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TOWARDS SHARED UNDERSTANDING ON COMMON GROUND, BOUNDARY OBJECTS AND OTHER RELATED CONCEPTS

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ABSTRACT

Since Aristotle, it has repeatedly been stressed that for engaging in meaningful discussion or debate, the discussion parties must share, besides a language, also knowledge, information, values and goals. What do we know today about this issue? How can that knowledge be used and advanced? The purpose of this paper is to consolidate our understanding on the many concepts that refer to preconditions for communication and collaboration in construction projects. The underlying research is conceptual by nature, and it is underpinned by a literature review. The findings show that currently there is a wide variety of terms and theoretical approaches that refer to the discussed phenomena. This situation invites for a conceptual synthesis and empirical research for its validation.

KEYWORDS

Shared understanding, boundary objects, common ground, mediating artefacts, standardized methods, situational awareness.

INTRODUCTION

Deservedly, "shared understanding" is one of the current buzzwords in construction, where it (or cognate terms) is used in connection with new forms of contracts like integrated project delivery (Aapaoja et al. 2013), as well as with building information modelling (Coates et al. 2010) and lean construction (Pasquire 2012). However, it

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emerges that different authors use this term in differing meanings, and also there are related terms with similar or at least overlapping meaning.

In view of this, this paper aims at adding conceptual and terminological clarity to the many concepts that refer to preconditions for communication and collaboration generally as well as in construction projects. It is structured as follows. After short presentations of six related concepts based on the literature, we briefly discuss them and draw conclusions for future work. The concepts discussed are: shared understanding, common ground, boundary object, mediating artefact, standardized method and situational awareness.

TERMS AND CONCEPTS

SHARED UNDERSTANDING

In a first comprehensive study on team work and social interactions in design, Cross and Cross (1996) identified that design teams spend a lot of effort to coordinate individual process of information processing in order to reach shared understanding of the problem. According to these authors, the teams have to manage conflicts based on different interpretations of ideas, concepts and representations. Shared understanding implies an overlap of understanding among design participants in the task (Maher et al. 1996), and a lack of shared understanding causes unnecessary iterative loops (Valkenburg & Dorst 1998) that can be further correlated to the notion of waste on design. Moreover, without shared understanding, decision-making processes will not be supported by all members (Valkenburg, 1998). In this case, later activities in the design process can be hampered by different views of the team members on fundamental topics (Valkenburg 1998). Arias et al. (2000) have also indicated the importance to focus at the social aspect of creating shared understanding in collaborative environments through human-computer interactions.

More recently, in product design research Kleinsmann (2006) defined shared understanding as a similarity between individual perceptions on the conceptual content of design. A more comprehensive definition is proposed by Smart et al. (2009), defining shared understanding as "the ability of multiple agents to exploit common bodies of causal knowledge for the purpose of accomplishing common (shared) goals". These authors also describe shared understanding "as the ability of multiple agents to coordinate their behaviours with respect to each other in order to support the realization of common goals or objectives." Seeing understanding as an ability, or "meaning in use", gives strength to the viewpoint that understanding is more than knowledge; it is reasoned action and has a dynamic state (Bittner & Leimeister 2013).

In spite of its development in the context of military coalitions and further applications on Systems Science, the definitions of shared understanding presented in Smart et al. (2009) can be related to the context of complex project delivery in construction. This means that collaborative multidisciplinary design process involves knowledge (understanding) creation and sharing to be integrated through design communication (Kleinsmann & Valkenburg 2008). In this case, representations can be correlated with process of developing mental models, which are mechanisms that humans

use to generate descriptions and formulate predictions on how systems works, and they play an important role in enabling understanding (Smart et al. 2009). This ability to engage in different aspects of the problem that are nevertheless collectively coordinated to each other is an indicative of shared understanding in collaborative situations (Smart et al. 2009).

This discussion on shared understanding embraces the dynamics of social interplay related to collaborative design, and it has been constructed on top of sociological and psychological research based on the concept of understanding, however with no further underlying theory of shared understanding. This implies that there is a lack of knowledge concerning the specific patterns of building shared understanding in collaborative design (Van den Bossche 2011).

COMMON GROUND

Common ground is a concept deriving from classical rhetoric. Already Aristotle (1998) contended that "if any two people are going to have a debate, there needs to be some common ground". However, the term common ground is of Anglo-Saxon origin. Common ground was a legal term, equivalent to "common land" or "commons", which was used in a metaphorical sense already in the 17th century (Koskela 2015).

Indeed, the starting point of persuasion in classical rhetoric is that there is a common ground between the orator and the audience, consisting of common values, mutually known facts, and commonly held presumptions (Perelman & Olbrechts-Tyteca 1969).

The idea and term of common ground were transmitted in the rhetorical tradition to the modern time. A turning point happened at the end of the 1970s, when several scholars, including Stalnaker (1975), Clarke and Wilkes-Gibbs (1986) and others, rediscovered the idea and started to research it.

For Clark (1996), common ground between speakers is "knowledge, beliefs, and suppositions they believe they share". The idea that common ground is a dynamic construct that is mutually constructed by interlocutors throughout the communicative process (Kecskes & Zhang 2009) is commonly accepted. In this regard, Clark and Brennan (1991) introduce the term grounding: in communication, common ground cannot be properly updated without a process they call grounding. The authors further contend that grounding depends on the purpose and medium of communication. By way of illustration, one interesting technique of grounding is referring to objects and their identities. This can be done through, say, indicative gestures, for example pinpointing.

Klein et al. (2005) extend the discussion to joint activity in the context of team coordination. To them, key aspects of common ground include: 1) The types of knowledge, beliefs and assumptions that are important for joint activity, including knowledge of roles and functions, standard routines, and so forth; 2) Mechanisms for carrying out the grounding process: to prepare, monitor and sustain common ground as well as to catch and repair breakdowns; 3) Commitment of the parties in a joint activity to continually inspect and adjust common ground. The mentioned authors have further studied the loss of common ground, and list a number of mechanisms leading to that. One reason, confusion on who knows what, is found so frequently that is has been named as Fundamental Common Ground Breakdown (Klein et al. 2005).

The relation of visual information and common ground has recently started to be studied (Kraut et al. 2002). Research shows that visual information supports conversational grounding (Gergle et al. 2013).

Empirical, theory testing research on common ground is somewhat scarce. Beers et al. (2006) found that paying attention to the negotiation of common ground by having participants verify their understanding and having them explicate their positions could increase the effectiveness of group decision support systems. The notion of common ground occurs also in prescriptive literature; for example Gray (1989) has developed a methodology based on common ground, for organizational problem solving, conflict resolution, mediation, and negotiation.

BOUNDARY OBJECTS

The concept of boundary objects (BO) was introduced in 1989 by Star and Griesemer to describe objects used by different actors for individual or collaborative interdisciplinary work, despite the absence of consensus. The term boundary describes a "shared space, where exactly that sense of here and there are confounded" (Star 2010), or a space where two or more worlds are "relevant to one another in a particular way" (Akkerman & Bakker 2011). Thus, boundary objects are used to describe objects that "inhabit several intersecting social worlds and satisfy the informational requirements of each of them" (Star & Griesemer 1989).

However, the meaning of boundary objects has been changing along the years. Lee (2007) defines boundary objects as a useful "theoretical construct with which to understand the coordinative role of artefacts in practice". In spite of the different definitions, boundary objects have some common aspects: (a) may be an abstract or concrete object; (b) must be "plastic enough to adapt to local needs"; (c) "robust enough to maintain a common identity across sites" (Star & Griesemer 1989); (d) must be temporal; (e) based in action, it means, its materiality derives from actor's action; and, (f) subject to reflection, or interpretive flexibility (Star 2010).

Furthermore, Star (2010) highlights other aspects that turn an artefact into a boundary object: material/organizational structure, and scale/scope. Normally, BO arises in organic infrastructures according to "information and work requirements perceived by groups who wish to cooperate" (Star 2010). Moreover, the level of scale and scope make an object more useful or not, for example, the use of BO at the organization level (Star 2010); otherwise any object might become a boundary object.

The concept of boundary object has been applied in different research areas, e.g., collaborative information systems, organization science, and information science (Lee 2007) to refer to a mediation role to improve the collaboration and common understanding among different social worlds. Boundary objects can develop a (1) syntactic role, when the object needs to develop a common lexicon for transferring the knowledge among parties; (2) semantic role, when it's necessary to create common meanings to identify differences and dependencies and translating the knowledge; and (3) pragmatic role, when the object establishes common interests for making trade-offs and transforming knowledge (Carlile 2004).

In research on construction, boundary objects have been understood as transferring and translation devices to improve the collaboration between designers and contractors. Such artefacts include: timelines, prototypes, sketches, designs and 3D CAD models.

Forgues et al. (2009) point out that the implementation of complex technologies, such as BIM, could act as a transformational device within the construction of new knowledge by experimentation. However, they also state that pragmatic barriers cannot be overcome without proper governance. All in all, boundary objects can facilitate the knowledge sharing in an integrated design process, but not resolve problems related to the pragmatic barriers by themselves (Forgues et al. 2009).

MEDIATING ARTEFACT

Mediating artefact is a concept with roots in the Soviet activity theory pioneered by Lev Vygotsky and Alexei Leont'ev (Bedny and Meister 2014) and later expanded by Engeström (2000) into Cultural-Historical Activity Theory (CHAT). The descriptive Activity Theory begins with the notion of activity as a system of human 'doing'; i.e. object-oriented, collective and culturally mediated working, or activity system, to transform the object into a desired outcome through the use of mediating artefacts (Engeström 2008).

Mediating artefacts, including tools, procedures, processes and accepted practices are expressions of cognitive norms and expected standards, or in other words standardized and externalized (objectified) cognitive procedures and structures, representing distributed cognition (Macpherson et al. 2006). These are 'artefacts of knowing' through and against which different communities can represent, interpret and contribute to the understanding of ongoing and unfolding activities (Ewenstein & Whyte 2005). 'Mediating artefacts' provide a syntax for intersecting work of knowledge domains, allowing the exploration of semantic differences and helping the joint transformation of knowledge between practices (Carlile 2004). Consequently, 'mediating artefacts' are central to both the representation of past learning and the construction of new meanings (Carlile 2004).

Mediating artefacts are broadly defined as usage of 'instruments, signs, language, and machines' (Nardi 1996), which according to Carlile (2004) have different capacities to represent common knowledge. Mediating artefacts help practitioners to make informed decisions and choices in order to undertake specific activities and they differ in a number of respects (Conole 2009): their format of presentation (textual, visual, auditory, or multimedia); their degree of contextualization (from abstract to contextualized); the level of granularity (i.e., the amount of details available within the mediating artefact about the activity); the degree of structure (flat vocabularies vs. typologies).

Cole and Engeström (1993) distinguished between artefacts and tools, where artefacts have diverse meanings, and tools are a subcategory of this wider overarching concept of artefacts. Based on the different processes artefacts represent, Engeström (1999) conceptualized different types of artefacts: 'What' artefacts, used to identify and describe objects; 'How' artefacts, used to guide and direct processes and procedures on, within or between objects; 'Why' artefacts, used to diagnose and explain the properties of objects; 'Where to' artefacts used to envision the future or potential development of objects.

Engeström et al. (1999, 382) explain the construction of artefacts as follows: "The artefact-mediated construction of objects does not happen in a solitary manner or in harmonious unison. It is a collaborative and dialogical process in which different perspectives and voices meet, collide and merge. The different perspectives are rooted in different communities and practices that continue to co-exist within one and the same collective activity system."

STANDARDISED METHODS

Star and Griesemer (1989) proposed two major factors that contributed to the successful co-operation between biologists and amateur naturalists: boundary objects and methods standardisation. In that article, methods standardisation was introduced first and most importantly was claimed to establish a '*lingua franca*' to enable co-operation between amateurs and professionals (Star & Griesemer 1989). However, it was the less stressed concept, and the title of article only referred to boundary objects but not to methods standardisation (Lee 2007).

The concept of standardisation is important to the concept of boundary objects in the way that boundary objects are heavily dependent on the concept of standardisation (Lee 2007). On the other hand, this method is not sufficient to ensure co-operation as such across divergent social worlds, and boundary objects are necessary (Star & Griesemer 1989). Star (2010) later concludes that standards and boundary objects are as inextricably related.

Standardised methods accentuate the collaboration of actors to **'get work done'** and simultaneously to maintain the integrity in their respective social world. Standardised method emphasises on **how** and not what or why; it makes information compatible and allows for a longer 'reach' across the wider divergent world (Star & Griesemer 1989).

Fujimura (1992) contends that the concept of boundary object is too flexible. Due to this limitation of boundary object, Fujimura (1992) conceptualised "standardised package" which is less abstract, less ambiguous and more structured. The standardised package, which is a combination of multiple boundary objects with the standardised tools, serves as interfaces between multiple social worlds, and facilitates the flow of resources (e.g. concepts, skills, materials, techniques, instruments) among multiple lines of work (Fujimura 1992). These are conventionalised ways of carrying out tasks or in other words, standard operating procedures, which could be easily adopted and incorporated by people in different lines of work to develop a common practice (Fujimura 1992).

However, the proposed packages have not been validated by other researches and there is still a gap in knowledge on how actors from different social worlds can collaborate while there are no pre-existing standards (Lee 2007). This gap is visible, for instance, in the context of Information systems (IS), as the number of IS and computing devices within organisations is exponentially growing, and there is a need to standardise and integrate them to enable dissimilar systems to co-operate and interoperate (Nyella & Kimaro 2015).

Situational awareness

Adamu et al. (2015) contend that an effective team task depends on a shared situational awareness among team members. Generally, situational awareness is considered as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future" (Endsley 1995, 36). However, a definition more suitable to design was proposed in the study of team cognition by Durso, Rawson and Girotto (2007 cited in Wickens 2008, 164) as the "comprehension or understanding of a dynamic environment". This is particularly important in the context of collaborative design, in which the issue of team situation awareness emerged as important factor in understanding team dynamics. In the research of teamwork behaviour, Endsley and Jones (2001) argue that it deals with what each worker knows about the understanding and workload of the co-worker, and how this is supported by communication between them. In reconfiguring Endsley (1995) definition, situation awareness would be the capacity to perceive and comprehend the characteristics of an environment within time and space supporting the realization of predicted futures aligned with a task or project.

DISCUSSION

The preceding reviews show that a number of connected ideas on what happens when people do something together, be it communication or action, are emerging from many different traditions and applied in many contexts. This multitude of approaches is an opportunity to create a rich synthesis; also it will be possible to identify gaps to guide future research. Unfortunately, this situation is also prone to create confusion and misunderstanding.

In spite of the many various terms used, it is possible to see invariantly surfacing ideas in different approaches. The dynamic nature of the common ground between parties is one such idea. Also, the taxonomies of the different aspects or parts of the common ground show considerable similarity.

It is tempting to contrast the reviewed approaches against the classical communication theory, which assumes that communication is about transferring information from one point to another. The reviewed approaches may show that the classical communication theory has had a too narrow and simplistic view on its subject – indeed they provide a serious critical challenge to it. Interestingly, this classical communication theory has been the background theory to the majority of information systems and managerial research.

This situation invites for fundamental research on communication and collaboration, for further progress and consolidation of our understanding. On the other hand, it seems that the opportunities for practical implementation of this understanding are huge. Indeed, many recently found methods for collaboration, say the methods of Big Room, A3 and Choosing by Advantages, easily allow theoretical explanation through the ideas discussed, as initially argued in (Koskela 2015).

CONCLUSIONS

As a phenomenon, collective human action is ubiquitous, and of extreme importance for the mankind. In view of this, theorizing on collective action has developed slowly and has remained fragmented. However, a review of existing approaches reveals a multitude of fertile ideas and wide agreement on many common concepts, in spite of differing starting points.

Management practices, both generally and specifically in construction, have in the recent years developed towards the target of supporting, enabling and realizing collaboration. These efforts have been practically based, without any theoretical backing. Now, it seems that the theoretical resources discussed above can with benefit be used for analysing, explaining and improving such efforts towards collaborative working. However, a synthesis of the many concepts and approaches, as well as added terminological clarity is needed. In turn, practical collaboration efforts also invite theory-testing research for validating and consolidating this important field of theory.

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REFERENCES

Aapaoja, A., Herrala, M., Pekuri, A., and Haapasalo, H. (2013). "The characteristics of and cornerstones for creating integrated teams." *International Journal of Managing Projects in Business*, 6(4), 695-713.

Adamu, Z.A., Emmitt, S., and Soetanto, R. (2015). "Social BIM: Co-creation with shared situational awareness". *ITcon*, Vol. 20, 230-252.

Akkerman, S.F., and Bakker, A. (2011). "Boundary Crossing and Boundary Objects." *Review of Educational Research*, 81(2), 132-169.

Arias, E., Eden, H., Fischer, G., Gorman, A., and Scharff, E. (2000). "Transcending the individual human mind—creating shared understanding through collaborative design. *ACM Transactions on Computer-Human Interaction (TOCHI)*, *7*(1), 84-113.

Aristotle (1998). *The Metaphysics*. Transl. by H. Lawson-Tancred. Penguin Books, London.

Bedny, G., and Meister, D. (2014). *The Russian theory of activity: Current applications to design and learning*, Psychology Press.

Beers, P.J., Boshuizen, H.P., Kirschner, P.A., and Gijselaers, W.H. (2006). "Common ground, complex problems and decision making". *Group Decision and Negotiation*, 15(6), 529-556.

Bittner, E.A.C., and Leimeister, J.M. (2013). "Why Shared Understanding Matters--Engineering a Collaboration Process for Shared Understanding to Improve Collaboration Effectiveness in Heterogeneous Teams". In *System Sciences (HICSS), 46th Hawaii International Conference* on IEEE. 106-114.

Carlile, P.R. (2004). "Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries." *Organization Science*, 15(5), 555-568.

Clark, H. (1996). *Using language*. Cambridge: Cambridge University Press.

Clark, H.H., and Brennan, S.E. (1991). "Grounding in communication". *Perspectives on socially shared cognition*, 13(1991), 127-149.

Clark, H.H., and Wilkes-Gibbs, D. (1986). "Referring as a collaborative process." *Cognition*, 22(1), 1-39.

Coates, P., Arayici, Y., Koskela, K., Kagioglou, M., Usher, C., and O'Reilly, K. (2010). The key performance indicators of the BIM implementation process. The International Conference on Computing in Civil and Building Engineering, June 30 - July 2 2010, Nothingham, UK..

Cole, M., and Engeström, Y. (1993). "A cultural-historical approach to distributed cognition." In: Salomon, G. (ed.), *Distributed cognitions: Psychological and educational considerations*, Cambridge University Press. 1-46.

Conole, G. (2009). "The role of mediating artefacts in learning design." In: Lockyer, L., Bennett, S., Agostinho, S., & Harper, B. (ed.), *Handbook of research on learning design and learning objects: issues, applications, and technologies (2 volumes).* IGI Global, Hershey, PA. 188-208.

Cross, N., and Cross, A. C. (1995). "Observations of teamwork and social processes in design." *Design studies*, *16*(2), 143-170.

Eastman, C., Teicholz, P., Sacks, R., and Liston, K. (2011). *BIM handbook: a guide to building information modeling for owners, managers, designers, engineers, and contractors*, John Wiley & Sons, Hoboken.

Endsley, M.R. (1995). "Toward a theory of situation awareness in dynamic systems". *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 37(1), 32-64.

Endsley, M.R., and Jones, W.M. (2001). "A model of inter- and intrateam situation awareness: Implications for design, training and measurement." In: McNeese, M., Salas, E. & Endsley, M. (ed.), *New trends in cooperative activities: Understanding system dynamics in complex environments*. Santa Monica, USA: Human Factors and Ergonomics Society, 46-67.

Engeström, Y. (2000). "Activity theory as a framework for analyzing and redesigning work." *Ergonomics*, 43(7), 960-974.

Engeström, Y. (2008). *From teams to knots: Activity-theoretical studies of collaboration and learning at work*, Cambridge University Press, Cambridge, UK.

Engeström, Y., Miettinen, R., and Punamäki, R.-L. (1999). *Perspectives on activity theory*, Cambridge University Press, Cambridge, UK.

Ewenstein, B., and Whyte, J. (2009). "Knowledge practices in design: the role of visual representations as epistemic objects." *Organization Studies*, 30(1), 7-30.

Forgues, D., Koskela, L., and Lejeune, A. (2009). "Information Technology as Boundary Object for Transformational Learning." *Journal of Information Technology in Construction*, 14, 48-58.

Fujimura, J.H. (1988). "The molecular biological bandwagon in cancer-research: where social worlds meet." *Social Problems*, 35(3), 261–283.

Fujimura, J.H. (1992). "Crafting science: Standardized packages, boundary objects, and "translation."." Science as Practice and Culture, A. Pickering, ed., University of Chicago Press, 168-211.

Gergle, D., Kraut, R.E., and Fussell, S.R. (2013). "Using visual information for grounding and awareness in collaborative tasks". *Human–Computer Interaction*, *28*(1), 1-39.

Gray, B. (1989). *Collaborating: Finding common ground for multiparty problems*. Jossey-Bass Publishers, San Francisco.

Kecskes, I., and Zhang, F. (2009). "Activating, seeking, and creating common ground: A socio-cognitive approach". *Pragmatics & Cognition*, 17(2), 331-355.

Klein, G., Feltovich, P.J., Bradshaw, J.M., and Woods, D.D. (2005). "Common ground and coordination in joint activity." *Organizational simulation*, *53*.

Kleinsmann, M. (2006). "Understanding collaborative design". *PhD. Thesis*, Delft University of Technology, Delft.

Kleinsmann, M. and Valkenburg, R. (2008). "Barriers and enablers for creating shared understanding in co-design projects." *Design Studies*, 29. 369-386.

Koskela, L., (2015). "Where rhetoric and lean meet." In: *Proc. 23rd Ann. Conf. of the Int'l. Group for Lean Construction*, Perth, Australia, July 29-31, 527-535.

Kraut, R.E., Gergle, D., and Fussell, S.R. (2002). The use of visual information in shared visual spaces: Informing the development of virtual co-presence. In *Proceedings of the 2002 ACM conference on Computer supported cooperative work* (31-40). ACM.

Lee, C. P. (2007). "Boundary negotiating artifacts: Unbinding the routine of boundary objects and embracing chaos in collaborative work." *Computer Supported Cooperative Work (CSCW)*, 16(3), 307-339.

Macpherson, A., Jones, O., and Oakes, H. (2006). "Mediating artefacts, boundary objects and the social construction of knowledge." *Proc., the First International Conference on Organizational Learning, Knowledge and Capabilities*, 20-22 March 2006, University of Warwick.

Maher, M. L., Cicognani, A. & Simoff, S. (1996). "An experimental study of computer mediated collaborative design." *Proceedings of WET ICE'96*. DOI: 10800-1383/96 IEE.

Nardi, B.A. (1996). "Studying context: A comparison of activity theory, situated action models, and distributed cognition." In: Nardi, B.A. (ed.), *Context and consciousness: Activity theory and human-computer interaction*, 69-102. MIT Press, Cambridge, MA.

Nyella, E., and Kimaro, H. (2015). "HIS Standardization in Developing Countries: Use of Boundary Objects to Enable Multiple Translations." *African Journal of Information Systems*, 8(1).

Pasquire, C. (2012). "The 8th flow - common understanding." In: *Proceedings of the 20th Annual Conference of the International Group for Lean Construction*, San Diego State University, USA.

Perelman, C. and Olbrechts-Tyteca, L. (1969). *The New Rhetoric: A Treatise on Argumentation*. Notre Dame, IN: University of Notre Dame Press

Smart, P.R., Mott, D., Sycara, K., Braines, D., Strub, M. and Shadbolt, N.R. (2009). "Shared Understanding within Military Coalitions: A Definition and Review of Research Challenges". In: *Knowledge Systems for Coalition Operations*, Southampton, UK.

Stalnaker, R. (1975). "Presuppositions." In *Contemporary Research in Philosophical Logic and Linguistic Semantics* (pp. 31-41). Springer Netherlands.

Star, S.L. (2010). "This is not a boundary object: Reflections on the origin of a concept." *Science, Technology & Human Values*, 35(5), 601-617.

Star, S.L. and Griesemer, J.R. (1989). "Institutional ecology, translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39." *Social studies of science*, 19(3), 387-420.

Valkenburg, R.C. (1998). "Shared understanding as a condition for team design". *Automation in Construction*, 7(2), 111-121.

Valkenburg, R., and Dorst, K. (2008). "The reflective practice of design teams". *Design studies*, 19(3), 249-271.

Van den Bossche, P., Gijselaers, W., Segers, M., Woltjer, G., and Kirschner, P. (2011). "Team learning: building shared mental models." *Instructional Science*, 39(3), 283-301.

Wickens, C.D. (2008). "Situation awareness: Review of Mica Endsley's 1995 articles on situation awareness theory and measurement." *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 50(3), 397-403.