On the Shortage of Engineering in Recent Information Systems Research

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Abstract

In this paper we argue that the so-called 'positivism'-versus-'interpretivism' conflict raised by some constructivist, postmodernist, relativist philosophers and methodologists in information systems research is merely a pseudo problem which has no basis in reality. This pseudo problem of so-called 'positivism' versus 'interpretivism' only distracts from the genuine problem of the information systems discipline, namely the design and construction of reliable devices from reasonable specifications, for well-defined purposes, on the basis of scientifically acceptable principles. In contrast to those relativist 'philosophies' we show that information systems research actually belongs to the domain of engineering which already has its time-tested methodology and epistemology, including a trinity of scientific-nomothetic, hermeneutic-idiographic, as well as pragmatic-normative elements. By accepting fact that information systems research is a specific instance of engineering research, which also includes (and has always included) the un-quantifiable 'human dimension', a number of fruitless debates can be terminated for the sake of genuine progress in information systems' theory, design and deployment.

Keywords

Information systems research as engineering research, Philosophy and methodology of engineering.

INTRODUCTION AND MOTIVATION

"The motor-car of today is the result of all the objections that were made against the motor-car of 1910"
– José Ortega y Gasset, 1930.

"Informatics must become a field of exceptional character at a new abstract level; the graduate of this curriculum must be a scientist of a class which has not existed until now: he must be an engineer by education and by mentality, but he must construct abstract objects which so far had been studied by mathematicians only. Mathematicians, however, study abstract objects for quite different purposes and in a different frame of mind"
– Heinz Zemanek, 1972.

Definitions

An *information system* is a hybrid human/task/technics-system for the acquisition, production, storage and usage of information (including communication) for the purpose of satisfying some users' information demand (Heinrich 1999). Thereby, *information* is understood as action-guiding knowledge about past, present or future states of reality, or events in reality, particularly in the context of commercial enterprises or administrative organisations (Heinrich 1999); the concept of information in this field is thus strongly related to the world of human life and must therefore not be conflated with the abstract technical notion of information (quantified in the unit of Bit) as in Shannon's mathematical information theory. *Human* is understood specifically as the bearer of some task within such an organisation (Heinrich 1999). *Task* is understood as one of the organisational or business processes to be supported by such an information system (Heinrich 1999). *Technics* (not to be confused with technology) is understood as the means, methods and devices by which such a system is materially implemented (Heinrich 1999). Examples of information systems cover a wide spectrum of possibilities, ranging

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from simple data bases installed in isolation on an individual computer to enterprise-wide network systems such as the company Oracle's *PeopleSoft* system, also artificial-intelligence-supported expert systems, etc. A finer classification of the various types of information systems can be found in (Heinrich 1999), too.

Information systems research is thus the (partly academic, partly industrial) discipline about how to conceive, to design, and to implement information systems in the best possible manner, concerning qualities such as availability, usability, efficiency, and the like (Heinrich et al. 1999). Thereby, to the extent that information systems are technically implemented as *software* systems, *software engineering* –which has its own science-philosophical and methodological problems itself (Gruner 2010; Gruner 2011; Northover et al. 2008)– can be regarded as one part of information systems research. To the extent that information systems, as defined above, find their specific place in socio-economic environments, questions related to the human disciplines of *psychology*, *sociology*, *cultural geography* and *economics* must *also* be taken into consideration by the discipline of information systems research (Heinrich et al. 1999).

What we have here called 'information systems research' is by-and-large the same as what is elsewhere called '*business informatics*' (Heinrich et al. 1999). Accordingly, business informatics studies information systems and information infrastructures in business enterprises and administrative organisations. Moreover, business informatics attempts at *explaining* such systems by means of developing a *theory* of information systems with the goal of being able to *forecast* their behaviour (Heinrich et al. 1999). Due to its above-mentioned *cross-disciplinary character* business informatics has also been classified as a so-called '*integration discipline*' (Heinrich et al. 1999), from which a number of science-methodological problems arise. Though by-and-large classifiable as '*real*' science (empirical), it also contains elements of a 'formal' science (rational-mathematical) (Heinrich et al. 1999). Though embedded into the social- and economy-sciences, strong influences upon business informatics from the field of *engineering* may not be ignored (Heinrich et al. 1999). From a methodological point of view, this twofold heritage results in a peculiar *mixture of sociological and engineering research* methods (Heinrich et al. 1999). This combination also characterises the discipline as an '*applied*' science, in contrast to a 'pure' science (such as, for example, theoretical astrophysics). As far as information systems rely on abstract *models* of socio-economical realities, on the basis of which an information system's data bases are structured and organised (Heinrich 1999), many science-philosophical questions and problems concerning models and modelling (Kreisel 1980; Stachowiak 1994) are relevant in and for business informatics as well. An overview of the *historical development* of the field of information systems research is given in (Hirschheim et al. 2012).

The discipline of IS often also identified as 'information technology' (IT) in the broadest sense. Such popular conflation of terms is (strictly speaking) wrong, because 'information technology' is (strictly speaking) a branch of electrical and electronic engineering – namely the branch that provides the physical knowledge and electrical apparatus for signal transmission (including network infrastructures, high-frequency antennae, etc.) and data storage devices (which are simply taken for granted at the level of information systems research). This notion of 'information technology' emerged as the accepted standard notion out of a *conceptual quarrel between business managers and engineers* during the third quarter of the 20th century (Kline 2006).

In summary: *Information systems* (IS) are socio-technical systems involving computer applications with software specifically in the domain of commercial enterprises or public administration. *Information systems research*, elsewhere also called business informatics, is the hybrid, socio-technical, academic and industrial discipline concerned with the theory and practice as well as the design, construction and deployment of information systems. Information systems research and *information technology*, though often conflated in colloquial language, are (strictly speaking) *not* the same. When we refer to 'information systems research' (IS research) in the remainder of this paper, it is this hybrid discipline which we have in mind.

Practical Problems with IS Projects

Over the past two decades the success rate of information systems projects has fluctuated between 30% and 50%, measured by various metrics and authorities (Marnewick 2012). Those success rate figures remained low over long periods of time, despite the effort spent on researching better development methods and finding risk factors for project failure. Similar project failure rates have often been reported in other branches of software engineering, too, which are related to IS research and development (as outlined above). Because of the 'dual nature' of the IS discipline it is difficult to pin-point a centre of responsibility (the software engineering part, or the part of socio-economics) in the case of project failures in this domain. Failure analysis, in such settings, is not an easy task.

Science-Philosophical Quarrels 'behind' the Discipline of IS

Whilst numerous IS projects are ailing and failing in practice, numerous philosophically minded members of the IS community are engaged in ideologically charged methodology-fights and quarrels or '*paradigm wars*' (Gruner

2008) about the correct scientific method for the IS discipline. Unlike in the field of software engineering, in which science-philosophical meta discourses are comparatively sparse (Gruner 2010; Gruner 2011; Northover et al. 2008), the science-philosophical and research-methodological meta discourses about IS research are very dense: see for example the annual *GTM* series of the *International Workshop on Grounded Theory Methods in Information Systems Research*. It seems plausible that IS researchers have 'inherited' those meta-theoretical discourses from their sociological tradition in which socio-philosophical and science-methodological reflections are known since the days of Auguste Comte. Those discourses climaxed in the rather fruitless *Positivismusstreit* of German sociology between the School of Frankfurt and the Critical Rationalists in the third quarter of the 20th century (Adorno et al. 1972). Nowadays a considerable number of meta-theorists of IS research (unlike 'typical' software engineers) are apparently still influenced by various ideas and notions related to the obsolete Positivismusstreit of German sociology. However, whereas the original Positivismusstreit had been fought between two profoundly *modern* philosophical groups, in the IS 'version 2.0' of Positivismusstreit the *so-called* 'positivists' appear now in opposition against *post-modern* ideologies such as socio-constructivism, the so-called 'interpretivism', or other types of relativism: see (Gregg et al. 2001) for comparison – an IS paper which was, unfortunately, also characterised by a gross misunderstanding of what is 'software engineering' in IS, because it did not properly capture the *engineering* in 'software engineering'. Generally it can be said that methodological fights between different 'philosophies' or 'schools' are often (though not always) indicative of the 'youth' or 'pre-paradigmatic immaturity' of an emerging scholarly discipline.

Our Position and Contribution

From a *historic* perspective we note that *positivism* was a phenomenon of the 19th century and does not exist nowadays any more. Already the Viennese Circle in the first half of the 20th century was no longer positivist: its philosophers were *neo*-positivists, with some important differences between them and the ideology of the 19th century. After the collapse of the Viennese Circle in sad historic circumstances, neo-positivism strongly declined as well. With genuine positivists no longer existing in reality, the historically wrong and defamatory misuse of the *word* 'positivist' by members of the School of Frankfurt, for the purpose of ad-hominem attacks against their philosophical opponents, was one of the ugliest characteristics of the notorious Positivismusstreit in German sociology (Adorno et al. 1972). Because those ideologically charged ad-hominem allegations of 'positivism' were historically outdated and had no basis in reality, the Positivismusstreit ended, all-in-all, rather fruitlessly. For this reason we argue that the same old quarrel should better *not* be continued almost half a century later in the contemporary discipline of IS.

Moreover we conjecture that those two issues with contemporary IS research, namely the high failure rates in practical projects and the widespread anti-'positivist' ideology, are non-arbitrarily linked with each other: see for comparison (Snelting 1998), in which an attitude of 'Feyerabendian' relativism in software engineering –also troubled by notorious project failure rates in practice– had been criticized.

After some recapitulation of related work, in which earlier authors have already brought forward their own critique against relativism in IS or other disciplines, we provide several examples of the factual existence of relativism and anti-scientific ideology in the philosophical meta-theory about IS research. Thereafter we, too, criticise such relativist ideology whereby we argue that the *proponents and followers of such ideology deliberately exclude themselves from the community of engineers* to which also the discipline of IS belongs. To offer a viable exit out of the fruitless 'positivism-versus-interpretivism' quarrel in the IS meta-theory, we briefly sketch the main features of a *philosophy and methodology of engineering* on the basis of *Vincenti*, and we conclude that none other than such a type of philosophy is needed to make the IS discipline both science-philosophically sound as well as practically trustworthy and reliable. As a consequence –in the spirit of *Ortega y Gasset*'s above-quoted aphorism (Ortega 1930)– the information systems deployed tomorrow will be the results of all the objections made against the information systems deployed today.

RELATED WORK

The vexing diversity of opinions about reality was the starting point of Socrates' and Plato's philosophising more than 2400 years ago. From their observation of such diversity of opinions, however, Socrates and Plato did not jump to the conclusion that there would have to exist a manifold of realities. Instead, they distinguished conceptually between 'mere opinions' and 'genuine knowledge', and they started a quest for finding genuine knowledge, beyond mere opinions, about reality. Relativists, on the contrary, have jumped to the conclusion that the observable multiplicity of opinions about reality would confirm the existence of a multiplicity of realities as such. This, however, is merely a linguistic confusion in which the meanings of the terms 'reality' and 'opinion about reality' have been conflated.

A strong, discipline-independent critique of relativism has been provided in (Neville 1981) on the basis of linguistic considerations: *Part of the purpose of a public proposal is that, when grasped from the perspective of all the evidence, it will be 'evident' to all inquirers that the subject matter is as proposed. Not to make it* *potentially accessible is to say that the proposal is 'true for those in privileged position X'. This, however, is to change the subject matter of the proposed hypothesis. For 'true for those in privileged position X' means: 'Those in privileged position X consider the proposal true'. The latter clause is not about the subject matter but about those in the privileged position. It is one thing to note that some inquirers do not have access to the evidence: In this case the proposal cannot be asserted as completely true, but only potentially true. It is another thing to assert the proposal to be true for those in a privileged position: This is to change the subject covertly* (Neville 1981). Further consideration along these lines lead to the insight that *stating the theory that truth claims are specific to languages or to traditions presuppose a theory of reference and truth contradicted by the theory asserted* (Neville 1981). In other words: cultural relativism is ultimately inconsistent from a logical point of view.

If the producers of faulty IS installations must appear before a court of justice in case that their product has caused material damage or human injury, they can only defend themselves against their prosecutors by appealing to objective principles. In such cases only hard evidence can be admitted to a legal hearing before a jury or judge can speak out a legally acceptable sentence. On the basis of a number of common features between IS research and Digital Forensics research the following considerations are noteworthy. *Forensic methods have occasionally failed those who were wrongfully convicted on the basis of low-quality evidence. In the past, the absence of strict scientific standards in some forensic practices has caused confusion about the reliability, validity, repeatability and accuracy of the outcomes, especially when the outcomes are presented in court, where the intended audience did not have the technical knowledge to judge the reliability of the presented evidence. Digital forensic scientists and practitioners have a duty to avoid repeating the mistakes of the past by scrutinizing the scientific maturity of their field, and by approaching and conveying evidence accordingly* (Olivier et al. 2013). In such cases we can see clearly how strongly the trust in public justice depends on the trust in the objectivity of science. Such trust, however, *is earned through the successful repeatability of processes, which render consistent, accurate, reliable and valid outcomes* (Olivier et al. 2013). Relativism in such matters would undermine this public trust in justice.

Similar to the 'positivism-versus-interpretivism' quarrel in the meta-theory of IS, there had been strong resistance against the scientification of engineering during the 19th century (Baber 1997). Software engineering, to which the discipline of IS is closely related, is nowadays in a similar situation as classical engineering had been in the 19th century: software engineering's scientification is imminent, too, albeit –again– against considerable resistance from particular groups of antagonists within the discipline. The transition requires that a *suitable culture must be built on and around that technical and scientific basis. Such a culture will be characterized by an engineering mentality, an explicitly felt sense of responsibility on the part of individual practitioners, and commonly employed procedures intended to ensure that human errors do not prevent the potential for error-free designs from being realized. Systematic and reproducible approaches to the verification of designs must be taken. Designs will be independently reviewed against their specifications as well as against other commonly accepted criteria* (Baber 1997).

A wide gap between theory and practice with severe consequences in the IS-related discipline of software engineering had been attributed in (Snelting 1998) to an attitude of *socio-constructivism*,[2] a variant of relativism according to which objective truths are merely social constructs, amongst members of the software engineering community. In that context it was criticized that a large number of papers published in software engineering contained merely 'ideas' without any work towards their empirical validation, upon which it was requested that software engineering should begin to accept the quality standards appropriate to the empirical sciences. According to (Snelting 1998) the shortcomings of constructivism can be revealed logically by applying constructivist ideas onto the theory of constructivism itself (Snelting 1998), similar to the language-logical argument of (Neville 1981).

Because a number of IS researchers seem to put themselves into the same academic category as sociologists or anthropologists, (Orlikowski et al. 2001) started with the *observation that the field of information systems (IS), which is premised on the centrality of information technology in everyday life, has not deeply engaged its core subject matter, the information technology (IT) artefact*. Instead, *IS researchers tend to focus their theoretical attention elsewhere, for example, on the context within which some usually unspecified technology is seen to operate* (Orlikowski et al. 2001). All in all, (Orlikowski et al. 2001) provides an argument against the anti-engineering attitude of *sociologism* in IS, which we criticise in our paper, too.

Compatible with a philosophy of engineering for IS, in favour of which we wrote this paper, (Lee et al. 2009) have argued that 'quantitative' and 'qualitative' research are both valid ways of conducting scientific research in IS, if and as long as they both fit into a unified framework of *logical reasoning*, because in such a framework it

[2] This is *not* to be confused with constructivism *in mathematics*, whereby general existence proofs are not accepted when carried out non-constructively by means of the reductio-ad-absurdum method without any confirming examples.

is possible to formally express the *falsification of hypotheses*. Moreover (Lee et al. 2009) distinguished between 'formative' validity (for ongoing research programmes) and 'summative' validity (for the results thereof), again for both quantitative and non-quantitative research methods, whereby 'summative' validity is connected with systematic *tests* or *experiments*. A few years later, this concept of 'summative validity' in IS research also found its way into the methodological considerations of (Wynn et al. 2012).

The related work samples recapitulated in this section should be regarded as the proverbial 'smoke', which indicates the occurrence of a 'fire'. A few 'flames' of this 'fire' shall be shown in the subsequent section.

SEVERAL EXAMPLES OF RELATIVISM AND SOCIOLOGISM IN THE DISCIPLINE OF IS

Due to page restrictions we cannot discuss in this paper all the subtle variants and variations in the meanings of the terms 'relativism' and 'sociologism'. For the purposes of this paper it is sufficient to understand these terms broadly as indicative of an *anti-engineering attitude* according to which the discipline of IS should be regarded mainly as a branch of the social studies, and/or according to which there are no objective procedures with which to arrive at statements of strong trans-subjective verisimilitude. It is this anti-engineering attitude (shown by example in the following paragraphs) against which we advocate the epistemology and methodology of engineering as the appropriate philosophy for the discipline of IS and its research activities.

In (Walsham 1995a) it was declared that there are three types of realism, namely *'external realism' which considers reality as existing independently of our construction of it, 'internal realism' which views reality-for-us as an inter-subjective construction of the shared human cognitive apparatus, and 'subjective idealism' where everybody is considered to construct his own reality*. Moreover, according to (Walsham 1995a), *the 'usual' ontological stance for an interpretive IS researcher would involve one of the latter two positions, particularly with regard to the human interpretations and meanings associated with computer systems*. The paper was highly influential with more than 2230 citations so far. The same story continued in (Walsham 1995b) according to which *interpretive methods of research adopt the position that our knowledge of reality is a social construction by human actors*, whereby *value-free data cannot be obtained*. Such *'interpretivism'* is opposed to the so-called *'positivism'* wherein *it is assumed that the objective data collected by the researcher can be used to test prior hypotheses or theories*. In other words: 'interpretivism' excludes itself from the realm of science in which all hypotheses must be amenable for confirmation or refutation by empirical or by logical means. Moreover, according to (Walsham 1995b), *the claim that interpretivism is a valid approach to research on IS in organizations has penetrated the mainstream IS community to the extent that it is taken seriously at least in written material which discusses research methodology* – in other words: the damage has indeed been done, and we are not merely discussing an insignificant 'red herring' at this point. Also [Wal95] was highly influential with more than 800 citations so far.

The same topic was picked up again in a much-used IS methodology textbook (Oates 2006), in which we can find that *the shared worldview of those who work in the interpretivist paradigm has the following characteristics. Multiple subjective realities: there is no single version of the truth. What we take to be 'real' or 'knowledge' is a construction of our minds, either individually or in a group*. Moreover, *the scientific method itself is a social construction, developed by a community of researchers over several hundred years as the 'right' way to do research* (Oates 2006) – whereby the word 'right' appeared derogatively between apostrophes, thus diminishing 400 years of scientific achievements, without any explanation about *why* such an allegedly 'merely constructed' method was so useful that it was actually able to survive over several hundred years (without having been given up again as useless after its first few decades). Also (Oates 2006) had considerable influence with more than 400 citations up to now.

More recently (Kroeze 2010) presented for the discipline of IS an enumeration of various features of *postmodernism* and described the typical effects of the rise of postmodernism in IS. According to (Kroeze 2010), *while IS research in the USA tends to be more positivist, believing that there is a single reality and truth, IS research in Europe is more interpretivist, using the point of departure of many realities*. With reference to the above-mentioned book (Oates 2006) it was postulated in (Kroeze 2010) that *interpretive studies try to understand a pluralistic world based on the principle that people assign meanings and values to their unique contexts*, whereby *it should be noted that Oates herself does not typify interpretivism as postmodern, but the following traits clearly point in this direction. The acceptance of the idea of multiple subjective realities and dynamic, socially constructed meaning, e.g. how different IT company cultures experience truth and knowledge and methodologies, is part and parcel of the interpretivist paradigm* (Kroeze 2010).

In (Stahl 2013) we can find an extremist polemic which aims at exorcising even the last few remaining traits of empirism out of the doctrine of 'interpretivism': *using quality criteria of different research streams related to interpretivism, the paper compares the role of empirical data in different types of research accounts with fairy tales* (sic!), noting that *interpretive IS research shares at least as many quality features with fairy tales as with* *positivist narratives*.[3] Moreover, (Stahl 2013) *argues that Walsham's position* –see above: (Walsham 1995a) (Walsham 1995b)–*represents core elements of current interpretive IS research*, some of which *are problematic because they are based on empiricist assumptions that are inconsistent with the philosophical roots of interpretivism* – which itself is inconsistent, by the way, with the official doctrine of pluralism and 'multiple realities' amongst the disciples of postmodernism. All in all, (Stahl 2013) *aims to be contrarian by questioning the foundations of empiricism in interpretivism*, whereby *the argument is that interpretivism renounces the idea of objectivity of research, and reinterprets the act of doing research as the development of useful narratives*. According to this ideology of IS, *researchers are storytellers* (sic!) *who construct arguments to help their audience understand a particular point* (Stahl 2013). Whereas *such a view might be heretical to a traditional objectivist and positivist position, it is consistent with the philosophical tenets of interpretivism* (Stahl 2013) – or, in simpler words: pseudo-science was elevated by (Stahl 2013) to the esteemed status of proper science in a quasi Orwellian 'newspeak' act. Last but not least it is also revealing to look at Table 1 on page 8 of (Stahl 2013) wherein different research paradigms (and fairy tales!) were compared against each other: the engineering of useful and reliable IT devices –i.e.: the most important part and purpose of the IS discipline– was not even mentioned in that table.

In (Koskosas 2013) we can find an overview of various approaches to the recently upcoming topic of information systems' *security* (ISS). In that context (Koskosas 2013) also reported the existence of 'interpretivism', according to which *the interpretivist paradigm approaches do not approach their studies from an objective point of view, but are more concerned with the subjective meaning that people attribute to their social situations*, whereby *they look at the world through 'nominalism'*,[4] *assuming that the world is constructed from names, concepts and labels that are used to structure reality* (Koskosas 2013). Moreover, *interpretive research within the tradition of phenomenology is concerned with the description and analysis of everyday life*, whereby *a phenomenological disposition involves giving up the natural science attitude and its assumptions* (Koskosas 2013) – see, however, (Bochenski 1954) for a more detailed characterisation of the phenomenological method. Thereafter (Koskosas 2013) listed many papers and authors who attempted to introduce such interpretivist, radical 'humanist', as well as radical 'structuralist' paradigms into information systems' security (ISS) – all of them variants of 'sociologism' in the broadest sense of the term.

Most recently also (Tsang 2014) provided a comparative overview of different 'paradigms' co-existing in IS research, whereby the so-called 'positivism', 'interpretivism', as well as critical realism were compared. The explicit differentiation between the so-called 'positivism' and critical realism (i.e.: the train of science-philosophical thought after Popper) is of particular interest at this point, since the School of Frankfurt had falsely conflated critical realism with 'positivism' in the Positivismusstreit of German sociology (Adorno et al. 1972). With regard to interpretivism, (Tsang 2014) asserted its existence in the discipline of IS and explicated that *unlike positivism, interpretivism considers the methods of natural science inadequate for conducting social science research. While the natural sciences seek to explain non-intentional phenomena, the job of the social sciences is to understand intentional phenomena by interpreting the meanings attached to the phenomena by their actors* (Tsang 2014). Moreover, *viewing reality as socially constructed, interpretivists adopt a relativist stance* (Tsang 2014): here is the 'smoking gun' that we were seeking. Also in (Tsang 2014) we can find evidence of the predominance of the old-fashioned and out-dated conflict between the natural-scientific and the sociologist 'paradigms' in IS, though (Tsang 2014) has *not* completely forgotten the engineering aspects in IS research: they were classified in (Tsang 2014) into the critical realist 'paradigm'.

AN EPISTEMOLOGY AND METHODOLOGY OF ENGINEERING FOR THE DISCIPLINE OF IS

IS research is neither pure science, nor philosophy, nor sociology. IS research belongs to the domain of the *applied* sciences which are closely related to the practice of *engineering* as well as the *engineering sciences* which support the practice of engineering theoretically and systematically. We conjecture that the ideological doctrines of relativism in the discipline of IS can only lead the community of IS researchers into a cul-de-sac in which *technical* improvements and innovations do no longer have any philosophical or methodological foundations, and in which the technical qualities of IT devices, including their possibly dangerous mal-functioning, cannot be reliably assessed beyond merely conventional 'I like' or 'I dislike' opinions any more. Standing on such an unstable philosophical basis, IT practitioners could never achieve the trustworthy status of 'certified professionals' by any serious chamber of commerce, and would also not be able to defend themselves before a court of justice in case that anything goes wrong with their devices. Still we believe –somewhat optimistically– that even the ideologically most hard-boiled interpretivist-relativist-culturalist IS 'philosopher'

[3] '*narrative*' ≈ 'tale' or 'story'

[4] The meaning of the term '*nominalism*' in that reference is *not* the same as the historic meaning of 'nominalism' in the context of the metaphysical dispute about the existence or non-existence of universals as ontic entities since the medieval-scholastic philosophy up to Quine.

would eventually wake up from his *dogmatic slumber* (Kant), if he would notice one morning that a mal-functioning banking software system would have irreversibly emptied his bank account via the internet, such that our multiple-realities relativist would now be penniless and would have to queue up at his municipality's social welfare office to obtain his daily bread without being able to construct for himself an alternative 'subjective reality' in which the IT system error did not happen and in which he still has got some money in his bank account. We do not doubt that in such an extreme situation even the most radical multiple-realities-relativist would be begin to agree that such a mal-functioning banking information system would have been *badly engineered*.

A Brief Sketch of Engineering according to Vincenti

From a number of historical *case studies* involving pilots (i.e.: humans), their aeroplanes (i.e.: devices), as well as device-*qualities which are hard to quantify* (e.g.: fly-ability) in (Vincenti 1990), the following seven steps of a general engineering workflow can be extracted. It is easy to see that these seven steps *include, comprise and combine* features which postmodernist IS philosophers had hitherto contrasted as so-called 'positivist', respectively 'interpretivist', against each other – now they are integrated into one and the same methodological framework which *differs* from the 'pure' scientific method in a number of points (Vincenti 1990):

1. The engineer *familiarises himself* with the given situation and recognises a problem.
2. The engineer *identifies* the basic 'variables' of the problem (which are amenable for modification in search for optimisation), and *derives* analytical concepts (models) as well as assessment criteria for them.
3. The engineer *develops* suitable means of instrumentation and techniques of measurement and system-manipulation.
4. The engineer *communicates* with the users in order to assess their opinion about the qualities of the implemented devices.
5. The engineer *combines* results and insights from steps 1-4 into a practice-oriented research project on the given matter.
6. The engineer *measures* relevant characteristics, whereby the choice of measurements is also informed by the criteria of above.
7. The engineer *assesses* all results from steps 1-6 to arrive at a well-grounded and implementable specification for the design and production of new devices.

In this scheme of engineering, communicative interaction with the users shall ensure that the to-be-engineered devices meet their *purposes*, whereas objective measurements and tests shall ensure that the to-be-engineered devices are reliable, trustworthy, and technically sound. Following such a professional method accurately to the best of knowledge, available in the *standardised engineering handbooks*, the engineer can also defend himself effectively in front of a court of justice if any unforeseeable technical accident with his devices is happening.

Within an engineering workflow on the basis of (Vincenti 1990) as outlined above, a number of *epistemic categories* and knowledge-producing activities can be identified, inluding:

- *design concepts,*
- *models* and *theories*,
- *practical considerations* and *human purposes*,
- *instruments* and *quantitative data*,
- *science-to-application transfer,*
- *explorative* as well as *hypothesis-testing experimentation*,
- *invention* and *innovation,*
- industrial *production*.

In this multi-dimensional epistemic field, the engineer's knowledge is partly *descriptive* (objective), partly *prescriptive* (normative) and partly also *tacit* (including personal experiences, spontaneous intuitions, as well as the proverbial 'secrets of the trade' which are never made explicit and which are hard to quantify). The engineer's knowledge is thus *partly idiographic* (i.e.: similar to the hermeneutical concepts of 'understanding' in the humanities) as well as *partly nomothetic* (i.e.: similar to the law-like concepts of 'explanation' in the natural sciences), whereby particular features of *crafts* (pre-scientific) and *science* (theoretical) are combined in practice.

The considerations of (Vincenti 1990) are consistent with the 'classical' demarcation between science and technology provided by (Arageorgis et al. 1989), whilst the latest fancy-fashion of the so-called 'design science' (Alturki et al. 1972) merely attaches a modish new label to well-established technical or engineering activities,[5] and is thus covered by (Vincenti 1990), too.

Relevance and Implications of Vincenti for the Software- and Information Systems Producing Disciplines

Amongst several others it was particularly Maibaum who has made insights from (Vincenti 1990) fruitful for the family of software-producing disciplines to which IS belongs. Out of Maibaum's many publications to this end, (Maibaum 2000) was chosen as the main basis for our concluding arguments – though very similar considerations were expressed independently of (Vincenti 1990) and (Maibaum 2000) also in the German *informatics* community (Broy et al. 1999), which is deeply rooted in the long and rich tradition of German engineering, and in which the IS-related development and operation of *large systems of digital information processing and communication* has been classified into the category of 'systems and software engineering' on the social premises that 'information' is nowadays regarded as a commercially and economically relevant 'resource' or 'ware' (Broy et al. 1999).

An important consequence from (Vincenti 1990) is a conceptual distinction between 'normal' and 'radical' engineering on the one hand, and a related distinction between 'devices' and 'systems' on the other hand. In terms of (Maibaum 2000), *a device is an entity the design principles of which are well defined, well structured, and subject to normal design principles. A system, the subject of radical design, is an assembly of devices brought together for a collective purpose in such a manner that it is not amenable for normal design. In software, examples of 'devices' include compilers, operating systems, or relational data bases, whereas air traffic control systems or mobile telephone networks could be mentioned as examples of 'systems'. As the engineering discipline progresses, 'systems' can become 'devices' when their design attains the status of being 'normal', i.e.: the level of creativity required in their design becomes one of textbook-based choices, based on standard definitions and professionally agreed criteria.* In other words: whereas science progressively seeks 'revolutions' for the sake of radically new knowledge, engineering conservatively seeks 'standardisation' for the sake of reliable and predictable success in practice. Such standardisation, however, can only be achieved through *specialisation and differentiation into well-understood domains and sub-domains* – in the field of applied IS for example: the public-health-domain, the E-commerce domain, the E-learning domain, etc. Neither software engineering nor IS have yet achieved this much-needed sub-domain-specialisation. As a direct consequence of this lack, the typical development processes in almost all SE/IS projects are still chaotic, error-prone, and hampered by ignorance. (For comparison the reader may imagine a technical environment in which we had only some unspecific 'hardware engineering' without any sub-domain specialisation into civil engineering, railway engineering, electrical engineering, or chemical engineering, in which the steady evolution and small-step-improvement of devices is now a matter of course.)

According to (Maibaum 2000) the terminology of software engineering is characterised by a number of '*-ility*' words –for example: '*reliability*'– which typically belong to a class of end-user-oriented, informal or semi-scientific concepts *which bedevil the subject* itself as well as the lawyers when terms and conditions of contracts between customer and provider are at stake. Not particularly interesting from the perspective of 'pure' science – see for example Dijkstra's famous distinction between correctness problems and mere 'pleasantness problems' in (Dijkstra 1986)– those '*-ility*' properties are, though *hard to quantify*, at the heart of engineering praxis in the day-to-day activities of normal design. *The problem with those '-ilities' is that they are dispositions, i.e.: theoretical properties that are not immediately observable though they have, ultimately, observational consequences. Many and varied and specialised in-the-small-theories to support engineering-design are thus needed, particularly for representing the '-ility' properties in a systematic manner.* As far as the theoretical or intellectual 'tools' from (Vincenti 1990) are concerned, a better general understanding of the *principles of modularity and decomposition* is particularly needed for all software-producing disciplines (Maibaum 2000) (because modularity is the only feasible way of coping with the confusing complexity of very large information systems), as well as useful *data-collections* (handbook-style) from past observations onto which future design-decisions can be based with high confidence.

Those readers, who are familiar with the out-dated 'positivism-versus-interpretivism' quarrel in the meta-IS discourse, will have noticed that the so-called 'positivism' and 'interpretivism' are so tightly interwoven that they

[5] Is the so-called '*design science*' a science about how to design something? – then it is an engineering science. Is 'design science' a science which *uses designs or designed things* for the purpose of achieving knowledge or other goals? – then it is no different from the majority of sciences which are already known to us since the end of the Middle Ages.

cannot be separated from each other in a methodological framework of proper engineering. *For example*: whilst it might well be up to interpretation how much *mean time between failures* (MTBF) ought to be allowed for an information system to be still regarded as 'reliable' in a particular social context of usage (e.g.: in a digital library, or in e-commerce), there is no more room for interpretation as soon as an empirical test has objectively revealed that two failures have occurred at times t and t', with $|t' - t| < |\mathrm{MTBF}|$. In such a case, the information system under observation *must* be regarded as unreliable.

CONCLUSION

In this paper we have shown that the so-called 'positivism-versus-interpretivism' quarrel, which had been unnecessarily made up by various socio-constructivist postmodernists in the discipline of IS, is actually a pseudo-problem. We have dissolved this pseudo-problem by showing that (and how) *IS research belongs to the domain of engineering* (Broy et al. 1999) which already possesses its firmly established methodology and epistemology (Vincenti 1990). This engineering methodology and epistemology combines a trinity of scientific-*nomothetic*, hermeneutic-*idiographic*, as well as pragmatic-*normative* features, in which the fruitless 'positivism-interpretivism'-opposition is dissolved. From the fact that we can recognise various aspects of reality (when beheld from various points) we *cannot* infer the existence of a multiplicity of 'realities'. As far as the discipline of IS is concerned, which is dedicated to the science-based engineering (i.e.: design and installation) of inter-subjectively *trustworthy* and objectively *reliable* information systems (devices), *the following three law-like constraints prohibit any further speculations* about IS research being an instance of 'story-telling' (or any other pseudo-scientific absurdities):

1. It is *impossible* to construct any 'reality' in which the operations of computer-based information systems do not need energy.
2. It is *impossible* to construct any 'reality' in which the point-to-point transmission of information through a lossy channel (such as the internet) is not limited by Shannon's channel capacity theorem.
3. It is *impossible* to construct any 'reality' in which the halting problem of Turing machines is decidable.

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