Emerald Journal of Engineering, Design and Technology

The 'Ological-triad': Considerations for Construction Management Research

Journal:	*Journal of Engineering, Design and Technology*
Manuscript ID	Draft
Manuscript Type:	Original Article
Keywords:	Research, Ontology, Epistemology, Methodology, Paradigm, Worldview

The 'Ological-triad': Considerations for Construction Management Research

Abstract

– **Purpose**: To consider an '-ological' (ontological, epistemological and methodological) triad in the context of construction management (CM) research. To explore the triad in terms of ontological/ epistemological viewpoints, paradigmatic approaches to CM research and ultimately, CM methodological decisions.
– **Approach**: Derivation of critical narrative and graphical models employing literature synthesis combined with experiential, methodological views of the authors.
– **Findings**: Conceptions of ontology, epistemology and methodology [the 'ological-triad'] demonstrate high variability – resultantly, their use in CM research is equally inconsistent, sometimes questionable, and in the extreme, sometimes overlooked. Accordingly, this study concludes that greater recognition of the 'ological-triad' is called for in CM research, especially at the design stage. A framework for doing this is proffered.
– **Originality**: Combined study of the 'ologies' within CM research uniquely consolidates previous disparate knowledge into a single, cogent, subject-specific discourse that inter-alia, both informs and illuminates CM research challenges. It also encourages critical debate on the issues highlighted.

– **Keywords**: Research, ontology, epistemology, methodology, paradigm, worldview.
– **Classification:** Conceptual paper.

Introduction

"The 'ologies' strike fear into the hearts of many students…" (Thomas, 2013).

This paper considers the act of construction management (CM) research *vis-à-vis* three sub-themes that respectively, are colloquially labelled members of the research '-ologies' (Young and Atkinson, 2013; Fellows and Liu, 2015). These sub-themes – hereafter, defined as 'the ologies' or 'ological-triad' for brevity, are ontology (the nature of being); epistemology (the theory of knowledge); and methodology (the science of research method). These sub-themes are discussed with specific emphasis on the CM research community in order to: i) strengthen familiarity with the ologies; ii) highlight contrasting views regarding their function; and iii) encourage their role in supporting robust research design decisions (Grbich, 2007).

The preceding ology summaries in parentheses are grounded by *a-priori* knowledge. However, these may not be viewed as 'precise' by everyone; because conceptions of these themes can vary considerably (*cf.* Lehaney and Vinten, 1997, p.5; Korděs, 2005, p.296; Ruwhiu and Cone, 2010, p.109) and especially, within the social sciences (Tight, 2012). They are therefore, indicative at this stage;

requiring further illumination from extant literature. For example, Farrell (2011) noted that CM research uses a *"...plethora of terminology"* and that sometimes this can be misleading for some. Hence, varying perceptions are fundamental to this study's thesis: the ologies can be interpreted in numerous ways so differences often surface as to what is 'appropriate' in CM research regarding epistemological and ontological viewpoints, methodological decisions [and ultimately therefore], associated paradigmatic approaches (Holt and Goulding, 2014). There are myriad tangential avenues in research discourse linked to the ologies, such as axiology, sociology and phenomenology [*cf.* Mattsson (1988); Courtney (2012); Spinelli (2005) respectively]. The ologies examined here are closely interrelated and (should) take precedence in the design of most research inquiries (Wellington, 2010, p.129; Hammett *et al.,* 2015). Those beyond the 'ological-triad' therefore, are beyond this study's remit.

There is an intrinsic link between: i) the differing interpretations of the ologies; ii) how they (should) influence research practice; and iii) fundamental dispositions regarding an 'optimal' approach to the research act (both broadly and within CM specifically). The latter is typically characterised by long-standing deliberation of methodological 'appropriateness', manifesting in its most simple form as a debate between proponents of quantitative and qualitative research methods (Kekäle, 2001). This is unbounded by subject discipline (Davies, 2007), and has borne strong, apparently unresolvable contention between these factions; which has frequently been labelled the 'paradigm war' (Anderson and Herr, 1999; Klaes, 2012). Such 'confrontation' has also frequented the CM discipline – see for instance, Seymour and Rooke (1995); Raftery *et al.* (1997); Runeson (1997); Seymour *et al.* (1998); Raftery (1998) and Pasian (2015). In fact, philosophical research incongruity tends to reign among specific paradigmatic 'cliques': where diverse schools of social theory for example, have long fought 'mock battles' within the qualitative research paradigm (Silverman, 2009).

While this paper highlights these 'disagreements', its rationale is not to extend this debate. Rather, it precedes it, insofar as the ologies represent philosophical issues underlying paradigms, which in turn, (should) come before and influence methodological choices (Punch, 2014, p.15). Acknowledging this, the consonance here is that for research to be considered 'robust' and 'defendable', it typically requires three questions to be answered at the design stage. These are:

1. What is the form and nature of reality; and therefore, what is (or can be) known about the research subject? (The ontological aspect).
2. What is the relationship between the 'knower' and what is (or can be) known? (The epistemological standpoint).

3. How [based on the chosen research paradigm resulting from answers to (1) and (2)] might the researcher go about finding what can be known? (The methodological decision) (Punch, 2014, p.15).

These ology/ paradigm/ methodology relationships are fundamental to research and to this study's thesis, because they both shape and inform the way in which the ologies are perceived; and (more importantly) their influence on CM research. They also guide research endeavour in terms of (*inter-alia*) the way it is conducted, the way it is perceived by others, the nature of its findings, and ultimately, its (perceived) validity.

The common thread running through this chain of (ological) interrelationships is the term 'worldview' – an individual's orientation of the world, research stance, and lens – which resultantly influences methodological decisions (Cresswell, 2009, p.6). Given this, paradigmatic choice – which is significantly influenced by worldview (Holt and Goulding, 2014) – is a personal approach of defining a problem, its model, and its pattern of inquiry. This is fundamentally important, as it incorporates an individual's assumptions and accepted facts – representing their ontological philosophy of reality, and their epistemological philosophy of knowledge (Dosi, 1982). Analogously in this regard, ontology and epistemology in particular, are lenses (*cf.* Fellows, 2010) through which worldview can be observed while being *transposed into methodological decisions*. Where the research (or theoretical) lens provides a guiding perspective, it shapes what is looked at, and influences the approach taken. As a case in point, an epistemological standpoint can [should] influence: the researcher/ research participant relationship; the way in which the quality of selected research methods is demonstrated; the actions implemented to ensure rigorous data collection and analysis; and researcher communication and conceptualisation with their (primary) audience (Morgan, 2015).

Unfortunately, ontology and epistemology are sometimes neglected or discounted (Dillon and Walsh, 1992); where one might reasonably infer, that this is because of divergence in: their definitions, their perceived roles in research decision-making, and the (resulting?) 'fear' alluded to by Thomas (2013). Taking account of this and the combined key research issues described above, the aim of this study is to explore the ological-triad *vis-à-vis* CM paradigmatic approaches and ultimately, CM methodological decisions. Linked to this, are two objectives: 1) to consolidate disparate 'ological' knowledge under a CM subject focus; and 2) to encourage further CM debate on those ological issues discussed.

Ontological Considerations

The precise meaning of the term 'ontology' remains vague and is (resultantly) used in different ways (Metaxiotis *et al.,* 2001). Notwithstanding this, column one of Table 1 identifies several definitions of

ontology, where these can adopt either a philosophical (*phil*.), or scientific (*sci*.) leaning (Petrov, 2010). In either instance, ontology can be broadly stated as dealing with the existence and classification of being. Gruber (1993) provides a commonly accepted and succinct definition in the scientific sense:

> *"[ontology is an] …explicit specification of a conceptualisation [which is in turn] …the objects, concepts, and other entities that are presumed to exist in some area of interest and the relationships that hold among them"* [see also, Studer *et al.* (1998)].

Ontology is a metaphysical branch of philosophy; its scientific orientation identifies that ontologies can support or inform taxonomies to encourage unambiguous understanding (Lee and Jeong, 2012) and facilitate specific context communication (e.g. knowledge representation, sharing and distribution) (Dutta *et al.,* 2015). This includes within both industrial and academic scientific systems. Examples of the former includes knowledge engineering for bespoke software design (Metaxiotis *et al.,* 2001), organisational knowledge management (Davies *et al.,* 2003), and the wider context of ontology/ metaontology development (Berto and Plabani, 2015). Some random illustrations of scientific ontologies pertinent to the CM research domain include those dealing with production (Rooke *et al.,* 2007), knowledge management (Anumba *et al.,* 2008), supply chain modelling (Grubic *et al.,* 2011), and construction informatics (Turk, 2006).

[Author note: Table 1 about here]

The need for Ontological Certainty

There is a specific distinction between 'pure philosophic' and 'applied scientific' ological definitions (Petrov, 2010); although, Jacquette (2002) asserted that the philosophical stance must always precede the scientific. Acknowledging this, from a CM research context, this suggests that one needs *"…to know what it means for something to exist"* [the philosophical prerequisite according to Jacquette (*op. cit*.)] before any domain of entities relating to it (i.e. scientific ontologies) can be proffered (*ibid*.). This therefore links to issues pertaining to perception, understanding and ambiguity, mentioned above.

The existence of scientific ontologies can also help elucidate the concept of 'ontological security' – a theoretical state that results partly from familiarity with one's surroundings (Grenville, 2007). The converse of this, infers that a CM researcher working among few, ambiguous, or no (available) ontologies might indeed feel 'ontologically uncertain' [the literal antonym of ontological security is avoided here, because 'ontological insecurity' refers to personal and identity issues (Jackson and Hogg, 2010)]. Especially, because ontological certainty is typically characterised by order and continuity (*ibid*.) – traits commensurate with research theory frameworks that form the basis of effective communication among a distinct research community (Nielsen, 2007).

Ontological uncertainty is nevertheless inherent between the real world and 'being' regardless of context. For instance, as a US Statesman once replied in response to a reporter's question:

> *"…we know, there are 'known knowns' … We also know there are 'known unknowns'; that is to say we know there are some things we do not know. But there are also 'unknown unknowns' – the ones we don't know we don't know"* (Rumsfield, 2002).

Since that time, the issue of the 'unknown unknown' has gained currency (BBC, 2007). Within CM research, ontological uncertainty – a melange of known and unknown unknowns – explains why sometimes, the CM field lacks an ability to communicate clarity on this issue unequivocally, and in a manner that satisfies all relevant stakeholders. This problem exists equally within the construction industry itself: evidenced in that alternative disciplines may use different terms to describe the same concept or the same term to describe different concepts (Anumba *et al.,* 2008). Despite construction dictionaries, glossaries and other such sources [see for instance, Gerring (2007, p.211-18); Oxford Reference (2012); Project Auditors LLC (2015); BuilderSpace (2015)], ontological uncertainty remains among CM research environments. These challenges manifest in almost every sphere of construction operations, most notably where seamless interoperability among computerised systems is required (Anumba *et al.,* 2008), and compounded further by increasing adoption of building information modelling within the sector (HM Government, 2012; Patacas *et al.*, 2015).

For example, from an ontological perspective, this paper considers construction to be a generic term that embraces both building and civil engineering. In turn, building is assumed to be characterised by the construction of products that tend to (remain in the same place and) develop vertically, such as a retaining wall, house, or factory; while civil engineering tends to move horizontally during its construction (e.g. a drainage system, public highway, or bridge crossing). Notwithstanding these descriptors, myriad other definitions of these terms also exist. Regarding 'construction' for instance, see Health and Safety Authority (n.d.); US Census Bureau (n.d.); and Health and Safety Executive (2015). These variances confirm said potential for CM ontological uncertainty.

Ontologies can be described at their most basic categorical level in terms of *concreta* [material objects in time and space], or *abstracta* [properties, facts, numbers, possibilities, etc.] (Effingham, 2013). In a metaphysical context, CM research *concreta* and *abstracta* are far from exhaustively listed. While such list will never be definitively complete (what would it ultimately include and ignore?), as alluded to above, entries already 'on it' fail to attract universal construction management research (CMR) agreement with respect to for instance, definitions, interrelationships, or causalities. Examples of this include the issue of poorly appreciated terminology relating to building costs research, originally

highlighted by Brandon (1982) and subsequently discussed by Fellows (2010); and more recently highlighted by the (then) President of the Chartered Institute of Building (CIOB), who confirmed that even the most fundamental CM concepts can be unclear:

> *"…I had long been aware of the lack of understanding and confusion of what is construction management"* (Bale, 2010)[1].

Ontology and Construction Management Research

Ontological considerations for the CM researcher include the following. First, apparent ambiguity between the philosophical and scientific definitions might be ignored because the applied, practical nature of CM suggests that the researcher will better identify with the scientific approach for both pragmatic and practical reasons. There is however, CM ontological uncertainty resulting from ambiguity, overlap, semantic differences, and disagreement; or in the worst case, the absence of ontology in a specific CM domain. Indeed, the problems of agreement on the existence and role of CM knowledge (for example, expressed as theories) have long been recognised (Love *et al.,* 2002).

This provides opportunities for CM ontological research *per se*, but should not be underestimated, because the 'problem' also exists at the domain level. As an example, see Ugwu *et al.* (2001) who focussed on communication and design (the *abstracta*) relating to production of portal frames (the *concreta*). In addition to the (here described in fundamental terms) decisional aspects of what CM objects may exist and whether they are *concreta* or *abstracta*, the researcher has also to consider many characteristics and relationships between them. Complex as this can be, there are fundamental rules that hold general agreement among ontologists (Chandrasekaran *et al.,* 1999). These are shown graphically in Figure 1 (and are further discussed later).

[Author note: Figure 1 about here]

Hence, as CM ontologies increase, on one hand this will address aspects of ontological uncertainty for the researcher: but equally, as semantic differences, heterogeneity and independency of data sources and repositories increase (Wang *et al.,* 2010), so will the need for CM ontological unification. Numerous methodologies have been proffered to address this challenge (Junwu *et al.,* 2009; Zhitomirsky-Geffet and Bar-Ilan, 2014; Zhitomirsky-Geffet and Erez 2014) – so this may become an area of increasing CM research endeavour. Ontology therefore, embraces several key aspects that the CM researcher might consider, especially in relation to their personal epistemological disposition and ultimately, methodological choices in performing the research act (see later).

Epistemological Considerations

Despite the many definitions and concomitant explanations (see for example, column two of Table 1), for many the term epistemology remains somewhat esoteric, which in turn obfuscates more than it enlightens (Johnson and Duberly, 2000). The Oxford (2016) dictionary defines it as the theory of knowledge and in particular, regarding its methods, validity, and scope; though epistemology is a philosophical concept, and from that standpoint, is defined as the study of knowledge and *justified belief* (Matthias, 2014) [nb. italics denote authors' position – whose reasoning is elucidated below].

Despite seemingly 'straightforward' definitions and associated concepts, epistemological theory can be very complex. For instance, regarding the dualistic and monistic epistemological positions of how reality (and hence knowledge) can be constructed (Montero, 2002). For the most part however, (argued here based on its practical, physical and applied nature) these psychological and sociological complexities need not be of excessive concern to CM research. Nonetheless, during research endeavour conflict can arise between concepts interpreted through ontological and epistemological lenses respectively; but in such cases – for example, where paradigms appear epistemologically and ontologically incommensurate (*cf.* Bryant and Lasky, 2007) – an eclectic approach to merging this 'imbalance' may be more valuable than distracting from the research and trying and reconcile it (*ibid.*).

Epistemic Notions for CM Researchers

An epistemological property that connects closely with this narrative is that of knowledge types. From a CM researcher's perspective and taking account therefore of the particularly broad remit of CM 'being' and concepts with which it is concerned, epistemologists have distinguished several species of knowledge (Moser, 2002). These include:

- 'How to' knowledge – such as the knowledge of how to measure a material quantity in accordance with a standard method of measurement;
- Non-propositional knowledge – such as a cost estimator's experiential and 'by acquaintance' knowledge; and
- Propositional knowledge – that is, proffering that something 'is so'. This may take the form of empirical (*a-posteriori*) propositions (in the present context resulting from empirical research); or non-empirical (*a-priori*) propositions (such as an induced, informed hypothesis).

The above is not an exhaustive list and contention reigns over the number and type of knowledge distinctions (Moser, 2002). The aspect of propositional knowledge (*p*) is of particular importance to the researcher, who after all is typically striving to proposition knowledge by way of a theory, hypothesis, concept, solution to a problem, and so forth. Indeed, contribution to knowledge is the defining

component of a PhD research programme (QAA, 2011 p.12; Murray and Beglar, 2013). The traditional philosophical approach to what constitutes *p* is defined in a tripartite concept of 'justified, true, belief' (JTB). That is, *p* requires: i) truth – because a false proposition cannot be known; ii) belief – because an unbelieved proposition cannot be known; and iii) justification – otherwise, *p* might be a matter of luck or coincidence (Matthias, 2014).

For a CM researcher therefore, knowledge underpinning a study, or for instance, relevant knowledge-related decisions, must demonstrate JTB. Equally, it is logical to infer that demonstrable (propositioned) knowledge resulting from CM research must exhibit this also; meaning that *p* must be: i) true – from robust research design, data collection and analysis, etc.; ii) believed – based on truth, worldview, and ontological certainty, etc.; and iii) justified. Justification often involves statistical validation for quantitative derivatives, or convincing and clear explanation for qualitative equivalents. Additionally, disseminators of *p* should commit to epistemological ethical values, which include honesty, sincerity, reliability and fairness (Spence, 2011).

In contrast to the above – and perhaps because of its disciplinary failure to determine what constitutes 'scientific knowledge' (Chau Kwong *et al.,* 1998) – the epistemological aspects of CM research have been described as being 'less clear' than those among its explanatory science counterparts (Voordijk, 2009). CM knowledge (*p*) has thus more conveniently (or pragmatically?), been typified under three assemblages: technological (based on empiricism and deduction therefrom); functional (being rule-based actions designed to achieve a desired outcome); and socio-technological (such as among construction process interrelationships) (*ibid*.).

Epistemological Influences on Paradigmatic Choices

Prominent, broad epistemological classifications are: i) *interpretive* (determination of 'reality', as seen by the researcher, based on meanings assigned to phenomena by actors involved); ii) *positivist* (observation of fixed, observable or measurable relationships); and iii) *critical* (identification and critique of contradictory social system conditions) (Sedmak and Longhurst, 2010).

The interpretative epistemology is generally associated with terms such as qualitative, subjective, a-posteriori, unstructured, attitudes, opinions, behaviours, perceptions, and induction. Regarding an interpretative research paradigm, this usually involves longer subject contact, narrative data, and ethnography or phenomenology (Holt and Goulding, 2014). Somewhat in contrast, terms generally linked to positivism include shorter subject contact, empiricism, objectivity, a-priori, structured method, numbers, statistics, models, algorithms, and deduction (*ibid*.).

Positivism expressed as empiricism proclaims that knowledge results from experience (Doyal and Harris, 2009). It is a doctrine well established within occidental academia (Stark *et al.*, 2008) – this is especially so in CM research and applied contexts – though others have suggested it is in decline (Caldwell, 1994). Finally, critical epistemology is linked with interventionism, critique (not 'criticism'), and transformative redefinition (Dumay, 2010). Examples of interpretative, positivist and critical inquiry applied to the CM research field may be observed in Holt (2015); Ogunbiyi, *et al.* (2013); and Adriaanse, *et al.* (2010) respectively.

Like-minded researchers can use an agreed epistemic approach to add to their communication ability regarding a subject (Brandenburger, 2007). Conversely, they can – it is argued here resulting from disparate worldviews – hold differing epistemological orientations (Barrett and Barrett, 2003). This is significant because epistemological beliefs can: i) influence students' learning strategies (Schommer, 1990); ii) present conflicting epistemological positions during research design; and iii) ultimately, affect the ability to guide methodological choices (Carter and Little, 2007).

Methodological Considerations

Research methodology refers to the system of methods, principles or procedures applied to a given context (problem, discipline, environment, etc.), but equally, can refer to the science of method; that is, the concepts and theories that underlie the methods in question (University of Manchester, 2015). Research methods meanwhile, are established systematic tools for implementing a methodological design. These definitions are often incorrectly used interchangeably (Crotty, 1998 p.3). The study of methodology has been described as an agonising task (Caldwell, 1994); a point reinforced by Lehaney and Vinten (1994) who suggested that the meaning of 'scientific methodology' is itself debatable. This perhaps helps explain the range of sample meanings listed in Table 1 – which is far from definitive, because the term can appear in numerous contexts, or be relevant in equally as many contexts, even when not mentioned explicitly (Lehaney and Vinten, 1994). According to Wilkinson and Moreton (2007), traditional methodology tends to be based in liberal-positivist epistemology using empiricism, objectivity, and rationalism as fundamental principles. Nevertheless, it is argued here that presently, the CM discipline's methodological predilections and those of the researcher acting within it tend to dominate methodological judgements.

Methodology and Research Discipline

For CM, the simplest methodological continuum extends from qualitative at one extreme to quantitative at the other, with a 'mixed methods' paradigm somewhere in the middle – what Holt and Goulding (2014) described as a 'convenient thirds' continuum delineation. This most fundamental model of the continuum is prone to myriad additional influences. These include specific academic

disciplines embracing methodological paradigms that characterise that discipline's extent of (methodological) development (Chynoweth, 2009) and is perhaps what Oakley (1999) meant, when referring to paradigmatic choice being affected by 'fashions'.

Philosophically, methodological decisions are in some measure a manifestation of the ontology and epistemology of a subject field (White, 1987). But as Bryman (2006) pointed out, selection of research methods – a fundamental methodological mission – should not be made on 'sympathies' toward a certain methodological camp, because methods are tools to answer research questions; not vice versa (Bryman, 2006). A study will thus characterise its host discipline, so CM decisions relating to the methodological continuum will be based on the type and availability of information required or available (Naoum, 2007). The latter is intrinsically linked to discipline and sub-discipline ontologies, suggesting that 'ologies' can sometimes operate 'covertly' – influencing methodological development (read: iterative decision making) via underlying ontological and epistemological assumptions, associated with a study (Kerry and Ostwald, 2004).

Methodology and the Researcher

Methodological decisions and challenges at the micro (or operational) level are often taken, or resolved respectively by a researcher's disposition to the research act. This disposition is influenced as much by philosophical worldview (Peterson and Gencel, 2013) as by external, situational, or broader philosophical factors (referred to as covert influences above). So much so, according to Morgan and Smircich (1980), that methodological debate often results from researchers failing to communicate with one another because of strong held personal assumptions in this regard (Mangan *et al.*, 2004). Such views can relate to what constitutes methodological 'quality' (Seale, 1999); issues of reliability, validity, generalisability and replicability (LeCompte and Goetz, 1982); decisions relating to quality criteria (Bryman, 2006); paradigmatic relationships such as between mixed methods and pragmatism (Cameron, 2009); and whether a chosen methodology is quantitative or qualitative (Kelemen and Rumens, 2012).

Hence, research inquiry strategy – the 'why' espoused mainly in paradigmatic choice and the 'what' characterised by method selection (Cresswell, 2009) – are moulded by operational challenges. These include things such as choosing participants (DeSilva, 2011); making explicit, sample design criteria, (Idrees *et al.,* 2011); selecting cases (Sobh and Perry, 2006) or apposite data (Bowen *et al.*, 2010; Gajendran *et al.,* 2011); and identifying appropriate research instruments (Crescentini and Mainardi, 2009). Notwithstanding this, a researcher's worldview (beliefs) is paradoxically also a manifestation of the subject field's ontology and epistemology (Germonprez and Mathiassen, 2004). It is therefore, obligatory for the CM researcher to understand these terms before they can suitably express their methodological position (Fellows, 2010); which in turn, means that researchers regardless of discipline

(Ivo and Lowe, 2011) should not take methodological decisions without due reference to ontological and epistemological questions (Sedmak and Longhurst, 2010). Otherwise, the resulting lack of 'philosophical engagement' that relies on the rationale and philosophical assumptions underlying a particular study (Dainty, 2008), can lead to 'mechanical methodology decision-making' – often typified by selecting a paradigm ahead of clarifying the research problem (Jones and Kennedy, 2011). After all, methodologies are research apparatus, not ends in themselves (Kelemen and Rumens, 2012).

Concluding Discussion

Figure 2 shows how some relationships among the ological-triad interact with CM research. Several key issues drawn from this are:

- Philosophically, but equally among CMR specifically, ological definitions can vary.
- A notable influence on ological discernment is that of individuals' worldview.
- Combined, the latter two states:
    - underpin divergent CMR ological perceptions; and
    - nurture inconsistency among CMR – in terms of acknowledging the ological triad and permitting it to influence research design.
- As with other research disciplines, ontology and epistemology are most relevant to CMR methodological decisions.

[Author note: Figure 2 about here]

Numerous ologies may be relevant to CMR beyond those studied here, but for robust methodological intention, ontology and epistemology are superlative dogmata. Explicit or otherwise, 'ological influences' can mould paradigmatic predilection, and in turn therefore, influence methodological design. Hence, a reciprocal union can exist, such that these can positively influence each other.

That worldview significantly impacts ological perception, suggesting that researchers may prefer to contemplate them subconsciously rather than explicitly – a proposition supported in part, given that much published CMR research fails to explicitly address the ologies or indeed make explicit its methodological design (Morris, 2010).

The overarching conclusion of this study therefore, is that for reasons of robustness, completeness and consistency among the field, increased recognition of the ological-triad is called for in CM research, especially during research design. That is, robust research requires that three groups of questions be

answered at the design stage, which in turn embraces several considerations, some of which are indicated as follows.

1. **The ontological aspect:** What is the form and nature of reality and what is already known/ possibly could become known about the research subject?
    a. Arguably of principal importance, what is the essence of the research subject, what issue should it be addressing and for what purpose? (Morris, 2010).
    b. Does an ontology of the research subject exist? If not, how will it be accurately defined? Or, will an ontology be developed for this purpose and if so, will this effort detract from the core research aim?
    c. Are there several ontologies relating to the subject? If so, do they conflict or overlap and can any resulting 'confusion' be surmounted, without detracting from the proposed research?
    d. Does ontological ambiguity or semantic disagreement exist? If so, can this be unravelled such that reality can be determined and/ or, so that the unknown can be defined?

2. **The epistemological standpoint:** What is the relationship between the 'knower' and what is already known/ possibly become known about the research subject?
    a. How certain is the researcher about the validity of existing knowledge? (Morris, 2010).
    b. Will underlying philosophies (e.g. of social science or 'established beliefs') influence what is, or might be known about the subject? (Oakley, 1999). If so, can the researcher differentiate between these influences in striving for objective decisions?
    c. What is (are) the optimal way(s) to go about finding out what can be known? (Punch, 2014).

3. **The methodological decision:** Based on the appropriate research paradigm resulting from answers to (1) and (2) above, how is the methodology appropriately described?
    a. Is the paradigm choice objective and free from conformity bias, given that for CMR the dominant paradigm has been positivistic and quantitative but that more recently, the qualitative, constructivist and interpretive approaches have gained ascendancy? (Fellows, 2010).
    b. Is the chosen paradigm free from other external influences such as CMR's history of being fertile soil for competing paradigms? (Collier, 2006).
    c. Have methodological choices taken into account the fact that the science of paradigms differs in terms of ontology and epistemology? (Lather, 2006). If so, these 'conflicts' must be explicitly resolved in the methodological description.
    d. Ultimately, have research methods been chosen based on rationality, informed principally by the specific research question, or research problem? (Oakley, 1999).

Finally, this study concludes by reiterating that good CMR research design synchronises with a clearly framed research aim, for which ample, reliable data are available; which is appropriately collected, analysed, interpreted and resultantly, rigorously reported. While many researchers do this well, we agree with the argument that education and training in this regard should commence at undergraduate level (Kelly and Kaczynski, 2006). Finally, we conclude by reinforcing the assertion that any quantitative/ qualitative methodological dichotomy is unproductive (Kelemen and Rumens, 2012), and unhelpful to the CMR discipline.

Footnotes

[1] From which a consultation exercise was undertaken to develop the CIOB's own CM definition (Bale, 2010).

References

Adriaanse, A., Voordijk, H. and Dewulf, G. (2010), The use of Interorganisational ICT in Construction Projects: A Critical Perspective. *Construction Innovation*, Vol. 10, No. 2, pp. 223-237.

Anderson, G.L. and Herr, K. (1999). The New Paradigm Wars: Is There Room for Rigorous Practitioner Knowledge in Schools and Universities? *Educational Researcher.* Vol. 28, No. 5, pp. 12-40.

Anumba, C. J., Issa, R.R.A., Pan, J. and Mutis, I. (2008). Ontology-Based Information and Knowledge Management in Construction. *Construction Innovation: Information, Process, Management*. Vol. 8, No. 3, pp. 218-239.

Bale, J. (2010). *CIOB's Professionalism: An Inclusive definition of Construction Management*. Accessed via: http://www.ciob.org/sites/default/files/Redefining%20Construction%20Management.pdf (2 March 2016).

Barrett, P. S. and Barrett, L.C. (2003). Research as a Kaleidoscope on Practice. *Construction Management and Economics,* Vol. 21, No. 7, pp. 755–766.

BBC (2007). *What we know about 'Unknown Unknowns'*. British Broadcasting Corporation news item. Accessed via: http://news.bbc.co.uk/1/hi/magazine/7121136.stm (2 March 2016).

Berto, F. and Plabani, M. (2015). *ONTOLOGY and METAONTOLOGY: A Contemporary Guide*, Bloomsbury Publishing Plc, London, UK

Bowen, S.A., Rawlins, B. and Martin, T. (2010). *An Overview of the Public Relations Function.* New York: Business Expert Press.

Brandenburger, A. (2007). The Power of Paradox: Some Recent Developments in Interactive Epistemology. *International Journal of Game Theory,* Vol. 35. No. 4, pp. 465–492.

Brandon P.S. (1982). Building Cost Research: Need for a Paradigm Shift? In: Brandon, P.S. (Ed.). *Building Cost Techniques: New Directions,* pp. 5-13. London: E&FN Spon.

Bryant, J. Lasky, B. (2007). A Researcher's Tale: Dealing with Epistemological Divergence. Qualitative Research in Organizations and Management: An International Journal, Vol. 2, No. 3, pp. 179–193.

Bryman, A. (2006). Paradigm Peace and the Implications for Quality. *International Journal of Social Research Methodology*. Vol. 9, No. 2, pp. 111-126.

BuilderSpace (2015). *Construction Dictionary and Glossary of Construction Terms.* Accessed via: http://www.builderspace.com/glossary.html (2 March 2016).

Business Dictionary (2016). *Research Methodology*. Accessed via: http://www.businessdictionary.com/definition/research-methodology.html (2 March 2016).

Caldwell, B.J. (1994). *Beyond Positivism. Economic Methodology in the Twentieth Century*. London: Routledge.

Carter, S.M. and Little, M. (2007). Justifying Knowledge, Justifying Method, Taking Action: Epistemologies, Methodologies, and Methods in Qualitative Research. *Qualitative Health Research*, Vol. 17, No. 10, pp. 1316-1328.

Chandrasekaran, B., Josephson, J.R. and Benjamins, V.R. (1999). What are Ontologies and why do we need them? *IEEE Intelligent Systems and Their Applications,* Vol. 14, No. 1, pp. 20-26.

Chau Kwong, W., Raftery, J. and Walker, A. (1998). The Baby and the Bathwater: Research Methods in Construction Management. *Construction Management and Economics*, Vol. 16, No. 1, pp. 99-104.

Collier, C. (2006). Researchers' Perceptions of the Development of Qualitative Approaches in Construction Management Research. In: Boyd, D. (Ed.) *Proceedings of the 22nd ARCOM Conference.* Held at Birmingham City University, 4-6 September, pp. 751-759. Birmingham: The Association of Researchers in Construction Management.

Collins (2016). *Methodology*. Accessed via: http://www.collinsdictionary.com/dictionary/english/methodology (2 March 2016).

Cameron, R. (2009). A Sequential Mixed Model Research Design: Design, Analytical and Display Issues. *International Journal of Multiple Research Approaches.* Vol. 3, pp. 140-152.

Chynoweth, P. (2009). The Built Environment Interdiscipline. *Structural Survey,* Vol. 27, No. 4, pp. 301-310.

Courtney, R.A. (2012), Public Sociology, Critical Sociology, and the Sociological Enterprise. In: Love, K. (Ed.). *Ethics in Social Research. Studies in Qualitative Methodology, Volume 12,* pp. 51-70. Bingley, England: Emerald Group Publishing Limited.

Crescentini, A. and Mainardi, G. (2009). Methodological Corner. Qualitative Research Articles: Guidelines, Suggestions and Needs. *Journal of Workplace Learning*. Vol. 21, No. 5, pp. 431-439.

Cresswell, J. W. (2009). *Research Design. Qualitative, Quantitative and Mixed Method Approaches (3rd edition).* California: Sage Publications Inc.

Crotty, M.J. (1998). *The Foundations of Social Research. Meaning and Perspective in the research Process*. London: Sage Publications.

Dainty, A. (2008). Methodological Pluralism in Construction Management Research. In: Knight, A and Ruddock, L. (2009). *Advanced Research Methods in the Built Environment*. London: Wiley-Blackwell.

Davies, M.B. (2007). *Doing a Successful Research Project using Qualitative or Quantitative Methods.* Basingstike, Hampshire: Palgrave Macmillan.

Davies, J., Fensel, D., and Van Harmelen, F. (2003). Towards the Semantic Web: Ontology-Driven Knowledge Management. Chichester, England: John Wiley and Sons.

De Silva, T.A. (2011). Mixed Methods: A Reflection of its Adoption in Environmental Reporting. *Qualitative Research in Accounting and Management*. Vol. 8, No. 1, pp. 91-104.

Dillon, C.L. and Walsh, S,M. (1992). Faculty: The Neglected Resource in Distance Education. *American Journal of Distance Education*, Vol. 6, No. 3, pp. 5-21.

Dosi, G. (1982), Technological Paradigms and Technological Trajectories: As Suggested Interpretation of the Determinants and Directions of Technical Change. *Research Policy,* Vol. 11, No. 2, pp. 147–162.

Doyal, L. and Harris, R. (2009). *Empiricism, Explanation and Rationality.* Abingdon, Oxon: Routledge.

Dumay, J.C. (2010). A Critical Reflective Discourse of an Interventionist Research Project. *Qualitative Research in Accounting and Management*, Vol. 7, No. 1, pp. 46-70.

Dutta, B. Chatterjee, U. and Madalli, D.P. (2015). YAMO: Yet Another Methodology for Large-Scale Faceted Ontology Construction. *Journal of Knowledge Management,* Vol. 19, No. 1, pp. 6-24.

Effingham, N. (2013). *An Introduction to Ontology*. Cambridge, England: Polity Press.

Farrell, P. (2011). *Writing a Built Environment Disseration. Practical Guidance and Examples.* Chichester, West Sussex: J. Wiley and Sons Ltd.

Fellows, R. (2010). New Research Paradigms in the Built Environment. *Construction Innovation,* Vol. 10, No. 1, pp. 5-13.

Fellows, R. and Liu, A.M.M. (2015). Research Methods for Construction, Fourth Edition, *Wiley Blackwell,* Chichester, United Kingdom.

Gajendran, T., Brewer, G., Runeson, G. and Dainty, A. (2011). Investigating Informality in Construction: Philosophy, Paradigm, Practice. Australasian Journal of Construction Economics and Building (online). Vol. 11, No. 2, pp. 84-98. Accessed via: http://epress.lib.uts.edu.au/journals/index.php/AJCEB/article/view/2201 (2 March 2016).

Germonprez, M. and Mathiassen, L. (2004). *The Role of Conventional Research Methods in Information Systems Action Research.* Accessed via: http://link.springer.com/chapter/10.1007/1-4020-8095-6_19 (2 March 2016).

Gerring, J. (2007). *Case Study Research Principles and Practices.* Cambridge, England: Cambridge University Press.

Grbich, C. (2007). *Qualitative Data Analysis An Introduction.* London, England: Sage Publications Ltd.

Grenville, J. (2007). Conservation as Psychology: Ontological Security and the Built Environment. *International Journal of Heritage Studies*, Vol. 13, No. 6, pp. 447-461.

Gruber, T. R. (1993). Toward Principles for the Design of Ontologies Used for Knowledge Sharing. *International Journal of Human-Computer Studies*, Vol. 43, Nos. 5-6, pp. 907-928.

Grubic, T., Vezab, I. and Bilicb, B. (2011). Integrating Process and Ontology to Support Supply Chain Modelling. *International Journal of Computer Integrated Manufacturing*, Vol. 24, No. 9, pp. 847-863.

Hammett, D., Twyman, C. and Graham, M. (2015). *Research and Fieldwork in Development.* Abingdon, Oxon: Routledge.

Health and Safety Authority (n.d.). *Definition of Constriction Work.* Accessed via: http://www.hsa.ie/eng/Publications_and_Forms/Publications/Construction/Definition_of_Construction_Final.pdf (2 March 2016).

Health and Safety Executive (2015). *Managing health and safety in construction: Construction (Design and Management) Regulations 2015. Guidance on Regulations* Accessed via: http://www.hse.gov.uk/pubns/priced/l153.pdf (2 March 2016).

HM Government (2012). *Industrial Strategy: Government and Industry in Partnership. Building Information Modelling*. Accessed via: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/34710/12-1327-building-information-modelling.pdf (2 March 2016).

Holt, G. D. and Goulding, J. (2014). Conceptualisation of Ambiguous-Mixed-Methods within Building and Construction Research. *The Journal of Engineering, Design, and Technology.* Vol. 12, No. 2, pp. 244-262.

Holt, G.D. (2015). British Construction Business 1700-2000: Proactive Innovation or Reactive Evolution? *Construction Innovation,* Vol. 15, No. 3, pp. 258–277.

Idrees, I., Vasconcelos, A.C. and Cox, A.M. (2011). The use of Grounded Theory in PhD Research in Knowledge Management. A Model Four-stage Research Design. Aslib Proceedings: New Information Perspectives. Vol. 63, No. 2/3, pp. 188-203.

IEP (2015). *Internet Encyclopaedia of Philosophy*. Epistemology. Accessed via: http://www.iep.utm.edu/epistemo/ (2 March 2016).

Ivo, D.L. and Lowe, A. (2011). Mixed Methods Research: Don't – 'just Do It. Qualitative Research in *Accounting and Management*, Vol. 8, No. 1, pp. 22–38.

Jackson, R.L. and Hogg, M.A. (2010). *Encyclopaedia of Identity Volume 2*. Thousand Oaks, California: Sage Publications Inc.

Jacquette, D. (2002). *Ontology*. Montreal: McGill-Queeen's University Press.

Johnson, P. and Duberly, J. (2000). *Understanding Management Research*. Thousand Oaks, California: Sage Pub,ications Ltd.

Jones C. and Kennedy, G. (2011). Stepping Beyond the Paradigm Wars: Pluralist Methods for Research in Learning Technology. In: ALT-C 2011, *Thriving in a Colder and More Challenging Climate*, 18th International Conference held 6-8 September, 2011, Leeds University, UK.

Junwu, Z., Wang, J. and Li, B. (2009). A Formal Method for Integrating Distributed Ontologies and Reducing the Redundant Relations. *Kybernetes*, Vol. 38, No. 10, pp. 1870-1879.

Kekäle, T. (2001). Construction and Triangulation: Weaponry for Attempts to Create and Test Theory. *Management Decision*. Vol. 39, No. 7, pp. 556-563.

Kelemen, M. and Rumens, N. (2012). Guest Editorial. Pragmatism and Heterodoxy in Organization Research: Going beyond the Quantitative/Qualitative Divide. *International Journal of Organizational Analysis.* Vol. 20, No. 1, pp. 5-12.

Kelly, M.A. and Kaczynski, D.J. (2006). Misconceptions Students Bring to Qualitative Research. *Qualitative Research Journal*, Vol. 6, No. 2, pp. 31-44.

Kerry, L. and Ostwald, M. (2004). Architectural Research Methods. *Nexus Network Journal*, Vol. 6, No. 1, pp. 51–53.

Klaes, M. (2012). Paradigm 'Wars' as Methodenstreit Methodology of Management Studies meets Economic Methodology. *International Journal of Organisational Analysis*. Vol. 20, No. 1, pp. 13-24.

Korděs, U. (2005). A Peaceful Coexistence of Epistemologies – Philosophy from the Constructivist's Point of View. *Kybernetes*, Vol. 34, Nos. 1/2, pp. 295-305.

Khun, T. (1962). *The Structure of Scientific Revolutions*. Chicago, Illinois: University of Chicago Press.

Lather, P. (2006). Paradigm Proliferation as a Good Thing to Think With: Teaching Research in Education as a Wild Profusion. *International Journal of Qualitative Studies in* Education, Vol. 19, No. 1, pp. 35–57.

LeCompte, M.D. and J.P. (1982). Problems of Reliability and Validity in Ethnographic Research. *Review of Educational Research*. Vol. 52, No. 1, pp. 31-60.

Lee, J. and Jeong, Y. (2012). User-centric Knowledge Representations based on Ontology for AEC Design Collaboration. *Computer-Aided Design,* Vol. 44, No. 8, pp. 735-748.

Lehaney, B.A. and Vinten, G. (1994). Methodology: An Analysis of Its Meaning and Use. *Work Study*, Vol. 43, No. 3, pp. 5-8.

Love, P.E.D., Holt, G.D. and Li, H. (2002). Triangulation in Construction Management Research. *Engineering, Construction and Architectural Management,* Vol. 9, No. 4, pp. 294-303.

Mangan, J., Lalwani, C. and Gardner, B. (2004). Combining Quantitative and Qualitative Methodologies in Logistics Research. *International Journal of Physical Distribution and Logistics Management*, Vol. 34, No. 7 pp.565–578.

Matthias, S. (2014). *Epistemology*. The Stanford Encyclopedia of Philosophy (Spring 2014 Edition), accessed via: http://plato.stanford.edu/archives/spr2014/entries/epistemology/ (2 March 2016).

Mattsson, J. (1988). Developing an Axiological Method to Measure Company Values. *European Journal of Marketing,* Vol. 22, No. 6. pp. 21-35.

Metaxiotis, K.S., Psarras, J.E. and Askounis, D. (2001). Building Ontologies for Production Scheduling Systems: Towards a Unified Methodology. *Information Management and Computer Security*, Vol 9, No. 1, pp. 44-51.

Montero, M. (2002). On the Construction of Reality and Truth. Towards an Epistemology of Community Social Psychology. *American Journal of Community Psychology*, Vol. 30, No. 4, pp. 571–584.

Morgan, S.T. (2015). *Epistemology and Ontology.* Accessed via: http://www.stmorgan.co.uk/epistemology-and-ontology.html (2 March 2016).

Morgan, G. and Smircich, L. (1980). The Case for Qualitative Research. *Academy of Management Review*, Vol. 5, No. No. 4, pp. 471-500.

Morris, P.W.G. (2010). Research and the Future of Project Management. *International Journal of Managing Projects in Business*, Vol. 3, No. 1, pp. 139-146.

Moser, P.K. (Ed.) (2002). *The Oxford Handbook of Epistemology*. New York: Oxford University Press Inc.

Mouton J. Marais, H.C., Prinsloo, K.P. and Rhoodie, N.J. (1996). *Basic Concepts in the Methodology of the Social Sciences*. Pretoria, S.A: Human Sciences Research Council.

Murray, N. and Beglar, D. (2013). *Inside Track. Writing Dissertations and Theses*. Harlow, Essex: Pearson-Longman Education.

Naoum, S.G. (2007). *Dissertation Research and Writing for Construction Students.* Oxford, England: Butterworth-Heinemann.

Nielson, P.A. (2007). Is Action research and its Criteria. In: Kock, N. (Ed.). *Information Systems Action Research an Applied View of Emerging Concepts and Methods.* New York: Springer Science+Business Media LLC.

Oakley, A. (1999). Paradigm Wars: Some Thoughts on a Personal and Public Trajectory. *International Journal of Social Research Methodology*. Vol. 2, No. 3, pp. 247-254.

Ogunbiyi, O., Oladapo, A. and Goulding, J. (2013). An Empirical Study of the Impact of Lean Construction Techniques on Sustainable Construction in the UK. *Construction Innovation*, Vol. 14, No. 1, pp. 88-107.

Oxford (2016). *Epistemology*. Oxford Dictionaries. Accessed via: http://www.oxforddictionaries.com/definition/english/epistemology (2 March 2016).

Oxford Reference (2012). *A Dictionary of Construction, Surveying and Civil Engineering.* Accessed via: http://www.oxfordreference.com/view/10.1093/acref/9780199534463.001.0001/acref-9780199534463 (2 March 2016).

Patacas, J., Dawood, N., Vukovic, V., and Kassem, M. *BIM for Facilities Management: Evaluating BIM Standards in Asset Register Creation and Service Life Planning*, Journal of Information Technology in Construction, Vol. 20, pp. 313-331

Peterson, K. and Gencel, C. (2013). *Worldviews, Research Methods, and their Relationship to Validity in Empirical Software Engineering Research*. Accessed via: http://www.researchgate.net/publication/257439331_Worldviews_Research_Methods_and_their_Relationship_to_Validity_in_Empirical_Software_Engineering_Research (2 March 2016).

Pasian, B. (2015). *Designs, Methods and Practices for Research of Project Management*, Gower Publishing Ltd, UK

Petrov, V. (2010). Dynamic Ontology as an Ontological Framework of Anticipatory Systems. *Foresight*, Vol. 12, No. 3, pp. 38–49.

Project Auditors LLC (2015). *Project Management Dictionary Terms and Definitions.* Accessed via: http://www.projectauditors.com/Dictionary/DictionaryHome.php (2 March 2016).

Punch, K. (2014). *Intorduction to Social Research. Quantitative and Qualitative Approaches. Third Edition.* Oliver's Yard, London: Sage Publications Ltd.

QAA (2011). *The UK Doctorate: A Guide for Current and Prospective Doctoral Candidates.* The Quality Assurance Agency for Higher Education. Accessed via: http://www.qaa.ac.uk/en/publications/documents/doctoral_characteristics.pdf (2 March 2016).

Raftery, J., McGeorge, D. and Walters, M. (1997). Note – Breaking up Methodological Monopolies: a Multi-paradigm Approach to Construction Management Research. *Construction Management and Economics.* Vol. 15, No. 3, pp. 291-297.

Raftery, J. (1998). From Ptolemy to Heisenberg: Quantitative Models and Reality. *Construction Management and Economics.* Vol. 16, No. 3, pp. 295-302.

Rajasekar, S., Philominathan, P. and Chinnathambi, V. (2013). *Research Methodology*. Accessed via: http://arxiv.org/pdf/physics/0601009v3 (2 March 2016).

Rooke, J.A., Koskelaa, L. and Seymour, D. (2007). Producing things or Production Flows? Ontological Assumptions in the thinking of Managers and Professionals in Construction. *Construction Management and Economics*, Vol. 25, No. 10, pp. 107-1085.

Routledge (2005). *Epistemopogy*. Routledge Encyclopedia of Philosophy. Accessed via: http://www.rep.routledge.com/article/P059 (2 March 2016).

Rumsfield D. (2002). *Unkown unkowns*. Accessed via: http://www.washingtonpost.com/opinions/richard-cohen-donald-rumsfelds-battle-with-truth/2014/04/07/e2ee3928-be7e-11e3-b195-dd0c1174052c_story.html (2 March 2016).

Runeson, G. (1997). The Role of Theory in Construction Management Research: Comment. *Construction Management and Economics.* Vol. 15, No. 3, pp. 299-302.

Ruwhiu, D. and Cone, M. (2010). Advancing a Pragmatist Epistemology in Organisational Research. *Qualitative Research in Organizations and Management: An International Journal,* Vol. 5, No. 2, pp.108-126.

Sage (2015). *Epistemology.* Sage Research Methods. Accessed via: http://srmo.sagepub.com/view/the-sage-dictionary-of-social-research-methods/n64.xml (2 March 2016).

Schommer, M. (1990). Effects of Beliefs about the Nature of Knowledge on Comprehension. *Journal of Educational Psychology*, Vol 82, No. 3, pp. 498-504.

Seale, C. (1999). *The Quality of Qualitative Research.* London: Sage Publications Ltd.

Sedmak, M. and Longhurst, P. (2010). Methodological Choices in Enterprise Systems Research. *Business Process Management Journal*, Vol. 16, No. 1, pp. 76–92.

Seymour, D. E. and Rooke, J. D. (1995). The Culture of the Industry and the Culture of Research. *Construction Management and Economics.* Vol. 13, No. 6, pp. 511-523.

Seymour, D. E., Crook, D. and Rooke, J. (1998). The Role of Theory in Construction Management: Reply to Runeson. *Construction Management and Economics*. Vol. 16, No. 1, pp. 109-112.

Silverman, D. (2009). *Doing Qualitative Research.* Oliver's Yard, London: Sage Publications Ltd.

Sobh, R. and Perry, C. (2006). Research Design and Data Analysis in Realism Research. *European Journal of Marketing*. Vol. 40, No. 11/12, pp. 1194-1209. Bingley: Emerald.

Spence, E. H. (2011). Information, Knowledge and Wisdom: Groundwork for the Normative Evaluation of Digital Information and Its Relation to the Good Life. *Ethics and Information Technology,* Vol. 13, No. 3, pp. 261–75.

Spinelli, E. (2005). The Interpreted World: *An Introduction to Phenomenological Psychology*. London, England: Sage Publishing Ltd.

Stark, E., Stepanovich, P., Poppler, P. and Hopkins, P.J. (2008). Surrounded by White Water: Conflicts in Management Sciences Regarding Truth and Reality. *Journal of Behavioural and Applied Management*, Vol. 9, No. 3, pp. 258-274.

Studer, R., Benjamins, V.R. and Fensel, D. (1998). Knowledge Engineering: Principles and Methods. *Data and Knowledge Engineering*, Vol. 25, Nos. 1&2, pp.161-197.

Thomas, G. (2013). *How to Do Your Research Project: A Guide for Students in Education and Applied Social Sciences*. Thousand Oaks, California: Sage Publications Inc.

Tight, M. (2012). *Researching Higher Education. Second Edition.* Maidenhead, Berkshire: Open University Press.

Turk, Z. (2006) Construction Informatics: Definition and Ontology. Advanced Engineering Informatics, Vol. 20, No. 2, pp. 187-199.

Ugwu, O.O., Anumba, A. and Thorpe, A. (2001). Ontology Development for Agent-based Collaborative Design. *Engineering, Construction and Architectural Management,* Vol. 8, No. 3, pp. 211-224.

University of Manchester (2015). *Research Methodology*. Accessed via: http://www.humanities.manchester.ac.uk/studyskills/assessment_evaluation/dissertations/methodology.html (2 March 2016).

US Census Bureau (n.d.). *Definitions of Construction*. Accessed via: http://www.census.gov/const/C30/definitions.pdf (2 March 2016).

Voordijk, H. (2009). Construction Management and Economics: The Epistemology of a Multidisciplinary Design Science. *Construction Management and Economics*, Vol. 27, No. 8, pp. 713-720.

Wang, J.Z., Farha, A. and Pradip K.S. (2010). An Efficient Method to Measure the Semantic Similarity of Ontologies. *International Journal of Pervasive Computing and Communications*, Vol. 6, No. 1, pp. 88-103.

Wellington, J. (2010). Weaving the Threads of Doctoral Research Journeys. In: Thompson, P. and Walker, M. *The Routledge Doctoral Student's Companion*. Abingdon, Oxon: Routledge.

WhatIs.com (2016). *Ontology*. Accessed via: http://whatis.techtarget.com/definition/ontology (2 March 2016).

White, D. 1987. Research Methods in Information Systems. *International Journal of Information Management*, Vol. 7, No. 1, pp. 58–59.

Wikipedia (2016). *Ontology*. Accessed via: http://en.wikipedia.org/wiki/Ontology (2 March 2016).

Wilkinson, S. J. and Morton, P. (2007). The Emerging Importance of Feminist Research Paradigms in Built Environment Research. *Structural Survey*, Vol. 25, No. 5, pp. 408–417.

Young, K. and Atkinson, M. (2013). Introduction: The Practice of Qualitative Research and thinking Qualitatively. In: Young, K. and Atkinson, M. (Eds.), *Qualitative research on Sport and Physical Culture*. Bingley, England: Emerald Group Publishing Ltd.

Zhitomirsky-Geffet, M. and Bar-Ilan, J. (2014). Towards Maximal Unification of Semantically Diverse Ontologies for Controversial Domains. *Aslib Journal of Information Management*, Vol. 66, No. 5, pp. 494-518.

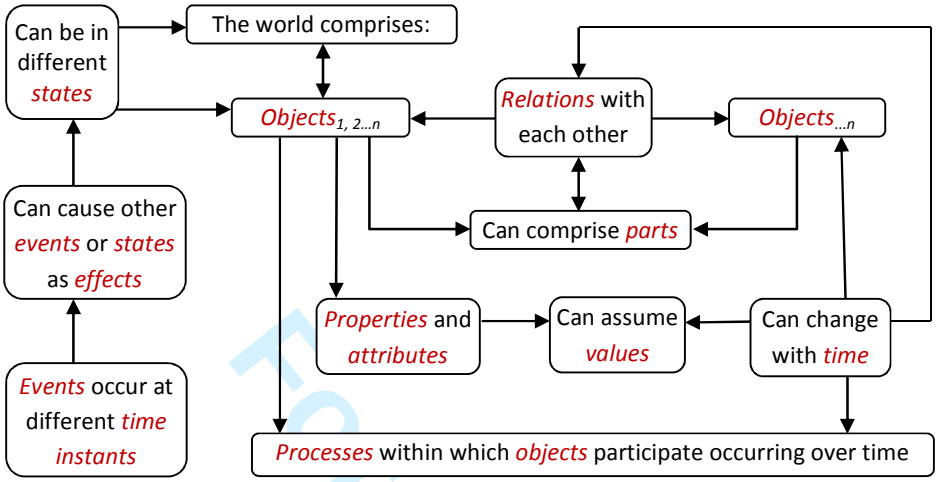
Zhitomirsky-Geffet, M. and Erez, E.S. (2014). Maximizing Agreement on Diverse Ontologies with 'Wisdom of Crowds' Relation Classification. *Online Information Review*, Vol. 38: No. 5, pp. 616-633.

Zhu, J., Wang, J. and Li. B. (2009). A Formal Method for Integrating Distributed Ontologies and Reducing the Redundant Relations. *Kybernetes*, Vol. 38, No 10, pp. 1870-1879.

Table 1. Definitions (random sample)

Ontology	Epistemology	Methodology
• …study of the nature of being, becoming, existence, or reality… basic categories of being and their relations … deals with questions concerning what entities exist or can be said to exist, and how such entities can be grouped, related within a hierarchy, and subdivided according to similarities and differences. (*phil*.) (Wikipedia, 2016). • …has practical application in information science and information technology, where it informs ontologies with chosen taxonomies. (*sci*.) (*ibid*.) • …study or concern about what kinds of things exist - what entities are in the universe…a branch of metaphysics , the study of first principles or the essence of things. (*phil*.) (WhatIs.com, 2016). • …a set of concepts …to create an agreed-upon vocabulary for exchanging information. (*sci*.) (*ibid*.) • …explicit specification of a conceptualisation (*sci*.) (Gruber, 1995).	• The theory of knowledge, especially with regard to its methods, validity, and scope, and the distinction between justified belief and opinion. (Oxford, 2016). • …concerned with the possibility, nature, sources and limits of human knowledge…whether or how we can have knowledge of reality… a central epistemological debate has been between empiricism and rationalism. (Sage, 2015). • … concerned with the nature, sources and limits of knowledge…primarily concerned with propositional knowledge, that is, knowledge that such-and-such is true, rather than …how to such-and-such. (Routledge, 2005). • … what does it mean to say that someone knows, or fails to know, something? …how much do we, or can we, know? How can we use our reason, our senses, the testimony of others, and other resources to acquire knowledge? (IEP, 2015).	• …the branch of philosophy concerned with the science of method and procedure (Collins, 2016). • … implies more than simply the methods you intend to use … [it is also often] necessary to include a consideration of the concepts and theories which underlie the methods (University of Manchester, 2015). • …the procedures by which researchers go about their work of describing, explaining and predicting phenomena …(Rajasekar et al., 2013). • …logic of the application of scientific methods to the investigation of phenomena (Mouton et al., 1996). • process used to collect information and data for …making business decisions (Business Dictionary, 2016).

Figure 1. General Agreement Regarding Ontologies



Source: Graphic the authors; based on Chandrasekaran et al. (1999)

Figure 2. Model of Key Ological-triad Relationships *vis-à-vis* CM Research