Naturalistic Inquiry and Requirements Engineering: Reconciling Their Theoretical Foundations

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Abstract

A growing awareness of the need to take into account social and contextual factors requirements engineering (RE) has led to expanded use of naturalistic inquiry (NI) methods, such as ethnography, for capturing relevant data. There is little debate about the potential value of NI to the development of systems; however, most previous discussions have emphasized practical techniques and benefits. Less attention has been given to the ontological and epistemological commitments that a naturalistic research paradigm assume and the extent to which these assumptions conflict with those that pervade RE practice. In this paper we present the axioms that NI. In each case we address both the points of agreement and tension that arise when these axioms are compared with the implicit assumptions upon which RE practice and research methods are based. We illustrate the discussion with specific examples from published sources and our experience.

Keywords: *ethnography, naturalistic inquiry, qualitative methods, design*

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In recent years, requirements engineering (RE) has witnessed a growing appreciation for and expanded use of naturalistic inquiry (NI) in requirements capture and systems design. We are using the term *naturalistic inquiry* here to refer to a suite of research methodologies which utilize the data collection techniques of participant observation, respondent interviewing, artifact collection and the generation of field notes. These techniques derive from two traditions: the anthropological tradition of ethnography and the more recent sociological tradition of ethnomethodology. Both are concerned overall with discovering the meanings and tacit understandings that participants in social contexts negotiate and derive from interactions with the artifacts and other participants there. Using these types of data during design may lead to a system to which people can adapt and be productive when the system is installed, thereby increasing the likelihood that it will be used effectively.

The cases of an air-traffic control (ATC) system and the London Underground Control Room system illustrate how using ethnographic methods can inform both original and adaptive design. In the ATC system, the design for a computer-based air-traffic control system was improved on the discovery of the controllers' practice of using paper flight strips as representational space for communication and for planning flight paths [17]. In the case of the London Underground Control Room system, ethnography was used to assess the use of a new complex computerized system complemented by an extensively modernized work space [10]. This study revealed how the new system interfered with established practices of information gathering, distribution and coordination of action among control room members. In this light, a redesign of the system was proposed to support how personnel make use of a paper timetable for communication and coordination. In both cases, NI was able to unearth the "native" uses of essential representational artifacts, the meanings and uses ascribed to them, and their function in a larger activity. Ignoring these in systems design can significantly decrease efficiency in an already stressful work environment.

Although there has been great interest in the techniques and benefits of undertaking NI, little attention has been given to the ontological and epistemological commitments that a such a research paradigm assume, and less still on the extent to which these assumptions conflict with those that pervade RE practice. The traditional RE research paradigm, in common with most engineering research and practice, is founded on the philosophical tradition of positivism, which construes knowledge as accruing through the systematic observation of stable and knowable phenomena. Such a world view is consistent with the objectives of RE, because the activity of capturing requirements assumes that stable and specifiable phenomena are out there in the customer's world available for discovery through surveys, interviews, the close reading of informal requirements documentation, participant design, modeling and even ethnographic techniques.

Requirements engineers are no more or less naive in their positivism than any other technical professionals. What happens, we claim, is that requirements engineers, being members of the culture of science, often fall back on and operate from a *tacit* positivism during RE. That modern philosophers of science and those scientists working in frontier areas of natural science repudiate naive positivism is beside the point; the point is that tacit positivism is generally a useful everyday epistemology (much more so than agonizing over the foundations of knowledge), because it is compatible with the need to capture and tie down clear-cut features that can be modeled and turned into artifacts.

As laid out by Lincoln and Guba [9], the axiomatic assumptions of NI contrast markedly with the tacit axioms of naive positivism and do not align with conventional RE practice. This means that RE practitioners who seek to adopt NI techniques cannot continue to operate within a positivistic perspective without at least making their tacit positivism explicit and therefore open to criticism and change. Lincoln and Guba's axioms can be restated as follows: (1) Identifying cause from effect is impossible because all entities simultaneously shape each other; (2) Knowledge can only be described idiographically as a working hypothesis that describes an individual case; (3) The inquirer and the phenomena under inquiry interact and influence each other, so they are inseparable; (4) Reality consists of multiple constructed realities that can be understood to some extent but cannot be predicted or controlled; and (5) All inquiry is value-laden.

In the next section of this paper, we discuss these five axioms in greater detail, contrasting them with their corresponding positivist assumptions. In doing so, we elucidate the points of agreement or tension that arise when these sets of implicit assumptions are set side by side. Our main emphasis is to show the consequences of questioning the tacit positivism of RE practice and replacing them with corresponding NI axioms. We then reexamine these correspondences as they apply to RE research. We conclude by considering the implications of the ontological and epistemological underpinnings of NI for RE practice and research and what it would mean to reconcile the apparent conflicts.

1. Axioms of NI as they apply to RE practice

1.1 Mutual influence and RE practice

> *Positivist view:* Most actions can be explained as the result of a cause.

> *Naturalist view:* Identifying cause from effect is impossible because all entities simultaneously shape each other

In NI, Lincoln and Guba claim, the bifurcation of events into causes and effects must be replaced by networks of mutual influence. This axiom is the most innocuous of Lincoln and Guba's challenges to customary RE practice (though not, as we shall see, to RE research). Constructing elaborate causal models is not generally important in RE practice; it is more valuable to understand relationships that exist between elements of the problem domain than to develop causal models of how things work. It is also widely understood that introducing a new system always changes the organization in which it is embedded; thus, the requirements for the system and its context of use continually shape each other as they evolve. As Dahlbom and Mathiassen [4] put it, system development is a dialectical process:

> The result of an intervention process is not a computer system representing the solution to a specified problem. A systems development project results in a changed organization. The best we can say is that a new situation has emerged. The best we can hope for is that more useful and effective procedures and tools for information processing have been introduced. The situation is different, and gradually new problems and conflicts will appear. [p. 120].

Thus RE practice enjoys the maturity of accepting that systems designed to meet requirements inevitably change those requirements.

1.2 Idiographic knowledge and RE practice

> *Positivistic view:* Inquiry aims to develop a nomothetic body of knowledge in the form of generalizations that are "true" and will hold for other times and places.

> *Naturalistic view:* Knowledge can only be described idiographically as a working hypothesis that describes an individual case

Most RE practice embodies *abstractionism* [], the doctrine that simplified models can capture the essence of application domains and systems. Abstractionism stems directly from the positivist approach to knowledge, in which only testable and generalizable claims are held to be worth making. Such claims are law-summarizing or *nomothetic*; they stand apart from and above the context in which they are made.

Thus, one could imagine developing a domain model of scheduling, in which abstract object classes, operations and rules that are relevant to scheduling were described generally. This domain model could then be reused, specialized, instantiated, or customized for a range of specific contexts, such as the specification of a meeting scheduler or an elevator scheduler. Or, one could write a number of specific scenarios with the intention of generalizing them into an "as-is" model of current scheduling behaviors or a "to-be" model of requirements for a scheduling support system [15]. In the abstractionist framework, descriptions of the particular are useful only to the extent to which they illuminate and help produce a description of the general.

Abstractionism does not require, of course, that every abstraction is universally applicable. The range of cases over which an abstraction is useful always depends on context. It is possible, for example, that the abstractionist might find elevator schedulers and meeting schedulers to have too little in common (perhaps because of fundamental differences among the things being scheduled or the processes involved in making scheduling decisions) to justify a common abstract model. However, more restricted nomothetic claims could still be made: for example, all meeting schedulers might have enough in common to be describable using the same basic abstractions.

An alternative design philosophy, *contextualism* [15], claims that the richness of a system's contexts of use is more important to its being understood than is an abstract model and, indeed, that it is impossible to stand apart from and above the contexts in which one operates. Context-bound knowledge is *idiographic*. According to contextualism, idiographic knowledge so dominates the inquiry situation that nomothetic abstractions tell us little and create an illusory sense of understanding, explanation, and control. Thus, a contextualist analysis of meeting scheduling might conclude that the practices of meeting scheduling in different organizations differed so much from each other that the tasks were fundamentally different and no common model of meeting scheduling could work across them all. To try to unify the scheduling practices that appear in different contexts into a family of policy abstractions of universal applicability is a quixotic quest, and the resulting abstractions will so oversimplify the domain of discourse that any system on which such a model is based would be doomed to ineffectiveness. Either the context-bound users of this general system would reject it, or they would have to develop workarounds to cope with its inflexibility, or they would have to change their behaviors to accommodate the system.

1.3 Perturbation and intervention in RE practice

Positivistic view: The inquirer and the object of inquiry are separate, discrete entities.

Naturalistic view: The inquirer and the object of inquiry interact and influence each other, so they are inseparable.

In the scientific study of most physical phenomena (other than the exotica of quantum theory) the investigator and the phenomenon investigated are treated separately. The phenomenon under study is assumed not to be perturbed by the act of studying it. If such a perturbation is possible, experimental conditions are set up in which the perturbation is eradicated or minimized. In particular, instruments are used to gather data in such a way that the investigator does not contaminate the data.

In contrast to the typical situation in the physical sciences, but in common with the well-known Hawthorne effect in social investigations, the setting for a system is very often changed by the very act of being analyzed. In RE, artificial instruments (such as surveys) are seldom used as systematically as they are in the social sciences. The requirements engineer therefore becomes a "human instrument," in that all requirements are gathered and assimilated through him or her. This has two consequences: the requirements engineer's values directly influence the way in which the system requirements are elaborated (a point to which we will return when considering Axiom 5); and the RE effort frequently becomes the focal point of power struggles within the organization, struggles which do not overlay the RE effort so much as define it. In this case, the perceived role and trustworthiness of the requirements engineer will strongly affect the types of information that he or she obtains [4].

1.4 Negotiated realities and RE practice

Positivist view: A single reality exists that is can be empirically observed, fragmented into variables and processes, predicted and controlled.

Naturalist view: Reality consists of multiple constructed realities that can be understood to some extent but cannot be predicted or controlled.

The existence and unity of physical reality is one of the most tenaciously held assumptions of tacit positivism. In everyday life, the world that we describe is the "real" world that exists equally for everyone. Thus, the fact that the world is not flat is not a matter of opinion that is true for some people but not for others. Not surprisingly, RE theoreticians and practitioners hold this tacit assumption

too, and demonstrate their belief in it by their choice of methods and terminology. For example, the environment in which a system is to operate is assumed really to exist and to be unambiguously describable (albeit with considerable effort) in models and specifications. Although a model necessarily simplifies some aspects of reality while preserving others more faithfully, and although different models may capture some stakeholders' issues or perspectives better than others, RE practitioners do not habitually question the assumption that these different models are models of the same underlying phenomena and that the phenomena exist independently of the act of modeling them.

> The essence of this kind of model is twofold. First, there is some description that applies both to the machine and to the reality it models, and captures what they have in common. Second, there is a correspondence between individuals in the machine and individuals in the reality. [8]

In many RE situations, such as those involving the monitoring and control of physical processes, the positivist assumption of naive realism can and should be made without problems. For example, the relationship between the levels of the rods in a nuclear reactor and the temperature of the core may be characterized precisely in mathematical formulae, and there is no practical need to question the assumptions that the rods and core really have certain properties, that these properties exist in certain relationships to each other, and that if the control system actuates changes in the height of the rods the core will respond in predictable ways. A control system embodies (or even is) a model of these phenomena and correspondences.

However, most systems (and, for that matter, most science and everyday thinking) depend on categories that exist only because of negotiated social processes of definition and designation. To say that a meeting scheduling system responds to meeting requests by executing certain scheduling and message-sending operations sounds similar to saying that a process control system responds to temperature fluctuations by actuating control rod movements, but the two cases are very different. The designation "meeting request" is much more obviously socially constructed than "temperature fluctuation". An e-mail message or telephone call only becomes a meeting request when it is understood to be one. Unlike the temperature fluctuation, the reality of meeting scheduling is *constitutive*: it is the describing of an act as an invitation that makes it one.

A recent example of the constitutive nature of a system's environment is provided by Sachs [16], who describes the development of a problem reporting system, TTS, in a telephone company. Management's goals were that the system would support troubleshooting and scheduling of maintenance tasks. An abstractionist perspective would hold that as far as the TTS requirements are concerned, only these activities were relevant. A contextualist analysis of the work practices within the organization showed, however, that many apparently off-task conversations between more and less experienced workers served a vital learning and mentoring role. When TTS was introduced, this function was lost because casual conversations were replaced by task-focused electronic messages.

It is usually possible with the benefit of hindsight to fix an abstractionist analysis of a problem so that insights gained from contextualist investigations seem to get taken into account. Thus, an abstractionist could propose fixing the TTS model to preserve the mentoring function of the original work practices by allowing more experienced users to send instructional messages to their less experienced colleagues. Such a hypothetical function would make explicit many of the normally tacit conventions of discourse. For example, an old hand would now have to invoke a mentoring dialog explicitly rather than weaving mentoring suggestions into an ongoing discussion. But the interactions among the workers in the pre-TTS environment, in common with interactions in most collaborative situations, were constitutive, and were inherently not specifiable or classifiable in advance. A conversation in the TTS environment can be classified as an act of mentoring only through the joint interpretation of the participants once the conversation is underway, and this is unlikely to be its only function. Workers in the original troubleshooting environment probably found such fluid instructional conversations gratifying in a way that explicit, decontextualized messages could never be.

One specific consequence of the socially constructed nature of reality for requirements and design specifications is that phenomena should be multiply describable and should be able to migrate from one description to another. In most modeling languages, a given object must be classified permanently because the reality being modeled is assumed to be fixed in structure. For example, a meeting request could not suddenly "become" an instruction. Similarly, in the TTS described by Sachs a trouble report could not suddenly become or be viewed as an opportunity for learning.

Some RE investigators are beginning to focus on these issues by emphasizing the coexistence and resolution of multiple viewpoints on business processes, entities or objectives and to propose new RE techniques that take multiple viewpoints into account [1][5]. However this line of research assumes that a common stable reality exists beneath these views, a reality that can be modeled

and confirmed by an enlightened stakeholder. According to social constructionism, however, it is meaningless to talk about such things as business processes as if they exist apart from the activities of enacting and talking about them. Business processes do not exist in businesses, but in the interpretation of business actions. They are constitutive.

1.5 Value-laden inquiry and RE practice

> *Positivist view:* Inquiry is value-free and maintained as such through use of objective methodology.
>
> *Naturalist view:* All inquiry is value-laden

Values lurk behind most investigations. The positivist response is to strive to purify all inquiry to eradicate the investigator's values. According to NI, however, values cannot be left behind. Rather, the naturalistic investigator is responsible for identifying the values that affect the findings of the study and continue to be aware of them during analysis. This is why many ethnographers keep two kinds of field notes: a first set of notes that record the observations that the ethnographer made about the setting or the responses of informants during interviews, and a second set of notes that record the ethnographer's impressions about the fieldwork experience itself. This second form of notes is increasingly finding its way into print as a legitimate result of the fieldwork experience. [11].

Lincoln and Guba [9] identify several kinds of values that affect the conduct of the inquiry. The most obvious and problematic way in which values affect the process is when there is obvious value resonance or value dissonance between the investigator and the other stakeholders. In interventionist settings, such as RE, some stakeholders' interests are often served by a proposed intervention whereas others are threatened.

In standard RE the customer authority is usually taken to be the organization's management, and in business process reengineering (BPR), in which the system is part of a broader effort to redesign business activities to meet management's objectives, the organizational objectives may conflict with the requirements engineer's values. Even if there is no conflict, it is important that the stakeholders are as explicit as the political situation in the organization permits about the values to be achieved by the project. For example, most BPR projects have as their goal improvements in the efficiency, throughput or customer-perceived quality of some value-producing process, goals which could conflict with others (such as the desire of some users or management for autonomy over their work).

There are two contrasting temptations here, most dramatically illustrated by two contrasting approaches to reflecting social and contextual factors in RE. The first temptation is for the requirements engineer to adopt unthinkingly management's goals because of the contractual nature of the relationship between the requirements engineer and management. The values to be promoted by the RE activity are usually the values of those who are paying for it. Occasionally the requirements engineer will be asked to reveal sources of information that were ostensibly confidential, or one stakeholder (often management) has a hidden agenda (often reduction in staffing) that is not to be revealed to other stakeholders during the RE process.

A countervailing temptation is to adopt the value system of the group of stakeholders with whom one is most in contact. In anthropology, this is known rather disparagingly as "going native," and it is most likely to occur in RE when a requirements engineer has a long-lasting and rich involvement in one community of stakeholders. This is most likely to be the case when doing workplace ethnography or facilitating a participatory design project, because in both situations the requirements engineer is closely involved with the work as seen from the perspective of one community of stakeholders. It is inevitable that some of how these stakeholders see their work will rub off on the requirements engineer.

Designers and requirements engineers are sometimes viewed as passive conduits of requirements information rather than stakeholders in their own right. This, however, is a simplistic view that has been replaced in analogous disciplines in the social sciences. Failing to reflect on one's own values can affect a requirements effort, usually detrimentally. A resonant example of a failure of a design team to reflect on what they were learning about the user community of their system is reported by Markus and Keil

[12] in their study of an expert system that they call CONFIG. This system grew out of a research project into knowledge-based system design, and the application was selected largely to impress company management with the relevance of the technology to the company's objectives. However, the specific context in which CONFIG was used, computer sales, imposed demands on the functionality of CONFIG that its designers steadfastly rejected over a period spanning several years:

> The developers of CONFIG didn't build what the users said they wanted; its intended users repeatedly made it clear that they wanted CONFIG to be integrated with PQS [a mainframe-based pricing quotation system], but the developers rejected this request. The developers cited technical concerns, but it may be more accurate to say that they could

not see the value in the users' request because it conflicted with their own preferred design concept - of CONFIG as a stand-alone system. [p.23].

A second intrusion of values into the investigation identified by Lincoln and Guba is the paradigm adopted by the investigator. In the case of RE, there are different paradigms for conducting RE that reflect alternative views of what the process is and what its goals are. Some of these paradigms assume tacitly a commitment to a value system, whereas others do so more explicitly. The conventional, contractual model, for example, views RE as a means of clarifying the requirements of a single, privileged group of stakeholders to whom the requirements engineer has a contractual obligation. The nature and force of this obligation is usually accepted implicitly. Soft systems methodology [3] views any planning and design project as serving the needs of several categories of stakeholders who must be distinguished carefully from the outset: the customer (or ultimate beneficiary), the owner (contractual sponsor or party who can declare the project a success or failure), and the actors (end-users and direct consumers of the system's results). Participatory design, on the other hand, reflects a strong ideology that end-users should be involved in the design of the system, not just because the system will be more effective by management yardsticks but also because it is morally right for them to participate in design.

The point here is not so much that different paradigms assume different value systems, and still less that some value systems are superior to others, but that the requirements engineer adopting one of these paradigms and using it effectively necessarily adopts some of its value system too. It is impractical, for instance, to adopt participatory design practices purely as technique without a commensurate adoption of the values of workplace democracy that underpin them.

A third form of value-ladenness is the influence of the substantive theory adopted by the investigator. In the case of RE, this amounts to the ontology underpinning the requirements method being used. For example, object-oriented and structured methods assume completely different perspectives on what a system is. When adopting an object-oriented method, the requirements engineer (who is a human instrument) is more finely tuned to pick up information about the structure of the task domain than the function or purpose of what happens there. A requirements engineer adopting a structured method, on the other hand, is more finely tuned to information about processes, steps and events, and less attuned to the structure of information. (To a child with a hammer, everything is a nail.) It may seem to stretch the meaning of the word "value" to regard as values the core ontological foci of object-oriented or structured methods, but these ontological emphases dictate how the requirements engineer interprets the context and what is worth giving attention.

2. Axioms of NI applied to RE research

RE research exhibits the same telltale signs of tacit positivism as RE practice. Next, we go through Lincoln and Guba's axioms once more, this time attending to the research implications.

2.1 Mutual influence in RE research

It is common to encounter to encounter claims in the RE research literature that an intervention (such as the adoption of an RE method) will cause improvements in productivity or quality. Thus the nature of the project and the initial result of the intervention are pretended not to affect significantly the intervention itself.

One consequence of this asymmetry in the research community's view of cause and effect is that empirical research that seeks to show the influence of a method on an outcome measure is more often valued as "research" in comparison with accounts of how experience with a method shapes subsequent applications of it, accounts that are marginalized often as "experience reports" or lessons learned during technology transfer. The first is allegedly principled scholarship, whereas the second is mere process improvement. Our view is that research goals and results shape each other much more directly than the pure cause-effect dichotomy implies and that valuable innovations can only come from tight intertwining of theory and practice, inquiry and interpretation [13].

Investigators in analogous fields see this intertwining as both inevitable and desirable. In qualitative social research, such as ethnography such intertwining goes by the name of "grounded theory" [6], theory that arises from and is shaped by a close interpretation of early findings in a study rather than by a fixed theoretical framework or set of hypotheses that the investigator adopts before the investigation starts and adheres to throughout. In the application of qualitative methods to organizational objectives, it is known as "action research" [3], a style of inquiry that deliberately mixes research and invention and involves organizational members as participants in and shapers of the research objectives.

2.2 Idiographic knowledge in RE research

Abstractionism is strongly advocated in RE research. The entire basis of methodological research and tool construction is predicated on the belief that what is good for one system is good for many (if not all). Very few proposed RE techniques, methods or tools are ever

described as being restricted to a small subset of RE contexts.

The reflective case study summarizes the idiographic knowledge gained from investigating a single use context and/or intervention in detail. Unlike the controlled experiment or the supposedly general RE method, which rest on the ability to generalize to multiple cases, the case study resides mainly at the level of idiographic knowledge.

2.3 Perturbation and intervention in RE research

The breakdown of the requirements engineer's neutrality is acknowledged and embraced in the Industry-as-Laboratory [13] and action research [3] paradigms of inquiry. In contrast to positivistic research, in which a phenomenon is assumed to be stable and is controlled as far as possible during the time span of the investigation; in action research, the investigator's interventions are driven by the evolution of his or her grounded theories.

Incremental intervention of this kind can be criticized on the grounds that failing to hold a phenomenon constant while a case study unfolds makes it impossible to generalize from the case study to other situations in which the phenomenon is of interest. However, it is unrealistic to try to apply the standards of quantitative, experimental science to most studies of interventions in RE projects. For the experimental situation to be interesting, it must be realistic. But no two real projects are similar enough ever to rule out the interpretation that it is differences among the contexts themselves, not the intervention being studied, that is the possible source of any differences in outcome. Moreover, stakeholders in a real project have personal and political interests in the outcome of the project and cannot therefore be treated like guinea pigs. They may demand that interventions be made or stopped when they judge them to be effective or harmful. The inevitability of these demands makes a controlled experiment almost impossible to carry out.

2.4 Negotiated realities in RE research

The implications of this axiom to RE research are also far-ranging. The RE literature is replete with claims about the reality of system development that should better be seen as claims about continually negotiated social agreements. Consider, for example, the concept of requirements "ambiguity." It is usually considered good to specify requirements unambiguously where unambiguity is defined by the IEEE Standard (830-1984) as:

> An SRS [software requirements specification] is unambiguous if - and only if - it has only one interpretation. [7]

Tacit positivism leads to the assumption that ambiguity inheres in a requirement and can therefore be engineered into a new specification language, rather than being a process of negotiated interpretation involving the writers and readers of a requirement. Designers of requirements specification languages typically take it for granted that ambiguity (in common with other desirable and undesirable features of a specification) is "out there" in a definitive semantic definition of the language. A reader or writer can only use the language correctly or incorrectly. According to the NI tradition, however, semantics of languages are created and resolved during events of language use, and a language designer's intended meaning or the formal semantics embedded in language support tools cannot claim absolute definitiveness. If all the consumers of a requirement interpret a requirement identically, it is unambiguous; if they interpret it differently, it is ambiguous. This suggests that RE research should investigate the interpretation and use of specification languages rather more, and investigate the formal properties of such languages rather less.

Similarly, requirements engineers are often encouraged to identify the "real" customers for a system, even though, in the case of packaged software, customers may be defined by the post-delivery act of buying the system, not by any pre-development agreement. For example, some recent empirical work [2] studied the process of conceptual design in a telecommunications development project. The project in question was a middleware platform on which future applications were to be built. Because it was removed from the concerns of application users, this project was hampered by not clearly identifying who the customers were, and the project team converged only very slowly on a vision of the product's requirements. It was inevitable that the definition of who the customers were should have evolved slowly during a process of discussion and negotiation. Searching for the "real" customers is futile when customers are created by the system and the system has not yet been created itself. Thus the emphasis of some RE research should move from the elicitation of requirements from customers, to the discovery and invention of features that will later be judged useful. (Such a shift would make RE research look more like design research.)

2.5 Value-laden inquiry in RE research

In RE research, different stakeholders, including the research investigators themselves, their peers, the reviewers of publications, funding agencies and potential adopters of research innovations conspire unconsciously to make RE seem to be a value-free pursuit. The usual way to judge whether a piece of research is good is to compare

it with the model of the physical sciences, a comparison that relies on a set of values derived from positivism. Soundness, repeatability, formal rigor and value-independence are values, and, like all values are open to question.

It is legitimate to worry that replacing or weakening the acceptance of these values might lead to research in which anything goes, in which casual interpretations of unverifiable data are presented as findings. Lincoln and Guba [9] address the issue of research trustworthiness in great detail, both undermining the purported trustworthiness of positivism-inspired values in the social sciences and discussing in detail practices that increase the trustworthiness of naturalistic research. There is no reason why similar practices could not be adopted in RE.

3. Implications

The previous discussion sets forth the challenges posed to RE by the epistemological and ontological foundations of NI. Clearly there are some correspondences where unproblematic alignment is possible, but there are more conflicts where alignment of any kind seems impossible. In this section, we concentrate on those themes that apparently make impossible any reconciliation of tacit positivism and NI. Accepting that the two approaches are irreconcilable would mean that they could not coexist effectively and that the RE community must repudiate one or the other (almost certainly NI). We contend that to sweep away the challenges that the axioms of a naturalistic research paradigm raise is to miss an important opportunity to rethink the whole enterprise of RE.

We frame this discussion around Table 1, which articulates the *Uncommitted,* or what might called "weak" view of RE, and the *Committed* or "strong" view. We use these terms to refer to either a willingness or reluctance to embrace the epistemological and ontological groundings of naturalistic inquiry and the resulting outcomes for RE.

The Uncommitted view construes NI as just another set of techniques that provide data unobtainable through other methods. Here the axioms convenient to the RE enterprise are brought on board while those raising challenges are jettisoned. Requirements engineers who use naturalistic data collection techniques but fail to embrace the axioms of NI gloss multiple realities as either customer fickleness or user inarticulateness. Moreover those ungeneralizable constitutive processes are nothing more than elusive causal chains merely needing to be tracked down and subordinated to the RE process. Overall, in the Uncommitted view, the enterprise still must pre-specify conditions as though such things were stable and to build systems based on those conditions.

The Committed view accepts the five axioms as fundamental to the RE enterprise. In this view, data

Table 1: Contrasts between the uncommitted (weak) and committed (strong) views of the role of NI in RE

Uncommitted (weak) View	Committed (strong) View
Axioms taken as practical warnings for RE technique	Axioms taken as fundamental to RE enterprise
Use ethnography and other qualitative methods because work processes can be richer than they look. The resulting system will be fitter for its purpose.	Human activity is inherently flexible and adaptive rather than rule-governed and pre-planned. A system based on abstract process models will be unsatisfactory.
Customers are fickle, so nail down as many requirements as feasible in advance and plan for change.	Intervening in an organization by introducing a system always changes the organization, surfaces , some contradictions between its objectives, and leads to new system requirements.
The information that customers tell you depends on how you ask for it and whose interests they think you are furthering.	Organizations' processes and requirements are constructed and modified by the act of reflecting about them.
To-be supported processes are difficult to elucidate. The RE has to manage the negotiation among multiple views.	To-be supported processes are constitutive. They only exist through an activity of negotiation.
Multiple models are necessary to describe the system to different stakeholders. It is important to be aware of organizational politics and cut through it to the customer's rational requirements.	System development is always value-driven. Conflict among stakeholders is inevitable. The RE also promotes values.

collection, contexts, requirements, and design must be understood differently. There is no reality out there to specify, only multiple constructed realities. Stable processes cannot be captured because all interactions are constitutive and negotiable. Systems can never be value-free; they are inherently saturated with someone's ideology, theory, past and present. Relevance is prized in place of the spurious sense that phenomena can be generalized and controlled. Such a paradigm shift means that the bedrock of RE must give way to shifting and unpredictable sands, a rather unappetizing prospect.

We realize that this Committed view leaves the RE community in a conundrum. If, as most would agree, systems design must be informed by both the technical and social elements, but NI eschews most of the very things that RE seeks to pin down, how can RE and NI be reconciled? If idiographic knowledge obtained during RE practice and research cannot be generalized, how can it then be useful? The key distinction to be made here is between generalizability and transferability [9]. In generalization, investigation of the controlled context gives rise to nomothetic knowledge, which can subsequently be applied to multiple application contexts. The success of this process depends on the abstraction being appropriate (that is, essential information being preserved in the abstraction while only inessential information is lost) and on the abstraction being relevant to the application (that is, the nomothetic knowledge encapsulated in the abstraction being salient to the new context). In transferability, in contrast, there is no abstraction, only a sending and a receiving context. This is much more like using analogies or cases to solve a problem. Whether idiographic knowledge gleaned from an investigation of the sending context can be transferred to the receiving context depends critically on what Lincoln and Guba [p. 124] call "fittingness," that is the degree of congruence between the sending and the receiving contexts. An appreciation of this degree of congruence can only arise from a rich knowledge of both contexts, and not from faith in spuriously general abstraction. Thus transferability sacrifices the largely illusory quality of generality in favor of the more substantive quality of relevance.

The second possible strategy is to trade the notion of isomorphism for "islands of stability". No longer would the aim be to map the "real' world onto a set of requirements devoid of subtle nonspecifiable entities. Rather it would be to search for places where fluid or constitutive activities occur, where negotiated meaning and understanding were arrived at, where the boundaries of varied activity types exist. The "islands" would be the boundaries or frames provided by the continually replayed types of events or activities identified by the respondents. The "seas" would be the large spaces available for constitutive behavior. The Nynex TTS [16] study discussed earlier begins to get at what this would look like. In that case, ethnography identified a sequence of established interactions that the new system by-passed. A reconceived system would provide intentionally seas of meaning-making that supported an already existing set of well-practiced activity types.

Another example is an educational learning environment we are developing at Georgia Tech that scaffolds middle-school students learning to design and learning science through design. From an ethnographic study of undergraduates in mechanical engineering learning design, process elements in a design sequence were identified. Cognitive phases such as problem formulation and understanding, criteria extraction, conceptualization, criteria application and decision-making, and resource gathering, to name a few, were identified. Tools are now being built to support these processes. Case studies of similar design problems and simulation tools will also be available to the teams. However, the function of this learning environment is not to prescribe a fixed route through a design space. Instead it is to support knowledge-building and meaning-making as the design team moves from an imperfect problem statement to a built artifact. When and how students choose to use the suite of tools is not fixed but negotiated as they wrestle with the design. These tools instantiate the frames that constitute complex problem-solving, but within these frames we expect fluid constitutive activity to occur.

Undoubtedly reconciling the foundational differences between RE and NI is problematic in a way that is not true of the incorporation of isolated NI techniques into RE methods. But naturalistic techniques cannot be seen merely as a set of slick tools for better and more sensitive data collection. Naturalistic methods can be valuable in practice, but to deliver this potential, they must be taken with their philosophical baggage intact.

References

[1] Boehm, B. and In, H. "Identifying Quality-Requirement Conflicts." *IEEE Software*, March, 1996. pp. 25-36.

[2] Catledge, L. & Potts, C. "Collaboration during Conceptual Design." *Proc. 2nd Int. Conf. Requirements Engineering*, Colorado Springs, CO, April 15-18, 1996. IEEE Computer Soc. Press, pp. 182-190.

[3] Checkland, P. & Scholes, J. Soft Systems Methodology in Action, Wiley, 1990

[4] Dahlbom, B. and L. Mathiassen, *Computers in Context: The Philosophy and Practice of Systems Design*, NCC Blackwell, 1993.

[5] Easterbrook, S. and Nuseibeh, B., "Managing Inconsistencies in an Evolving Specification." *Proc. RE'95: 2nd Int. Symp. Requirements Engineering*. York, UK, March 27-29, 1995. IEEE Computer Soc. Press, pp.48-55.

[6] Glaser, B. & A. Strauss, *The Discovery of Grounded Theory*. Aldine, 1967.

[7] IEEE Guide to Software Requirements Specifications (ANSI/IEEE Std. 830-1984). IEEE Inc., 1984

[8] Jackson, M. A. *Software Requirements and Specifications*, Addison-Wesley, 1995.

[9] Lincoln, Y.S. and Guba, E.G. *Naturalistic Inquiry*, Sage Publications, 1985.

[10] Luff, P., Heath, C. & Greatbatch, D. "Work, Interaction and Technology: The Naturalistic Analysis of Human Conduct and Requirements Analysis," in M. Jirotka & J. Goguen (Eds.) *Requirements Engineering: Social and Technical Issues*, Academic Press, 1994, pp. 259-288.

[11] Malinowski, B. *A Diary in the Strict Sense of the Term*, Harcourt, Brace & World, 1967.

[12] Markus, M.L. and Keil, M. "If We Build It, They Will Come: Designing Information Systems that People Want to Use," *Sloan Management Rev.*, Summer, 1994. pp. 11-25.

[13] Potts, C. "Software Engineering Research Revisited," *IEEE Software*. September, 1993. pp. 19-28.

[14] Potts, C. "Using Schematic Scenarios to Understand User Needs," Proc. DIS'95: Designing Interactive Systems, Ann Arbor, MI, August 23-25, 1995, pp. 247-256.

[15] Potts, C. & I. Hsi, Abstraction and Context in Requirements Engineering: Toward a synthesis, *Annals Software Eng.* (to appear).

[16] Sachs, P. "Transforming Work: Collaboration, Learning, and Design." *Comm. ACM, 38(9)*, September, 1995. pp. 36-45.

[17] Sommerville, I., T. Rodden, P. Sawyer, R. Bentley and M. Twidale, Integrating Ethnography into the Requirements Engineering Process. *Proceedings RE'93: International Symposium on Requirements Engineering*. San Diego, CA: January, 1993. IEEE Computer Society Press

[18] Suchman, L. "Making Work Visible," *Comm. ACM, 38(9)*, September, 1995. pp. 56-64.