, there is conspicuously little literature on the topic a quarter of a century later. In this respect, there is a notable contrast to the proliferation of literature

on information systems (e.g. Irani & Love, 2001; Irvine & Hall, 2015) and process evaluation, including the work on assessing information value chains (e.g. Koutsoukis & Mitra, 2013; Joseph, 2006).

As Kari (2011) observes, the literature on information evaluation that exists, discusses the question from a variety of perspectives. A partial explanation is undoubtedly the conceptual heterogeneity concerning information, impact and related notions (Meadow & Yuan, 1997). Evaluating information defined in terms of Shannon's theory of communication and related models (e.g. Al-Fedaghi, 2008) is different from the assessment of information conceptualised in the context of decision-making (e.g. Gigone & Hastie, 1997; Julien, 1997; Citroen, 2011), sense-making (Kari, 2001) or practice-based approaches (Savolainen, 2008; Lloyd, 2009). The second problem is the definition of the concept of impact: what is being measured and how measurable (easy to measure) the possible effects are. As Meadow and Yuan (1997) note, the most forms of impact are difficult to measure and the impact assessments are bound to be unreliable: "we may be able to detect an action or decision, but can rarely confidently attribute it to any specific information" (Meadow & Yuan, 1997).

Ahituv (1980) distinguishes perceived, revealed and normative values of which, according to him, the revealed value is closest to its realistic value. Saracevic and Kantor (1997) follow Ahituv's model in their value framework and distinguish inherent, intrinsic, instrumental and contributory values, and three approaches: normative, realistic and perceived values of information. Tanner (2016) distinguishes value and impact in a balanced scorecard-based evaluation model of digital resources. His model is based on a faceted approach with internal, innovation, economic and social facets of impact, and five value drivers of utility, existence, education, community and bequest. Even if it makes sense to distinguish value and impact as two different constructs, in the Saracevic and Kantor model, the inherent (e.g. contribution to good experiences, aesthetic value), instrumental and contributory values are also (relative) measures of impact similarly to how the intentional impact of information can be conceptualised in terms of use-oriented value. Also, the work of Tang et al. (2015) exemplifies this overlap. They used a value-based framework to study the utility and impact (realistic value) of feedback (a type of information) and found that the inherent value was a significant enabler of realistic value, intrinsic value had an impact on the state-of-mind of the user of the information, instrumental value led to improvements in information production, and contributory value supported information producers mandate and competitive advantage.

As Meadow and Yuan (1997) stress, it is important to be careful about the selection and definition of the variables influenced by information. "In physics, it might be the change in momentum; in agriculture, a change in crop yield; in medicine, a change in a community's mortality or morbidity rate." (Meadow & Yuan, 1997). In doing so, a common problem is that effects can be potential rather than real (Spink & Cole, 2006), immediate or delayed (Kari, 2007) and they are seldom direct consequences of mere information use (Kari, 2001). Information either helps or hurts (as Dervin 1999 notes) but is seldom attributable as the only cause of a particular impact (Kari, 2011). The locus of impact is also a matter of relevance. Menou suggests a model to measure the impact of "information-as-contents" and its capability to "transform the paradigmatic structure of the knowledge bases" (Menou, 1995b). Al-Fedaghi (2008) proposes a model of measuring impact according to 1) informational sphere of a person (cf. Menou, 1995b), 2) non-informational sphere (of a person), and 3) the outside sphere (external to the person). Even if Al-Fedaghi is not the only one to acknowledge that information can have impact outside of strictly personal level (e.g. Menou 1995a stresses that potential impact ranges from a global to personal level and Darlington et al. 2008 underline the importance of being explicit of the organisational level of information evaluation), in information science, it has not been especially common to investigate empirically other than personal-level impact (Kari, 2011) on informedness (knowledge) and/or behaviour (e.g. Kirk, 2002; Lee et al., 2008).

When scoping the breadth of the impact of information, it is also necessary to consider that the context of the impact tends to be wider than that of the subject of its (primary) repercussions. The recent work that attempts to measure the impact of cultural heritage is illustrative of the potential breadth of the implications of intangible phenomena and the difficulty of drawing a line between direct and indirect effects with secondary impact (e.g. Bowitz & Ibenholt, 2009). Especially in the cultural domain, it is not uncommon that much of the worth is realised as option value i.e. value of being in a possession of a particular resource available for possible future use (Aabø, 2004) rather

than as a value stemming from the possibility to use it directly. The temporality of valuations means that in addition to framing the subject, also the motivation to evaluate (at a given moment) and the stage of information (similarly, at a given moment) matter (Darlington et al., 2008). Stages can be conceptualised in terms of a life-cycle (Darlington et al., 2008) or continuum. The latter acknowledges that same information can simultaneously reside in different stages of a life-cycle (Huvila et al., 2014) and used for different purposes (Upward et al., 2018).

Finally, in addition to a temporal stage, also the context of using information has repercussions to its impact. There are major differences to what extent the issues of impact and value have been studied in specific contexts. López et al. (2013) are undoubtedly correct in suggesting that 'more insights can be gained from studying how knowledge evaluation and selection actually happen in different organizational contexts' (López et al., 2013, p. 16). Even if there is still undoubtedly a lot of room for conducting research on the impact of health information (cf. Eriksson-Backa, 2003), the effects of information in that particular field have been studied to a comparably large extent. In contrast, one of the relatively unexplored contexts is, among several others, the domain of archaeological information.

4.   Issues in archaeological information and knowledge management

The struggle of managing archaeological information has a long history (Braccini & Federici, 2010). In this respect, the story of computerised management of archaeological information (Lock, 2003), which dates back to the pioneering work of such groundbreakers as Gardin (Moscati, 2013), Spaulding or Clarke (Dallas, 2015), is shorter. The roots of the radical escalation of the problems and the emergence of the so called 'curation crisis' (Flexner, 2016) can be traced back to the years of intense development activities in a large number of countries across the globe during the decades after the Second World War and to the introduction of new archaeological heritage legislations that require land developers to finance archaeological surveys and rescue excavations (Börjesson & Huvila, 2019). As a consequence, the poor and uneven preservation of archaeological information (Huvila, 2016b), and later on, especially the question of appropriate management of digital data (e.g. Richards, 2002, 2016) have been common concerns among archaeology professionals and heritage administrators. However, as Huvila (2019) remarks while reviewing earlier literature on archaeological information and knowledge management, perhaps somewhat unintuitively considering the long interest in managing information, there has been relatively little exchange between archaeological information management and general information and knowledge management fields – even if there are exceptions to the rule.

A part of the peculiarities of archaeological information management can be traced back to the nature of archaeological information (Huvila, 2019). One of the key questions is the diversity of things that can be informative for an archaeologist and about archaeology. Information takes many forms from various types of material artefacts, landscapes, measurements, images, drawings, geophysical and chemical data to reports and literature (Huvila, 2006, 2014). Archaeological information is also temporally heterogeneous. Evidence from different historical time periods can be radically different from each other similarly to how the archaeological documentation produced in different projects at different times and locations by different individuals varies considerably (Huvila, 2019; Pavel, 2010; Trigger, 2006). There are also multiple competing standards and assumptions of what archaeological information is and how information becomes archaeological (Huvila, 2019). Further, the available information tends to be highly incomplete and disconnected. Patrik (1985) doubts for a reason whether the fragmentary pieces of archaeological evidence forms a comprehensive whole at all. Finally, even if non-destructive methods of inquiry have increased in popularity, the fragmented assemblage of evidence that is available on a specific archaeological site is in many cases unique. The destructive nature of archaeological excavation process means that an, which has been unearthed, cannot be brought back (Kilbride, 2016).

Similarly to how archaeological information is heterogeneous and often unique, also the ways how archaeologists and other stakeholders use and manage it differ from each other. Archaeological heritage administrators, educators, the general public and researchers with their specific research agendas have widely different information needs and preferences (Lucas, 2012; Huvila, 2014, 2018a; Khazraee, 2019) even some specific types of information, especially investigation reports,

have become a generally accepted and popular sources – not least because of the lack of easily accessible and usable alternatives (Huvila, 2016a). The stakeholders have different means to engage in the process. Administrators influence information production through legislation, and guidelines, the general public through the public opinion and discourse, whereas researchers participate in the scholarly agenda setting of what is significant and interesting for archaeology at a given time.

A common trait in archaeology is that individual projects, operators and organisations develop their own in-house or in-project information management systems and schemes (Khazraee, 2019) either together with external database experts or by relying on information management minded archaeologists. Because of this tendency, there are a lot of examples of prototypes and production versions of both generic and locally deployed databases, archaeological knowledge management systems (e.g. Wattrall, 2011; Karmacharya et al., 2008; Valtolina et al., 2012, 2013), and virtual research environments (e.g. Dunn, 2006; Mills & Baker, 2009; Warwick et al., 2009) for managing and working with archaeological data. Even if the problem of the fragmentation of systems and data models has been recognised for a long time (e.g. Bekiari et al., 1999; Huggett & Ross, 2004), the practical work towards a wider interoperability of systems has gained significant traction through national (e.g. Richards, 2016; Gilissen & Hollander, 2017; Larsson et al., 2017) and international (e.g. Meghini et al., 2017) efforts only fairly recently. As a result, archaeological information tends to be poorly available (e.g. McManus, 2012; Huvila, 2006), management procedures have been criticised of being often under-developed (Federici & Braccini, 2012), and there are multiple issues that make archived data difficult to use (e.g. Verhagen, 2009; Roth, 2010). There is also a wide consensus that new strategies and especially implementation of that what is already known is needed to cater for the needs of the current and potential users of archaeological information (e.g. Arnold & Geser, 2008; Geser & Niccolucci, 2016).

Archaeological data archives like the Archaeology Data Service (UK) and IANUS (Germany) have surveyed their stakeholders (Beagrie & Houghton, 2013; Schäfer et al., 2014). There are also studies focusing on specific groups (e.g., land developers, information managers, maritime archaeologists, researchers (e.g. Ní Chíobháin Enqvist, 2018; Faniel et al., 2013; Huvila, 2016b, 2017)) and organisational contexts (e.g. Federici & Braccini, 2012; Powlesland et al., 2010). As a whole, however, in spite of the genuine efforts to understand users and their priorities, Geser and Selhofer's (2014) critique that relatively little is known of how information is used and valued by different actors is still painfully actual.

In addition to a plethora practical, economic and policy-related problems (see e.g. Federici & Braccini, 2012), a very fundamental issue that curbs the management of archaeological information stems from the epistemological roots of the discipline that do not necessarily see information as equally foundational to archaeology (cf. Braccini & Federici, 2010) than narratives and knowing beyond data (van der Valk, 2010; Huvila, 2019). It can be argued that there is a certain mismatch between the information-as-thing-oriented (cf. Buckland, 1991) processing of granular data that is prevailing in archaeological information management, and the narrative, social and practice-oriented focus of archaeological knowledge production (Perry, 2018; Huvila, 2018b). Using the terminology of Cook and Brown (1999), the systems tend to be built on the premises of the 'epistemology of possession' rather than the 'epistemology of practice' (Cook & Brown, 1999), or more broadly, on social forms of knowledge and knowing (exceptions e.g. Braccini & Federici, 2010; Engel & Grossner, 2016; Huvila, 2012; Kilfeather et al., 2003). Information is considered as a thing to *have* rather than something that people *do* (Newell et al., 2009). From this perspective, it is not surprising that archaeological information systems (e.g. Geser, 2016; Valtolina et al., 2012; Missikoff, 2004) are often built on geographical information systems (e.g. Wattrall, 2011; Conolly & Lake, 2006), relational model (Codd, 1970, for examples see e.g. Campana, 2016; Counts et al., 2016) and more recently, Semantic Web and Linked Data (e.g. Isaksen et al., 2010; Tudhope et al., 2011), rather than process or learning oriented foundations.

The epistemological incompatibilities can also provide at least a partial explanation to the proliferation of local information management practices and organisation schemes. They can be seen as repeated attempts to develop local solutions in the context of the first-mentioned epistemology to a wider discipline-level problem that is firmly placed in the latter. They can also be linked to the intra-disciplinary fault lines in archaeological inquiry (Khazraee, 2019) and the disconnectedness of archaeological information processes that has made researchers to question its linearity and uniformity (e.g. Buchanan, 2016; Huvila, 2018b; Khazraee, 2019) and claim that archaeological

information changes shape (cf. Khazraee, 2019; Huvila, 2018b) and quite literally enters a new regime (as for Boltanski & Thévenot, 2006) or life-cycle (for Braccini & Federici, 2010) with its own values and priorities whenever it taken up by a new group of users in a new context and situation.

5. Evaluation of archaeological information

Even if many of the specific knots of archaeological information work are particular to the discipline, there is a lot of evidence of the inherent complexity of informational undertakings across domains (e.g. Carr, 2005; Fook et al., 1997; Jenkins et al., 2009; Byström, 1997). A powerful conceptualisation of the continuity of discontinuities is the information and records continuum theory of Upward and colleagues. The continuum perspective criticises life-cycle-based approaches by drawing attention to that the life of information seldom follows a linear path. Rather it tends to be in different phases of a life-cycle in different contexts at the same time (Upward et al., 2018) and follow a trajectory that is far from the idealism of simplified information process models (Oliver & Foscarini, 2014).

In the light of the complexity of how information is intertwined in human pursuits, it is understandable that assessing information and knowledge has proven to be notoriously difficult. The earlier work on the topic is dispersed across different disciplines and contexts. The individual studies have proven to be difficult to compare to each other (López et al., 2013) because the studies have shown that the goodness of information and knowledge is relative to the circumstances within which they come into being (Garfinkel, 1967; Suchman et al., 2019), inherent to what is understood as being knowledge and information (López et al., 2013), and dependent on a norm or ideal state of comparison (Daghfous et al., 2013) that are to a high degree context-specific. As a consequence, it is hardly surprising that there is a lack of comprehensive models for conducting such evaluations (Lerro et al., 2012).

Even if it has proven to be difficult to evaluate the goodness of information and knowledge, a broad variety of approaches have been found useful in *measuring* their impact or a part of it. In the research literature, both qualitative and quantitative methods, including interviews (e.g. Citroen, 2011) document analysis (e.g. Kari, 2011), surveys (e.g. West & Noel, 2009) and various types of operative (often quantitative) indicators, have been commonly used. A typical approach has been to apply a combination of external evaluations, comparisons of outcomes to plans and strategies, and indicators selected by the evaluated organisation (e.g. Jennex, 2008). Similarly, even if the costs and especially benefits related to largely non-economic assets like archaeological information have no market value, their value can be established using non-market valuation methods (cf. Grindley et al., 2014). However, even if the general approaches to the evaluation of information should not be disparaged, the lack of comprehensive understanding of the specifics of information and knowledge work practices in particular domains (for archaeology, Huvila & Huggett, 2018) can limit their direct usability in specific contexts. Moreover, the valuation-based approaches have a tendency to operationalise impact on scales that do not give answers to the question of *how* information influences practice and is influenced by it.

Even if it is apparent that more empirical research on information use would be useful in archaeology and other domains (López et al., 2013), the already existing findings can provide guidance for future research efforts on understanding the impact and value of information. In the context of archaeology, multiple authors have emphasised the change of the relevance of information. Holtorf (2015) refers to Ingold's (2010) theorising on buildings and people as processes rather than, as earlier, as things. Instead of evaluating things, it seems plausible to suggest that it could be useful to put more focus on evaluating the processual aspects of both archaeological work and archaeological things – not to evaluate the work or things themselves – but to obtain a better understanding of their repercussions, and their informative potential and consequences. Pavel (2010) has studied the changes in archaeological documentation practices. Her findings seem to confirm casual observations of the increasing formality and a growing and officially endorsed trend and requirement to collect and preserve more data to substantiate interpretations presented in the final report. As she notes (Pavel, 2010), the meticulous preservation of detailed information has implications not only to the reporting but also to how and whether the value, quality and potential impact of information can be assessed and used by other archaeologists. When the change of documentation practices in time is combined with the repercussions of inter- and intra-disciplinary,

national and regional variation and changes in documentation and documentation practices (e.g. Nissley & King, 2014; Carver et al., 2015; Novaković et al., 2016; Huvila, 2017) and consequences of the non-linearity of archaeological information processes (Huvila, 2018b), it is not surprising that fit (for purpose[s]) and sustainability (over time) of the management of archaeological information (Huvila, 2006, 2008b) have been proposed as critical success factors of archaeological information work. A major consequence of the volatility of archaeological information work is that impact and value are inevitably moving targets and relative to the actual making and use of information rather than a gold standard.

6. Embracing the dance of information making and information taking

We have established so far that the typicality of non-linear information processes and a gap between ideal and actual procedures of information work are well-documented in the literature both within and outside of archaeology (e.g. Upward et al., 2018; Savolainen, 2018; Federici & Braccini, 2012). Huvila (2018b) has proposed an approach to conceptualise the non-linearity of an information process by framing it as a continuum of information making and information taking (Huvila, 2018b). A diagrammatic representation of the continuum is presented in Figure 1. Information produced by one or several actors and appropriated to use by others in a specific situation (Huvila, 2015) rather than handed over or transferred (Huvila, 2018b). This does not mean that linear processes would be absent from archaeology or other contexts of information work but that they tend to be specific to particular situations (e.g. individual projects, sub-disciplines of archaeology, or national and regional archaeological heritage administration processes, e.g. Mills & Baker, 2009; Federici & Braccini, 2012; Larsson et al., 2017) rather than to be characteristic to archaeology (or any other domain) as a whole.
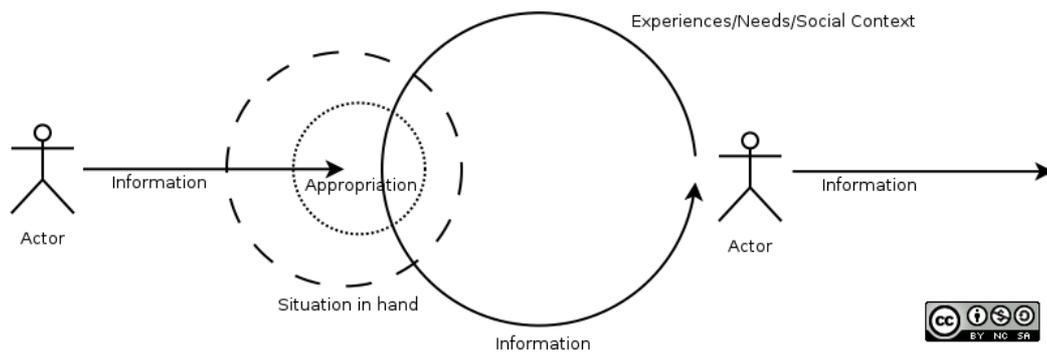

Figure 1: Ecological continuum of information making and taking (Published earlier in Huvila, 2018b, p. 134, CC-BY-NC-SA).

Pickering's notion of dance of agency (Pickering, 1995), which refers to the reciprocation of human and non-human influence in sociomaterial practices, provides a parallel lens to the dynamics within an ecological continuum of information making and taking. The major insight that can be drawn from the framework is that the evaluation of information requires specific sensitivity to information as and when it is with particular actors, and how human and non-human 'things' involved in the making and taking of information influence its outcomes and how these outcomes are perceived. While agency shifts between different groups of users or producers of information, information or different technologies, the agent that leads the dance, is the one whose priorities of the goodness or badness of information take the lead and sets the agenda of how information should be managed.

As noted earlier, the different stakeholder groups have different means to take the lead in the dance. Administrators do it through the legislative and administrative apparatus, non-archaeologists through public opinion-building and researchers in the archaeological scholarly discourse. Also information itself have certain degree of agency and by being what it is, it influences what can be managed, what is managed and what can be known. Its agency has become especially prominent as a part of the attempts to get grips with the curation crisis and the rapidly increasing amounts of

digital information. Even if the explicit priority would be to focus on managing relevant information, in practice, the focus turns easily to managing what is available and determining the value of managed assets not only by their usefulness but also by the possibilities to deal with that what is manageable.

Seeing the interplay of information-making and information-taking as performed by both human and non-human actors as dance-like movement underlines the importance of a proper understanding and management of the discontinuities in the process as a key aspect of how the value, impact and usefulness of information unfolds. Acknowledging the reciprocation of agency and being sensitive to who or what is setting the agenda at a given point of time helps to acknowledge the pertinence of a variety of views of what is valuable and useful. Simultaneously, it can facilitate a greater sensitivity of information use and production as parallel and recurrent activities in the information management processes. This applies also to translations between disciplinary, intra-disciplinary (Khazraee, 2019) and intra-institutional (as e.g. in Federici & Braccini, 2012) fault lines that are contemporary to each other. In both senses, a better documentation of work process emerges as a key to enhancing the 'takeability' and usability of documentation for a broader variety of purposes, and further, as an incentive to concentrate efforts to manage information for its broad usefulness and value rather than for the purposes of individual groups of agents or its immediate manageability.

7. Framing a framework

At this point, if the theoretical and empirical insights drawn from the literature earlier in this article are drawn together, it begins to be possible to sketch a provisory structure for framing some of the pertinent aspects of information production and use and their implications to understanding the impact and value of information in archaeology, and with certain reservations, beyond that particular domain. As Meadow (2002) stresses, the difficulty of defining variables should not serve as an excuse for not doing that. When the central question is to measure the value and impact of information in general (within a particular domain or not), it is necessary to define measurable variables that are indicative of the transformations caused (or influenced) by information use in a specific context and/or situation. First, a central question is to find more about how information is made. Second, after establishing a working understanding of where information comes from, it is easier to anchor (e)valuation to the specific processes and contexts of production and use and to define measures to reveal (cf. Ahituv, 1980) value (or values) of information as a function of production of information in relation to its use(s). The value (including inherent, intrinsic, instrumental and contributory as in Ahituv, 1980) and impact (whether real, immediate or delayed, direct, indirect or optional cf. Spink & Cole, 2006; Kari 2007, 2011; Aabø 2004) depends on the specific situation and context of use and can be difficult to estimate. Analysis of information processes in the given context and theoretical models of the use of information such as the records continuum model together with related models of information and information systems continuum (Upward et al., 2018) can be useful in providing guidance and good enough estimations, at least, in a part of the key issues. Using these premises as a starting point, the evaluation can be extended to economic assessments and quality measurements.

In comparison to the generic impact assessments of (unspecific) information (e.g. Menou, 1995b), similarly to other fields where information is used in the context of work (as noted e.g. by Suchman, 2006), the contexts and situations of the use of (archaeological) information have boundaries even if they would appear invisible and difficult to discern (Suchman, 1995; Szymanski & Whalen, 2011) and we might know too little about them (i.e. about *actual use* versus expectations and generalisations). Firstly, its specificities influence how information is used, how well it serves various purposes explicitly and implicitly as expressed by different stakeholder groups, and why, and to what extent information (kept and appearing in various forms) is consulted in practice in that specific context. Secondly, the scope of the direct impact of (archaeological) information (as contents) is more limited than with some other types of information. Whereas, for instance, in the context of healthcare, it can be relevant to assess whether individuals change their diet after receiving information about the adverse effects of excessive intake of sodium (i.e. *direct use*), with archaeological information, a more relevant question could be whether a particular piece of information has helped, for instance, researchers, administrators or non-experts to do whatever they were about to do (i.e. *experienced use*). The downside of this type of focus is that the impact becomes more difficult to measure (cf. Meadow & Yuan, 1997) due to the increased complexity of

determining relevant variables to assess. Sodium consumption is a relatively easily measurable variable in contrast to, for instance, 'positive impact on work practices'. Similarly, even if 'health' is notoriously subjective and difficult to measure, it is fair to argue that the outcomes of archaeology (e.g. knowledge of the past, self-understanding, orientation) can be even more difficult to assess. Considering these premises, it is hard to believe that it would be possible to develop a universally useful generic 'data management ontology' that links a data or information quality model with a task model (cf. Stvilia et al., 2015) of how information is being used in archaeology or in any other contexts lacking a strong consensus of guiding norms – and in fields where guiding norms are regularly appropriated, ignored or worked around. Such a model can be obviously useful as a guideline and norm but should not be seen as a representation of reality. A more plausible alternative could be to propose a model (or models) for ontological enquiry i.e. a method or model for analysing and explicating differences between different perspectives to information. This approach could have potential in the context of specific archaeological tasks such as for archaeological predictive modelling, specific types of research tasks and administrative work.

Considering that what is known about archaeological information and information work, it seems plausible to suggest that in the evaluation of archaeological information, following principles (drawn from the two observations of the relative lack of the actual and experienced use of information) could be used as a starting point

Focus on *how* information is produced (or comes into being) in specific processes that are selected on the basis of their perceived relevance and impact for scholarship and society.

    (a) Qualitative measurements of *how well* the current work practices of producing information are aligned with their stated goals and the scholarly and societal priorities of archaeological work.

    (b) Quantitative measurements of how much and which resources, infrastructures and repositories are used by actors involved in the specific processes.

Focus on *how* information is used in specific processes that are selected on the basis of their perceived relevance and impact for scholarship and society.

    (c) Qualitative measurements of *how well* users consider that currently available information is helpful for them to be successful in their pursuits, combined with heuristics of how well the current work practices are aligned with their stated goals and the scholarly and societal priorities of archaeological work.

    (d) Quantitative measurements of how much and which resources, infrastructures and repositories are used by actors involved in the specific processes.

Benchmarking of existing and possible alternative methods of providing the same or better information service for its users at a price the society is willing to pay for archaeological work.

Even if much of the earlier discussion in this article has focussed on explicating the idiosyncrasies of archaeological work and information and even if archaeology is a specific context with its very own peculiarities, the issues of sustainability and fit of information are by no means unique to that particular discipline. Also medical information have many stakeholders with different and contrasting preferences (Ammenwerth et al., 2003; Cajander & Grünloh, 2019; Huvila et al., 2019), the processes are convoluted and a large part of it is far from being uniform (Rebuge & Ferreira, 2012; Berg & Bowker, 1997). The same applies to many other fields from financial markets (Riles, 2011) to engineering (Buch, 2015) and particle physics (Pickering, 1995). A feature that distinguishes archaeology from many other contexts of work is that at least so far, it has resisted attempts to standardise work and information management practices to a degree and especially in ways which have been characteristic to professional work in many other fields (cf. e.g. Gerdes, 2008; Germov, 2005; Nerland & Karseth, 2015). Even if it should probably be taken as a thought-experiment rather than a definite proposition, at least before additional work in other domains, reiterating the archaeology-specific principles in general language sets out a tentative framework for scoping the premises of impact and value of information in contexts outside of archaeology:

Focus on *how* information is produced (or comes into being) in specific processes that are selected on the basis of their perceived relevance and impact for the principal stakeholders of the activity.

(e) Qualitative measurements of *how well* the current work practices of producing information are aligned with their stated goals and the central priorities of the analysed activity.

(f) Quantitative measurements of how much and which resources, infrastructures and repositories are used by actors involved in the specific processes.

Focus on *how* information is used in specific processes that are selected on the basis of their perceived relevance and impact for the principal stakeholders of the activity.

(g) Qualitative measurements of *how well* users consider that currently available information is helpful for them to be successful in their pursuits, combined with heuristics of how well the current work practices are aligned with their stated goals and the priorities of the analysed activity.

(h) Quantitative measurements of how much and which resources, infrastructures, tools and repositories are used by actors involved in the specific processes.

Benchmarking and comparison of existing and new alternative methods of providing the same or better information service for its users at a price the financer of the activity is willing and capable of paying.

When these steps are combined with the model of archaeological information process proposed by Huvila (2018b), the result is a model that provides a framework for elucidating production and use as aspects of impact and quality evaluation of information (depicted in the Figure 2) that is conscious of the gaps in an information process caused by problems with fit and sustainability of information flow.
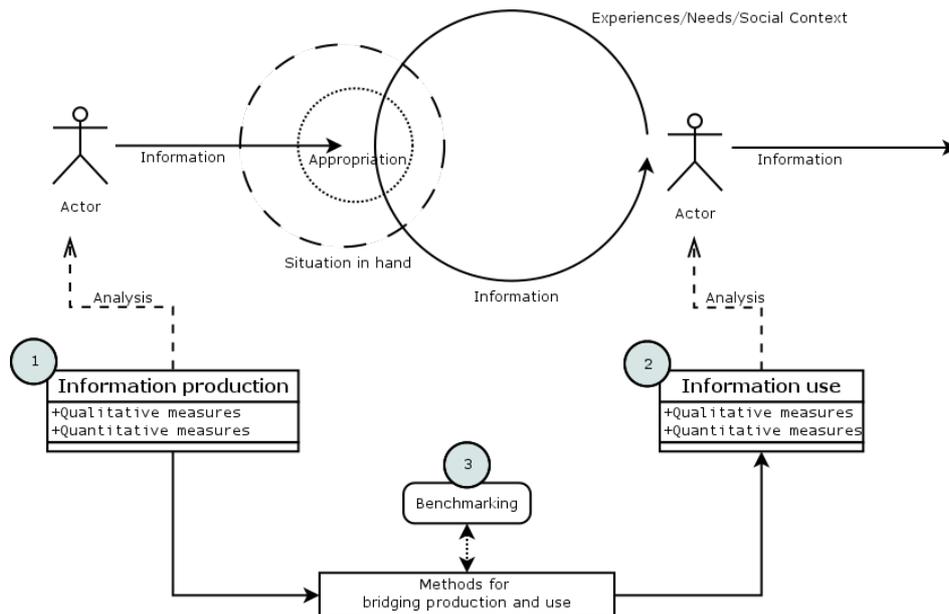

Fig. 1. A model for accounting for production and use practices as an aspect of impact and quality evaluation of information (Based on the model in Huvila, 2018, p. 134, CC-BY-NC-SA).

The key aspects of the process is to start with information production to establish an understanding of the premises of information-as-being-made as it becomes available. The following step is to see how a specific type of information (in making) is useful and how it is used by others (i.e. turning to information-as-being-taken), and finally to obtain an understanding of existing and possible measures of bridging the gap between how impact and value unravels as a function of how information is produced and used. Further, instead of framing the making and taking of information as mere acts of mechanical production and exploitation, using Pickering's notion of the dance of agency (Pickering, 1995) as a lens helps to highlight the reciprocal and equally essential but

essentially different influence of human actors, information and the material things (including non-human infrastructures and resources), engaged in the making and taking of information. Even if material things or information would be *used* (as expressed also in this article), from the perspective of the dance of agency 'using' comes closer to swaying and spinning than sweeping a broom, and therefore also the evaluation, understanding and management of information and information processes turns to an exercise oriented towards facilitating making and taking rather than administering exploitable commodities or resources.

Instead of being an instrument for conducting practical evaluations, the proposed framework is a meta-model that points to factors that should be considered in evaluation and assessing information and information practices. It can eventually function as a basis for developing practice-oriented valuation schemes but also in informing theoretical and empirical research that accounts for information production and management practices and the present and anticipated use of these resources as an aspect of the impact and usefulness of information. Instead of starting with how to match users' needs and preferences to information managed with a specific stack of technology (in Figure 2, moving from 3 to 2, or in some cases to 1, to 3), the proposed framework attempts to shift emphasis to negotiating what is being done and why, what should be done, and first then pursuing whether a specific piece of information managed in a particular way could be useful and of value in the nexus of these specific activities.

8. Conclusions

A better understanding of the usefulness, usability and use of information is one of the central contributing aspects to the sustainability of undertakings across the sectors from healthcare to manufacturing industry and cultural field. Similarly to many other domains, archaeology is struggling with the question of how to decide what are the most appropriate practices of archaeological information work, information seeking, production and preservation at the advent of a large scale availability of digital archaeological information. As Holtorf and Kristensen (2015) emphasise, as it is impossible to keep everything, it is necessary to make choices, and consequently, to understand how choices are made and can be made (Holtorf, 2015). A better understanding of *how* things are produced, used and acted upon and who (or what) is taking the lead in deciding what forms a baseline for making such choices and a complement to the measures of the frequency of use, associated costs and their (often theoretical) intangible value. Considering the variety of practices, similarly to how Pavel (2010) notes of her work, the aim of such an understanding does not need (and should not) be a rigid evaluation framework for archaeological recording, documentation and preservation. What would be more important, would be to increase awareness of possible approaches to how information is used and produced, and their mutual implications to each other. The conceptual framework proposed in this article can provide guidance in this attempt, similarly to how the concepts of information taking and making, and sensitivity to the reciprocity and dance of agency between the human and non-human stakeholders of information work can be helpful in (re)thinking about the priorities of information and knowledge management.

Even if the empirical focus of this article has been archaeology, the explored challenges are far from being exclusive to this specific context. The question of appropriate practices of work, information seeking, production and preservation and at the advent of a large-scale availability of digital information, and the digitalisation of the work itself are equally pertinent in other fields as well. Studies ranging across contexts from healthcare to creative work (e.g. McLoughlin et al., 2017; Gregg, 2011) give strong indications that many of the observed problems and opportunities relate to the use and making of things rather than to the digital artefacts themselves. Considering this, an increased awareness of the approaches to how information is constantly being used and produced in a continuum, and their mutual implications to each other could provide a major push towards a better understanding of how the impact of information comes into being – and at the same time, provide a push towards a use rather than information or technology-oriented information and knowledge management.

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