Words and Objects in Information Systems Development: Six Paradigms of Information as Representation

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Abstract

The notion of 'information' is one of the most basic in the Information Systems field. However, a clear consensus of what the term signifies remains evasive to both theorists and practitioners. Even in the applied discipline of Information Systems Development, the notion of information as representation is ambiguous. To motivate the discussion, we demonstrate a variety of contradictory stances held by several researchers in this domain. To make sense out of this perplexing variety, we develop a philosophical framework to highlight the divergence in philosophical assumptions. Our goal in this exercise is to delineate the ontological and epistemological bias of six exemplars of systems development techniques: software engineering, ontological engineering, ontological design, conceptual modeling, database normalization, and formal methods. A deeper understanding of the implicit philosophical premises can enlighten the choice of an appropriate method to address specific, concrete developmental challenges, as well as provide an understanding of the philosophical genesis of widely applied developmental tools.

Keywords: Information, Ontology, Epistemology, Information Systems Development Approaches, Assumption Analysis.

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Introduction

The notion of 'information' is one of the most basic in the Information Systems field. However, a clear consensus of what the term signifies remains evasive to both theorists and practitioners. We argue that the widespread, unquestioned use of the term 'information' can lead to misunderstandings among practitioners and undermine the theoretical rigor of the IS discipline.

At face value, it may appear that seeking a generic definition of 'information' is a sophomoric exercise. However, we suggest that the assumptions made about 'information' have important repercussions, either when devising Information Systems Development (henceforth ISD) methods, or applying them. Consider a simple example, Berners-Lee's Semantic Web proposal, where "the Semantic Web is not a separate a Web but an extension of the current one, in which *information is given well-defined meaning*" (italics are ours) (Berners-Lee et al., 2001). Suppose for the sake of argument that terms do not have a fixed and precise meaning, but just a fluctuant, slippery usage. This stance would cast some doubts about the viability of the Semantic Web. Here, the success of this project is crucially grounded on the assumption that terms can be unambiguously defined.

Admittedly, it could well be that delineating a single, general definition of information may be a futile goal; one can only talk about definitions bound to a given context or task. Consider that the notion of information in physics is very different to that of mathematics (Chaitin, 1982), which is different from Shannon's in his communication theory, which, in turn, has no semantic dimensions (Shannon, 1948). Even within the information systems discourse, notions of information and knowledge are polemical and controversial. For instance, Weber (1997) disagrees with Hirschheim et al. (1995) when discussing the ontological and epistemological assumptions of data modelling; and in a more general and philosophical mode Klein (2004) and Monod (2004) debate Mingers'

(2002) proposal of critical realism as an underpinning philosophy of information systems.

In this paper, we study the notion of 'information as representation' and show that even in this application, there are diverse and contradictory stances. To make sense out of this perplexing variety, we draw upon philosophy to build a framework which situates the diverse philosophical assumptions of a variety of ISD methods. We delineate the ontological and epistemological premises of six exemplary information systems development techniques, belonging to the schools of: software engineering, ontological engineering, ontological design, conceptual modeling, database normalization, and formal methods. The aim of the exercise is to develop a deeper understanding of the philosophical assumptions concerning the notion of information as representation of leading ISD methods, and thereby: a) enlighten the choice of an appropriate method to address specific, concrete developmental challenges, and b) inform debates concerning the philosophical genesis of widely applied developmental tools and their consequent outcomes.

Ontologies: Realism/Idealism Vs. Realism/Nominalism

In a series of papers, Iivari, Hirschheim, Klein and Lyytinen, drawing upon the work of (Burrell and Morgan, 1979), build several dimensions to classify ISD methods (Klein and Hirschheim, 1987; Hirschheim and Klein, 1989; Iivari, 1991; Hirschheim et al., 1995; Iivari et al., 1998; Iivari et al., 2000). These authors augment Burrell and Morgan's work with an additional dimension; information/data, qualifying a dichotomy: descriptive facts and constitutive meanings. The authors present the two positions as opposed: "the difference is whether one believes that a data model 'reflects' reality, or consists of subjective meanings and thereby constructs reality" (Klein and Hirschheim, 1987 p.9). These authors use the terms Realism/nominalism in an unusual way. They name nominalism what is normally termed idealism (Burrell and Morgan, 1979 p.4).

The overarching theme of this paper is to argue that notions employed by these authors are insufficiently granular to understand the philosophical underpinning of information within the ISD discourse. Rather, we seek a deeper understanding, and therefore delineate the ontological and epistemological assumptions of the notion of information as representation within the ISD domain. We contend that previous studies have employed the terms nominalism and idealism synonymously. We distinguish these two terms as individual concepts, and use this differentiation actively in our analysis.

We will first address ontology. Ontology is basically a question of what is out there; a question of idealism or realism but also of nominalism or realism. We argue that the sometimes conflated dimensions idealism/realism and nominalism/realism are independent. Idealism is the doctrine that holds that "whatever exists, or at any rate whatever can be known to exist, must be in some sense mental" (Russell, 1912 p.19). Within this statement, we can identify two kinds of idealism, ontological idealism, which posits that the existence of objects depends on someone perceiving them; and the epistemic idealism, which asserts that we do not have access to the thing in itself (the Kantian *ding an sich*) and thus all we know is a mental construction. A representative of the first kind of idealism is Berkeley (1710) who posited that only what is perceived exists ('*esse est percipi*'). A representative of the second type of idealism is Kant (1781) who argued that our perception of reality is a product of *a priori* filters of human reasoning, and thus to understand the ultimate nature of things is, in fact, a futile pursuit.

The conceptual opposite of idealism is realism, which is also multiform. For example, a form of realism is materialism, which claims that the basic substance of the world is matter. Another realist position is naïve realism, opposed to Kant's idealism, which declares that ultimate reality is as we perceive it.

On the orthogonal vector, we find the philosophies related to the meaning of words, the concepts of realism/nominalism. To present this dimension, we use Plato's theory of Ideas. The pursuit of knowledge requires us to classify things. Knowledge is not of particular things, for instance, my dog, but of general things, such as dogs, which he called Ideas (later also called 'universals', as distinguished from particulars). As there are no two equal particular things, classifying things requires us to discover what is generalizably essential to them, e.g. 'dogness'. This essentiality is what Plato called 'Idea', 'Essence', or 'Form'. Moreover, he posited that ideas maintain a separate existence from objects, claiming that ideas exist before things: *Universalia ante rem* (universals before the thing). As Plato gives pre-eminence to ideas before the physical world, he is considered an idealist, but he also declares that ideas, universals, have a reality out of human cognition and is in hence an extreme realist. We will call this kind of realism, $\text{realism}_{\text{U (universals)}}$. We will call $\text{realist}_{\text{W(world)}}$ the form of realism related to the reality of the physical world, that which is opposite to idealism.

Another form of realism related to universals, $\text{realism}_{\text{U}}$, is that of Aristotle, who denied the world of Ideas, but claimed that essences exist in the things, not before them. Objects are not pale copies of Ideas, but rather, universals are in the thing; *Universalia in re*. So, while Plato was a $\text{realist}_{\text{U}}$ and also an idealist, Aristotle was a $\text{realist}_{\text{U}}$ and a $\text{realist}_{\text{W}}$. Other ancient Greek schools argued the notion of *Universalia post rem* (universals after the thing), suggesting that ideas do not exist independently of the human mind. This stance was later called nominalism.

The dimension $\text{realism}_{\text{U}}$/nominalism is often traversed in many philosophical doctrines. For instance, in phenomenology, often considered a form of idealism, Husserl's stance is at one extreme with his method of eidetic reduction, a procedure not very far from Plato's maieutic anamnesis, used to discover the 'pure essence of things', to which the author also refers as 'invariable essence', or 'universal', or

'eidos', meaning 'form' in Greek (Smith, 2003). At the other extreme is Gadamer (1975), who is associated with the phenomenological tradition (he was a disciple of Heidegger, who in turn was a pupil of Husserl). However, his position concerning the meaning of words was closer to nominalism, corresponding to his affiliation with Dilthey and Schleiermacher's hermeneutics.

Moreover, with respect to the dimensions realism/idealism and realism/nominalism, Kant holds an intermixed stance. Ontologically he is a realist; he accepts that something exists out there, the thing in itself. Epistemologically he is an idealist; we do not have direct access to the physical reality. However, he defends that we have direct access to Platonic Ideas through reason, turning again to realism when considering the reality of Ideas (universals). His stance regarding universals is very explicit and clear, although excluding its mystical aspects, he is an unapologetic defendant of Plato's position (Kant, 1781 pp.395-396). Idealism is often conflated with nominalism, and correspondingly realism (about the world) with realism (about words), but they are independent dimensions.

We substantiate this argument by showing that there have been great philosophers in history which have held any possible combination of these 4 positions: $Realism_U$&$Realism_W$, $Realism_U$&Idealism, Nominalism&Idealism, Nominalism&$Realism_W$. Figure 1 summarizes the positions and places representative philosophers in each quadrant[1]. Where Russell is a $realist_U$, Locke, Berkeley and Hume are nominalists. However, while Berkeley is an idealist, Hume, Locke and Russell are $realist_W$. Hume's position is controversial due to the sceptical nature of his philosophy. However, some authors attach him to a $realist_W$ stance (Beauchamp, 1999).The cell $Realism_U$&Idealism is

[1] See, in particular, the chapters 'Of General Ideas' by (Locke, 1690)pp.367-376, 'Introduction' by (Berkeley, 1710)pp.7-23, 'Of abstract ideas' by (Hume, 1740)pp.64-73, and 'The World of Universals' by (Russell, 1912)pp.52-57)

represented by Plato, Kant and Husserl. They all agree in defending the existence of universals (Platonic Ideas), $realism_U$.

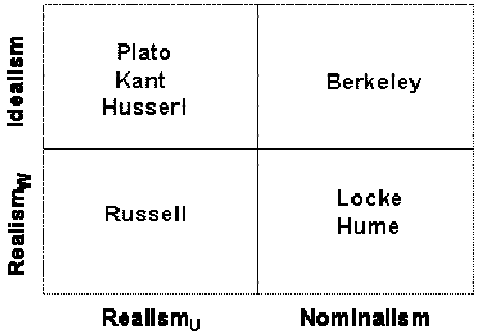

Figure 1. Independence of Idealist and Nominalist dimensions

Within this broad framework, certain philosophical tensions are more germane to specific intellectual pursuits than others. For example, the philosophical conflicts on the $Realism_W$/Idealism dichotomy are highly manifest in sociological discourse. In contrast, these tensions are less crucial to the Information Systems discipline, given its large linguistic component. Consequently, we turn our attention to the linguistic and representational facets of information and their relevance to information systems development. We regard information systems as "…formal linguistic systems for communication between people which support their actions." (Goldkuhl and Lyytinen, 1982) Accordingly, the relevant question is whether concepts (general terms) with objective and precise meanings exist, the question posed by the dimension $Realism_U$/nominalism. As such, we will focus primarily on this dimension.

Although Locke, Berkeley and Hume shared their $anti\text{-}realist_U$ position since they believed that universals are a human invention, hence postulated conceptual relativism, they disagreed on the characteristics of concepts. According to Berkeley's interpretation, Locke thought that "…every name has, or ought to have, *one only precise and settled signification*, which inclines men to think there are…abstract, determinate ideas that constitute the true and only immediate signification of each general name" (Berkeley, 1710 p.12)

(italics ours). In contrast, Berkeley and Hume subscribed to semantic relativism, they held "...that there is no such thing as abstract or general ideas, properly speaking; but that all general ideas are, in reality, particular ones, attached to a general term, which recalls, upon occasion, other particular ones, that resemble, in certain circumstances, the idea, present to the mind" (Hume, 1758 p.205). In short, while Locke held that there are concepts, that is, general terms with precise and somewhat context independent meaning, Berkeley and Hume defended blurred and situation dependent meanings of general terms.

Historians of philosophy have labelled these two attitudes, calling Locke's stance 'conceptualism', and Berkeley and Hume's position 'nominalism'. Consequently, we have an ontological dimension with three possible stances: a) *realism* which talks about universals, ideas, forms or essences; b) *conceptualism*, which deals with concepts; and c) *nominalism*, which only accepts general terms. This has been a recurrent philosophical debate. We will demonstrate how these positions parallel the present situation in the information systems field.

Epistemology: Preceptive & Pragmatic

In addition to the ontological dimension of realism/conceptualism/ nominalism, we need to define an epistemological dimension as well. Consider Plato and Aristotle, both realists (universals, the meanings of general terms, exist 'out there', and the intellect can discover them). An epistemological continuum consists of Platonic rationalism at one node (reason and logical deduction are the sure source of knowledge), where the other end is represented by Aristotelian empiricism (experience and observation are the source of knowledge).

As our purpose is to distinguish ISD authors' positions, whose aim is eminently practical, we define the positions 'preceptive' and

‘pragmatic’. We will call ‘preceptive’ those who subscribe to a canonical doctrine, such as analytic metaphysics, or a set of general precepts or rules, such as formal logic. We label ‘pragmatic’ those positions more sceptical, who show some kind of epistemic agnosticism and search for ad hoc solutions to the problems. Examples of ‘pragmatic’ problem solving can be found in Stroustrup, the designer of C++, and Gabriel, one of the designers of CLOS (another OO-programming language). When questioned on what rules they used to identify classes, Stroustrup answered, "It's a Holy Grail. There is no panacea." Gabriel contends, "That's a fundamental question for which there is no easy answer. I try things” (Booch, 1994 p.145).

These two additional dimensions enable the construction of a framework with six possible stances portrayed in table 1. We conducted an extensive search in the ISD literature, identifying well known authors whose positions exemplify those stances. Our purpose was not to do an exhaustive and classificatory study, but rather to demonstrate the striking diversity of stances held by extant researchers.

We asked the papers the following questions concerning the nature of information as representation: Do concepts exist that claim to describe reality? If true, do criteria exist to attain those concepts? If false, are concepts human constructions? Do concepts have a precise meaning? Are they somewhat fixed and context independent? Does some process exist to validate the precision and independence? In the instance that the author denies any kind of objectivity of concepts, does a method exist to solve the problem? Table 1 summarizes the basic traits of each of these positions.

Table 1. Basic traits of the different stances

Stance	Nature attributed to meaning	Body of Precepts
1. Preceptive Realism	Platonic Idea Exists 'out there' Discovered a priori	Analytic Metaphysics
2. Pragmatic Realism	Classes Exist 'out there' Discovered a posteriori	Empirical, ad hoc.
3. Preceptive Conceptualism	Concepts. Human invention. Conceptual relativism. Meaning is precise and somewhat context independent	Philosophy
4. Pragmatic Conceptualism		Ad hoc
5. Preceptive Nominalism	General Terms Human invention. Conceptual and semantic relativism Meaning is blurred. Context and situation dependent.	Mathematical logic. Meaning defined
6. Pragmatic Nominalism		Ad hoc Meaning negotiated.

Isd Exemplars

In the following section, we present examples from the ISD literature that are representative of the philosophical stance of each category of our framework. The examples are not exclusive; many methods can embody a given position. However, we have chosen examples that are well known and effectively demonstrate the position.

Preceptive Realism

In their introduction to the Second International Conference on Formal Ontology and Information Systems (FOIS'01), Smith and Welty complained of the great number of different definitions of the term 'ontology', and proposed a 'philosophical ontology', to which they also name 'analytic metaphysics':

"…What classes of entities are needed for a complete description and explanation of all the goings-on in the universe? Or: What classes of entities are needed to give an account of what makes true all truths? They have been designed to be exhaustive in the sense that all types of

entities should be included, including also the types of relations by which entities are tied together. ...information systems ontology is itself an enormous new field of practical application that is crying out to be explored by the methods of rigorous philosophy" (Smith and Welty, 2001 p.iii)

And they assert that "computer scientists are beginning to recognize that the provision, once and for all, of a common, robust reference ontology –a shared taxonomy of entities– might provide significant advantages over the ad hoc, case-by-case methods previously used."

Guarino and Welty propose ontological engineering as a discipline belonging to philosophical research, and can be intended as a theory of a priori distinctions between the entities of the world, as well as meta-level categories used to model the world (Guarino, 1998; Guarino and Welty, 2002). The purpose is to convert Ontology, 'an arcane art form', into a rigorous engineering discipline called Ontological Engineering. To this end, they introduce formal notions such as 'essence', 'permanence' or 'rigidity'. Let us see how they define 'essence' and 'permanence':

"The first formal notion we will discuss is essence. A property of an entity is essential to that entity if it must hold for it…. For example, consider the property of being hard. We may say that it is an essential property of hammers, but not of sponges. Some sponges (dry ones) are hard, and some particular sponge may be hard for its entire existence, however this does not make being hard an essential property of that sponge. The fact is that it could have been soft at some time, it just happened that it never was" (Guarino and Welty, 2002 p.61).

Pragmatic Realism

Pragmatic realism is the position assumed by the majority of software engineers. In fact, they aspire to emulate the well-established

theoretical foundations of civil, chemical or electrical engineering (Booch, 1994). For this reason: “We must understand what goes into making 'industrial processes' successful and then apply this knowledge in an appropriate manner to the software industry.” (Jacobson et al., 1992 p.1) If the natural stance of a civil engineer when building a bridge is empirical realism, the position of software engineers often approaches this as well.

This stance represents engineering orthodoxy. Hence, software engineers do not feel the necessity of explicitly acknowledging their ontological or epistemological assumptions. However it is clearly Aristotelian. Concepts are identified:

“For users, most abstractions are not that hard to identify because, typically, they are drawn from the things that users already use to describe their system. …[to] make sure that each class is crisply defined” (Booch et al., 1999 p.55).

Concepts have a clear and well delimited meaning: “We define an object as a concept, abstraction, or thing with crisp boundaries and meaning for the problem at hand” (Rumbaugh et al., 1991 p.21). Concepts have essences that can be captured: “Naming things properly --so that they reflect their semantics-- is often treated lightly by most developers, yet is important in capturing the essence of the abstractions we are describing” (Booch, 1994 p.163).

Preceptive Conceptualism

As a representative of preceptive conceptualism, we propose the ideas of Yair Wand and Ron Weber (Wand and Weber, 1990; Wand and Weber, 1988) two well-known authors in the conceptual modelling field (Wand and Weber, 2002). As conceptualists, they assume that concepts are mind-made; as they say, perceived by users; so they subscribe to conceptual relativism: “Conceptual models or semantic

data models were developed to capture the meaning of an application domain as perceived by someone" (Wand et al., 1999 p.494). However, they are not relativist when deciding which concepts represent things or properties:

"To illustrate the problem of classifying phenomena, consider the constructs of 'things' and 'properties of things'. Determining whether a certain phenomenon should be designated as a thing or a property is often difficult. For example, should the colour 'red' be modelled as a thing with properties (e.g. hue) or a property of some other thing (e.g., a car)? Some researchers adopt a relativist viewpoint… Others assert that a phenomenon must be either a thing or a property of a thing -- it cannot be both" (Wand and Weber, 2002 p.369).

Unlike pragmatic realism, they regret the absence of a solid theoretical foundation of the field:

"…even though a substantial amount of work had been done on building conceptual models and designing databases, some of it was a-theorical. In particular, while research on data normalization was grounded in solid theory, research on conceptual modelling was virtually devoid of theory" (Weber, 2003 p.viii). This is why they searched for some grounding and proposed Mario Bunge's philosophy (Wand et al., 1999 p.497).

Pragmatic Conceptualism

Most researchers in the conceptual modelling field can be considered conceptualist. This community takes concepts as something given, rarely discussing them explicitly. Accordingly, in order to provide evidence, we will employ assertions made in the sibling field of computational ontologies, where the positions are explicit.

This group prefers to use the term ontology instead of conceptual model, and posits ontology as a countable noun. An example where concepts are clearly posited as something different from terms is: "Ontology is a representation vocabulary, often specialized to some domain or subject matter. More precisely, it is not the vocabulary as such that qualifies as an ontology, but the conceptualizations that the terms in the vocabulary are intended to capture. Thus, translating the terms in an ontology from one language to another, …does not change the ontology conceptually" (Chandrasekaran et al., 1999 p.20).

We have selected Thomas Gruber as a representative of this position (Gruber, 1995; Gruber, 1993). Although his papers are relatively scarce, they are frequently cited and very explicit. For him, an ontology is a synonym of a conceptual model. "A conceptualization is an abstract, simplified view of the world that we wish to represent for some purpose. …An ontology is an explicit specification of a conceptualization" (Gruber, 1995 p.1). Concepts, the shared vocabulary, are a human invention, the result of a choice: 'Formal ontologies are designed. When we choose how to represent something in an ontology, we are making design decisions' (Gruber, 1995 p.2). And he denies a priori reasoning: "To guide and evaluate our designs, we need objective criteria that are founded on the purpose of the resulting artefact, rather than based on a priori notions of naturalness or Truth (Gruber, 1995 p.2). And he also denies semantic relativism: "An ontology should effectively communicate the intended meaning of defined terms. Definitions should be objective. ...the definition should be independent of social or computational context."

Preceptive Nominalism

One of the answers to the problems posed by software engineering and systems developers are formal methods, a clear example of preceptive nominalism. This body of discourse prescribes the use of mathematical logic as an avenue to formally specify and communicate

user requirements. As such, it seeks to reach the 'enviably well-established repertoires of theoretical foundations and practical disciplines' of traditional engineering (Jackson, 1995 p.283; Saiedian, 1996).

Normally, they do not use the notions of 'concepts', 'classes' or 'ontologies'. Instead, they speak of 'terms' and 'primitive terms'. Terms signify reality directly, without intermediaries: "Any formal representation uses primitive terms with no inherent formal meaning. In requirements engineering, the meaning of these terms lies in the real world, and the validity of any formal assertion relies on it. …The only way to establish the meaning of a primitive term is to provide an informal explanation of it. This explanation must be clear and precise; it must be written down; and it must be maintained as an essential part of the requirements documentation" (Zave and Jackson, 1997 p.3).

Pragmatic Nominalism

This point of view is followed by a minority; however it does represent a diverse portfolio of stances. Some authors representative of preceptive nominalism can also be classified in category when they argue that there is no point in searching for a universal specification techniques, such as formal logic, and propose developing ad hoc notations instead (Lamsweerde, 2000; Zave, 1996).

Perhaps the best example of a formal ad hoc development is Codd's normalization theory. Codd, as quoted by Weber, defends semantic relativism: "When seeking to distinguish between entities and relationships, (Codd, 1990 p.477) also refers to the problem of semantic relativism: "... one person's entity is another person's relationship... If there are 10 people in a room and each is asked for definitions of the terms "entity" and "relationship", 20 different definitions are likely to be supplied for each term" (Weber, 1996 p.138).

In the requirements engineering field, this position is defended by Goguen: “An item of information is an interpretation of a configuration of signs for which members of some social group are accountable” (Goguen, 1997 p.4).

The most explicitly argued position is that of Ronald Stamper who, after years of collaboration in the IFIP WG8.1 Task Group FRISCO (Framework of Information Systems Concepts) (Falkenberg et al., 1998; Verrijn-Stuart, 2001) felt obliged to argue his dissenting position: “If we define meaning as the relationship established by people in a language community between thing-A (sign) standing for thing-B (object), we see that meanings always depend on the interpreter(s)” (Stamper, 1998 p.195).

He defends his proposal of a new paradigm: “A system developed on the basis of this position of radical, socially-based subjectivism allows for semantic diversity. …Meanings are not the possession of the words themselves, they have to be provided by identifiable agents. ...Every word in the system has to be linked to a responsible agent (individual, group, or role) and the meaning has to be explicable in terms of action, not just defined using other words. Different agents are entitled to their own interpretations…” (Stamper et al., 1991 p.75).

Summary and Discussion

Figure 2 presents a summary of the findings of our analysis.

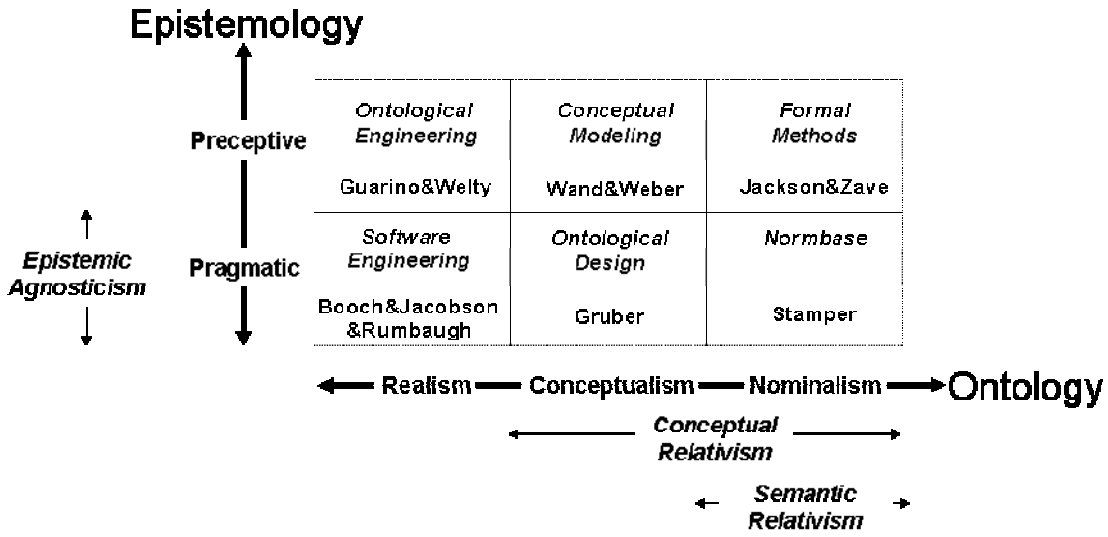

Figure 2 Ontological and Epistemological positions in Systems Development

Our study shows the divergence in philosophical positions concerning information as representation held by researchers in our sample. One possible inference is that the ontological and epistemological positions can have greater relevance, depending on the task being solved.

For example, realist stances cannot be uncritically dismissed. Consider that many social institutions (e.g. the game of chess, or money) have a precise meaning. They approximate the idea of Platonic Ideal: reality is a product of the idea. Formal design sciences adopt a similar posture, where systems and artefacts result from preconceived ideas (Hevner et al., 2004).

Conceptualist positions also have their place. Hard sciences show that is not impossible to achieve a sufficient convergence and precision in the meaning of the terms used by a community in some domain of problems, which is an essential factor to build rigorous and cumulative science.

On the other hand, young disciplines show that their general terms have an instable and blurred meaning; they do not have the category of concepts yet. However, science advances by refining continuously the meaning of its general terms. For instance, mass and weight were synonymous before Newton and later Einstein showed that the concept of mass has also other meanings. A clear example of a fuzzy term is, as we have discussed, the notion of information in our field.

Consequently, if solutions are domain dependant, then we present in table 2 a summary of philosophical positions, ISD approaches, basic assumptions, and potential domains of relevant problems.

Table 2 Problem domains addressed by each position

Philosophical Paradigm	Systems Approach/Method	Basic Assumptions	Problems Addressed
Preceptive Realism	Ontological Engineering	• A priori distinctions between entities of the world • Discover the meaning of entities	Universal Ontologies Software Agents
Pragmatic Realism	Software Engineering	• Capturing the essence of the abstractions • Crisp definitions of classes • Identify meaning of entities	Communication Machine/Machine
Preceptive Conceptualism	Conceptual Modeling	• Search of criteria for correct construction of concepts • Build entities with meaning	Grounding Modeling Methods
Pragmatic Conceptualism	Conceptual Modeling	• Concepts are mind-made • Their meaning can be independent of context and situation • Capture meaning of entities	Misunderstandings Analyst/User
Preceptive Nominalism	Formal Methods	• Deny use of concepts as intermediaries • Define meaning of terms • Primitive terms undefined	Misunderstandings Analyst/Programmer
Pragmatic Nominalism	Ad hoc methods Focus on validating use of terms	• No use of concepts as intermediaries • Subjective/inter-subjective meanings Fluctuant meanings of terms depending on context, situation and agent • Treat meaning of terms	Misunderstandings Analyst/User User/User

Limitations

The purpose of this exercise is to define a framework and present ISD methods that exemplify each specific position. For this reason, our criterion of selection has been to find contrasting positions. The authors presented have been chosen because of their stances are exemplars, paradigmatic in the pre-Kuhnian sense of the term: an outstandingly clear or typical example.

Furthermore, studying the notion of information only in its representational mode is clearly focused on a limited range of ISD method characteristics (Hirschheim et al.,1995). Other complementary

notions of information relevant to ISD problems are numerous and relevant, but are out of the scope of this paper.

Conclusions

We believe that the study of information as representation is worthy in itself, but argue that it is pre-eminent in the field of information systems development (e.g., see all of the methods presented in (Iivari, 1991). As one of the main uses of information systems is helping users to refer to sets of objects, properties and events, the human act of referring cannot be avoided when designing and using an information system.

Our study highlights the divergence in philosophical positions held concerning information as representation by a variety of ISD researchers. Normally, both the research and practice of ISD tend to assume, rather than make explicit, the notion of information. Explicating epistemological and ontological assumptions is not just an academic exercise, but a prerequisite to better understand the full consequences of any ISD method. Moreover, discourse is a necessary condition to pursue a convergence of meanings; to build cumulative science. In science, taxonomy usually precedes theory. This paper attempts to be a first step in building a sound, robust taxonomy of information in information systems development.

References

Beauchamp, T. L. (1999) “Editor's Introduction”. In: Hume, D. An Enquiry concerning Human Understanding. Oxford University Press.

Berkeley, G. (1710). *Principles of Human Knowledge and Three Dialogues,* Oxford University Press, 1999.

Berners-Lee, T.; Hendler, J., Lassila, O. (2001) “The Semantic Web”, *Scientific American* (284)5, pp.34-43 .

Booch, G. (1994) *Object-Oriented Analysis and Design.* Addison-Wesley.

Booch, G.; Rumbaugh, J. E., Jacobson, I. (1999) *The Unified Modeling Language User Guide.* Addison-Wesley, 2000.

Burrell, G.; Morgan, G. (1979) *Sociological Paradigms and Organisational Analysis.* Ashgate, 1998.

Chaitin, G. J. (1982) “Gödel's Theorem and Information”, *International Journal of Theoretical Physics* (22), pp.941-954.

Chandrasekaran, B.; Josephdon, J. R.; Benjamins, R. (1999) ”What are Ontologies, and Why do we Need them?” *IEEE Intelligent Systems* (14)1, pp. 20-26.

Codd, E. F. (1990) *The Relational Model for Data Base Management: Version 2.* Addison Wesley.

Falkenberg, E. D.; Hesse, W.; Lindgreen, P.; Nilsson, B.; Oei, J. L. H.; Rolland, C. ; Stamper, R.; Assche, F. J. M. V. ; Verrijn-Stuart, A. A. ; Voss, K. (1998) *A Framework of Information System Concepts (The FRISCO Report).* IFIP; 1998

Gadamer, H. G. (1975) *Truth and Method.* Weinsheimer, J. and Marshall, D. G., Translators. Continuum Publishing Group, 2004. 2nd ed.

Goguen, J. A. (1997) "Towards a Social, Ethical Theory of Information". In: Bowker, G.; Gasser, L.; Star, L.; Turner, W. (eds.) *Social Science Research, Technical Systems and Cooperative Work: Beyond the Great Divide.* Erlbaum 1997. pp. 27-56.

Goldkuhl, G.; Lyytinen, K. (1982). "A Language Action View of Information Systems". In: Ginzberg, M.; Ross, C.(eds) 3trd International Conference on Information Systems.

Gruber, T. R. (1993) "A Translation Approach to Portable Ontology Specifications", *Knowledge Acquisition* (5)2, pp.199-220.

Gruber, T. R. (1995) "Toward Principles for the Design of Ontologies Used for Knowledge Sharing", *International Journal Human-Computer Studies* (43)5, pp. 907-928.

Guarino, N. (1998) *Formal Ontology and Information Systems.* International Conference on Formal Ontology in Information Systems, Trento, Italy. pp.3-15.

Guarino, N.; Welty, C. (2002) "Evaluating Ontological Decisions with OntoClean". *Communications of the ACM* (45)2, pp. 61-65.

Hevner, A. R.; March, S.T.; Park, J.; Ram, S. (2004) "Design Science in Information Systems Research", *MIS Quarterly* (28)1, pp. 75-106.

Hirschheim, R.; Klein, H. K. (1989) "Four Paradigms of Information Systems Development", *Communications of the ACM* (32)10, pp. 1199-1216.

Hirschheim, R.; Klein, H.K.; Lyytinen, K. (1995) *Information Systems Development and Data Modeling: Conceptual and Philosophical Foundations.* Cambridge University Press, 1995.

Hume, D. (1740) *A Treatise of Human Nature.* Penguin Books, 1985.

Hume, D. (1758) *An Enquiry concerning Human Understanding.* Oxford University Press, 1999.

Iivari, J. (1991) "A Paradigmatic Analysis of Contemporary Schools of IS Development", *European Journal of Information Systems* (1)4, pp.249-272.

Iivari, J.; Hirschheim, R.; Klein, H. K. (1998) "A Paradigmatic Analysis Contrasting Information Systems Development Approaches and Methodologies", *Information Systems Research* (9)2, pp.164-193.

Iivari, J.; Hirschheim, R.; Klein, H. K. (2000) "A Dynamic Framework for Classifying Information Systems Development Methodologies and Approaches", *Journal of Management Information Systems* (17)3, pp.179-218.

Jackson, M. (1995) *The World and the Machine*. 17th International Conference on Software Engineering, Seatle.

Jacobson, I.; Christerson, M.; Jonsson, P.; Övergaard, G. (1992) *Object-Oriented Software Engineering: A Use Case Driven Approach.* Addison-Wesley, 1995.

Kant, I. (1781) *The Critique of Pure Reason.* Guyer, P. and Wood, A.W., Editors and translators. Cambridge University Press, 1998.

Klein, H. K. (2004) "Seeking the New and the Critical in Critical Realism: deja vu?" *Information and Organization* (14)2, pp.123-144.

Klein, H. K.; Hirschheim, R. (1987) “A Comparative Framework of Data Modelling Paradigms and Approaches”, *The Computer Journal* (30)1, pp.8-15.

Lamsweerde, A. V. (2000) *Formal Specification: A Roadmap. International Conference on Software Engineering,* Limerick, Ireland. pp. 147-159.

Locke, J. (1690) *An Essay Concerning Human Understanding.* Penguin Books, 2004.

Mingers, J. (2002) *Real-izing Information Systems: Critical Realism as an Underpinning Philosophy for Information Systems.* Applegate, L.M., Galliers, R.D., and DeGross, J.I. 23rd International Conference on Information Systems, Barcelona, Spain.

Monod, E. (2004) “Einstein, Heisenberg, Kant: Methodological Distinction and Conditions of Possibilities”, *Information and Organization* (14)2, pp.105-121.

Rumbaugh, J. E.; Blaha, M. R.; Premerlani, W. J.; Eddy, F.; Lorensen, W. (1991) *Object-Oriented Modeling and Design.* Prentice-Hall.

Russell, B. (1912) *The Problems of Philosophy.* Oxford University Press, 1998.

Saiedian, H. (1996) “An Invitation to Formal Methods”, *IEEE Computer* (29)4, pp.16-17.

Shannon, C.E. (1948) “A Mathematical Theory of Communication”. In: Sloane, N. J. A.; Wyner, A. D. (eds). Claude Shannon Collected Papers. IEEE Press 1993. pp. 5-83.

Smith, A. D. (2003) *Husserl and the Cartesian Meditations.* Routledge.

Smith, B.; Welty, C. (2001) *FOIS Introduction. Ontology: Towards a New Synthesis.* 2nd International Conference on Formal Ontology in Information Systems, Ogunquit, Maine, USA. pp.iii-ix.

Stamper, R. (1998) "A dissenting position". In: Falkenberg, E. D.; Hesse, W.; Lindgreen, P.; Nilsson, B.; Oei, J. L. H.; Rolland, C.; Stamper, R.; Assche, F. J. M. V.; Verrijn-Stuart, A. A.; Voss, K. Authors. *A Framework of Information System Concepts* (The FRISCO Report). IFIP 1998. pp. 191-196.

Stamper, R.; Liu, K.; Kolkman, M.; Klarenberg, P.; Slooten, F. V.; Ades, Y.; Slooten, C. V. (1991) "From Database to Normbase", *International Journal of Information Management* (11), pp.67-84.

Verrijn-Stuart, A. A. (2001) Editor. *A Framework of Information System Concepts.* The Revised FRISCO Report (Draft). IFIP; 2001

Wand, Y.; Storey, V.C.; Weber, R. (1999) "An Ontological Analysis of the Relationship Construct in Conceptual Modeling", *ACM Transactions on Database Systems* (24)4, pp.494-528.

Wand, Y.; Weber, R. (1988) *An Ontological Analysis of some Fundamental Information Systems Concepts.* 9th International Conference on Information Systems, Minneapolis, Minesota.

Wand, Y.; Weber, R. (1990) "An Ontological Model of an Information System" *IEEE Transactions on Software Engineering* (16)11, pp.1282-1292.

Wand, Y.; Weber, R. (2002) "Research Commentary: Information Systems and Conceptual Modeling --A Research Agenda", *Information Systems Research* (13)4, pp.377-388.

Weber, R. (1996) “Are Attributes Entities? A Study of Database Designers' Memory Structures”, *Information Systems Research* (7)2, pp.137-162.

Weber, R. (1997) *The Link Between Data Modeling Approaches and Philosophical Assumptions: A Critique.* Indianapolis, Indiana.

Weber, R. (2003) “Editor's Comments: Still Desperately Seeking the IT Artifact”, *MIS Quarterly* (27)2, pp.iii-xi.

Zave, P. (1996) “Formal Methods are Research, not Development”. *IEEE Computer* (29)4, pp.26-27.

Zave, P.; Jackson, M. (1997) “Four Dark Corners of Requirements Engineering”, *ACM Transactions on Software Engineering and Methodology* (6)1, pp.1-30.