Global Software Development: The Next RE Frontier?

Merete Crofts  
*School of Information Systems*  
Deakin University, Victoria, Australia  
merete.crofts@deakin.edu.au

Ross Smith  
*School of Information Systems*  
Deakin University, Victoria, Australia  
ross.smith@deakin.edu.au

Bardo Fraunholz  
*School of Information Systems*  
Deakin University, Victoria, Australia  
bardo.fraunholz@deakin.edu.au

Abstract

Requirements Engineers face an emerging set of challenges, which compound the traditional Requirements Engineering (RE) challenges (stakeholder identification, domain expertise, communication, analytic skills, problem solving, ...) that have arguably still not been fully addressed. This is the challenge of RE in the world of global software development, with requirements teams working in virtual mode (possibly on different continents), with the software having to operate in multiple contexts, addressing the needs of different cultures and legal jurisdictions, and having to build sales in different marketplaces. Further the need arises to specify software that is progressively enhanced through regular releases, rather than the "green field" specification of products.

This theoretical paper introduces these challenges, and presents an initial selection of theoretical models, drawn from many and varied source disciplines, which might be employed to gain insight into various features of RE in support of global software development. To illustrate the potential relevance of this selection of models, a longitudinal case study with a recently identified software developer, to follow the specification and subsequent roll-out of a future release of a software product for sale globally, is introduced. Features of the situation faced by that organisation are highlighted, to illustrate the potential relevance of the diverse models that have been identified.

1. Introduction

Requirements Engineering (RE) has emerged over the last twenty or more years, as a discipline focussed on both understanding and producing tangible improvements to the processes, techniques and tools employed when eliciting, representing and validating user needs for systems to support various organisational objectives (where the concept of organisation is used to represent any collection of purposeful activities). Much has been achieved, with substantial advances in understanding areas such as stakeholder identification, required domain expertise, communication, analytic and problem solving skills etc., although arguably these have still not been fully addressed.

In this paper we argue that there has been, over the last several years, an important shift in the organisational context facing the requirements engineer. This is the challenge of RE in the world of global software development, with requirements teams working in virtual mode (possibly on different continents), with software having to operate in multiple contexts, addressing the needs of different cultures and legal jurisdictions, and having to build sales in different marketplaces. Further the need arises to specify software that is progressively enhanced through regular releases, rather than the "green field" specification of products. In this paper we introduce the challenges this contextual shift places before the RE discipline. To seed this discussion we present an initial selection of theoretical models, drawn from various possible source disciplines, which might offer insight into some aspects of RE in support of global software development.

In Section 2 of this paper we examine the motivation for this emerging stream of RE research. Section 3 then makes the point that research of this type is not currently underpinned by a body of theory reported in the traditional RE literature, but that relevant ideas might be drawn from a number of associated source disciplines. A selection of such possible theory elements is presented. Section 4 then introduces the situation at a case study site, which is to be the focus of a substantial future stream of research. The discussion in Section 4 draws upon this situation to illustrate the possible relevance of the theory elements presented in Section 3. Finally, some specific potential research directions are canvassed in Section 5.
2. Motivation

Information systems developments are notoriously difficult. The ultimate test of a delivered system is arguably how well it represents the stakeholder’s needs and whether it is developed on time and within budget [1-3]. Failure records show that over 30% of projects are cancelled before they are completed [4] and 40% of software developments are never used after completion [5]. Statistics also indicate that on average only 16% of software projects are delivered on time and within budget, and this percentage is substantially less for developments for large organisations [4].

In view of the cost to industry of such failures to meet target, much research has been undertaken to address issues surrounding the prioritisation of requirements (‘triaige’) involving the balancing of features, cost constraints and schedule deadlines [6]. To support such judgements, the focus of research needs to shift to the elicitation processes and to stakeholders. This raises questions concerning stakeholder identification, domain expertise [7] and communication skills [8] on the client side of the project and also questions of the analytical, problem-solving [9, 10, 11] and the communication skills of the engineers on the development side.

The requirements engineer now faces an emerging set of challenges which, it is argued in this paper, compound the RE problems introduced above - problems which still have not been fully addressed. Global software development must not only address the complexity of client and engineering teams communicating, but also the complication of lack of face-to-face discussion [12], time-zone problems [13-15], knowledge management issues [16] and cultural differences [17-20]. Further, analysts are faced with generating not just a single model relevant to a proposed system but rather a model that retains the most desirable system features consistent with the client’s budget and timeline [6]. This preferred model emerges from negotiations, judgements and perceptions involving developers, marketers, and financial directors [21] [22].

Requirements engineering has been the subject of intense research for more than fifteen years but is still characterised as an error-prone activity [23]. Requirements elicitation research has focussed on methods such as facilitated group sessions and workshops, brainstorming, interviews and observations [2, 23, 24]. Although some important models have emerged [16], research into global software development, where stakeholders and developers are typically several steps removed from each other, is still in its infancy. There are few if any workable models and associated theories to help the understanding of the special issues surrounding teams working in this virtual mode.

Contemporary organisations frequently work across international boundaries, with distributed analysis teams collaborating on global releases of software; software that might have a common core but often has special features that are unique to local laws and customs. To build our understanding of the issues, we need to examine how software development teams build and share mental models of problem domains and possible solutions, in particular when working in distributed or virtual environments.

There is some emerging evidence that training in perceptual skills greatly improves decision-making processes [25-27]. However, much of the research into mental model sharing has been conducted in academic situations or laboratory environments. The relevance of behaviours observed in experimental studies, to those of industrial professionals, is questionable [28] [29]. Several authors have questioned a lack of industry based research in the area of global software development [30-33].

To progress our understanding of the problems faced by requirements engineers working in the world of global software development, we suggest that two principles should underpin future work:

1. Researchers must be prepared to draw upon a range of theory sources, drawn from a selection of source disciplines such as team and project management, human learning and knowledge creation, development and sharing of mental models, and associated psychology theories and cultural and sociological understandings; and

2. Researchers must move beyond laboratory settings, and observe and analyse the behaviour of such teams in situ (i.e. in industry).

3. Body of Literature

In the previous section research into present software development practices has been briefly reviewed and some of the issues facing globally distributed software development teams have been introduced. It has been suggested that researchers in such areas must be prepared to draw upon a range of theory sources.

In this section we move to an initial brief investigation of several such domains (Requirements Engineering; Team Thinking; Working Globally; Knowledge Sharing). This choice of domains drawn from the extant literature is by no means complete, but it serves to open up discussion of various areas of theory which we will subsequently bring together for reflection in Section 4 of this paper. These are presented in four subsections, but it is appreciated that these domains are overlapping, extending across wide disciplinary areas.

3.1 Requirements engineering

Requirements engineers determine the specification of a system. At the specification stage the development team builds an understanding of stakeholder needs, following an iterative process of eliciting, analysing,
representing, documenting and validating information [34]. These activities require the analyst, on one hand, to have personal skills in the form of both formal and practical knowledge [35, 36] and on the other, to have interpersonal skills to identify users and other stakeholders, understand their problems or needs and finally to specify a satisfactory system from the obtained material [37]. The dialog between the analyst and stakeholder does not reflect the participants' views but rather helps to develop a concept of perceived reality or mental models of the issues [21]. Systems development is therefore an iterative never-ending learning system very much based on the analyst's and stakeholder's judgements and communication abilities [38].

The most crucial aspect of information systems development is gathering and validating the requirements. This is difficult because requirements come from both technical and social domains. The technical element is fairly straightforward to identify, but how do you capture and validate the requirements of a social domain where values and decision making is embedded in a unique organisational culture? Blyth identifies that the best source of requirements is domain knowledge and that the stakeholders are the holders of domain knowledge. Many of the reported difficulties in requirements analysis are associated with linking problem owners and problem solvers [2, 37, 39]. The initial issue for analysts is therefore to identify the appropriate stakeholders and other parties that may be affected by the proposed developments. Without the support of key decision-makers to approve the developments on one hand and concerned individuals on the other, successful solutions and implementations are in serious doubt. Analysts must also address questions of why and how some information flows are important and meaningful and why a goal is important and from where it originates [7].

Vickers explains that systems analysis should not be seen as a method for solving problems but rather as a means of understanding situations. Once a situation is fully understood, both what can and what needs to be done can become apparent [9]. Systems development rests on analysts' and stakeholders' judgements and communication abilities [38].

3.2 Team thinking

Projects and tasks of significant size are assigned to teams or business consultants because of time and knowledge constraints. The amount of work in the allotted time is greater than one person can possibly achieve and the required knowledge and skills are more than an individual possesses. Further, a wide breadth of knowledge is able to produce higher standards and quality [40].

Each individual analyst will hold their own mental model underpinning their understanding of the required system [41-45] which, during the course of investigation will be synthesised with the mental models of other development team members and stakeholders, progressing to a unified specification/design [27, 46-49]. This process requires that their conceptualisations of both problems and solutions must be, in some sense, compatible [50]. Mental models are able to describe the purpose and form of systems and to explain the functions and states of what the system is doing [51]. Furthermore, analysts are able to run mental models to predict outcomes and future states of a system [52]. These are important mechanisms that underpin the requirements engineering processes.

Over the years, investigation into individual mental model construction has been patchy, at best. The behaviourist movement argues that psychology is a purely objective and experimental branch of natural science, 'the science of behaviour'. Methodologies available to relate emotions or motives however, even for well-trained subjects, are of questionable adequacy [53]. It is generally agreed that research based on linguistic material is far more controllable than empirical research on mental imagery [54]. For example, some interesting investigations have been completed into the functions of an airline crew and pilots, both in flight simulations [55] and in real-time air disasters [25]. And there are now further developments in techniques, methods and the analysis of team mental models which enable more rigorous research into shared mental models [56, 57].

Organisations usually employ teams to increase productivity; however, some say that this increase in cognitive power can lead to a whole that is less than the sum of its parts. Sources of failure in team production include poor communication, inadequate situation assessment and pressures to conform [58]. Walz has found that there are two states where individuals may hamper coalescence of a design. Firstly, if their mental models or goals are too different or incompatible and secondly, if team members have incomplete mental models due to lack of knowledge in the relevant area [50]. Group software design is usually highly complex and time-driven and therefore requires exceptional cooperation and communication between the members.

3.3 Working globally

Studies into global teams focus on the problems of communication across space and time [13, 15, 59], on trust [60, 61] and on culture differences [20]. Global teams use a variety of tools and technologies such as phone, video conferencing, email and groupware [62]. On one hand, the literature argues that working across time zones creates time management problems. A situation, such as waiting for the response to an email becomes very frustrating when taking weekend closure into consideration [30, 62]. On the other hand, some studies have found that teams are able to utilise time differences and technology to hand over development at the end of the working day to the team where the day has just begun, creating round the clock productivity [13, 15].

12.3
Research into the issue of trust describes it in the context of knowledge sharing. Strong ties between employees appear to facilitate knowledge sharing, the link being trust. Trust is of two specific types: benevolence-based; and competence-based. Benevolence-based trust is built on the notion that one person will not intentionally harm the other. Opportunistic or egotistic behaviour, such as manipulation of organisational politics and competitive pursuits of career opportunities, might be considered as abuses of benevolence-based trust [63]. Competence-based trust is important to knowledge sharing because we need to believe that the other person brings adequate and reliable skills and knowledge to a relationship [61, 64, 65]. This is particularly important when working across space and time. Jarvenpaa found that a high level of trust was important to productivity and morale in virtual teams. Her research suggests that some transient teams develop swift trust as a mechanism to enable the members to work more efficiently from the start. There is no time to examine and develop the individuals' feelings and commitment, so team members chose to take skills and dedication for granted [66]. Such teams appear to enjoy high levels of positive feedback and knowledge sharing [60].

Research into the problems of transferring knowledge has discovered that the sharing of simple knowledge in teams that are dispersed and have infrequent interaction (weak ties) is more efficient than in closely related knowledge workers with strong ties. It is therefore thought that effective knowledge sharing depends more on trust than on the links between knowledge workers [61]. It has also been found that knowledge sharing is reciprocal and that valuable global professional networks are formed exercising this practice [67].

Culture might be defined in terms of the degree of shared values and beliefs that the members of a community have in common. It is clear that global cultural differences will influence decision making, knowledge sharing and communication in general but organisational culture is also important. Organisations are intrinsically different; two organisations operating in the same business environment will not necessarily deliver the same end product. Groups of people create a unique set of meanings that are transmitted to new and existing members and enforced by the interactions in performing the daily tasks. These interactions create, modify or sustain the organisational culture. Therefore, some parts of organisational learning are bound to a specific organisation. It is possible to imitate other organisations but it is the collective knowledge that makes the outcome distinctive [68]. Cook and Yanow understand organisational learning to be largely tacit in nature. Processes and procedures are straightforwardly expressed but the ways of doing things are reflected in the storytelling, metaphors and myths much in the same way tribal culture is enforced. Organisational culture therefore influences knowledge creation, distribution and storage in ways that should be identified when examining knowledge related behaviours.

Organisations may have explicit corporate culture and politics, often stated by management through the mission statement and other articulated means. However, the implicit subculture and the hidden assumptions that underpin it, are a great influence on what is perceived as relevant knowledge [69, 70]. Management may, for example promote one type of knowledge sharing behaviour as being desirable but actually reward another by means of promotions [71]. Moreover, people are often not aware that they hold knowledge that is either unique or crucial; it remains tacit but can be conveyed through socialising.

Much of this research is done in academic environments comparing face-to-face communication with technology based situations [28]. However, it is possible to draw a sensible connection between similar themes from the literature that describes global teams working on different product development. For example, useful research has been done on experts working as virtual teams, both in developing solutions to a complex rocket design and also in developing industry technology solutions in general. These studies focused on technology and structure adaptation and extended adaptive structuration theory [28, 72, 73].

### 3.4 Knowledge sharing

The requirements elicitation stage might be considered as a learning and knowledge sharing process. The notion of knowledge sharing and knowledge management has created a great deal of interest during the last decade. Much has been written about the definitions of knowledge types and levels to facilitate knowledge creation, storage and dissemination. Research into organisational behaviour and knowledge management is thought to be important to explain knowledge sharing in team situations.

De Long and Fahey have identified three types of knowledge and explained the tacit degree in each: human knowledge that is manifested in skill and expertise and is both tacit and explicit in nature; social knowledge that exists only in relationships between individuals such as colleagues and social networks and is largely tacit knowledge; and structured knowledge which is embedded in rules, processes and organisational systems and obviously explicitly enforced [70]. Levels of knowledge can be viewed as the process of learning that becomes a person's knowledge, which is then stored as memory and is a reflection of personal wisdom.

Much research is focused on the capacity and limits of the human mind and most researchers agree that learning involves a shift in the mind [74, 75]. A learner's stored understandings and experiences are altered or created and recreated in a continuous process [76, 77]. Learning is therefore about making meaning out of experiences as they present themselves. Many authors subscribe to the notion of learning from
mistakes and that individual and organisational learning can be observed if some change has taken place. In this theory, organisational learning is tied to an increase in performance; we behave more efficiently if we have learned. Further, it is assumed that when an error or failure has been detected, learning goes through an action–failure–feedback–correction cycle [68, 78, 79]. This notion is reflected in Argyris and Schön's well-known double-loop learning system. In a single-feedback loop of learning, errors are detected and corrected but the system does not investigate why the error has occurred.

Hedberg (1981) has explained how humans store experiences for later stimulus-trigger recall at terminal nodes in a list structured long-term memory. In this theory the stimuli will be matched with the appropriate response much as experts in Dreyfus' model of skill acquisition. Expertise is achieved when enough experiences in a variety of situations have been responded to successfully. The expert decomposes classes of situations into subclasses that share the same response. This allows immediate intuitive action to be applied [80]. Levitt and March (1988) have observed that organisational behaviour is based on the routines of matching procedures to situations rather than on calculating choices and secondly, that organisational action is based on past events. Decisions are motivated by interpretations from the past rather than expectations of the future.

Researchers agree on one hand to the cognitive perspective of organisational learning but on the other also recognise that individual learning in organisations relies very much on social interactions and human relationships. Fiol has pointed out that organisational learning is not embedded in any single person but instead entails the ability to share a common understanding. "Collective learning, by definition, encompasses both divergence and convergence of meaning that people assign to their surrounding" [81].

It is generally agreed that knowledge is needed to make informed decisions [82, 83] but residual organisational memory embedded in culture, values, structures and systems can make it difficult for organisations to learn and implement new ventures. The memory of past failures cannot simply be unlearned, especially the cognitive maps that connect organisational outcomes and actions [76, 84]. However, Klein (1986) has found that employees will resist learning that is imposed rather than gained through experience and will return to tried and true methods rather than follow the new instruction [85].

A major barrier to knowledge sharing lies within an organisation's political system - namely interest, conflict and power. An employee's interest is divided between the job or task, career and ambitions and personal life. Conflicts often arise when interests are unbalanced. Organisations openly promote competitive environments between peers to extract that extra mile from employees. Such rivalry can be pitted against teams, divisions and other organisations. The importance of power is increasingly being recognised as a powerful force of control. It guides how, when and to whom information is distributed. The controllers can hoard crucial knowledge so they are perceived by the organisation as either expert or indispensable. This may enhance the individual's promotional possibilities but it is detrimental to the success of Knowledge Management systems [86]. The policies of an organisation are therefore responsible for why some organisations actively learn from their mistakes while others foster an environment where errors are covered up [71]. This is supported by the theory that closely related teams can develop a culture of recycling redundant information whereas knowledge workers with weak ties are able to provide access to unique and new ways to solve problems [87].

A knowledge-sharing environment is not necessarily part of a globally connected community. Successful knowledge transfer appears to be closely related to trust and developments of relationships rather than proximity. However, in complex knowledge transfers and knowledge creation, face-to-face encounters are still considered essential [88, 89].

### 3.5 Theoretical Lenses

The literature examined above, drawn from four associated domains, has served to highlight several matters:

- The extant literature does not address specifically, in any substantial way, requirements engineering as it relates to global software development, although a number of associated issues are addressed.
- Further, there is no explicit body of theory that has been applied directly to requirements engineering as it relates to research into global software development.
- Nevertheless, relevant ideas and theories might be drawn from a number of associated source disciplines, elements of which have been uncovered in the preceding literature review.

To progress this further we turn now to the notion of various viewpoints, or theoretical lenses that might be adopted by researchers into requirements engineering as it applies to global software development. In the next section we examine three such lenses, drawing upon the material above to group various elements of theory that might be relevant to the interpretation of data collected by researchers applying each of those lenses (organisational behaviour; communication; and virtual teams). Of course other lenses/viewpoints might be taken (e.g., a systems view, a socio/political view ...). The three that have been chosen serve to demonstrate how various elements of theory, drawn from a variety of source disciplines, might prove relevant.
4. Theory and Pending Case Study

In Table 1 (next page), we collect the various elements of theory uncovered in the review of literature drawn from the four domains discussed in Section 3, and group them according to various viewpoints that might be taken in future research into RE and global software development. Each element of theory is presented in terms of the body of literature it comes from, the model or theory itself, a brief description of the area of application it might have in RE research, and the key authors.

To provide a context for demonstrating the potential application of each theoretical lens, we now briefly introduce the major characteristics of a case study organisation recently contacted, which is to be the focus of a substantial future stream of research. The discussion in this section draws upon this situation to illustrate the possible relevance of the theory elements.

The full background to the case study organisation is to be the subject of future papers. For present purposes, the following seven characteristics are relevant:

1. The organisation is a large software development firm that is involved in global software development for an international market;
2. The requirements of the primary software product are adapted to suit the specifications of individual organisations and countries;
3. The software is not produced in a green-field situation but is produced according to release rollouts each 12 – 18 months;
4. The requirements specification teams involved are globally distributed and come together to work on specific projects;
5. Product development is distributed across six countries, with Australia being the parent company;
6. The developers have complex communication processes which are, at present, largely mediated electronically; and
7. The specific project in this case study will primarily span two continents: one team in Australia and another in the USA.

4.1 Group 1: Theories of organisational behaviour

Potentially relevant to characteristics 1, 5 and 7 above is the viewpoint we have grouped under "Theories of organisational behaviour", which is focussing on how individuals view themselves, and how they form coalitions within the organisations to which they belong.

According to social identity theory, people have a perception of how they fit into various social categories, such as gender, age, nationality, and organisational membership. People use this categorisation process, both to identify others and to define their own position in a social environment [90]. Social identification may therefore be a useful framework to support building an understanding of the individual and team behaviours that may or may not appear rational to an outsider. Social identity is likely to affect group values, practices and prestige and the influence of competition within and between groups and is therefore also expected to impact the communication and decision making processes of requirements teams [91].

When exploring the processes involved in requirements engineering it is important to focus broadly on the human interactions and relationships and to include the organisational, local and social contexts that might influence communication, such as might arise given characteristics 1, 5 and 7 above.

A key problem area when working in a global setting is potentially in understanding group processes, and in members identifying with teams. This is particularly interesting when considering situations where members come from different cultural and organisational backgrounds. Problems such as hierarchy and the status of teams within an organisation, local and organisational culture, political and legal differences, conflicting goals and performance expectations, communication and problem solving methods, are all areas expected to have important influences on a project.

4.2 Group 2: Source disciplines of requirements elicitation

Potentially relevant to characteristics 2, 3, 4, 5, 6 and 7 above is the viewpoint we have assembled under “Source disciplines of requirements elicitation”, focussing on how individuals share data, ascribe meaning to that data, and solve problems.

Consistent with Vickers’ concept of an appreciative system, it is expected that the communication and problem solving attitudes of a team will be influenced by individual and collective perceived values and beliefs. Vickers explains that reality is perceived selectively and valued judgements are made of the elements in the communication process, depending on life experiences [8].

The problem solving process adopted by a communicating team might be viewed through Simon’s goal seeking model, although elements of Vickers’ relationship maintenance model might offer insight. Vickers’ work questions the goal seeking model of problem solving, replacing it with the notion of relationship maintenance [9].

Communication and problem solving processes are the tools that help analysts build mental models of the requirements domain. As they learn more about the issues they dismiss and add parts to their models, eventually agreeing on a model that appears to best represent the situation to be expressed in the requirements documentation. These issues potentially relate to characteristics 2, 4 and 6.
<table>
<thead>
<tr>
<th>BODY OF LITERATURE</th>
<th>MODEL OR THEORY</th>
<th>AREA OF APPLICATION</th>
<th>KEY AUTHORS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong></td>
<td><strong>Theories of Organisational Behaviour</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Culture Power Politics</td>
<td>• Identity theory</td>
<td>Affects both individual’s satisfaction and effectiveness – deals with issues of cultural identity</td>
<td>Ashford and Mael[90]</td>
</tr>
<tr>
<td></td>
<td>• Focalism &amp; Coalition Formation model</td>
<td>Focusing on how resources and power distribution affect coalition formation</td>
<td>Murningham [92]</td>
</tr>
<tr>
<td><strong>Group 2</strong></td>
<td><strong>Source Disciplines of Requirements Elicitation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Judgement Perception</td>
<td>• Vickers’ Concept of an Appreciative System</td>
<td>Reality is perceived selectively and valued judgements are made of elements in the communication process depending on our life experiences</td>
<td>Checkland and Casar [93]</td>
</tr>
<tr>
<td></td>
<td>• Organisationa</td>
<td>Knowledge Categories and Transformation Processes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Tacit Dimension</td>
<td>Knowledge sharing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Knowledge sharing</td>
<td>Tulving’s Theory of Memory</td>
<td></td>
</tr>
<tr>
<td>Mental Models</td>
<td>• Defining Mental Models</td>
<td>Understanding the concepts</td>
<td>Getner and Stevens; Johnson-Laird[44,45] Rasmussen[96] Cannon-Bowers, Sales and Converse; Converse, Cannon-Bower, Salas; Rouse, Cannon-Bower and Salas[27, 57, 97]</td>
</tr>
<tr>
<td></td>
<td>• Taxonomy of Purposes of Mental Models</td>
<td>Explains the functions of mental models. Explains the evolutionary steps in the requirements specification process May provide an explanation of team performance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Shared Mental Models</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group 3</strong></td>
<td><strong>Theories Pertaining to Virtual Teams</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group development</td>
<td>• Developmental Sequence in Small Groups</td>
<td>The stages of group development may explain behaviour and interactions</td>
<td>Tuckman [98]</td>
</tr>
<tr>
<td></td>
<td>• Periodic Table of Organisational Elements</td>
<td>A practical way of categorising observed elements in a two-dimensional space</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Information Sharing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Transaction Memory</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Group Learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Cognitive Consensus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trust</td>
<td>• Swift Trust</td>
<td>Trust is believed to be an important factor in effective communication &amp; knowledge sharing</td>
<td>Javenpaa [60] Levin [61]</td>
</tr>
<tr>
<td>Interaction</td>
<td>• Distributed Cognition</td>
<td>Understanding human-computer interaction</td>
<td>Holland, Hutchins and Kirsh [105]</td>
</tr>
</tbody>
</table>

Table 1: A classification of theoretical elements potentially relevant to research into RE and global software development
Theories of learning, knowledge sharing and memory may well support understanding of the learning stages analysts go through to collect a sufficient understanding of requirements. For example, some forms of tacit knowledge are not easily shared across space and time, and the sharing of such understandings may well constitute a substantial problem to distributed teams. Concepts such as Polanyi’s tacit dimension, Hedlund’s categorisation, Agris and Schön’s double-loop learning and Tulving’s theory of memory, may well be helpful. Knowledge sharing processes might be understood according to Nonaka’s theory of knowledge sharing and Dixon’s models of sharing of common knowledge.

Finally, the body of theory surrounding mental models includes concepts [45] which might facilitate the understanding of observed phenomenon, the taxonomy of purposes of mental models [96] and the notion of shared mental models [57, 97]. These theories are underpinned by cognitive and in particular distributed cognitive theory. These elements may be particularly important given organisational characteristics 2, 4, 6 and 7.

4.3 Group 3: Theories pertaining to virtual teams

Potentially relevant to characteristics 2-6 above is the viewpoint we have arranged as “Theories pertaining to virtual teams”, focussing on issues of team development and structure when members are distributed, relying upon electronic communication technologies.

The area of team development and structure might well be understood by application of elements of Tuckman’s well-known stages of group development.

Two other models that may be useful to understand and explain a team’s interaction are Lipnack’s and Stamps’ four-dimension model and the periodic table of organisational elements. The four-dimension model explains a team’s ability to consider several viewpoints simultaneously and the periodic table provides a practical way of thinking about elements observed in a two dimensional space, such as a global team. These theories relate to characteristics in the case study identified as 3, 4, 5 and 6.

Various types of trust have been identified in the literature, including swift, benevolent and competence based trust. Swift trust is potentially important to understanding transient teams, such as those identified in organisational characteristic 4 and 6 given that these teams have neither the time nor opportunity to develop benevolent or competence trust in face-to-face meetings.

Information sharing and interaction refers to information already held by team members before discussion begins. It is included here because theory in this area argues that shared information is more likely to enter discussion than new information [100]. In principle, teams produce better decisions by pooling knowledge; however distributed cognition theory suggests that teams promote a rehashing of shared information at the expense of unshared information. Transactive memory [101] is a social relationship phenomenon where people often supplement their own unreliable memory by engaging other people’s opinion, usually experts. This suggests both a convergence of knowledge and the notion of dividing work loads, for example. Further it is expected that group learning theories [102, 106] and cognitive consensus [103, 104] may be able to assist with the understanding of how global teams share knowledge and define and conceptualise key issues. This may be relevant to understanding case study characteristics 2, 3, 4 and 6.

5. Conclusion

In this paper we have argued that Requirements Engineers face an emerging set of challenges, which compound the traditional RE challenges (stakeholder identification, domain expertise, communication, analytic skills, problem solving, ...) that have arguably still not been fully addressed. This is the challenge of RE in the world of global software development, with requirements teams working in virtual mode (possibly on different continents), with the software having to operate in multiple contexts, addressing the needs of different cultures and legal jurisdictions, and having to build sales in different marketplaces.

We have examined the motivation for this emerging stream of RE research, making the point that research of this type is not currently underpinned by a body of theory reported in the traditional RE literature, but that relevant ideas might be drawn from a number of associated source disciplines. A selection of such possible theory elements has been presented. We have introduced the situation at a case study site, which is to be the focus of a substantial research stream, and drawn upon this situation to illustrate possible research viewpoints and the relevance of the theory elements presented.

Each of the viewpoints introduced (organisational behaviour, communication and virtual teams) constitutes a potential stream of future research. It is acknowledged, however, that these viewpoints are not exhaustive, and many other rich viewpoints will undoubtedly emerge as research develops.

The challenges of understanding RE as it relates to the world of global software development offer a rich agenda of future investigation.

Acknowledgement

The authors gratefully acknowledge helpful discussions with Professors Paul Swatman and Peter Juliff.