Interaction Rules and their Role in Collaboration Software.

by

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Statement Of Originality

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Statement Of Co-Authorship

The publications of the work undertaken in the course of this research are the following:

Kildare, RA (2004) Ad-hoc on-line teams as complex systems: agents that cater for team interaction rules. In: *7th Asia-Pacific Conference on Complex Systems*, December 6th-10th, 2004, Cairns, Australia.

· Mr. Robert Kildare (100%) is the primary author. He proposed the initial research question, conducted the research and prepared the material for publication.

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· Mr. Robert Kildare (80%) is the primary author. He proposed the initial research question, conducted the research and prepared the material for publication.

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Statement of Ethical Conduct

The research associated with this thesis abides by the International and Australian codes of human and animal experimentation, the guidelines of the Australian Government's Office of the Gene Technology Regulator and the rulings of the Safety, Ethics and Institutional Biosafety Committees of the University.

Abstract

The need for on-line teamwork has increased - particularly in transnational collaborations and in regional and rural areas, where distance and time prohibit easy face-to-face communication. On-line collaboration, however, exacerbates the forces that cause difficulties in face-to-face teams. This research identified a facility for creating and monitoring rules of interaction as a useful component for supporting virtual collaboration. Investigations in the disciplines of team psychology, sociology, education, computer supported collaborative work and computer supported collaborative learning, contributed to the design of the facility. Its value was examined in real-life venues and by teamwork experts.

Communities build structures devoted to norms of interaction, making these norms overt and regulating interaction. The creation of this social capital is deeply linked to notions of trust, which has been identified as a major contributor to successful virtual teams.

There has been little attention paid to providing software support for the sociological aspects of collaboration. Because (virtual) teams are complex, the patterns of interaction that suit a particular team may or may not be predictable, making the creation of software difficult. The sociology underlying community development and the social psychology of team interaction suggest the need for an interaction rule facility and the principles upon which the design should be based. Interaction rule software would further optimise the performance of virtual teams by nurturing trust and may be of assistance in training potential virtual team members in the behavioural issues of on-line collaboration.

Can we design software to further develop levels of trust in on-line teams by emulating societal structures of behaviour regulation? A prototype was developed and deployed in educational scenarios to explore this question. The implementation of Phreda, an editable interaction rule facility, addressed a major difficulty in current research; the inability to determine which team member behaviours are important and what they signify.

The rule module positively influenced behaviour. Although team members could construct and manipulate rules, they did not do so voluntarily. Indications were that the participating teams were not sufficiently remote, independent and virtual to make full use of the module.

Experts concluded that being involved in Phreda processes would increase member commitment and hence trust. Its effective use should be early in a team's life for team-critical behaviours and involve all members. Recommended rules can be helpful. Team knowledge gained during the process of rule construction, was seen to be more important than the corresponding artefacts. By using the rule module, members would learn what was behaviour was important, (and hence the meanings of the rule artefacts) and gain skills in the process of establishing team norms.

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Chapter 1 Introduction

This research focuses on providing software support for asynchronous on-line teamwork. Given the recent explosion in Internet reach and bandwidth, on-line collaboration has become an increasingly common part of everyday life. On-line teams take advantage of the ability to escape the constraints of time and distance, at the expense of face-to-face contact.

It seems clear that the problems of face-to-face teams are exacerbated by the lack of interpersonal contact to sort out the social issues team members confront. Initial research indicated that two discipline areas were focusing on understanding and enhancing virtual collaboration. This thesis began with a consideration of Computer Supported Collaborative Work (CSCW) and Computer Supported Collaborative Learning (CSCL). Was there something missing from existing collaboration software that might provide a way to support asynchronous teamwork? Further reading about the problems faced by teams delved into the domains of the social psychology of teams, social structures and human learning. The research area that emerged as the starting point for this thesis was a link between trust, central for the optimum performance of teams, and interaction rules, used by social units to codify expected behaviours.

A link has been made between the absence of non-verbal cues in asynchronous teamwork and the effect on trust development. There have been expressions of the need for support for team well-being and there has been some work on trust as a factor central in the performance of teams.

Support for interaction rules expressed in existing software has either not addressed the deeper structural issues of rules generally, focusing on specific process templates, or has been unable to solve the problem of determining which rules are important for a given team. It was found that key sociological, psychological and educational principles should be used in the design of new software.

Virtual teamwork can be seriously handicapped by the difficulty of accessing the non-verbal cues which we use to understand each other. Manninen and Kujanpää (2002) identify these categories of non-verbal information media. A Cisco study (Cisco,2006) reported in the mass media (Bulkley, 2006) links the absence of these cues to the slow development of trust between team members and therefore as a source of sub-optimal performance:

> "…virtual teams can take up to four times longer to build trust than face-to-face teams. If you throw different cultures into the mix, it can take virtual teams up to 17 weeks before they bond and perform as well as a team in one location…" (Bulckley, 2006)

The study goes on to suggest greater integration of chat and video conferencing with current virtual team software and heavy leader intervention for encouraging trust (Cisco, 2006). However, synchronous communications such as chat and video conferences are not always possible and teams do not always have designated leaders.

Face-to-face contact is the vehicle for the resolution of many interpersonal issues. Norms of interaction are established as team members go about their tasks. There is little in the way of collaborative software that tries to accommodate this aspect of teamwork. Attention has been given to facilities in which social activities can take place - creating an environment in which interpersonal norms might develop (Kreijns & Kirschner, 2002). Scripts have also been created specifying behavioural rules for ordering work process interaction such as decision-making (GroupSystems, 2004).

Norms of behaviour are developed to support the team's well-being, as well as that of the individuals in the team, in addition to carrying out the productive functions that bind the team (McGrath, 1991). The norms collectively are like a 'team conscience' and have organisational, community and societal equivalents. Existing software fails to address the more general issues such as the way humans deal with domination, freeloading, and insecurity, focusing rather on specifics such as routines for decision-making.

The absence of 'team conscience' software was evident in the frustrations of a moderator of an on-line forum. She complained of the need to constantly screen posts. She objected to being placed in the position of having to define what behaviour was and was not acceptable and then policing behaviour. She objected to dealing with complaints from participants when they were not prepared to contribute to these definitions (Rosser, 2004). The moderator was forced to exercise policing power when actually interested only in the ideas and the network created by the forum. These complaints reinforced the need for exploring the role of interaction rules as a means of developing trust in on-line team software.

Further exploration of disciplines dealing with computer support for collaboration also pointed to the need for research into the area of interaction support. Work done in the Computer Supported Collaborative Learning (CSCL) research area has identified the need for software tools aimed at improving team member interactions. Such tools are needed to support the survival of the team itself, not just the completion of the task that is the focus of their collaboration. Kreijns and Kirschner (2002) commented on the lack of attention paid to social interactions when they introduced widgets for providing social affordances. Reimann's investigations centred on providing graphical feedback based on "team well-being" polls (Reimann, 2003). More recent work has focused on graphical representations of task engagement that have the potential to hold social implications for the team (Reimann *et al*., 2005).

Mühlenbrock (2000) and Zumbach *et al* (2005) attempt to identify sequences of individual actions that might be interpreted as interactions of a particular type, as do Aviv *et al* (2003) with their notion of "passivity" identified in knowledge sharing behaviour.

While a behaviour or sequence of behaviours might be able to be identified; determining whether this is important for the team and what that behaviour actually means to the team, is an essential prerequisite for the provision of useful team support. This issue of meaning is similar to issues underlying Rosser's frustrations as a human moderator. Members of her group may not have

understood the way that other members interpreted their interactions and why certain behaviours were unacceptable.

Behaviours (actions) leave traces after members have used software resources. Combinations of actions between members of the team are considered to be "interactions" (Mühlenbrock, 2000). It would seem that any action in a shared space that changes the space, is an interaction, because it has an effect on the team members to some extent. Even an action such as downloading a file and reading it or reading the discussion board will have an indirect effect on the team, because it changes the experience of the member and thus the nature of his or her subsequent contributions.

The third motivation for studying interaction rules comes from another multi-disciplinary collaboration domain. Research in the Computer Supported Collaborative Work (CSCW) area is predominantly aimed at optimizing team performance. This presumably results from the strong commercial influence on the notion of "work" – collaborative or otherwise. "Trust" has been identified as a key factor for effective and creative teamwork (Fernández, 2004; Hertel, 2004; Hung *et al*., 2004; Jarvenpaa & Leidner, 1999). Several destructive and supportive behaviours within teams have been identified (Hertel, 2004; Neece, 2004). Teams perform sub-optimally if misunderstandings of meaning or process are evident (Armstrong & Cole, 2002) or if interpersonal conflicts affect team interactions (Crampton, 2002; Yeatts & Hyten, 1998). Trust and risk are linked to the distribution of rewards (in the broadest sense) within a team (McGrath, 1991). Rosser's frustrations revolved around being left with the responsibility for providing security for her team.

While creating a software moderator to replace a human being's role is rather ambitious, some of the human moderation activities of managing the behavioural norms of the virtual organisation can be automated. Monitoring on-line behaviour and, to a lesser extent content, is possible. It is also possible for messages to be sent to those who behave in a defined manner and for other actions to occur (which are within the capability of the machine) such as changing permissions, filtering and sequencing.

In this way the research area resolved into the following. Simply monitoring behaviour should reduce the load on managers, moderators or, in the case of equals, each team member. In addition, having humans involved in the *process* of defining the behaviours and determining the actions and content of any messages should lead to a clarifying of expectations. Participants would then share an understanding of the meaning of the *product*. Divesting much of the policing role to software could reduce the frustration levels experienced by human moderators and improve levels of trust among the participants. Two important matters of perspective are worth noting. Firstly, a lack of face-to-face contact during teamwork can have positive effects. It allows team members to mull over issues and allows individuals to escape peer pressure (perceived or otherwise). Secondly, having facilities for supporting interaction does not necessarily mean that participants will use them. For example participants may not understand the underlying concepts, may not need the support such a facility provides, may not feel that they have the authority to use the facility, or may not know how to use it.

Accordingly this research set out to develop software that provided interaction rule support for ad-hoc virtual teams with independent, leaderless membership,

In order to ascertain the value of the software the following questions were identified (section 4.1):

- Do rules from the software module affect team member behaviour and is that effect constructive?
- For what behaviours will the rule module be suitable, if any?
- Will there be an increase in the levels of trust as a result of the rule module?

The literature review in Chapter 2 explores the theoretical background to team interaction in greater depth, from which design principles for interaction support can be derived. Chapter 3 develops the design, which involves two major components and outlines the implementation of the first of these components; a software moderator. It also explores issues raised in the design that will need to be addressed when constructing the second component. In addition, chapter 3

describes the simple collaborative environment to which this software moderator has been added.

Iterative multiple case studies (Yin, 2003) were used to explore the software in real-life venues. Focus groups (D. L. Morgan, 1997) of teamwork experts were used to further explore the research goals, because they avoided the pitfalls faced in real-life study. Chapter 4 details these methodological issues.

Chapters 5 discusses the findings and Chapter 6 concludes the dissertation by summarising what has been learnt and outlines proposals for further research.

This research contributes an understanding of the importance of overtly specifying interaction rules for on-line teamwork. Given the absence of such a facility from existing software, the research also presents design principles for creating a rule module based upon underlying sociological and psychological principles for learning and social interaction. The principles were implemented in the Phreda prototype and attached to a representative asynchronous collaboration environment.

Chapter 2 Theoretical Background

The goal of designing a module that supports team interaction by monitoring and administering democratically constructed interaction rules is the result of revisiting the social theory underpinning teams and teamwork

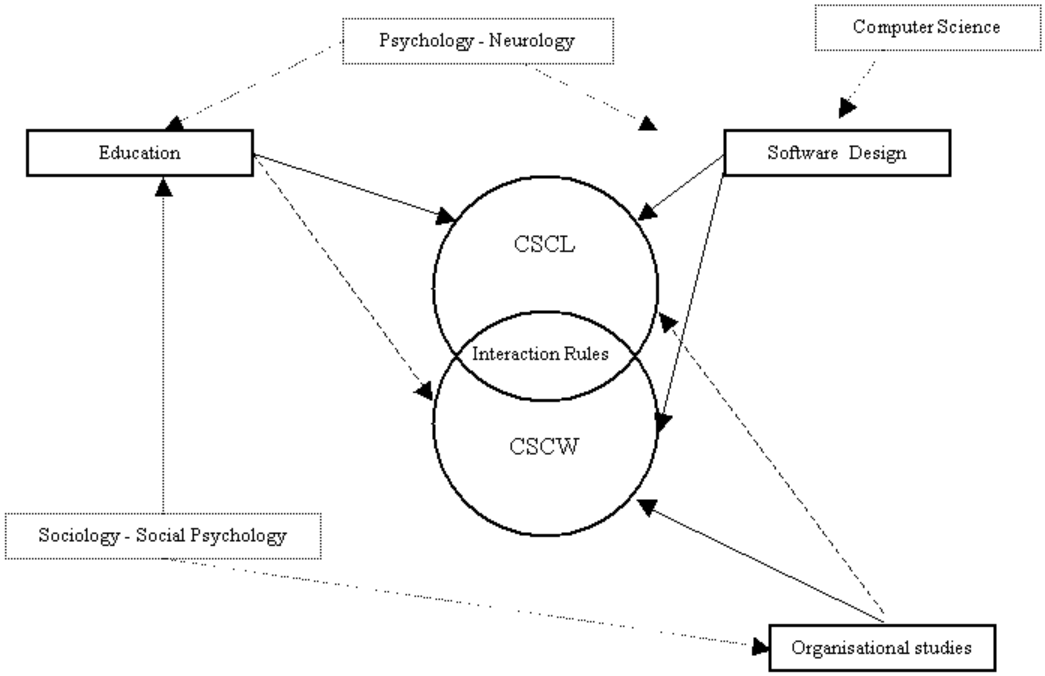

Figure 1. Interactions are mentioned in the studies of many disciplines. In the area of computer-enabled collaboration, the above diagram locates the areas of Computer Supported Collaborative Learning (CSCL) and Work (CSCW) as the disciplines dealing directly with interaction. The two layers of disciplines that inform the immediate areas are also included

The following exploration of team interaction begins by considering a virtual ad-hoc team of independent members who might or might not work together again, as a likely venue for exploring interaction rules. Such a team would work predominantly asynchronously and remotely and would not have a defined leader. Such a team would have to develop its own interaction behaviours rather than rely on them to be provided by an outside institution or an appointed "leader". An example of such a team might be a team of professionals (for example a surgeon,

general practitioner, home nurse, physiotherapist and a builder) working on a particular case or job (a patient needing post surgery rehabilitation and assistance with a disability). Another might be a group of academics from different countries working on a particular project.

McGrath and Tschan (2004) distinguish between a task force, a team and a crew, based on the context that forms the group. A task-force is formed around the needs of a particular task and dissolves when the task is completed. A crew is formed around the functions of a particular tool, such as a yacht with the members having specialised technical tool skills. A team is formed around a particular set of role relationships that may be applied to several tasks, such as a football team. They identify these groups as most vulnerable to changes in the formative period (McGrath & Tschan, 2004).There are problems of mutual exclusivity with these definitions. Take for example a national surf-rescue competition team. They come together from different surf clubs for one contest and then disband. They have some members who use specialised equipment and are therefore crew, task-force and team at once. The main focus of this research is on the teamwork that is generated within the team, whatever the classification of a particular team. Group development is driven by internal forces and is derived from the local dynamics as well as contextual forces (McGrath and Tschan 2004) and it is the development of interaction norms within a team that is the focus of this research. Behavioural norms are common to teams, task forces and crews so the term "team" in this research will be understood to include these three forms.

As will be shown, such an ideal team (a remote group of ad-hoc independent team members), if one does exist, is very hard to find. For the purposes of understanding theory however, such a team provides the smallest unit of analysis which could be used to examine the development of interaction rules.

The literature synthesis starts with an examination of teams, including their general activities and functions, drawing on work from the social psychology discipline. The synthesis then moves to an understanding of interaction; what motivates it and how rules emerge from the interaction. Social structures such as rules are fundamental to sociology. Issues of team complexity are then explored

and shown to be central to the design of a module that allows these rules to develop.

It was anticipated that team members would learn about their team's expectations, about the nature of collaboration and about the task they perform. They would also have to learn how to use the interaction rule module. This learning binds the Computer Supported Collaborative Learning (CSCL) and Computer Supported Collaborative Work (CSCW) disciplines together. We all continue to learn after leaving educational organisations and joining workforce organisations. In both of these organisations, knowledge is developed (discovered, created or constructed), and this includes knowledge about collaboration in teams. The participatory and knowledge acquisition metaphors for learning are explored in this chapter for two reasons. The first is to help understand the learning experiences for team members. The second reason is to inform the design of software that is required to manage knowledge acquisition, construction and retrieval. The construction of team knowledge by a team parallels the academic activities of teaching and research. As has been discussed in the introduction, rules and trust are tightly entwined. Trust is crucial for team members to perform optimally and figures extensively in CSCW research. The relationship between rules and trust, commitment and conflict are explored in section 2.4.

Finally, implications for software design are developed and existing collaboration software is investigated in order to identify the extent to which such design features are already addressed.

2.1 Teams and Team Performance

Virtual teams are a subset of teams encountered in all walks of life; from sports teams to astronauts and nuclear reactor operators. Virtual teams vary along similar dimensions to face-to-face teams, including the tasks they perform, their size, the expertise of the members, the interdependence of the roles fulfilled by the members, the degree to which they are self-managed and the degree to which they operate on-line. The factors that optimize performance are similar to those for face-to-face teams and the issues that handicap performance are also similar.

Wong and Staples in drawing up a list of optimum behaviours for virtual teams reference Cohen's 1994 model of face-to-face team effectiveness (Wong & Staples, 2004). Problems, however, tend to be exacerbated due to the lack of face-to-face communications; a price that must be paid in exchange for escaping the constraints of time and location. For the purposes of this study a team is "virtual" if the predominant medium for interaction on a given task is via the Internet. To understand the particular issues of virtual teams a review of the literature relating to all teams is necessary.

2.1.1 Definition

Traditional team studies (Baker & Salas, 1997) and more recent cross–system analysis (Anderson & Franks, 2004) (comparing definitions from the fields of insect behaviour, robotics theory and human team studies) both concur with the following definition:

A team is two or more individuals with specific (although not fixed) role assignments who must perform specific tasks and must interact or coordinate to achieve a common goal or outcome. The efforts of the team must amount to more than the sum of its parts.

If there is any advantage in using teams, in terms of efficiency, in overcoming lack of ability, improving fault tolerance, or if it is cheaper to use a team of single taskers than pay for a multitasking individual, then the efforts of the team should amount to more than the sum of their parts (Anderson & Franks, 2004). It will be difficult to find a group that does not provide any of these benefits.

There are difficulties in the literature with "teams" and "groups" being used interchangeably. The key difference is that groups are not necessarily tightly bound to a central goal, problem, case or task. "Small groups" or "work groups" are essentially teams if they have such a focus, even if that focus is not stated explicitly (Baker & Salas, 1997). The concept of "Community of Practice" is a broader organisation with a common area of practice rather than a specific task. Such communities often contain teams. The concept of a community of practice is dealt with in section 2.1.3.2.

2.1.2 Operational functions and modes

Because teams are organisations that emerge from a social context and comprise individuals, they automatically become subject to scrutiny by two disciplines; sociology and psychology. In Figure 2 we see a summary of the initial work of social psychologist McGrath, represented by his Time Interaction Performance (TIP) Theory. In TIP theory a group can be seen as moving between 4 stages (or "modes") and, in the process, fulfilling three functions (McGrath, 1991). These functions are further elaborated in work with his two collaborators, Arrow and Behrdal in 2000.

> "All groups have two generic functions (a) to complete group projects and (b) to fulfill member needs. A group's success in fulfilling these two functions or purposes affects the viability and integrity of the group as a system. Thus a third generic group function – (c) to maintain system integrity – emerges from pursuit of the other two and in turn affects the group's ability to complete group projects and fulfill member needs." (Arrow et al., 2000) p. 47

McGrath's modes are similar in nature to the phases of team behaviour commonly found in management texts, for example, Bruce Tuckman's "forming, storming, norming and performing." (Tuckman, 1965) and work by Morgan et al (1993) which sees the activity modes of teams as goal choice, means choice, policy choice, and goal attainment.

McGrath's modes are shown in Figure 2. His first and last modes can be considered as phases of stability – the former, setting up the group, can be regarded as the outcome of some external complex system. The final mode is the mature state of the group where little change occurs to processes. It will produce output that is of value to the external system that enabled the team to form. The notion of stability will be explored further in section 2.2.

MODES	FUNCTIONS		
	Production	**Well-Being**	**Member Support**
Mode I. Inception	Production Demand/ Opportunity	Interaction Demand/ Opportunity	Inclusion Demand/Opportunity
Mode II. Problem Solving	Technical Problem Solving	Role Network Definition	Position/ Status Attainments
Mode III. Conflict Resolution	Policy Conflict Resolution	Power/ Payoff Distribution	Contribution/ Payoff relationships
Mode IV. Execution	Performance	Interaction	Participation

Figure 2. McGrath's analytical framework for team performance. (McGrath, 1991)

Two modes are identified which encapsulate the active formation of both the team and the task processes - the "problem solving mode" and the "conflict resolution mode". McGrath shows that teams continually switch between these modes. They are not sequential and the structures that will be produced are not easily predicted.

McGrath identifies the functions that the team performs for both the team and the members when in this state of process building. The functions identified in his earlier work are consistent with those used in collaboration with Arrow (Arrow et al., 2000) In Figure 2 the "Production" function equates to what in his later work was termed fulfilling the group task function. The "Well-Being" function equates to "maintaining system integrity". The "Member Support" function revolves around satisfying the needs of the individual. These three functions define the main types of interactions It is while a team is in the second and third modes of operation that a set of rules of engagement will emerge.

Before exploring these rules further, it is important to understand what motivates their emergence as many of the problems experienced by teams are rooted here. McGrath's theory mentions status and payoffs. This corresponds to sociologist Max Weber's theory of group formation and closure. Weber explained the motives for nations, communities, groups and associations to form as being the desire for wealth, power and status (Abukuma, 2003; Andreski, 1964). Wealth and status need to be treated carefully as they can include learning (acquiring knowledge which may or may not be a tradable commodity, in this author's view)

and honour (self esteem that may or may not be public esteem, in this author's view). McGrath's second and third modes are specifically associated with the acquisition and distribution of feedback in terms of wealth, power and status. Deciding how to carry out the activities that provide the payoff also occurs during these two modes of activity.

Kreijns and his associates see the rewards of social interaction as central to their domain of on-line delivery of university level education through collaboration (Kreijns & Kirschner, 2002; Kreijns et al., 2003; Kreijns et al., 2007). They base their work on the need for people to belong and the need for recognition from the group to which they belong.

Thus team interaction is based not just around the completion of a task (or solving of a problem), but around the acquisition and distribution of a variety of rewards associated with the task. This necessarily involves looking after the well-being of the team and the individual members.

For the individual there is a tension between competing with fellow members for the rewards acquired by the team and co-operating for the acquisition of those rewards. Every social system must accommodate this tension if it is to survive (Ostrom, 1990). These two forces, essential to ecological sustainability, are explored in game theory (the classic prisoner's dilemma) (Ostrom, 1990) and are exploited in the CBS reality television series "Survivor". Recent studies argue that co-operation and altruism are innate, and that the competitive force for "survival of the fittest" is not the only force basic to survival (Bekoff, 2004).

Rule creation software could assist in maintaining team co-operation by explicitly identifying exploitative behaviours such as domination and freeloading. It could enact consequences that either reward or discourage the behaviours considered important by the team.

2.1.3 Team Context

Teams do not exist in isolation. The definition of a team used in this research describes the points of contact between a team and its context.

A team is two or more individuals with specific (although not fixed) role assignments who must perform specific tasks and must interact or coordinate to achieve a common goal or outcome. The efforts of the team must amount to more than the sum of its parts.

The points of contact between team and context are the task set, the individual members working on the tasks and the outcomes that follow from that teamwork. Usually a team is required to perform a specific task that is assigned from an organisation or a group, either containing or related to the team. Also, the team is comprised of individuals who have complex links to the society beyond the team. The skills and knowledge that each individual bring into the team are a result of their 'outside' experiences. Once the team has performed their task the total of their "efforts" are usually valued and rewarded with externally defined gratifiers.

The social psychology literature has provided a view of the functions that a team fulfils and the way in which they operate. Literature from sociology describes how larger social units in a team's context develop their rules of behaviour. Giddens' concept of structuration outlines how social structures are created, maintained and changed. There is no reason to suppose that teams do not conform to Giddens' concept. His principles inform the manner in which software can facilitate the development of social norms in teams.

2.1.3.1 Structuration

Teams are usually spawned, fractal-like, from a larger organisation, often hierarchic in nature, but not necessarily. The parent organisation could typically be a government department, corporation or educational institution. These organisations are part of a social system that acquires and distributes rewards. The organisations will have evolved their own rules and norms of action and interaction. These norms and rules will influence those of the team. The degree of self-management within a team, for example, is dependent upon the power structures that led to the creation of the team (Yeatts & Hyten, 1998). Communities are more likely to be successful if they find their own local solutions to problems of survival and the consequent distribution of rewards, than

if their patterns of behaviour are prescribed from outside the community (Ostrom, 1990).

Structuration theory explains the mechanism through which rules and norms are created in the organisational parents and, by implication, in the social relations within teams themselves. Anthony Giddens' famous text "The Constitution of Society: Outline of the Theory of Structuration" (Giddens, 1984) has been adopted by Poole and de Sanctis as a means of analysing information systems. Structuration can account for the interplay between people and technology, as well as the less than full predictability of IT use in groups and organizations.

Poole and de Sanctis describe stucturation in their contribution on the appropriation of technology to information systems.

> "Structuration is the process of putting structures into action. Structuration is 'the structuring of social relations across time and space, in virtue of the duality of structure'… [Poole and DeSanctis cite Giddens, 1984.]
>
> "…Giddens uses the verb *structuration* to stress that 'structures are systems of ongoing action, being continuously produced and reproduced through time'. The concept also emphasizes the 'duality of structure: the mutual dependence of structure and agency'. Structuration occurs as actors move to invoke existing structures or to create new ones, *producing* and *reproducing* the structures and the associated social system. Structures include *resources* (command over people or material goods) and *rules* (recipes for action) which operate to provide a social *system* with power (structures of domination), norms/routines (structures of legitimation) and meaning (structures of signification). In this way, the social order of a system is maintained over time (*stability*) and yet has the capacity to adapt (*change*) as actors modify structures in the course of their interactions with one another. The routine of everyday structuration constitutes the social order of a system."[italics: Poole and DeSanctis](Poole & DeSanctis, 2004).

The practices of team members produce patterns of behaviour that can be regarded as the structures of their system. The structures cannot exist without their continued use. Members alone cannot be the source of behavioural norms as the members are shaped by the social context that encompasses them. Poole and DeSanctis (1990) argue that the way technology is used can also be explained using the concept of stucturation.

In the context of virtual teams, a norm of behaviour or routine of interaction adopted by the team would be considered to legitimise an overtly stated recipe (i.e. a rule) for that behaviour. Written social meanings (such as a judgement of consequences for breaking the rule) would be considered a structure of 'signification'. Use and re-use of that rule would reinforce the structure. If the rule became redundant the structure would be dropped and the system would be considered to be adapting to social changes. When a rule of behaviour is legitimised, whoever enforces that rule has been given the authority to do so by the actions of those who established the norm in the first place. If software administered the rule, the software would be seen as having absorbed the power created by the legitimising process rather than making the power available for team members to acquire. The software would then defuse the potential for conflict over any misuse of that power by a team member.

The material from Giddens explains how the structures are formed within a virtual team. The material from Weber and McGrath explains why they are formed. Just what is formed by a virtual team is not yet fully explored. Structures have either tacit or overt meaning for the participants of the team. This meaning is addressed directly by theorists working with the concept of the Community of Practice. Knowledge is considered a by-product of a functioning system.

2.1.3.2 Communities of Practice and Interest

CSCW and CSCL researchers locate their interests primarily in either commercial organizations or learning institutions. Wenger's "Community of Practice" has proved a useful concept in both disciplines. A community of practice is a group of practitioners who share a common domain. Team members could fall into this

definition because they practise on a shared task, but a community of practice is larger than an individual team and not limited to a single task. Wenger considers there to be a hierarchy among the members, with seniority based upon their participation within the community (Wenger, 1998b). Teams with specific tasks are often created within such a community. Gerhard Fischer and his associates extend this notion to include "Communities of Interest" to encompass collaborations where multiple Communities of Practice are represented. These Communities of Interest best describe the type of team with which this investigation commenced - a virtual ad-hoc team of independent members that might or might not work together again, representing multiple practices. Collaboration is seen by Fischer*, et al*, (2005) as an exercise in knowledge management where solutions are found through the design and redesign of knowledge shared between collaborators. (dePaula & Fischer, 2005; Fischer & Ostwald, 2005).

> "…knowledge is regarded as being distributed among stakeholders and artifacts, being enacted while they carry out design activities within communities of practices and/or interests. As such, this framework draws on the concepts of distributed cognition, social networks, and information ecologies….. knowledge is a collaborative by-product of work. By actively participating, stakeholders become 'knowers,' and by collaborating, they construct knowledge….. the design process considers learning as a process of knowledge construction acquired as stakeholders act and improvise while carrying out their activities"(dePaula & Fischer, 2005).

The knowledge by-product of team collaboration is created from the community context each member brings to the collaboration. The flow of knowledge within a team and between the team and its context is an important design consideration for team software. Interfaces, repositories, access and messaging functions must be designed to accommodate the management of knowledge. The knowledge is not just task related, but also related to the other team functions of team well-being and member support and hence to a module for administering interaction rules.

The modes and functions of team behaviour are well defined, as are the nature of any structures created by that behaviour. Team structures and team knowledge are emergent in nature and must go through processes of change and stability, suggesting that virtual teams are likely to be complex systems.

2.2 Complexity

Substantial literature exists on organisations as complex systems (Marion & Bacon, 2000; Ng, 2003) and a significant history of research exists on emergent co-operation (Schweitzer *et al*., 2002). The literature implies that teams should be considered complex systems and team processes regarded as emergent patterns. Any software designed to support team interaction will need to accommodate the issues that follow from the nature of complex systems. It is likely that, as with fractals, teams being the offspring of complex systems, they too will be complex systems (Waldrop, 1992).

Being 'contained' or generated by other complex systems is just one feature of complex systems. They demonstrate non-linear relationships between variables and demonstrate particular phases of behaviour that are subject to the effects of feedback (Waldrop, 1992).

2.2.1 Non-linearity

Toquam et al (1997) identify four sources of variability that present problems when evaluating team performances:

- Member Characteristics – features of the individuals such as dexterity and cognitive skills
- Team Characteristics – features unique to the team such as cohesion, homogeneity, length of shared history and communications structures
- Task Characteristics – features related to the problem to be solved, such as difficulty and complexity
- External Conditions Imposed on the Team

Toquam *et al* (1997) found that team performance could not be linearly predicted when changing task characteristics. Choosing any of the other major 'internal' variables as predictor is likely to have the same effect. For example, one would expect that changes in team characteristics, such as a new member arriving, would influence individual members in different ways. This would have a non-linear effect on team performance. Considering team maturity will further complicate the relationship. As the team matures, processes change and shared knowledge changes.

The third internal variable identified by Toquam and associates is the set of characteristics of each team member. What goes on in the mind of the individual, mediates changes to both task and team characteristics before being translated into team performance(Toquam et al., 1997). McCrone summarized recent research in neurology, memory and learning. The brain is seen as a highly complex system of weighted pathways and interconnections that are activated, refreshed and reorganised according to the experiences of the individual. Included in this summary are findings that suggest mechanisms for why memories change and how learning occurs. What goes in and what comes out of an individual member consequently cannot be directly predicted, since the human 'CPU' changes with input (McCrone, 2003).

These key variables of team performance relate to each other in a non-linear fashion. Similar issues will arise if we look at the external environment providing the conditions imposed on the team. Relations between variables are bound to be non linear.

2.2.2 Feedback

Feedback in complex systems theory is either positive or negative. Negative feedback drives a system toward balance or stability, while positive feedback causes a system to change, possibly to a state of chaos or destruction. The feedback is an external input to the system or can be the result of outcomes within the system, creating what is known as a feedback loop (Waldrop, 1992).

One can reinterpret previous discussions of team behaviour and formation in terms of complex systems theory. The first and last modes of McGrath's model of team activities are not ones where processes and patterns of behaviour are being developed. The first mode encompasses the formation of the group as part of an external complex system, and the last, assuming the team gets that far without imploding, sees the emergent patterns in action. Two modes are identified which encapsulate the active formation of both the team and the task processes - the "problem solving mode" and the "conflict resolution mode". Teams continually switch between these modes. McGrath identifies the functions that the team performs for both the team and the members when in this state of process building. The team constructs policy and mechanisms for the resolution of conflicting ideas related to the task. It also constructs power relationships, roles and payoff structures. The forces for change (positive feedback) could be seen to be the payoff for the performance or perhaps some change in availability or type of resources for their productive enterprise. Changes in these external forces might prompt the emergence of new patterns of behaviour. Patterns of behaviour can also feed back (via a feedback loop) leading to further evolution. The domination of team decision-making by one member, for example, might result in a lack of interaction among the others. The dominator, seeing the lack of performance by other members might then take on a greater role, *possibly* with dire consequences. One of the features of complex systems, is that the shift between constructive patterning and chaos can be precipitated by a very small perturbation (Waldrop, 1992).

The notion of feedback in teams closely resembles that in ecosystems and trading systems. Concepts of co-evolution have been part of complexity studies since the early days of its inception, with simulations such as Conway's Game of Life (Waldrop, 1992) and Brian Arthur's analyses of trading partners (Waldrop, 1992). Issues of co-operation as found in the Prisoner's Dilemma problem have also come under much scrutiny (Waldrop, 1992). More recently attempts to model the nature of symbiosis, competition and the predator-prey relationship have been undertaken (Lopez-Ruiz & Fournier-Prunaret, 2004) and an interesting 5-person team spatial simulation of the Prisoners' Dilemma has been created. (Schweitzer

et al., 2002). A team of two or more shares similarities with a symbiotic arrangement between species, with a granularity closer to a mini-ecosystem as the numbers within the team grow. As with a trading bloc, or any symbiotic relationship, there has to be some payoff for the participants. A small payoff, although sufficient for the participants, may be insufficient to cause change in the system. Too great a payoff may cause a phase of instability in the system itself. If the feedback is not too large, new patterns emerge. Trading partners, while they don't necessarily multiply like ecosystems, do change the patterns of resource use and productivity in response to sufficient positive feedback. Old forms of productive behaviour are destroyed and new patterns emerge (such as new employment, infrastructure and resource usage patterns). These incorporate a variety of different relations with the trading partner(s). Trade agreements formalise the relationships between the parties. Throughout the process of emergence, at the edge of chaos, there is uncertainty as to what patterns will emerge or whether the old patterns will dissolve altogether. Similarly the processes between and within team members are potentially volatile and unpredictable.

The software proposed is intended to implement team interaction rules that are analogous to trade agreements and as such it needs to accommodate unpredictability. If virtual teams are complex systems, then one would expect teams to respond differently to the same set of rules fed back from outside their domain.

Since a virtual team is not set of trading partners, it is important to be clear on how to define team interaction and the rules associated with the team's patterns of interaction.

2.3 Interaction

As discussed in Chapter 1, any action by a virtual team member in a collaboration environment can be considered an interaction. If a member creates a discussion thread, and another responds to that thread, then one can easily identify the two actions as an "interaction"; perhaps even label it "response" or "feedback". If a

member uploads a file and another downloads and reads it, then these two actions are linked, perhaps becoming an "inform" interaction. What if the downloader does not read the file? Such an action could imply absolute trust and be considered a compliment, by the uploader, or the downloader might treat the file as valueless and it could be considered an insult by the uploader.

There are two issues here; firstly, that a lack of action can convey meaning, and is therefore an interaction, despite the absence of a second action and secondly, that there may be more than one meaning for the same behaviour. This research defines asynchronous on-line 'interaction' differently to the typical two-party exchange.

In the case of a virtual team, any attempt to use the (software) tools appropriated by the team for the acquisition and or distribution of team rewards is considered an interaction with the team. An absence of action can be identified by comparing the team actions with those of an individual member.

Simply checking a team calendar has an effect on the team. The member is informed and this has ramifications for the team's performance. Any member action in the collaboration environment is an "interaction" and also an absence of action is an interaction, especially if other members have carried out that action. These actions can be counted.

However, what these measures of action actually mean to the team, is not so easy to pin down, as previously noted in Chapter 1. Complexity of teams is at the heart of this matter. Issues related to learning and the meaning of knowledge are further explored in section 2.5. The discussion branches here to follow the structuration of interactions.

2.3.1 Norms

To move from interaction to interaction rules, as suggested by Giddens, one must consider "norms".

> "Team norms are those practices and procedures within the team that occur without conscious planning and often develop and evolve during the course of the teams existence." (Yeatts & Hyten, 1998)

Examples include: how often and regularly team meetings occur, the ethic that all members communicate freely and often, or that a few members or the team leader dominates the discussion. Team norms of how communications will occur, their quality and their frequency, evolve through the act of communicating, in other words, through interaction.

Team members start a task with expectations of all sorts, not just those associated with communications. The "norming" activity identified by Tuckman (1965) is one of alignment of expectations until the team's practices and procedures stabilise. As mentioned, Morgan, *et a*l (1993), see this as choosing means and policies(B. B. Morgan et al., 1993).

Norms feature in Gidden's sociology of structuration (Poole & DeSanctis, 2004) as routines which provide an organisation with structures of "legitimation". They are the patterns of behaviour which legitimately belong in the reward acquisition and distribution system. A facility for formalising interaction rules would enable the stabilising of patterns of team behaviour.

2.3.2 Rules

Rules are the "recipes" or formalisms used to describe the legitimate patterns of behaviour in a system. Preserving these norms in writing, helps to maintain continuity when members of a team or organisation change.

Communities and organisations have many different structures of "legitimation" where the rules of behaviour are stated explicitly (but are still validated by their use). Examples of these include legislation and common law, at a coarse level of granularity, and employment contracts or, at a finer level, forum moderation policies where the social system has fewer individuals. These policies emerge as a means of ensuring that the organisation will continue to deliver what the participants value and ensuring that the participants do not exploit each other (Hertel, 2004; Ostrom, 1990). They are a form of security for the participants,

since it is in an individual's interest to contribute as little as possible for their share of the reward (Hollingshead *et al.*, 2002). Rules sit at the interface of competition and co-operation. It is difficult for individuals to come to terms with the conflicting forces of competition, offering the lesser chance of greater reward, versus the more secure, but smaller return, that comes from co-operating (Ostrom, 1990). Fernández argues that virtual teams can replace trust with written contracts, which are agreed expectations of behaviour in the relationship (Fernández, 2004).

Rules are symbols representing patterns of behaviour formed through repeated actions. The participants of the social system consider these patterns worthy of being made explicit.

Interaction rules are symbols representing patterns of team behaviour for the acquisition and or distribution of team rewards.

2.4 Trust

Many observations have been made about the behaviour of effective teams and those with problems. The classic problems, caused by differences in the individuals who attempt to dominate a team (Ostrom, 1990) or freeload (Brannick et al., 1997; Tompson, 1997) on the work of others, are well known to every high school student who has tackled a "group" assignment or participated in a team sport. Having members with different cultural backgrounds can result in misunderstandings (Jarvenpaa & Leidner, 1999). Erratic attendance by a team member, a lack of regular involvement in communications, and not contributing reliably to team artefacts are also identified as problems. One cause for this behaviour may be because members feel insecure (Aviv *et al*., 2003). Sub-grouping within a team, that is the existence of diverse allegiances rather than a common commitment, is also potentially destructive (Hertel, 2004). Real personal conflicts may exist, or conflicts of ideas wrongly attributed as personal may cause problems (Crampton, 2002).

Desirable traits in teams include stable and open patterns of communication and prompt responses to other members (Jarvenpaa & Leidner, 1999), disciplined

commitment to a common goal (Hertel, 2004; Murphy, 2004) and plenty of feedback to and assistance for fellow members (Daradoumis *et al*., 2006; Leonard, 1996). Explicit conflict resolution processes are also desirable (Crampton, 2002). Above all, trust is seen as a crucial factor in optimal team performance.

If an interaction rule facility is to help with the establishment of behavioural norms, then the module must assist trust, which encourages both risk taking and also creativity. Trust and risk arise as key areas of research in the CSCW community. Hung defines trust in this way:

> "Trust in a dyadic work relationship is defined as an individual's willingness to be vulnerable to the actions of the other involved party based on a particular action important to the trustor, irrespective of the trustor's ability to monitor or control the trustee." (Hung et al., 2004).

Fernández (2004) provides an extensive summary of the nature of trust as part of his study of "meta-teams" – teams that extend across multiple corporations or institutions. In his business scenario virtual teams can replace trust with contracts – they can write the relationship down. They cannot, however, write down everything. Risk is defined as "trusting uncontrollable others" (Fernández, 2004). In other words, risk is considered an inherent part of trust.

Trust is also bound up with the equitable distribution of rewards that flow from being part of a team, in exchange for the contribution from each member. Members must either trust or regulate to ensure that other team members will neither dominate nor freeload (Hertel, 2004; Ostrom, 1990) and thus skew the equitable nature of the distribution of rewards. These rewards can be monetary (Simmel *et al*., 1978) or more abstract (e.g.: knowledge, status, influence), as theorized by Max Weber (Abukuma, 2003; Andreski, 1964). Along with writing contracts, some form of regulatory control is also needed.

> "The need to "write the relationship down" is as unquestionable as the need to implement appropriate controls… We maintain that trust cannot be totally replaced. This is so because its replacement, total

> control, is a delusion in complex sociotechnical systems; and we know that contracts and specifications are inherently imperfect. … Therefore writing a relationship down will always involve elements of risk and misinterpretation" (Fernández, 2004).

Fernández argues from the literature that trust "facilitates open communication, cooperative efforts, reduction of uncertainty, resolution of conflicts, common understanding, and control of transaction costs." Trust is both a cause and an effect of co-operation. Trust and mistrust are not absolutes but either end of a continuum where a balance between regulation and trust is struck. His study reveals that both too much and too little trust caused team failure and that feedback mechanisms amplified both the mistrust and the trust within the team. He argues that the correct balance of trust to regulation can only be understood in hindsight; that it emerges from team interaction (Fernández, 2004). This observation suggests the behaviour of a complex system and is important to consider when designing computer support for regulatory processes. Self-controlled governance replaces formal authority-based regulation and the consequent trusting environment enables "open and substantive information exchange" (Neece, 2004).

Trust is established early in the formation of a team, especially through face-to-face meetings (Hung et al., 2004) "when there is a common belief that others will make good-faith efforts to behave in accordance with commitments (explicit or implicit) and act honestly in negotiation of those commitments" (Hertel, 2004).

The trust found in virtual teams is different from that expressed by teams within a corporation and from those teams which are co-located. The trust relies on loyalty to design (loyalty to the team's focal task), harmonious patterning and creativity; goals to which all team members aspire. Non-virtual loyalties are either to the regulations and goals of the corporation or, in the case of co-located teams, loyalty to each other (Murphy, 2004).

Black (2008) sees commitment and trust as key concepts in a supply chain business relationship. Trust between supplier and purchaser must exist before there is a commitment to the relationship. Financial commitment breeds trust.

Trust and commitment encourage managers to he more willing to take high-risk actions because they believe their partners will not act opportunistically. Both commitment and trust have rational and emotional aspects to their nature. Black sees three forms of trust, an equivalent to initial trust called “Dispositional Trust”; “Credibility Trust” which is the belief that the other party has the expertise to perform the job effectively; and “Benevolent Trust” which is an emotional belief in the other party’s good intentions. These forms of trust echo those in the Cisco Report on the psychology of dispersed business teams (Cisco, 2006). Commitment can be “Calculative”, the extent to which the parties are bound together by processes and “Attitudinal”, the extent to which one party has an emotional loyalty to the other. Black found that improvements in Credibility and Benevolent trust led to increases in commitment of both sorts (or inversely, the higher the commitment of either kind, the higher the trust of either kind). Increases in initial (or Dispositional) trust correlated with increases in Benevolent trust, but not Credibility trust (Black, 2008). One would thus expect software that builds on initial trust to have corollary effects on commitment.

On the other hand, trust is undermined by an undisciplined, laissez faire attitude to commitments (Hertel, 2004). Both Neece and Fernández recommend education for all team members in the nature and value of trust. Methods include early familiarity-building project meetings, responses to deadlines, acceptance of deliverables, detected contract breaches, or joint conflict management and resolution efforts (Fernández, 2004; Neece, 2004). These methods do not necessarily have to occur face-to-face, but they do require an understanding of the team expectations and awareness of breaches of these expectations in order to work effectively.

2.4.1 Conflict

A major part of trusting each other is the knowledge of how to deal with disagreements, which can be either constructive or destructive for a team. Differences of opinion can be beneficial if they are addressed and resolved. Trust builds in a team that can resolve its conflicts amicably. Creative solutions to conflicting ideas are often generated as a result. Two types of interactive conflict

exist; task-based (often conceptual) conflicts and interpersonal conflicts. Personal animosity is highly destructive to performance and may even cause a team to implode. Differences of opinion can be taken personally. Trust mediates the resolution of task conflicts and prevents such misattributions from occurring. The more trust that exists the more likely the members are to take risks in putting forward ideas for consideration and the less likely they are to take personally any challenges to the ideas. It is less likely therefore, that there will be destructive interpersonal conflicts (Crampton, 2002).

Another way of looking at the impact on team performance of conflict is to value the learning takes place in a climate of psychological safety, openness and innovation. Interpersonal trust and respect permits greater risk taking and thus exploration of the unfamiliar (Crampton, 2002). In this way, learning is inextricably linked to team performance and to team maturity. The team's patterns of behaviour will change as they learn more about each other and the task at hand. This maturation process further complicates the task of predicting which patterns of interaction are important for a team, and what they may mean to the team.

At this stage an understanding of how teams function has been presented, why teams exist, the nature of the structures that are likely to be found in them and the member (inter)action upon which these structures are founded. A link has been established between trust, interaction and team success. The notion of learning ties in with the knowledge by-products that are the consequence of teamwork. Learning also ties in with a trusting environment. Collaborative learning is well researched and has disciplines focusing on the virtual forms of collaborative learning (CSCL and CSCW). It is a technique that has been used as a teaching tool for three decades by the author. One would expect collaborative learning to occur in the virtual teams under scrutiny in this research.

2.5 Collaborative Learning

Both the CSCL and CSCW communities recognize the importance of knowledge and learning; not just learning about the task or problem itself, but learning about

the processes of collaboration and the nature of one's team. Knowledge sharing and creation is seen as an adjunct to collaboration and building a knowledge base as a necessary component of any team product. Both learning institutions and organisations value creative products and the development processes that emerge from the creation of these products.

The design of an interaction rule module has to take learning into consideration. Members will incrementally learn patterns of interaction appropriate to the team's well-being, not just those patterns of interaction that are driven by the task. This learning will change the context in which the team is operating and may provide sufficient feedback to change the patterns of interaction. Members may learn to check messages twice every day, for example, until they settle on tasks and deadlines, then may reduce their level of contributions so that a daily check may be all that is necessary. The module will need to accommodate this learning. However, such a module is also likely to limit what can be learnt by team members.

Learning can be viewed from the team perspective, in structural terms, and from an individual perspective, in terms of personal "growth" (Stahl, 2006). The former can be viewed in terms of participation in the knowledge management process and the social consequences that ensue. Using the cognitive, "acquisition" metaphor of learning for the latter, the results of participation can be viewed as an extension of personal experience. The act of participation in a social setting (in this case, the team) results in the acquisition of personal knowledge as well as the creation of social artifacts and structures which affect future participatory experiences (Sfard, 1998). The structuration perspective (or "participation" metaphor) as applied to knowledge underpins work by Wenger, Fischer and others (dePaula & Fischer, 2005; Fischer & Ostwald, 2005; Wenger, 1998a) in developing their theories of community previously discussed (section 2.1.3.2). Dimitracopoulou (2005) on the other hand defines the role of computer-based collaboration for purposes of personal "student" knowledge acquisition (section 2.5.1). Sfard (1998) strongly advocates the use of both metaphors. The acquisition metaphor is the one most closely aligned with neurological understanding of learning (Koch, 2004; McCrone, 2003), so this will be the

predominant approach taken when dealing with the individual; each with their own neurological representation of social context. When dealing with emergent structures, the participatory metaphor is of more use. This research needed to explore the value of both the rule artefacts themselves and the process of creating them.

2.5.1 Learning as Participation

Teams can under certain conditions be regarded as Communities of Practice (CoP) given the definition below.

> [Wenger sees a] "CoP as a social structure that captures the interdependence and relationship among individuals, (legitimate) participation, communities, and sociocultural practices. A CoP creates the conditions for its members to put their knowledge into practice." (dePaula & Fischer, 2005).

Wenger binds notions of social structure, situated experience, social practice and identity into a social theory of learning. He argues that within a social structure [such as a team], while carrying out the practices by which the structure organizes and coordinates its activities, there is a development of identity through individual participation (Wenger, 1998b). Knowledge is both tacit and explicit. It can be specific to individuals or general. If behavioural norms can be regarded as tacit and generalisable to at least the team, then interaction rules would be the explicit form of this knowledge. Rules, generalisable outside the collaboration group, could be considered predictable to some degree. Fischer and dePaula (2005) also draw on Schön to distinguish between knowledge generated phenomenologically through practice ("design process knowledge") and commodity knowledge that comes from outside the CoP, often from socially privileged academics. This line is also taken by McNiff and Whitehead (2006), proponents of Action Research. Whether an academic is a "practitioner" or not is beyond the scope of this study, but issues of predictability and the need for seed rules do relate to the practicalities of design and testing of the interaction rule module. To what extent are interaction rules (if they exist) emergent or predictable by experts? How does

one encourage and explain the use of the module to the team members if relying solely on emergent knowledge?

DePaula and Fischer (2005) point out that an externally defined taxonomy of knowledge cannot be used as the basis for designing a knowledge management system and that the separation of tacit knowledge from its experiential context causes problems in the process of making it explicit. When applying this perspective to the knowledge needed to create interaction rules, it is unlikely that an external source of rule knowledge such as an established theory or the words of an expert will suffice. These sources of knowledge are too removed from the context in which the action takes place.

The author takes the position that design of an interaction rule module will need to be open to both predictable and emergent knowledge. The team will need to use whatever knowledge is applicable to support team interaction, whatever its source.

The issues of how knowledge comes in to, and how generalisable knowledge goes out of, the module is addressed further in Chapter 3. As pointed out by Sfard (1998), the transfer of knowledge challenges the participatory metaphor (Sfard, 1998). The boundary of the system is probably the point at which one changes from the participatory to the acquisition metaphor when discussing learning, as do dePaula and Fischer with their definition of a seed.

> "A seed is a boundary object that, while helping users make sense of the sociotechnical system by linking innovation and existing practices, creates opportunities for them to rethink and improve these practices in this new context. It is the first step to facilitate a meaningful integration between 'traditions and transcendences'" (dePaula & Fischer, 2005).

Just as one reaches the external boundary of a team, so one also has an internal boundary; the complex system that is each individual. Discussion of learning with regard to the individual most definitely uses the acquisition model.

2.5.2 Learning related to Task

A trusting environment has implications for learning about the task set for a team. A rule module could be an important addition to any software designed to leverage collaboration software as a tool for learning about specific topics. Educators use teams in their classes when fostering learning through collaboration. Teams are primarily concerned with the sharing, acquisition and creation of knowledge and teachers must increasingly prepare students for these activities in a loosely coupled cyber-world of collaboration.

Dimitracopoulou (2005) distils the aim of computer-based collaborative educational systems in her literature review:

> In all these systems, collaborative learning is viewed as a pedagogical method that can stimulate students to discuss information and problems from different perspectives, to elaborate and refine these in order to re-construct and co-construct (new) knowledge or to solve problems. In such situations, externalisation, articulation, argumentation and negotiation of multiple perspectives are considered the main mechanisms that can promote collaborative learning. (Dimitracopoulou, 2005)

Problem Based Learning (PBL) uses a common problem as the stimulus for collaboration. Collaboration brings with it advantages of sharing cognitive load and expertise (Chernobilsky *et al.*, 2005). Knowledge sharing, its construction and reconstruction, occurs with the social purpose of solving the shared problem. Iteratively internalizing the knowledge and making it available socially are the general processes for learning through collaboration (Eleuterio *et al.*, 2000; Ertl *et al.*, 2005). PBL uses scenarios found outside educational institutions as a means of preparing students for tasks they will experience in their field of practice. Learning about knowledge associated with the task can be considered the primary focus or first order (Ulicsak, 2000) of collaborative learning. Externalisation, articulation, argumentation and negotiation are unlikely to occur freely if participants are risk averse. This study does not address the value of the rule

module for primary collaborative learning, rather, it looks at whether the module affects the level of risk.

2.5.3 Learning related to Collaboration

Teamwork has also been seen to promote the second order learning of individual responsibility, social awareness and communication skills (Ulicsak, 2000). It is in this area that computer support has been lacking; an area vital to the success or failure of the team. Having team members learn about team processes rather than the primary knowledge issues can be considered an end in itself. It is important to learn collaboration as well as to learn while collaborating.

What team members learn about team processes is not just available 'off the shelf'; it is generated through their own collaboration so an ongoing repository of team interaction knowledge may be of assistance, rather than have the repository in each person's head. Having team members using an external repository and communicating about its contents may increase the efficiency of the trial and discovery process needed to learn shared interaction norms. It could take quite a while otherwise for everyone to hold a common understanding of these norms, which is the basis of the trust seen as pivotal for successful teams. Anything that can enhance the discovery process should have implications for enhanncing trust.

Assuming it is possible to create an adaptive repository for interaction rules, the interesting research goals are: how would this mesh with the management of interaction rules and what consequences would there be from a learning perspective? A repository could act as a seeding mechanism and then the team could participate in adapting the seed to their circumstances. The individual members would learn what the team felt was important, and how to address social issues of interaction within the team. If the process was successful, the team environment would be more trusting and the task-based knowledge development would be more open and creative.

Rule software must also monitor interaction to see if rules are broken, then act out some consequence. As discussed next, this feedback also has an educational impact through the process of mirroring.

2.5.4 Learning related to the Technology

There is now a long history of the use of ICT in education and the mechanisms for learning are well understood. Learning through participation involves interacting with a context; imposing changes and evaluating the outcomes, then acting again in the light of new understanding. The process of strengthening and refining prior knowledge has ample neurological evidence. Re-evaluation, however requires focusing before any changes can occur; the equivalent of loading the concepts into RAM before they can be acted upon (McCrone, 2003). Educators and intelligent software 'agents' (as well as unintelligent ones) can mediate in this focusing. Intelligent agents in the educational sense are software components with varying degrees of autonomy that use machine intelligence to try and personalise feedback intended to support learning, (There may be debate about how "intelligent" that feedback is, of course). The International Journal of Artificial Intelligence in Education, (IJAIED) is dedicated to developments in this field. Unintelligent agents, on the other hand, although providing feedback behaviour, lack the ability to classify system state and choose behaviour accordingly. A plain, pre-programmed action would be the simplest consequence that could occur if an interaction rule was "broken". For this to be meaningful, the team should define the consequent response.

The educational technique of "mirroring" is used in software when guidance from either a human educator or intelligent agent is not available. The participant is made aware of their actions by the software, requiring that the participant re-evaluate these actions (Jermann *et al.,* 2001). A number of visual "widgets" have been used for providing awareness about issues such as social interaction (Kreijns & Kirschner, 2002), team well-being (Reimann, 2003) and task management (Reimann *et al*., 2005). Reimann's earlier work, based on McGrath's team functions, provides well-being support by visualising team responses to two key questions. Team members are asked to rate how satisfied they are with the team performance and how motivated they feel to carry out the team's task. The voting behaviour of the team is mirrored to the team as two pie charts, each displaying the proportionate rankings of team feelings. Members can see, for example, the proportion of the team that is highly motivated or extremely dissatisfied. This

facility was reproduced in the experimental collaborative environment used in this research. (Reimann et al., 2005) and Kay *et al*., (2007) report on the use of a number of diagrams including "wattle diagrams" which mirror particular types of task-oriented behaviour to team members (Kay et al., 2007). Individuals in these diagrams, although anonymous, are represented by lines with various appendages (leaves, nodules and branches). On these lines, measurements are displayed such as attendance, file behaviour and the allocation, receipt and completion of job tickets. The diagrams mirror various types of data as images in the hope that they will be important to the team members and, that the meaning of the images will be understood by all. Jermann identifies two categories of educational collaboration software that do not use mirroring (metacognitive tools and advising tools), both providing evaluated feedback to the user. To do this the software must hold some model of what is desired (Jermann, 2001). The software is constrained in its ability to adapt to the needs and circumstances of the users by the values espoused in the design of the model. The design in this research attempts to extend existing work on mirrored interaction by permitting users to choose the measurements they consider to be important and to explain the significance of these measurements. There is also no need to limit the design to task or well-being interactions. Any interactions measurable by the software can be used.

A rule module that uses 'mirroring' for more than one person would need two features. Firstly the module should deal in symbols to convey meaning. Secondly, the rules should be editable. If the members do not like the current rule set they should be able to evaluate it and make changes. This process allows for both emergence and learning to take place within the software.

One potentially significant problem for the interaction module is the fact that the team will have to learn how to use an additional software tool. Even if useful for a team, the cognitive load of devising rules and then learning the interface for their implementation would be a major disincentive for team members to engage with the module (Sintchenko & Coiera, 2003). The focus of the team is most likely to be on its primary task, not social considerations.

2.6 Current Collaboration Software

Collaboration Software has had some time to develop, with a number of open-source and commercial products in existence. They vary from those that fulfill specialised functions such as Thinktank (GroupSystems, 2008), designed to facilitate knowledge creation and VIP Task Manager (VIP Quality Software, 2008) for task and project tracking, Trac(Software, 2008) for the tasks and version control associated with software engineering, StudyWiz (Etech, 2007) and Moodle (Moodle, 2008) for educational course delivery, to those intended to cover broad enterprise demands, such as IBM Lotus Quickr (IBM, 2008), Jive Clearspace (JiveSoftware, 2008), SimpleGroupware (SimpleGroupware, 2008), eGroupware (E-GroupWare, 2008) and Open-Xchange (Open-Xchange, 2008). Wikipedia has a non-exhaustive list of groupware, and a comparison of the features that they offer (Wikipedia, 2010). When generalised, the functions of the various tools included in the software can be reduced to synchronous and asynchronous mechanisms for:

- *Resource management* such as documents, messages, contact lists and multimedia objects. The management includes categorising, searching and version control facilities.

- *People management* where collaborators have profiles and roles often expressed as groups with specific permissions.

- *Time management,* which uses facilities such as schedulers and calendars.

- *Task management*, which uses facilities for allocating and tracking individual jobs, projects and the progress of various workflows such as lifecycles or auditing processes.

- *Communications* facilities such as discussion boards, email, chat and video conferencing, wikis, reports and voting tools. Communications may be stored as resources and then may be

searched, classified (usually by topic or content), shared and displayed as appropriate to the medium and its purpose.

Interaction occurs in all of these areas, so norms of behaviour may emerge in relation to any of the tools mentioned. Typically any behaviour that has been represented in existing software is based on a specific tool, rather than being seen more generally as "interaction". Version control systems such as Subversion (Tigris.org, 2010) display who modified what and when, a scheduler might show late items in red for example 37 Signals' Basecamp (37Signals, 2008), a file repository might show who has been uploading, downloading and modifying files Mindquarry (Mindquarry, 2008). It is assumed that what is shown will be actually useful to the collaborators and that they will share similar interpretations of what is shown.

Some software does address quite specific business rules, channeling task-based behaviour through templates. EMC Documentum's Board of Directors eRoom is a particularly good example of this. It is organized for compliance with, and the administration of, the U.S. Federal Public Company Accounting Reform and Investor Protection Act of 2002, passed in response to the Enron debacle. It hard codes templates of audit workflows and lifecycles as well as tightly controlling permissions. It provides monitoring of these business rules with regard to the associated document management and provides multi-level permissions for access to levels within the system.

Group Systems ThinkTank (GroupSystems, 2008) is quite unusual in that it attempts to provide behavioural guides for its software. It is designed to facilitate brainstorming, setting of priorities and building of consensus. The software is biased towards voting and discussion facilities, which can be used both synchronously and asynchronously. The behavioural rules for achieving consensus, for example, are provided in a set of steps to be filled out in a document template. They also offer a human service to provide expert training in the behaviour pattern that best suits an organisation and in the creation of customised templates.

Templates in ThinkTank are controlled from outside the collaboration system, through experts charged with writing them, rather than the collaborators themselves agreeing on what behavioural patterns are important. The templates are very specifically task-focused, and so do not address any social issues, differing expectations of task behaviour and differing opinions. On the other hand, the ThinkTank template for consensus forming is a set of behaviours designed to allow these critical areas to be addressed. It is a set of behaviours for arriving at an agreed set of behaviours. The website describes the benefits of consensus as follows:

> "Consensus building resolves conflict, creates and builds workable solutions. Conflict requires an enormous amount of energy that might be better used towards a common good. It also undermines progress towards the goal. When the conflict is thoroughly processed, it can create a better, more lasting and viable solution" (GroupSystems, 2008).

While this statement is purely a marketing assertion, it underlines the importance of trying to find the best software support for collaborative environments. Most of the available software does have an administrative interface. Some of these allow human managers and experts to set desirable behavioural patterns. A rule facility available to the team members themselves would permit the creation of local knowledge from the actors themselves (from the bottom up). It would also cater for leaderless teams.

2.7 Design Implications

Several reasons exist in the literature for giving team members free access to the rule construction process. Previous studies suggest that free access is important for team stability and productivity and that there is a need for knowledge to be generated in a grounded fashion, to allow for issues of unpredictability.

The literature also suggests that the interaction rule module created as part of the research described in this thesis, Phreda, must cater for emergent knowledge. The team's understanding of appropriate interaction rules will change with circumstances. The process of writing the rules is likely to help members

understand each other better, immediately changing the context in which rules apply. There are two instances when a member *perceives* another to be reneging on a behavioural contract – when the second member is deliberately doing so and when the members share differing expectations (Piccoli & Ives, 2003). Making behavioural expectations explicit helps to eliminate this second, perceived breach of contract.

The system should allow for self-management, since in some teams the members themselves are expected to control their own interaction. In many situations self-managed teams are more productive than those where hierarchic authorities dictate behaviour (Yeatts & Hyten, 1998). Studies of local communities show that when community members make their own decisions over the use of resources, sustainable solutions are more likely to be found than if solutions are imposed from outside the community (Ostrom, 1990). The decision to build open access to rule management is reinforced by drawing an analogy between a local community and the smaller complex social system of the team. Such a structure should help the sustainability of the team as a unit.

Economics is a discipline where decisions need to be made in the context of a complex social system. Determining which theoretical model to use is not always possible. Knowledge, and rules based on the knowledge, can be both predictable (ergodic) and unpredictable (non-ergodic) (dePaula & Fischer, 2005; Dow, 2004). The Bank of England chooses an existing model for determining interest rates, dependent upon the immediate context and the “instincts” of the decision-makers. That model informs the rule announcing which rate to charge (Dow, 2004). The mechanism for deciding upon interaction rules should allow situated, local input and not rely on pre-existing knowledge alone. This approach is also in keeping with the functioning of a practitioner in a community of practice. A practitioner uses any pertinent knowledge, regardless of whether it was also applicable in other instances (dePaula & Fischer, 2005). The epistemology of Layder addresses these differences between positivists and grounded theorists. He sees existing theory as a guide, and direct experiential engagement as a modifier or shaper of knowledge (Layder, 1998).

It is critical from philosophical and practical standpoints that the software be able to capture grounded knowledge from the participants.

The literature provides guidelines for how to construct a software system that supports the creation of interaction rules and manages them in a manner akin to a human moderator. If one is to create a module that fulfils the role of moderator, it will have to monitor aspects of member interaction, and provide consequences if a monitored behaviour is recognised. The interaction rule module must allow team members to select meaningful measures of behaviour, and allow symbols to be associated with these measures of behaviour as well as with the consequences that ensue should the behaviour occur. This would enable norms of behaviour to be explicitly stated as rules, providing opportunities for team knowledge to be acquired and learning to occur. If team managers or leaders were team members, there would be a mechanism for democratic local rule making, as well as for the inclusion of already established knowledge. A facility for creating contractual relations defining acceptable behaviour could replace the need for trust to some degree. It is also possible that the process of creating the rules might generate sufficient understanding amongst members to make the resultant rules redundant. Finally, the rule module would need to be fully editable by all participants. With the ability to disable, modify and create rules as desired, a dynamic and complex team would be able to develop evolutionary structures; guidelines reflecting current patterns of behaviour and also be sensitive to team maturation.

This software description fits nicely into the definition of a “User Adaptive System”. The fundamental components of such a system were recently described by deVrieze (2006). A user adaptive system contains a user model, which de Vrieze defined as “a model of relevant characteristics of a user that is or can be used to personalise the behaviour or presentation of a system.” Such a model can obtain its characteristics adaptively (for example from an “intelligent agent”, mentioned earlier), or can be explicitly given them by the user.

One can replace the term ‘User’ with ‘Team’ in de Vrieze’s calculus without altering his software model. Replacing the term ‘User’ with “Complex System”

extends the applicability of the model still further. The diagram used by de Vrieze captures the components of all adaptive systems.

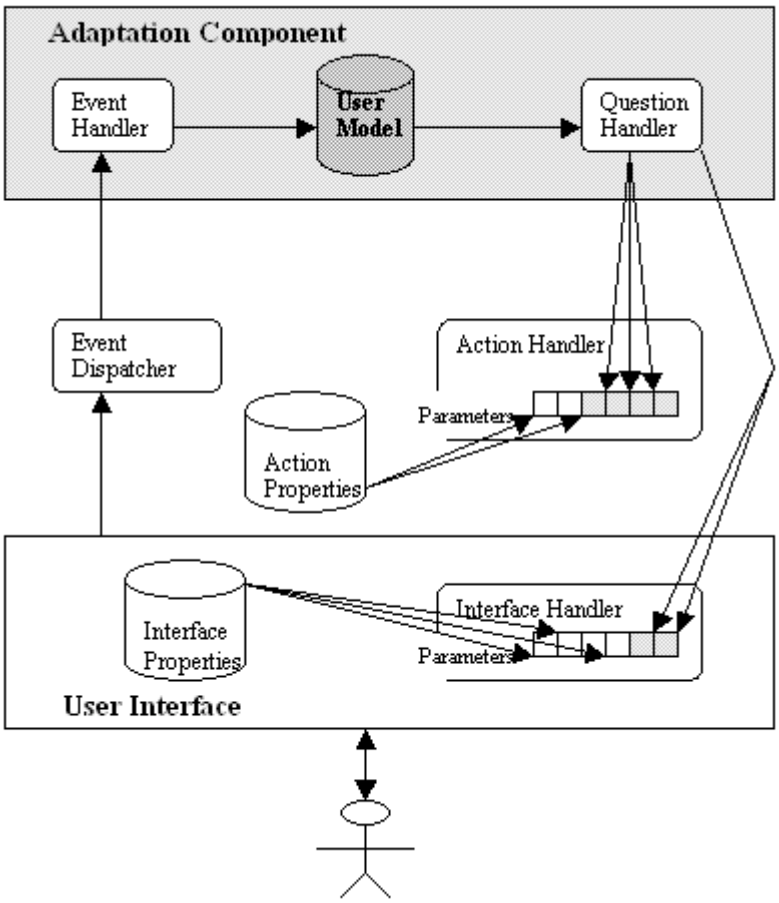

Figure 3. The fundamental components of a user adaptive system. (de Vrieze, 2006).

The adaptation component (Figure 3) is activated by user events. It personalises both the user interface (via the interface handler) and the behaviour of the system (via the action handler). The question handler provides answers about the user needed for the modification of the system. The question handler has the ability to act on the performance of the system, affecting the action properties and its appearance, and hence affecting the interface properties.

The design for providing software support for interaction, learning and knowledge and dealing with teams as complex systems used in this research, extends de Vrieze's work on adaptive personalisation (section 3.1.3).

2.8 Conclusion

Software supporting asynchronous virtual teams has been suggested as able to optimise team performance. One factor that can affect team performance is the influence of the behaviour patterns of the members. Software to date has not addressed this issue at a sufficient level of generality to encompass support for team behaviours as well as those behaviours specific to the team's task. It has been shown that central to any software design to support human collaboration is the ability to adapt to the complexity both within the team and in the team's environment. Learning, trust and cognitive load are also pivotal in understanding how norms of interaction affect on-line performance and thus should be considered in the design of any such software.

Chapter 3 Software Design

An application was created to explore the research goals chosen for exploring the role of interaction rules in on-line collaboration. Phreda (the Personalising Human Rule Elicitation Design Assistant) contains three modules, a web interface, a small application and a database. It allows users to encode interaction rules and provides each user with an appropriately altered software environment, as dictated by these rules. It acts as a human group moderator might, by monitoring the state of interactions and enacting rules dictated by the group's policies. Phreda is attached to a simplified, web-based, collaborative environment that contains the key tools found in most web–based collaboration software. Users are able to manage time, people, their actions, their communications and files (representing personal and private knowledge, resources and artefacts). This chapter looks at the overall approach to handling interaction rules, the collaborative interface, training materials and seed rules needed for carrying out the case studies and with a discussion of the further developments needed to fully implement the interaction rule design.

3.1 Design

The creation of a rule facility hinges on the ability of software to link meaning to the database traces of behaviour within the software environment. The measures of behaviour that are seen as important by the team, need to be selected by the users of the software from a list of measures. Users also need to attach text expressing the significance of the measured behaviour. Administering rules implies that a consequence follows when the key behaviours occur. The software would need to not only check for the behaviour, but enact the conseqeunces.

3.1.1 Captured Meaning

The area of expert systems is an early attempt to try to solve the computing problem of programming intelligence. An expert system is a computer system that emulates the decision-making ability of a human expert (Giarratano & Riley, 1998). The production rules found in expert systems provide a way of attaching meaning to attribute-value pairs. Attributes can be represented as columns in a database table, or as metadata in a record set from a query on a database. The values are found in the records for that table or record set. Production rules follow the principles of first order predicate logic, where multiple attribute-value pairs can be defined to imply a consequent. If certain pairs exist as facts then the implication or consequent becomes true. In expert systems, this consequent can be given a label when it is defined. Multiple consequents can be asserted, therefore multiple meanings can be accommodated.

Traces of team behaviour can be aggregated using Structured Query Language (SQL) found in all relational database management systems (RDBMS). Collaboration tools such as calendars and task managers ('ticket' or 'job' allocation systems) typically use an RDBMS for persistent storage of data. An SQL query could be designed to reveal the number of tasks allocated by each team member, for example. Aggregate team calculations such as the total number of tasks or the average number of tasks for the team can also be obtained, providing a comparator for an individual member's behaviour. Inaction on the part of an individual can be assigned meaning and can be identified by comparing individual behaviour with the team behaviour.

One could assume that discussion posts could be stored in the database, together with a username and the type of post and that one such type could be the "social" post. Queries could be constructed that measured the frequency of each type of post and of all posts in total. A user could construct an interaction rule that compared the frequency of say "social" posts for the individual, M_1, to the total of posts for that individual M_2. If that ratio was greater than a given value, V, the consequent, C_1, might be that the interface was altered to deliver the message "Thank you [username] for keeping team morale high."

IF (M_1 / M_2 > V) **THEN** C_1

Queries could also be constructed that provided aggregates of all "social" posts for the team and all posts for the team. There could be many types of posts.

Queries could be constructed to describe resource usage for the set of collaboration tools in the system, not just the discussion forum.

System = { T_1, T_2, T_3… T_n }

Tool Queries = { T_iM_1, T_iM_2, T_iM_3… T_iM_n }

The user, if able to construct production rules, could choose which attribute-values were important and decide on what they meant. Users could then change these meanings as the team matures. It is also conceivable that the same measures have different meanings for different people:

IF (T_dM_1 / T_dM_2 > V) **THEN** C_2

Where C_2 is the message "[Username], you should focus more on the task at hand. You are wasting team time." and T_d is the discussion tool.

Tagging measures with meaning, (attaching the knowledge to database traces) allows the development of a usage dictionary associated with those traces and perhaps, by looking up the meanings associated with a particular trace, the ability to extrapolate the degree to which the knowledge is generalisable to other teams.

3.1.2 Software Expert

A facility for team interaction rules should have the potential for seeding and for modification by the team members. Some transient, ad-hoc teams may not have the expertise to provide seed rules, appropriate to the current team or to provide the rules which will be needed as the team matures. The burden of maintaining a current legislature in the absence of an expert member, as well as the burden of completing the team's task is likely to be untenable due to cognitive load (Sintchenko & Coiera, 2003). This suggests another role for software. There

should be some mechanism for harvesting interaction knowledge created within the team in case it is generalisable to other teams.

It would be desirable to provide a software agent to aggregate interaction rules developed by multiple previous teams, prioritise the rule set and provide suggestions to a particular team as to which rules work best in their situation. This "recommendation engine" is explored further in appendix IX.

3.1.3 Adaptive Personalisation

Both Phreda and the recommendation engine suggested above fulfill the definition of a "User Adaptive System" described by deVrieze (2006). Figure 4 shows the steps in the user modelling loop. The system collects data about the user; the adaptation component puts this into a user model and processes that model to provide answers about the user. These are passed to the system to enact the adaptation effect (de Vrieze, 2006).

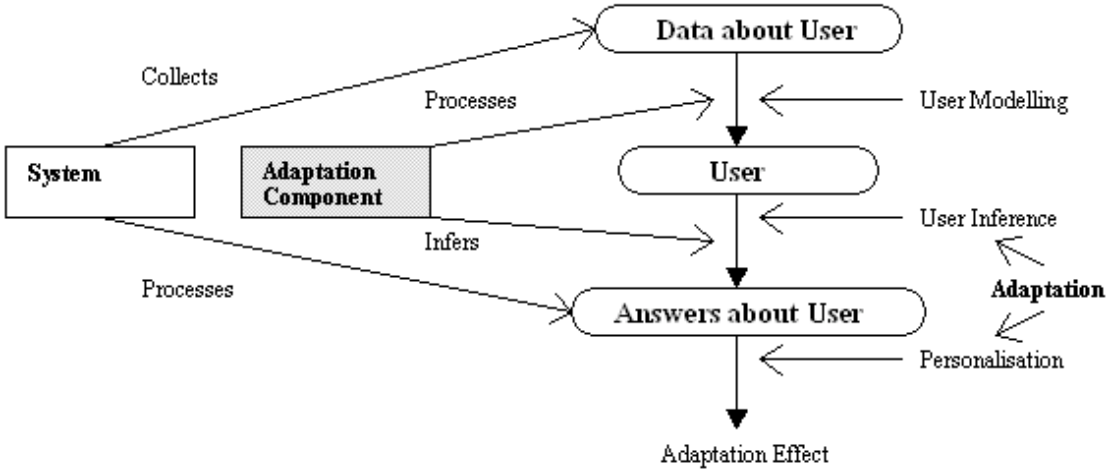

Figure 4. The User Modelling Loop (de Vrieze, 2006).

The collaborative environment allows for the collecting of characteristics of multiple users, and is 'informed' by the user-created rules. Phreda processes data about each user (and aggregates for the team) from the database by applying the rules. Phreda then answers questions about the user and the team, which it passes to the system. The combination of data and rules constitutes the user model for

the team. De Vrieze's model is equally applicable to an individual user or an organisational unit such as a team. For example, in the individual's case a user data model might consist of a username and a series of completed mathematical skills in a given maths course, in an organisational unit the model might hold the name of a class and the list of skills mastered by all members of that class. In the Phreda software we find that the model for the team consists not of a simple list of skills, but a collection of all member interactions and also the rules of interaction that the team hold in common. Applying the rules to the data is the equivalent of drawing inferences for each user in the team, and for the team as a whole ('User Inference' in Figure 4).Working to the next stage of the User Modeling loop we see that Phreda answers the questions: What do I display to the individual? What do I display to the team? How do I alter the system? Finally, the 'Adaptation Effect' mentioned in Figure 4 is the outcome – the alteration to the system, which in the case of Phreda is the display of customised messages.

While Phreda does have a facility for team members to 'inform' the system, there is no dedicated facility in this version for obtaining knowledge about rules from an expert outside the team. Recommendations for rules must be coded by a team member through the system interface, or by the author directly into the database. Knowledge is obtained from the outside and used to create seed rules (section 3.4) as a substitute for a recommendation agent (whether software or human).

3.2 Implementation Environment

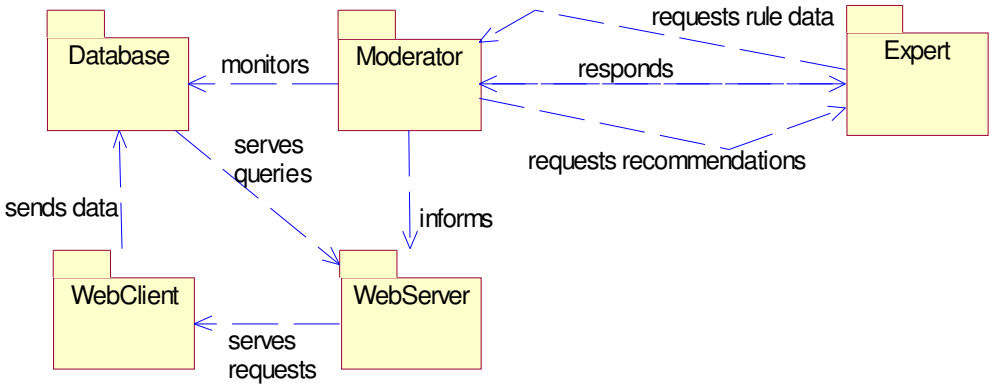

Figure 5. The Basic Architecture of the Interaction Rule Support System. Phreda includes the Moderator, the rule creation interface on the web site

and support tables on the database. There is also space on the web site for personalised messages. The Expert would be in contact with several Moderators.

3.2.1 Web Platform

Phreda was attached to a web-based collaboration environment. This appears to be the most common environment for asynchronous teamwork (Figure 5). The environment for many groupware applications and social tools commonly involve the Apache web server, a mySQL database and the PHP server-side programming language. This combination was chosen for the implementation.

3.2.2 Cut-down Groupware

Collaboration software includes groupware such as the group facilities provided by Yahoo's content management portal (Yahoo, 2007), on-line education delivery software such as StudyWiz (Etech, 2007) and project management facilities such as PHProjekt (PHProjekt, 2004). Each of these in some way provides facilities for managing people, files (resources and knowledge), time (calendar), activities (tasks) and communications. Polling facilities are provided for finding out what members think as an adjunct to discussion boards, blogs and wikis. Persistence is achieved through database tables.

Phreda was integrated with a custom-made piece of groupware that contained simplified tools fulfilling each of these groupware functions. The aim was to provide a simple, generic environment that could be easily learnt by study participants. Apart from simplifying the research context, it made the test bed portable. Since this research was prompted by a general desire to best support on-line teamwork, it does not have a specific context with its own pre-existing collaboration environment. The small, representative environment can be used readily in many contexts for a one-off team project. Each team was provided with their own independent environment and integrated version of Phreda. Discussion of the environment facilities and screen shots can be found in Appendix I.

Three features are worth noting at this point. Firstly the personalised feedback provided by Phreda is displayed at the top of the home page, so it is immediately

visible. Secondly, there are only two fixed polls, monitoring team motivation and satisfaction levels. The team results can be viewed as a pie graph. This facility is based on the mirror facilities reported by Reimann (2003) as part of his research in team support. Finally, discussion entries and calendar events must be classified by participants before they are accepted. Contributors are asked to choose a term from a list that best describes the main aim of the entry. The classification of discussion posts into different types allows the team to evolve their own usage for these terms and to then make rules about the different types of comments. They may, for example, wish to make a rule about the proportion of social posts that are made by an individual.

3.3 Phreda Modules

Phreda allows users to encode interaction rules and provides each user with an appropriately altered software environment, as dictated by these rules. Phreda was integrated with a collaborative environment (figure 5.) in order to be used to explore the role of interaction rules in enhancing trust. Phreda comprises three components, a server-side Java application (section 3.3.1), database tables (section 3.3.2) and a user interface integrated into the collaboration environment (section 3.3.3). Training materials were accessible through the collaboration environment. Dependences between Phreda and the environment are discussed in section 3.3.4.

3.3.1 Moderator

The Moderator is a small Java application that contains the JESS expert system shell and a standard mySQL database connector. The Moderator polls the database once, when the user logs into the web site. The measures stored in Phreda's database tables are retrieved, measurements taken and written to file as "facts". This set of facts constitutes the model (or state) of the team at the time. For the rule engine to work, definitions (or templates) for the structure of each fact are also constructed and written to the file. The team's rules, also stored in Phreda's database tables, are added to the file.

Once the file is constructed, recording the state and rule set at the time of execution, the JESS expert system shell is instantiated and the rules checked against the facts. It is possible for output from JESS to be passed to different files. In the case of Phreda, two output files are produced: one holding messages intended for the entire team and the other intended for individuals. While new state files are created with each login for research purposes, the output files are overwritten. The output files are read by the web application and the home page is personalised by providing current messages for each team member.

3.3.2 User Interface

The team mission statement introduces the home page. In the navigation bar, above the personalization, one can see the links to each of the collaboration tools. Personalisation from Phreda (‘Moderator Feedback’) appears at the top of the key information of the collaboration site Screenshots of these tools can be found in the Appendix I. Unread discussion posts are also listed on the home page, as are upcoming events and outstanding tasks (Figure 6).

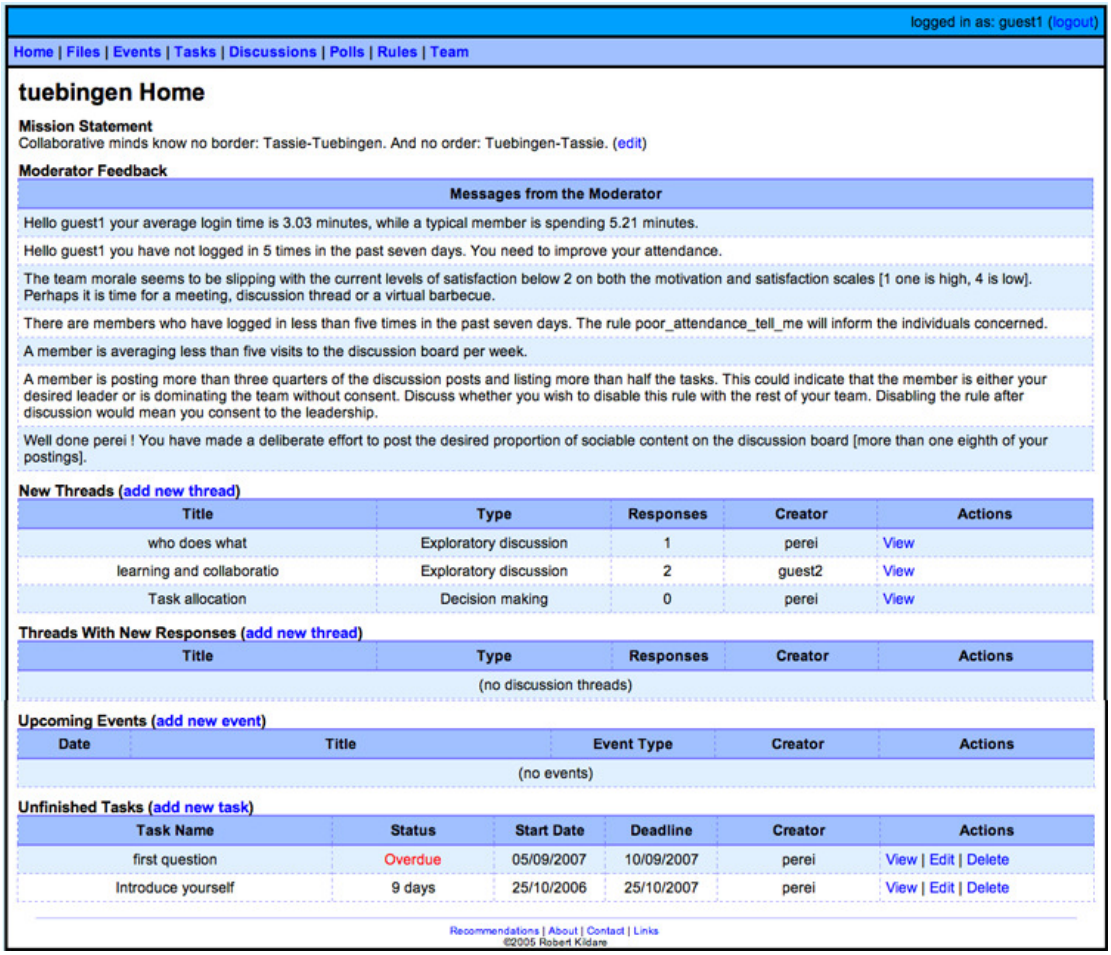

Figure 6. The collaboration site's home page.

The rule facility provides training materials for rule construction, a means of inspecting the details of existing rules, the ability to disable or modify existing rules and the ability to create rules (Figure 7). Conclusions from existing rules can be used as conditions in new rules.

Figure 7. The Rule Details page.

The rule creation process involves four steps:

i). Naming and describing the rule,

ii). Choosing the measures (or attributes) to be tested as conditions of the rule,

iii). Establishing the values of the measures and any relationships between the measures,

iv). Creating the consequent of the rule.

The fourth of these steps is shown in Figure 8. The accumulation of the first three steps is displayed at the top of the step 4 web page.

The language used by JESS for creating expert system rules is very technical and user-unfriendly. It is a functional language that uses prefix notation. The language has been seen as an obstacle to the success of expert systems since the early days of their use (Giarratano & Riley, 1998).

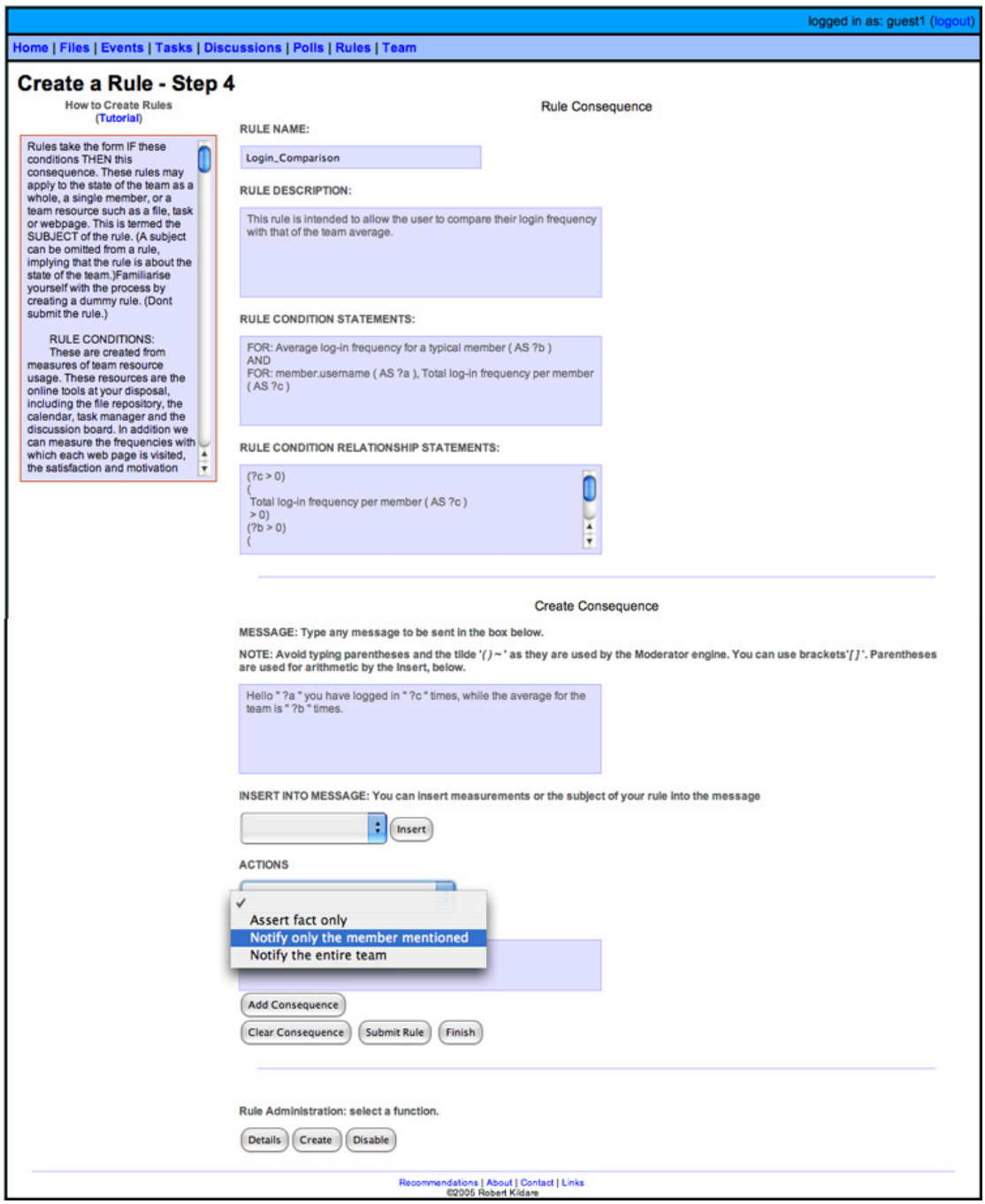

Figure 8. Completing rule creation by adding the consequent. The user has written a message for the rule to send and is selecting the "Notify member" action. When the conditions shown are met, the message is sent.

While the purpose of this research is not to solve the usability problem (XML solutions show some promise) a number of attempts were made to make the interface user-friendly. Language was "translated", JESS functionality constrained and educational materials and help files were provided.

3.3.3 Database

Phreda needs six database tables in order to provide storage for measures, constants, temporary table definitions, rules, rule conditions and rule consequents. These will be briefly described below. The detailed description of the structure is available in the table definitions packaged with the software.

The first table to be used by the Moderator is the one that stores definitions of temporary tables. These 'views' of the collaboration database are used to simplify the measurement queries. Simplified queries can interrogate views rather than the database itself. This has the advantage of allowing the measures to take the form of generic, unsophisticated SQL, which can be constructed by most novices. The researcher or programmer determines what is measured within the constraints of the software environment. The Moderator creates any temporary tables before the measurements are taken. Each entry in the 'temptables' table contains the SQL definition and a description of what that view is intended to do.

The measures themselves are stored with a description of what they measure, exactly how the measurement is calculated and how it might be used. The description is part of the contextual help available in the user interface. A short phrase is also stored to name the measure, in addition to its unique identifier. The unique identifier is used by the Moderator for the construction of measurement 'facts' and their templates. The name or phrase is what is used in the user interface.

For example, "*Average contribution by typical member"* is seen by the user in the list of discussion board measures. If they select this measure they are shown the contextual help:

"*The total number of KB of text posted by the entire team, divided by the number of team members. This figure can be used, for example, in comparison with the average length of message for an individual member, or a against a benchmark*."

The software sees its unique identifier as "AV_SIZE_POST_HYMEMB". The actual value of that measure at a given time is converted to a JESS fact after being found using the mySQL database query:

```
" SELECT IFNULL(sum(MessageLength)/(numUsers.num),0) as
AV_SIZE_POST_HYMEMB FROM bboard, numUsers ")
```

This, however, is completely hidden from the user. Resource constants include the names of key web pages, types of events and types of discussions. The resourceConsts table is needed for the user interface, so that rules can be made about the types of discussions, events or specific web pages. The constants used will vary from one collaborative environment to another. For example, if we measure the number of visits to the page named "team" holding the team members' biographies, another environment might call this page "members". The constants table allows a measure like 'total visits to each page' to be taken by having a fixed list of the page names. Zero visits to a page is potentially an important fact and cannot be calculated from log accesses. This means that the existence of that page must be recorded elsewhere.

Administrative information about rules is kept in one table, with the rule identifier being associated with rule conditions in the 'condition' table and potentially multiple rule consequents stored in the 'consequent' table (although Phreda only works with one consequent per rule). Each rule has a status: whether it is functional or has been disabled. A certainty value can also be associated with the rule, to accommodate fuzzy logic or Bayesian input (Phreda does not use this currently). The rule name and a description are stored and reused in the user interface. Each conditional element on the Left Hand Side of a rule is stored as an individual record in the 'conditions' table. These include attribute value pairs and arithmetic relationship tests. The consequent includes an optional message to be delivered when the rule fires, and the action type to be carried out.

Both the name of the rule and the message in the consequent are ways of attaching meaning to the measurements seen as important by the team member.

3.3.4 Dependences

While Phreda is reasonably modular in design, there are certain areas where integration with the collaborative environment is necessary. Some of these areas could be managed by re-engineering the software to allow for a flexible interface, but other areas of handcrafted linkage are inescapable. Phreda requires database tables. These are currently designed for a mySQL database, to match the environment in which it currently functions. When attached to the 'Trac' wiki and ticketing groupware, the latter had to be changed to use mySQL rather than sqlite, (the Trac default database) (TRAC, 2010). A facility for multiple database connections should be implemented in the future.

Because Phreda needs to access the database, connectors and query syntax also depend upon the database used. Phreda will be able to run any queries used as measures of the system, provided they use simple SQL syntax. Complex queries are handled by creating views (temporary tables), which can in turn be queried simply. This issue can be reduced if not eliminated by better use of table metadata. Otherwise, if measurements exist, Phreda will take the measurements, test them against user rules and carry out the consequent actions.

Some of the measures used in this implementation query page accesses and file behaviour. The collaboration environment has been designed to record these in database tables for the sake of simplicity. Files were stored within the database for security purposes, so Phreda did not need to create and monitor user accounts on a file server. The pages accessed on the site were recorded with each session as part of the "login" table. The actual address of each page was reformatted to hold an equivalent descriptor to that found in Phreda's list of login constants.

The "resource_constants" table that is part of Phreda's database is also used to store the discussion board's discussion types and the calendar's event types. The table provides a mechanism to collect possible dependencies peculiar to the environment, that can then be used in defining measures.

The other tables belonging to Phreda are used to collect rules from the rule-making interface that was embedded in the collaboration environment. For

convenience, the same programming language (PHP) is used to create the interface as well as the Cascading Style Sheet (CSS file), which defines the formatting for the rest of the environment. Some compromise was necessary in order to integrate the management of interface source code with the source structure used in the environment. The division of source code into page templates and functions influenced the location of files for the Phreda module. The location of most of the functional code for the rule interface has been simplified to be stored beside the code that generates the web pages.

Finally, the collaboration environment's login and home pages needed to be minimally edited to run Phreda; once at login time and then to print the personalised output for the user.

3.3.5 Training materials

In addition to the contextual help available for each measure, a series of definitions of interaction rules and resources are included in an FAQ section. The contents are stored in a database table. A tutorial is available that explains fully the rationale behind the rule creation process. Simple and complex examples are given with numerous sequential screen shots matching the creation process.

The provision of on-line contextual help and extensive tutorials does not mean that they will be used. Simple tutorials, with mechanical steps and no underlying reasoning were also provided for participants, as were live demonstrations showing how to use the collaboration environment, what interaction rules are and how to make them. The structure of the training materials is addressed in the following chapter (section 4.2.1.3.2), a tutorial has been appended (Appendix II) as well as the training session materials for venue V5 (Appendix V). Information packs describing the research were also created for distribution to potentially interested parties.

3.4 Seed rules

Since the recommendation engine has not been implemented, the author has acted as the substitute "expert" in order to use Phreda to test one aspect of this research.

A set of seed rules was devised, to overcome the problems of cognitive load that has been mentioned in chapter 2.

The seed rules listed below were designed to address issues of domination and freeloading and to prompt some of the desirable qualities of the communication process upon which collaboration depends.

3.4.1 Poor_Attendance_Tell_Me / Poor_Attendance

The attendance rules were created based on the assumption that an individual member would be concerned if other members of the team were not as committed to the project as they were, or if others expected more than an individual felt was appropriate (Fernández, 2004). The idea was that team should be able to come to an agreement on what was an acceptable frequency of logins, and the software would then monitor the actual attendance. The `Poor_Attendance_Tell_Me` rule notified an individual, upon login that they were not attending often enough. The `Poor_Attendance` rule fired simultaneously (using the same conditions), but notified the entire team without mentioning any names. The offending party gets two messages. If, in the future, Phreda is refined to use an email client, this will significantly improve the utility of this rule.

The rule was written assuming near daily attendance as being appropriate – that members should log in more than 4 times per week. Because it is unlikely to suit many teams, this was considered to be a prime target for the team to change.

3.4.2 Being_Sociable

Friendliness and social chit-chat are important for enhancing interaction between people (Kreijns & Kirschner, 2002). It was thought to be particularly important in a virtual setting, as the avenues for such exchanges are limited. `Being_Sociable` attempted to praise participants whose discussion postings were more than 1/8 classified as social.

3.4.3 Not_Following_Discussions

Freeloading by logging in but not bothering to read the discussions frequently enough, is also likely to be a concern (Ostrom, 1990). It was assumed that if more than four logins were required, then a corresponding minimum number of viewings of the discussion board would be appropriate. This rule notified the team that a member was not following discussions.

It was noted prior to the research that there might be fewer postings in any given week and that this rule would quickly be dropped as it became annoying rather than helpful.

3.4.4 Dominating_Proceedings

It is not always desirable for a member to assume the role of leader of the team and the motives for someone doing so could be suspect. On the other hand the so called "dominating" behaviour could be very helpful to the team (Yeatts & Hyten, 1998). It was considered to be leading behaviour if a member posted more than ¾ of the discussions and allocated more than half the tasks for the team.

It would be obvious to the team that this particular member was taking the leadership role. There would be no need to name names as part of the consequence – rather to suggest to all that the team consider deleting the rule if they felt that such leadership was welcome. It should in this way overtly raise possible conflicting expectations for resolution.

3.4.5 Morale_Slipping

The two polls implemented in the cut-down groupware asked questions about individual satisfaction and motivation levels. During training, team members were shown how to vote on these aspects and encouraged to vote often. These questions reproduce studies by Reimann*, et al* (2003) into the provision of graphical awareness of team well-being. Members were able to view the graphs of anonymous team results by clicking on a hyperlink. The morale-slipping rule was provided as a contrast to the graphs, drawing attention by firing only under certain conditions and delivering an interpretation of the graphical measures. If, when a

vote was taken, the average score for the team fell below half-way on both measures, it was suggested that the team address this. The rule pointed out the loss of morale and suggested dedicating a new discussion thread or a “virtual barbecue” (some sort of social gathering) to work out what was going wrong.

3.4.6 Give_Feedback

One of the features of an optimally performing team is the amount of feedback that members give each other. This is particularly important when working virtually, as otherwise one's efforts would seem to be disappearing unappreciated into cyberspace. `Give_Feedback` notified an individual if they were classifying less than a tenth of their postings as feedback and suggested that they offer more support to their fellow members.

3.4.7 Low_Content

If uploading less than half the number and less than half the quantity of files relative to the team average, it is possible that a participant is not contributing their share of the work. It may also be the result of circumstances and have no significance whatsoever. This rule merely asserted the fact rather than drawing any conclusions. It was used as a condition in the following rule.

3.4.8 Hesitates_To_Offer_Ideas

If an individual is not contributing much to the team's knowledge pool and is not contributing to discussions, but is avidly reading the discussions then it is probable that the member is interested rather than freeloading. They may be feeling hesitant about contributing and should be encouraged to do so. `Hesitates_To_Offer_Ideas` identified such a situation, and notified the team of the fact and recommended that people be encouraged to offer incomplete ideas and incidental thoughts. Airing incomplete ideas is important for the creative process, for finding alternative solutions and for avoiding group-think (where all members agree for fear of offending).

3.5 Conclusion

Source code for the prototype, together with the collaborative environment and the database resources used can be found in the included CD. The link and access details to a live site are also included. The contents of the disc are itemised in Appendix VIII.

Behavioural norms are structures created by groups of individuals as they interact. These norms are necessary for the organization to survive and thrive. They can serve productive functions, provide support for group well-being and support for individual members. Social norms are often formalized as rules. The Personalising Human Rule Elicitation Design describes a method of creating these rules as software support for virtual teamwork.

Adaptive software that is intended to support a complex human environment must be able to change to suit the environment and the changes to that environment. It must acquire knowledge from the users within the environment and from the environment's context. Users are able to attach meaningful labels to measures of software usage through production rule technology. The additional effort involved in using the rule-making facility should be reduced as much as possible through the use of recommendations. The patterns of behaviour that constitute these recommendations may be able to draw upon greater environmental complexity if the software is embedded in a multi-agent system (see Appendix IX).

Will such rule software contribute to the design of future collaborative environments? A prototype rule module, Phreda, was implemented and embedded in a collaborative environment that included the key features of existing asynchronous collaboration software. Questions of value based on this prototype were then explored.

Chapter 4 Methodology

This chapter outlines the research goals, methods and analytical processes used to explore the value of Phreda. Two approaches were taken in the exploration; the analysis of real-life venue behaviour and the canvassing of expert opinions via virtual focus groups. On-line behaviour associated with Phreda was observed in virtual teams, drawn from different educational contexts. Focus groups of participants with expertise in teamwork and familiarity with on-line interaction were also asked to evaluate the rule module.

4.1 Research Goals

The research goals in this study evolved as a result of the iterative experiences with real-life teams. The lack of success with the live teams led to developing other research questions suitable for focus groups. The questions that follow were addressed.

a). Can we design software to further develop levels of trust in on-line teams by emulating societal structures of behaviour regulation?

Team members risk some investment in a collaborative venture based on the assumption that other parties will do likewise, with a view to a long-term success that is of greater value than the risk. Does this initial trust (Hung et al., 2004), more recently termed 'predispositional' trust (Black, 2008), lead to the development of further trust through the use of the software? Social rules are seen to act as a contract in that a set of behavioural expectations are articulated and agreed upon. Does using software that allows the creation and administration of these rules, further develop the levels of trust between individuals in the team?

The theoretical framework predicted that the rule module would be valuable because, via improvements in team trust, performance would benefit. Increased risk-taking implies increased trust, if the reward from participation remains constant. It was not possible to find and survey risk-taking behaviour in real-life

venues. Given the limited value of the real-life studies, the research sought to discover if there was any indication in the discussions of the focus group participants that linked the rule module to the levels of trust in the team.

b). Do rules affect behaviour? If so, are the changes in behaviour constructive?

If the rules did not affect behaviour then the module would have had little value.

In keeping with the two views of learning referred to in section 2.5, the participatory and acquisition models, the research focused on both the rule artefacts, or products and the process of creating those objects. Both of these areas were examined to determine whether the rule facility was worthwhile incorporating in collaboration software. It was considered likely that, given the complexity of teams, any effects would apply to some teams and not to others, to some participants and not to others, and the nature of the effects would be idiosyncratic.

c). For which behaviours are rule artefacts valuable?

d). For which behaviours are the processes of constructing rules valuable?

These questions were explored just by focus groups because of the lack of interaction with Phreda in live studies. Live team members could not answer questions about processes they did not engage in, or draw a distinction between these processes and the artefacts they may have experienced. Focus group participants were asked to identify which behaviours were critical to teamwork and then to comment on whether the rule module artefacts and processes would be useful for optimising these behaviours. This question assumed that the module was usable and that the module affected behaviour in a positive way. Empty lists could be used to negate these assumptions.

e). Why did the real-life studies produce such limited results?

A number of contextual issues could have inhibited the construction of rules in real-life venues. The team managers, but not the team members engaged with the rule module. The researcher was left wondering whether the rule module would

be used under different circumstances. A scenario was developed to encompass the circumstances for which the software was designed and presented to the focus group experts.

i). Was the scenario realistic?

The focus group experts needed to confirm that the scenario, representative of the circumstances upon which the design was predicated, could have occurred in real-life. If so, the following questions were pertinent.

ii). Would scenario members use the rule module?

The software was designed to accommodate leaderless teams with independent members. Perhaps leaders were essential for managing norms of team behaviour. Part of the stimulus for the design was to prevent a moderator from being forced to exercise policing power.

iii). *Would a scenario team leader use the module?*

The literature on cognitive load led to the design of a recommendation engine. There was only a small response to the preset rules. Perhaps the absence of a well targeted set of recommended rules might have inhibited the construction of rules in real-life venues.

iv). *Would a set of recommended rules encourage the scenario team to use the module ?*

4.2 Methods (in general)

The paths taken by this research were intended to ensure that the Phreda prototype was usable, and then to confirm the belief that such software was valuable (i.e. that a tool for creating and administering interaction rules has a place in collaboration software.) Both real-life cases and expert focus groups were used. The real-life studies attempted to develop participants' expertise in creating and using rules and validate the observed expertise with survey questions. Difficulties with the contexts of these studies seriously limited findings. Real-life studies were completed before the focus group study. Lack of use of the rule module emerged

as a common (grounded theoretical) phenomenon (Corbin & Strauss, 1990) from multiple cases, thus requiring further exploration.

The focus group approach was intended to draw on participants with previous expertise in the field of on-line collaboration and teamwork. Participants were chosen who had experience in at least one of the following team contexts:

- community groups
- work groups
- formal educational groups.

They were given a scenario for which the software was designed, experience with the environment, a demonstration of that software and asked similar questions to those in the real-life team surveys. Validation of findings was based on consensus within each focus group and externally by comparing more than one group.

The limited findings from the live studies were able to be confirmed by the focus group findings. Reasons for the limited findings were also explored to determine, given its initial lack of uptake, whether the module was a worthwhile addition to collaboration software. A simple usability study was required to establish that the rule creation interface and support materials were sufficient for users, other than the researcher, to be able to create rules.

Usability studies of software rely on the observation of participants as they carry out a particular task. The observations may be carried out by trained observers or may be recorded using a technological aid. Software engineering practice incorporates methods for studying usability for many users. Observations can be taken where software is used in specific scenarios and information can be obtained from user surveys, checklists, journals and questionnaires (Abowd et al., 1997). User interface development is based on a cycle of prototype development, followed by evaluation and then further development based on feedback provided by the evaluation (Pressman, 2001). The research software, Phreda, would be considered a first prototype in this classification and likely to be changed in many ways to enhance user efficiency and comfort. While the main goal of the usability

studies in this research, with Phreda, is to determine the usability of the software in its current version, the opportunity still existed to gain insights that could guide possible future modifications.

Determining whether software is valued is a far more complex issue than determining whether a mechanical skill can be mastered. Quantitative validation of knowledge typically occurs with respect to a population, as represented by a sample in an experimental context. Qualitative methods are used to validate knowledge when insufficient quantitative data are available to support statistical validation techniques, and this typically occurs when studies are conducted in the context of real-life. Qualitative methods have been designed to assist us in understanding social and cultural phenomena (Meyers, 1997). Studies situated in a real-life venue rather than within a controlled experimental setting depend very much on the emergence of understanding through multiple data sources. Grounded Theory (Gasson, 2004; Meyers, 1997), Case Study Research (Yin, 2003) and Action Research (McKay & Marshall, 2005; McNiff & Whitehead, 2006) all address the problems of developing theory in real-life contexts. These approaches are often used in educational, workplace and design science research. Whitman and Woszczynski (2004) outline a number of approaches for the studying of Information Systems. While information systems are by no means restricted to workplaces, the workplace is the primary focus of the Information Systems discipline. The chapters on Grounded Theory (Gasson, 2004) and Virtual Teams (Robey & Jin, 2004) provide guidance on how to deal with the real-life study of virtual teams.

These qualitative approaches rely on iterative actions on the part of the researcher i.e. multiple visits to data, visits to multiple data sources and observation in multiple cases.

A research routine is needed to strengthen the reliability of the results and permit some degree of reproducibility. Using these methods, internal validity is established by triangulating multiple data sources from the one case and exposing one's findings to participants for verification. External validity comes from the

use of multiple cases where similar concepts can be observed in different contexts (Yin, 2003).

The focus group has been shown to be an efficient way to explore and discuss a specific topic. It is a suitable method for canvassing the opinions of experts in the field of collaboration and on-line work. Focus groups were originally made popular for market research rather than academic study (Rezabek, 2000). The electronic focus group methodology has been used increasingly as remote communications have become widespread. It was used by Rezabeck as early as 1999. He canvassed expert opinion as a component of academic research into the take-up of distance education (Rezabeck, 2000). Early focus groups used asynchronous discussion boards or list serves while more recent ones use synchronous technologies such as chat (Cameron et al., 2005).

Focus group data can be acutely focused or require wide-ranging analysis. Focus groups are more complex than surveys or interviews of individuals because interaction adds complexity to observations. Frequency or intensity of interpersonal exchange, not just narrative may be meaningful (D. L. Morgan, 1997; Willis, 2009). Consensus of opinion within and across focus groups validates research findings. The researcher can also confirm interpretations with participants. Focus group findings can also used for triangulating in mixed methods studies (Willis, 2009; Morgan 1997).

4.2.1 Real life teams

4.2.1.1 Purpose

It was anticipated that real life teams using the Phreda software would produce rule sets while conducting on-line tasks. It was anticipated that responses to rules would demonstrate:

- that rules changed behaviour and that these changes were constructive - research goal b),
- that users could create meaningful rules - research goals c) and d.),

- that a recommended set of rules would prove useful - research goal e).
- that these rules had an effect on levels of trust. - research goal a).

The failure of teams to generate rules required that all expectations except the first had to be abandoned and that research goal e) be created and pursued in focus groups.

4.2.1.2 Data

The data streams that were included in the study design were the logs of rules and behaviour traces generated by the virtual team members using Phreda, team discussion board content, surveys of participant perceptions and observations from team managers.

The real-life studies identified changes of behaviour associated with changes in the rule set or associated with the firing of existing rules. Because participants in live venues did not create rules, the live studies only contributed to research goal b). It was also possible to eliminate one of the likely explanations for lack of engagement as part of research goal e) by carefully restructuring the rules for teams in the final live venue to be different from those in the previous trials. If the preset, recommended rules were perfect to begin with, then there would be no need to create new rules or modify or disable old rules. Venue 5 teams were structured to have different or no preset rules.

4.2.1.3 Challenges

This section discusses the challenges that influenced the methods used in this research

4.2.1.3.1 User Understanding of Interaction Concepts

It was possible that research participants might not be able to understand the concepts of interaction norms and rules. Both social experience and the ability to deal with social abstractions were considered necessary conditions for this understanding. Developmental educationalists such as Piaget and Maslow

regarded social abstraction to be one of the most advanced stages of human development. Some participants might not be able to grasp the ideas upon which the software was based. Even if participants were capable of grasping these ideas, personal meaning would need to be built based on the participant's experiences of social interaction.

Participants would therefore need to be selected from groups whose current or past context required such understanding. The choice of examples used to explain the interaction concepts would also need to be tailored to suit their experiences.

4.2.1.3.2 User understanding of rule concepts

Several key concepts are necessary for understanding what interaction rules actually are and how they have been integrated into the collaborative software. Participants of all studies were given a firm grounding in these ideas in order to understand the training material provided within Phreda. Participants needed to be clear on the definition of an interaction rule. They also needed to be comfortable with the environment, and the measures that were used to construct the rules. In order to use the rule facility effectively each participant needed to understand the following:

i). A group of humans will develop norms of behaviour.

ii). A norm can be formalised into a rule.

iii). A rule can be expressed as a set of conditions and a consequence, which will automatically follow if the conditions are met.

iv). Measures of on-line usage can be used as conditions.

In order to facilitate this, users were required during initial training to log in, modify their user information, see details of other team members and contribute to an on-line discussion in the collaboration environment. The researcher ensured that the participants understood these basic principles by assisting them to become familiar with the interface and by presenting them with some example Phreda rules that illustrated these concepts.

4.2.1.3.3 User Mastery of the Mechanics of Rule-building

Some users may not be able to create rules because of their inability to use the rule-building features of the software. Participants needed to be given the option of handing over the rule construction task to others. The software also had to be tested to ensure that it could be used by those other than the author.

4.2.1.3.4 Lack of reproducibility

It is difficult to make statistical inferences from real-life situations because they are unlikely to be closely comparable with other real-life situations and so a qualitative approach was needed to underpin the research (Myers, 2007)

4.2.1.3.5 Contextual interference

Live venue research can be derailed by influences beyond the control of the researcher. In this instance the primary task of each team was not the domain of the research or the researcher and as such it could be altered from outside the research framework. Someone else's agenda might influence participation.

Excessive cognitive load imposed on users when using the software could cause research priorities to be abandoned in favour of completing work tasks (Sintchenko & Coiera, 2003). This load could be reduced, if necessary, by having the researcher offer to create or disable rules at the request of the team, saving the participants the effort of learning and undertaking the rule making process. The researcher however, had no control over the cognitive load generated by the real-life task.

Conversely, if the researcher is embedded in the real situation, their presence may alter the behaviour of participants. Wherever possible, the role of observer was taken by a supervisor, rather than the researcher. In situations where the researcher was present in the team, the role played by the researcher was as supervisor of the task. The research observations came secondary to the primary supervisory role. Mention of the research was avoided during the completion of team tasks and validation of observations occurred after completion of the team task.

4.2.1.3.6 Difficulties in finding optimal venues.

It was not possible to find venues where an ad-hoc team of independent members was working virtually on a particular project. There were degrees of "virtual" and many team members could share factors in the context in common, such as having worked together before, or having worked with other members' peers. The supervisory role varied from interventionist to purely administrative, which affected the degree of independence of team member participants. Any theory developed from data collected from multiple venues would need to consider whether these differences influenced findings.

The difficulties that arose from finding optimal venues and the likelihood that the study of any real-life venue can be compromised, required a backup approach to evaluating Phreda's usefulness. Experts familiar with on-line collaboration and with teamwork in real-life may share common opinions about Phreda's worth. The opinions of experts are derived from real-life and any study of these opinions avoids the challenges thrown up by real-life studies. On-line Focus Groups were used to obtain these opinions. The research goals (section 4.1) for this thesis were finalised to suit the change from a live to a derived study. Data streams from the live study were still useful in pursuing whether rules could constructively change behaviour (research goal b.)

4.2.1.4 Process

A variety of community, government, corporate and educational entities were approached for an expression of interest in this research, Descriptions of the selection process, the teams and their activities are appended (Appendix III), while a summary table is shown below (Figure 9).

Venue	Teams	Members	Description	Observer
V1	1	6	17-18 year-old senior secondary students.	teacher
V2	1	7	Academic in-service training group	conveners / researcher
V3	1	5	Mature-aged adults, second-year under-graduate student tutorial group.	researcher
V4	1	5	17-18 year-old senior secondary students.	teacher
V5	5	25	16 year-old secondary students from two remote schools.	teachers

Figure 9. Profiles of the five live venues participating in this research.

Once a venue had been identified and a collaboration environment created for each team in the venue, participants were given access to their team environment.

Each team participant was taken through training where the concepts of interaction rules were explained. This was accompanied by a familiarisation session with the collaborative environment. The process varied slightly from group to group depending on context, but the concepts and skills that were introduced remained the same. Participants were told of the rule tutorial materials and it was suggested that they explore the rule facility as it suited them. Since they were primarily concerned with completion of a set task, participants were told that requests for rules, and rule changes, would be taken by the researcher who would implement these rules, where possible. The participants would thus not have to learn the mechanics of how to create the rules and could just focus on their primary activity. Support would be given should participants wish to create rules themselves. The researcher could also be contacted if there was any problem when using the system generally. The only additional cognitive load for the participants was in understanding rule concepts, thinking about what they needed rules to achieve and discussing this with the other team members.

Teams were given software that either did or did not have preset rules. Providing teams with preset rules gave them an example of what could be achieved, gave the team members an opportunity to remove inappropriate rules and allowed the researcher an opportunity to test whether these rules did have an effect on behaviour. The preset rules have been discussed in section 3.5. Behaviour with

regard to the rule module itself, and behaviour that was associated with specific rules, could be compared between teams with and teams without, preset rules.

The software required participants to classify their discussions by choosing from a list ('Administration', 'Assistance Request', 'Decision Making', 'Exploratory Discussion', 'Feedback', 'Social', 'Task Content', 'Other'). This was intended to give a general guide to the content of their communications. The meanings of these terms would ultimately be defined by the team's own usage. Participants were instructed to use the classification that best described the main purpose of the discussion posting. Some of the predefined set of rules were constructed to encourage / discourage certain types of discussion communications, such as providing feedback (section 3.5).

The manager of each team, upon conferring with the researcher, instructed the members on how the collaborative environment could be used to complete their tasks. Team members were given varying degrees of independence over the manner in which their task was completed. The researcher was available for troubleshooting, but all requests for assistance were to be passed via the manager.

As previousy described, the software recorded a profile of team state each time a member logged into the system. The manager of the team was asked to comment on any conflict within the team and on any behavioural effects that might be attributable to the rule module. Also, the software database contained the content of discussion posts.

4.2.2 Focus groups

4.2.2.1 Purpose

The focus groups of Internet-literate, teamwork experts were intended to provide opinions on the worth of Phreda. The focus group methodology was used to overcome the limitations of live venues. Knowledge gained from focus groups is a derivative of real life and so avoids the problems associated with finding the right venue for research. The success of that research is not dependent on the live venue context, either.

4.2.2.2 Data

A number of data streams were available for analysis – the discussion board text was available from the asynchronous component of the study, recordings of each web conference were retained and verbal discussions were transcribed. Screen shots of team voting were taken and retained as images. Email communications confirming researcher perceptions were also available.

These data existed for three focus groups.

4.2.2.3 Challenges

There are three main risks to the success of Focus Groups as a research method; moderator interference, group pressure on the stated opinion of individuals and inappropriate participant background (D. L. Morgan, 1997). A fourth risk is particularly attached to conducting focus groups on-line; that of technology failure.

4.2.2.3.1 Moderator Influence

The first risk is that the researcher or moderator of the group distorts the results by their presence. Four strategies were used to combat this likelihood. The beginning of the exercise involved an asynchronous discussion board. Participants were anonymous and had a chance to share ideas and orient themselves to each other and the on-line environment. Secondly the role of the moderator was stated explicitly as being available for information, for practical, technical assistance and to keep the process on track. Thirdly, after web conference discussions, using the quiz mechanism, the participants were given the opportunity, privately, to summarise their perceptions of their group's opinions. They were asked to present any personal differences to that consensus in writing. Finally, the participants were given a copy of the researcher's understanding of the consensus and the divergent views expressed across all groups and they are asked to validate and comment upon them.

4.2.2.3.2 Participant Influence

The second risk is that the participant interaction prevents individuals from truthfully exposing their attitudes and opinions. Individuals may tend to conform and withhold views that they may hold in private. They may also tend to polarize and take a more extreme public position than the one they would privately adopt (Morgan, 1997). This research tackled the risk by using multiple groups to cross correlate opinions. Any common opinion withheld by multiple individuals from multiple teams would not be the result of participant interaction. As mentioned previously, individual participants also had the opportunity to summarise group and personal views privately. Healthy groups were expected to demonstrate differences of opinion, compromise and agreement, not just agreement.

4.2.2.3.3 Destructive Conflict

Thirdly, to ensure that there was no breakdown of relationships between members and that they only influenced each other's opinions through reason rather than the exercise of power, the researcher looked for signs of conflict and domination. The groups' interactions were analysed to confirm that the results were a result of healthy exchange.

4.2.2.3.4 Technological Breakdown

Focus groups traditionally take the form of moderated face-to-face discussions. They can most closely be emulated on-line, in a web or video conference. Asynchronous discussions are similar to synchronous video conferences without the video. Typing replaces the voice, and thus the opinions have more time to be considered and composed. Also, the participants can remain anonymous.

Asynchronous virtual discussions are not such a risk as synchronous ones. It is easy enough to suffer a period of interruption without destroying train of thought or destroying the exchanges that are working towards a conclusion. Synchronous discussion without video retains immediacy and permits shared demonstration and exchange. Any advantages of this immediacy (intangibles such as hearing the tone in a person's voice, spontaneous, uncontrived offerings, etc) would have to

be sacrificed if the complex web-conferencing environment failed. Asynchronous alternatives thus need to be in place in the event of such a failure occurring.

4.2.2.4 Process

Participants for the focus group study needed to have expertise in collaboration and on-line work, rather than the more varied participants available in specific real-life team contexts. They were selected from three sectors to cover a diverse range of experiences of teamwork. The selected focus group participants had experienced teams in either the community, workplace or educational contexts, or some combination of these three sectors for example a sports teams, work or social teams, and via collaborative learning. They had taken leadership roles and drawn generalisations about their experiences.

Participants were selected for the following characteristics:

- Basic computer literacy including Internet and email use,
- Familiarity with blogs, or discussion forums; participants had already engaged in a loosely defined community of practice by reading or contributing on these asynchronous collaboration tools,
- Expertise in teamwork in either a face-to-face context or on-line or both.

It was assumed that volunteers would require flexibility of space and time in order to participate, so the focus group study occurred on-line.

The participants were evenly distributed across two asynchronous discussion board groups and provided with an on-line team scenario with which to focus the discussions. The study participants were then given time to understand the environment in which the scenario teamwork would occur (Phreda's collaborative environment). They were directed to discussion threads defining and exploring concepts of on-line interaction, behavioural norms associated with teamwork and rules. Their ideas and the research focus were shared amongst all participants in their discussion group. It would have been clear from the exchanges if anyone had an inappropriate background and was unable to comment at the level required.

Twenty-five participants volunteered and were allocated to one of two implementations of the Phreda collaborative environment. It was assumed that 15 members per focus group would be the maximum number for effective, intense exchange on a discussion board and also that some participants would drop out. This maximum number of participants per group was based on the author's previous experience with discussion boards in tertiary on-line teaching situations. Two synchronous web conferences for evaluating the rule setting tool (Phreda) were allocated for each discussion board group. These will be referred to as the "focus groups" as distinct from "discussion groups". Four focus groups, each of 4-8 individuals would raise most of the key issues (Walter, 2009), Morgan 1997).

Of these 25 initial volunteers, 9 completed the process. Many of the withdrawals occurred in the two-week, "discussion group", first phase, but most of the 25 did make some contribution. By the end of the fortnight, three focus groups could be created, two from one discussion environment, as planned and one from the other environment. (Most drop-outs came from the one environment.) The focus groups each originally comprised three groups of five people, but two failed to start and three withdrew during the second stage, partially because of Web Conference Software problems.

The breakdown of network connections during the synchronous second stage of two focus groups required that second web conferences be scheduled and that (eventually) the asynchronous back-up plans be implemented. The second stage "funnelled down" (Morgan, 1997) to tightly structured focus questions. This and the existence of some synchronous communications, made it easy to finish discussions using a discussion board, and to answer the questions using email instead of the web conference quiz tool.

Participants with experience in community, work and education teams could be found in each of the focus groups, despite the dropout rate.

The discussion board, Phreda's collaborative environment, was set up to hide the rule module. This ensured that discussion topics would focus on preliminaries and not stray onto the module, until it was demonstrated in the synchronous focus groups. All focus groups saw the demonstration before the web conferences were

interrupted. The `Attendance` rule was created, showing the individual participant their log-in frequency and the average log-in frequency for the team. Two purposes were served here. The first was that it gave the participants an example of how a rule might operate, and secondly it provided a concrete "hook" for the evaluation questions that followed in the focus groups. It provided participants with a common concrete experience of the rule artefact (product).

The use of the two stages of the research allowed for a 'funnel' of general to specific focus, as recommended by Morgan (1997) and also ensured that participants were appropriately qualified to answer the specific questions in the second part of the study.

Three introductory discussion threads were present from the outset of the first stage and three questions were used to introduce the knowledge required for understanding the rule module.

The introductory threads explained the scope of the research, role of the researcher and introduced terms associated with the rule module. They provided familiarisation activities for the participants.

The first of the serious threads asked participants to consider how the scenario team might use the environment's tools to carry out the imagined task. This question was intended to assist participants in identifying what can be measured as conditions for interaction rules. The second of these threads asks participants to relate their experience, as experts, to what constituted optimal team behaviour. Discussion board interactions were expected to be well focused on the topic of on-line interaction at this stage. The last thread asked participants to discuss specific behaviours in greater depth – in particular how to identify the behaviour when it occurs on-line, and what rules might be established for that behaviour. It was expected that some of the answers in the previous question would overlap, and that the same behavioural norm might be viewed in its constructive or destructive form. The full text of these threads can be found in Appendix VI.

As mentioned in the previous paragraph, participants in the focus groups were provided with a team scenario so that they understood for whom the software was designed.

The team scenario identified a team of individuals with similar interests, a common on-line task and no clear team leader. The scenario individuals might or might not have known each other and might not necessarily have shared the same culture (either lifestyle or work style). A number of different rewards and risks for the scenario team and its individual members were outlined.

In order that the focus group participants could engage with the scenario, they were asked to construct a scenario persona including a risk / benefit evaluation. At the end of the study participants were asked whether the scenario was realistic. The full text of the scenario and associated instructions can be found in Appendix VI.

Participants were emailed the scenario and instructions on how to log in to the discussion board environment. They were given usernames and encouraged to maintain anonymity. Anonymity was expected to eliminate some of the interactive problems that might result from participants knowing each other; participants feeling inhibited or participants experiencing various kinds of bias such as gender, race and disability. Once in the discussion board environment, participants were greeted by a welcome message and asked to read the information and guidance threads already provided as part of the Phreda software.

The discussion board phase of the study was intended to last for two weeks, with the participants checking in five out of every seven days, for about thirty or forty minutes each time.

The researcher's role was to sort out technical and training issues and clarify misunderstandings in the instructions. This included steering the key threads back to the research plan if they lost focus, as would be done by the moderator of a face-to-face focus group (Morgan, 1997). Participants were free to start their own threads and use the environment as they pleased and could wander off focus (in all but the key threads) if they wished. The study was open to emergent ideas and

any posts that had the slightest connection to teamwork would be analysed in accordance with a qualitative technique such as open coding, used in grounded theory. The same technique would also apply to transcripts of the focus group discussions. Further discussion of coding is presented in the Evaluation Techniques section (section 4.3.2), below.

The synchronous web conference was planned to allow participants to engage in more dynamic discussion than possible in the asynchronous environment, in response to the rule module demonstration. A proprietary web conference tool, "Elluminate Live," subscribed to by the University of Tasmania, was used. The software provides audio, video, file, desktop and multi-media sharing, a whiteboard and a quiz delivery mechanism.

It should be noted that problems with audio feedback necessitated a "hand raising" protocol be implemented.

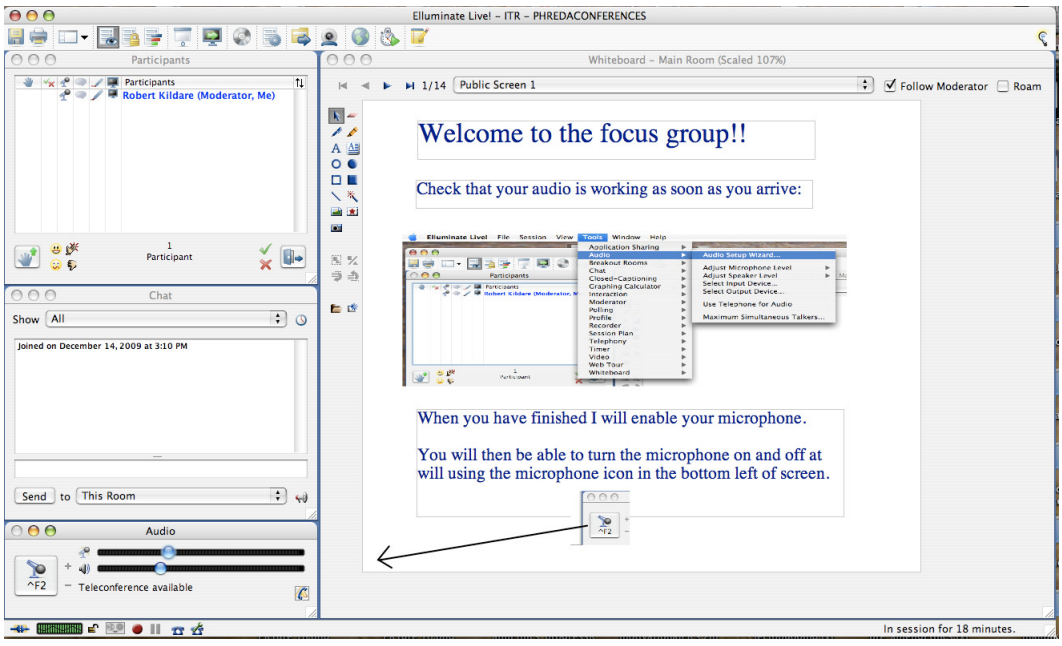

Figure 10. The "Elluminate Live" interface, showing the whiteboard welcome slide, the participants window (top left) the chat window below it and audio controls (bottom left).

Participants were provided with login instructions, software and network training, as well as assistance with setting up headphones. The participants were limited to

audio communication only, for simplicity (technological and communications distractions were kept to a minimum) and to retain anonymity.

A demonstration movie was recorded, showing how to construct a rule using the rule module. This demonstration and an accompanying explanation preceded two sets of six questions evaluating the rule module. A series of 14 whiteboard slides were prepared as the anchor for the focus group process. Two Elluminate Live quizzes were also prepared, providing a mechanism for collecting individual written answers. Most of these "quiz" questions asked the participant their perception of the group viewpoint after discussion, and gave participants a way of presenting a dissenting view, or qualifying what was said.

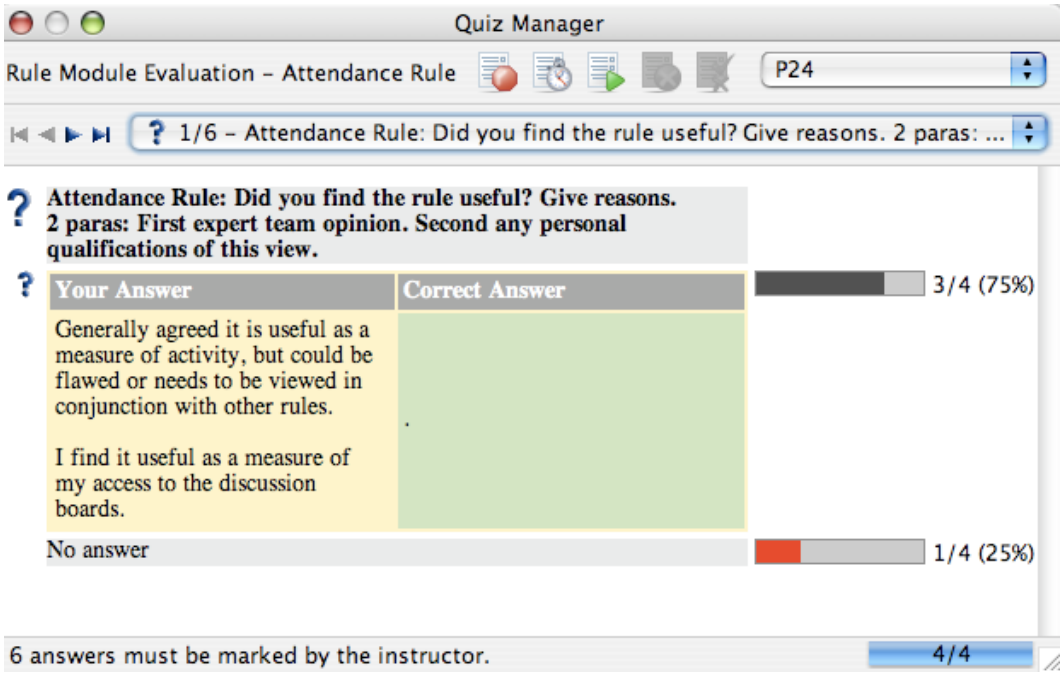

Figure 11. A completed answer from Quiz tool in "Elluminate Live". The answer shows the question, the participant's perception of the group discussion and the participant's own qualification of that view.

The evaluation questions were first applied to the Attendance Rule. The rule fired each time the participants logged in to the discussion board. The output of the rule showed log-in frequency for the participant and the average log in frequency for the team.

The questions attempted to explore the dimensions of usefulness as they related to the participants' experience of the rule module and its research context. The first three questions addressed different perspectives of the rule product and the second three asked the same questions about the process of constructing the rule. Apart from the questions using participants' common concrete experience to start the discussion, these questions could reveal whether the rule module, via the attendance rule, affected behaviour constructively (research goal b)).

Q1. *Did you find the rule useful?* This question introduced the focus of the study, value, and tied it to their experience of a rule artifact, and the demonstration of how to make a rule.

Q2. *For which scenario members, if any would such a rule be useful?* This question generalised the focus to tap into each participant's expertise in teamwork. The focus here is on team members.

Q3. *Do you think that the rule might affect team performance?* This question focussed on the team as a whole.

Q4. *Do you think that the process of arriving at the rule would be useful?* This question introduced the distinction between the rule artifact and the process of construction of the rule.

Q5. *If the process is useful, to whom might it be useful?* This question linked the process of rule construction to the team members.

Q6. *Do you think that the process of constructing the rule might affect team performance?* This question linked the process of rule construction to the team.

The second set of questions linked the concept of usefulness to the behaviours participants considered to be critical for teamwork. The behaviour list for each focus group was taken from the earlier contributions that they had made on the discussion board. Participants were asked to confirm that the list of behavioural norms was accurate and complete. Questions 7 and 8 below directly extend from

research goals c) and d). If the rule module was not useful for any of the key teamwork behaviours, then the value of the module would be very limited.

Q7. *List the behavioural norms for which rules might or might not be useful. Give reasons*. Participants were asked to tick checkboxes for those behaviours for which rules could be useful. They gave their reasoning via the quiz tool. The question attempted to discern whether or not there were any types of behaviours for which rules (as artifacts) were inappropriate.

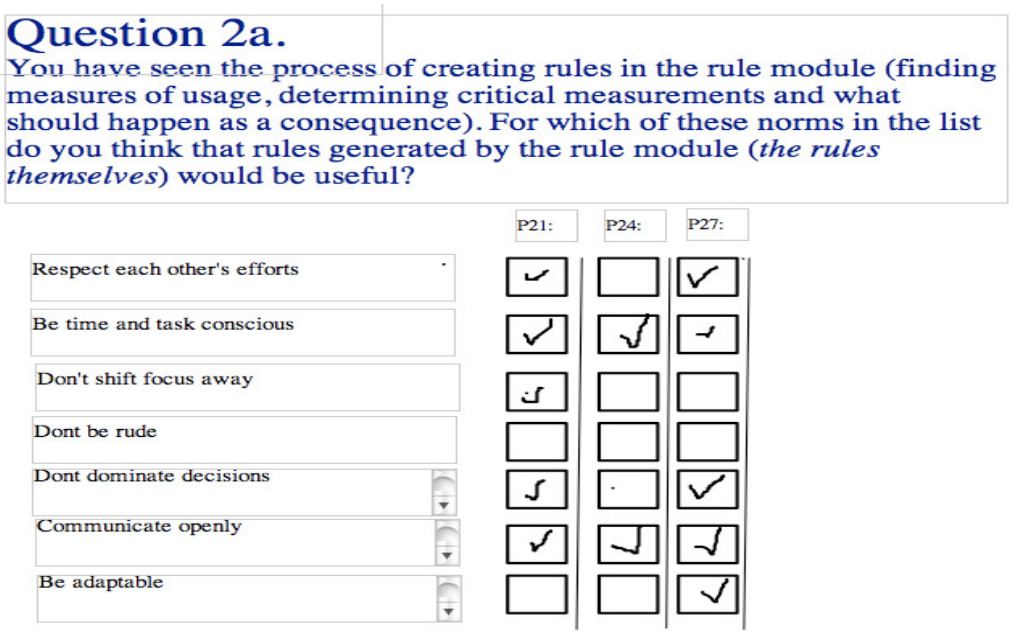

Figure 12. The interactive whiteboard showing checkboxes from the first web conference. Participants were anonymous and presented their reasoning via the conference software's quiz facility shown in Figure 11.

Q8. *List the behavioural norms for which the process of rule construction might or might not be useful*. Give reasons. Participants were asked to tick checkboxes for those behaviours for which rule building could be useful. They gave their reasoning via the quiz tool. The question attempted to discern whether there were any types of behaviours for which rule building was inappropriate.

Q9. *For the fictional scenario team: Do you think the team members would use the rule module or ignore it?* For whom is the rule module useful? This

question stems from research goal e) and goes to the heart of whether the rule module software was fit for purpose.

Q10. *For the fictional scenario team: If they had a leader do you think the leader would use the rule module?* This question introduces the idea of a team leader guiding the team. A number of issues about leadership and any lack of a formal leader may have influenced real-life venue behaviours. Leadership may be relevant to democratic, consensus decision-making processes. This question was not directly addressed in the software design.

Q11. *For the fictional scenario team: If an initial set of recommended rules were provided, would this make it more likely that the rule module would be used?* This question introduced the hypothesised idea that a recommendation might ease the difficulty of creating rules.

Q12. *Do you think that the scenario was realistic?* This question ensured that the scenario did represent a realistic situation. The answer served two purposes; firstly it would test the validity of any conclusions drawn from the scenario. Is the theoretical framework a figment of the researcher's imagination or is it rooted in reality? Secondly. if the scenario was found to be realistic, this would help to contextualise the results from the actual real-life venues that were available from the research.

4.3 Evaluation techniques

Qualitative techniques were used for evaluation. Evaluation of real-life team data involved triangulation of multiple data sources, and focus group knowledge came from both participant consensus and the open coding of their deliberations.

4.3.1 Real-life Teams

Log traces (profiles of team state) were chosen as a data stream because these were more readily identifiable by software than the profiles of team interaction developed by Bales based on textual analysis of communications (Bales, 1950). The proposed recommendation engine was anticipated to use team state profiles for providing recommendations. Variants of Bales categories were used for

manually coding the interactions of virtual teams for studies of trust (Coppola et al., 2004; Jarvenpaa & Leidner, 1999). Textual analysis remained an option, should an additional data source have been necessary.

Log traces of participant behaviour were available not just to the researcher, but measures of these traces were also available to participants for the construction of rule conditions. The firing of rules produced a unique file each time a participant logged on to the system.

These files were created as expert system scripts and provided a profile of team state. A small application containing the JESS expert system shell was constructed to run each of the scripts. The application printed the output from each script to a correspondingly labelled output file. The history of rule firing in the live context could then be reproduced and compared to behaviour traces in the collaboration environment's database at corresponding dates. The traces were analysed from just prior to a rule firing for the first time, to compare team states before and after the firing.

Rules could be made about the types of discussions that team members posted. The preset `Give_Feedback` rule was first selected for tracing because this rule fired frequently across all venues. This rule provided a message for the individual member when the proportion of their posts classified as feedback fell below 10% (section 3.5). The preset attendance rules available to the live venues were not suitable for close analysis, because participant attendance for three of the venues was severely biased by the circumstances surrounding each study. This left preset rules about the type of content posted in discussions available for analysis. `Being_Sociable` encouraged social postings. The teenage groups, unsurprisingly, were high in social postings. The adult groups, with far more serious time pressures were not high in social postings, despite the encouragement of the rule. Other preset rules did not fire frequently enough to be worth pursuing. This erratic response to preset rules was anticipated, given the complexity of teams and their contexts. (It was unlikely that the preset rules would be sufficiently accurate to negate the need for new or edited rules.)

Importantly, the `Give_Feedback` rule, appeared in four venues' trials but not in the venue 5 trial. The venue 5 trial contained two teams without preset rules and three teams with preset rules conceived by the team manager.

As indicated, behavioural changes could be characterised by variations in the type of discussion message posted. However changes in posting classifications could be attributed to a number of causes, not just the firing of a rule message. Typically, much behaviour is task driven – for example there may be a flurry of "task content" postings close to a deadline. Traces of whole team classification for a discussion thread were used to see if patterns in team behaviour existed and were influential. The team usage, and the text of the discussion posts, helped to provide triangulation for interpreting the behaviour of individuals, as did observations made by team managers.

The `Morale_Slipping` rule was identified in the Venue 2 team by the researcher who was acting as one of three facilitators for the group and saw the rule fire. It was not necessary to use log traces. Behaviour was easily identified as contingent upon the firing of the rule by observation and reference to discussion texts.

Rules related behaviour were identified in venues V1 and V2.

A number of other techniques were applied for other research goals, but failed to give results due to the idiosyncratic limitations of the live studies and because no live venue created or requested a rule. (See Appendix IV, p.187, for the major live-study survey, and Appendix III, p.178, for a description of all venues and their activities.) It was not possible to question participants about specific behaviour traces as the teams had disbanded by the time analysis was completed, and existing survey questions did not uncover information at this level of granularity.

It was however, possible to compare rule–related behaviour to the responses of experts from the focus groups, to their `attendance` rule.

Managers requested that rules be created, even though team members did not. They were curious to see if their rules worked. Their requests were documented

along with their observations, even though they were tangential to the outcomes of this research.

4.3.2 Focus Groups (specific)

Two opposing methodological forces exist at the point of extracting meaning from the focus group study. The principle of the focus group is to deliberately focus on what the researcher wants (Morgan, 1997). The principle behind open coding is for the researcher to extract concepts and categories of knowledge as they emerge from a sample of a real-life situation (Corbin and Strauss, 1990). Layder argues that ground up (bottom up) emergence cannot occur without some pre-existing theoretical influence (top-down) on the participants, the researcher and the situation itself. This research agrees with Layder and assumes that one can learn from concepts developed in either direction (Layder, 1998).

The focus group questions were evaluated using top down techniques. Further exploration of the textual data was expected to yield reasons for the values expressed and could be compared against the hypothesis that “trust” issues were central to the value of the rule module. While the focus group did not reflect the loose and open, real-life situation typical of a grounded study, the reasoning upon which the participants based their opinions was open. Extracting concepts from their text was found to be revealing. All audio transcriptions and written artefacts from the discussion board and quizzes were available for analysis.

Answers from the focus groups were synthesised into single, general statements for each question with ungeneralisable opinions added as qualifications. While uncoded, the generalisations were based on the same principles of concept extraction as those in grounded theory as espoused by Corbin and Strauss. (Corbin and Strauss, 1990). The twelve statements were then recirculated to participants for validation. Participants were asked if their views had been misrepresented or omitted, and whether they had any further comments to make. Because the qualifications and corrections were made by only one participant each, revision of the original general statements was not required. Had there been multiple similar qualifications for a given synthesis, revision would have been required. Participant qualifications additional to the synthesis were included in the

reported results in the next chapter. The general statements formed the core of the findings of the value of the rule module software.

The textual data were then open coded for concepts that were raised across the questions. The theoretical perspectives brought to the design of the software and the research methodology guided the search for further concepts. In particular the coding sought to check on the health of the focus group discussions, any failings or confusions with the research methods, any comments on software design and any reasoning that involved trust.

In keeping with Corbin and Strauss's grounded method, each synthesised concept was considered provisional and had to earn its place as a result of recurrence in the data. Conceptual tags were created using TAMS Analyser software (Weinstein, 2009) and discarded if they bore no relevance to the issue under scrutiny (Corbin and Strauss, 1990). In particular, concepts related to social banter, questioning and providing additional information were coded, but passed over.

To ensure that there was no breakdown of relationships between members and that they only influenced each other's opinions through reason rather than the exercise of power, transcripts of the discussions were coded for signs of agreement and disagreement in keeping with both Bales' classification of 'decision' interaction (Bales, 1950) and Morgan's view of healthy focus group behaviour. Morgan demonstrates the way in which consensus and diversity of opinions are revealed, when participants are comparing and sharing experiences and perspectives with each other (Morgan, 1997). If compromise positions were suggested in this study, these were considered to occupy the ground between 'agree' and 'disagree' and were also coded. The content of these coded comments could inform any determination of undue influence, reticence or polarisation within each group. Coding responses for Bales' 'antagonism' interaction sub-category (Bales, 1950) could also identify potentially dysfunctional focus groups – those with personal rather than conceptual conflicts.

The TAMS Analyser is shown below (Figure 13) with tags applied to a transcript. The content of the transcript provides insight into interpretation. One comment

can be classified in more than one way. Further, if a particular tag such as "Commitment_Comment" is ascribed to one participant, another participant may agree with the idea without making a tagged comment. P194 in the example below says, "Just to endorse what has already been said." This was tagged as "Agreement", but the substance of the opinion held did not appear in the list of Commitment_Comments. Confirmation of the strength of the idea cannot rely on the frequency of tags alone. Validation of any conclusions had to come from asking each participant what they considered to be the general view of the group (for each question) and by asking participants to comment on the researcher-synthesised conclusion. Tagging was used primarily to identify comment patterns that existed across questions. The main benefit of viewing frequencies of particular tags is to see that they came up in all focus groups (Figure 16).

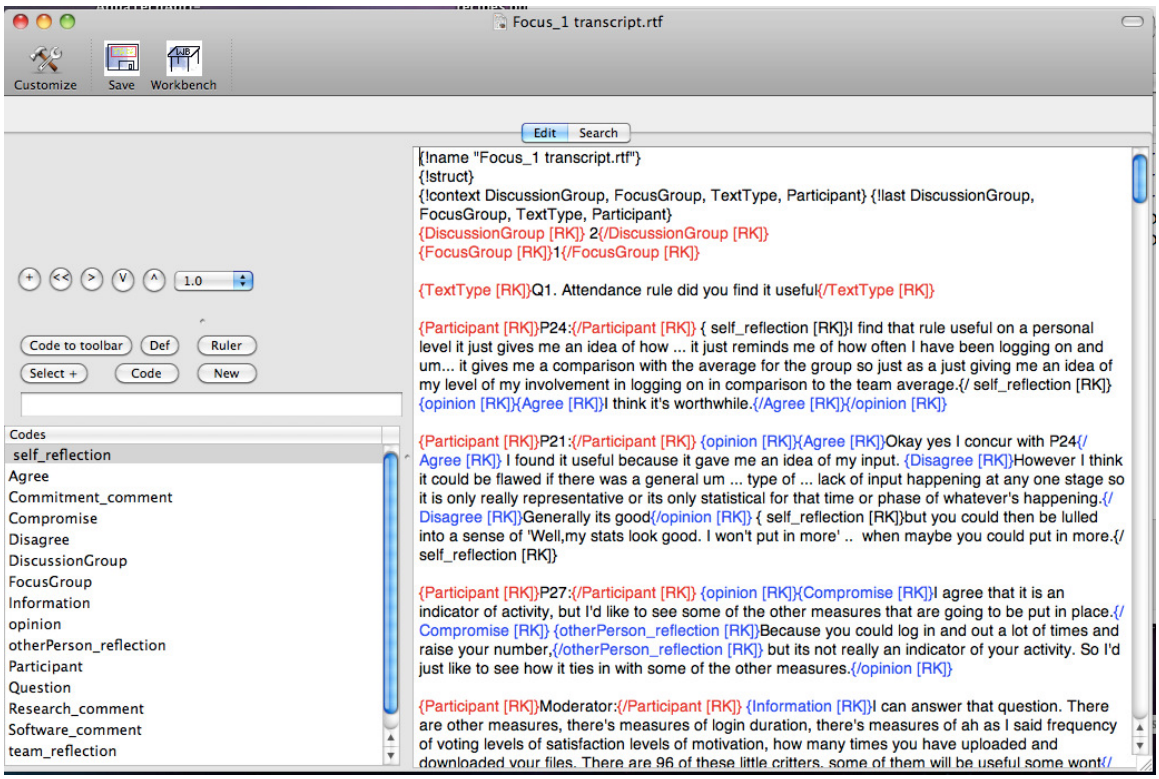

Figure 13. A tagged TAMS Analyser transcript. Structural tags appear red while content tags are blue.

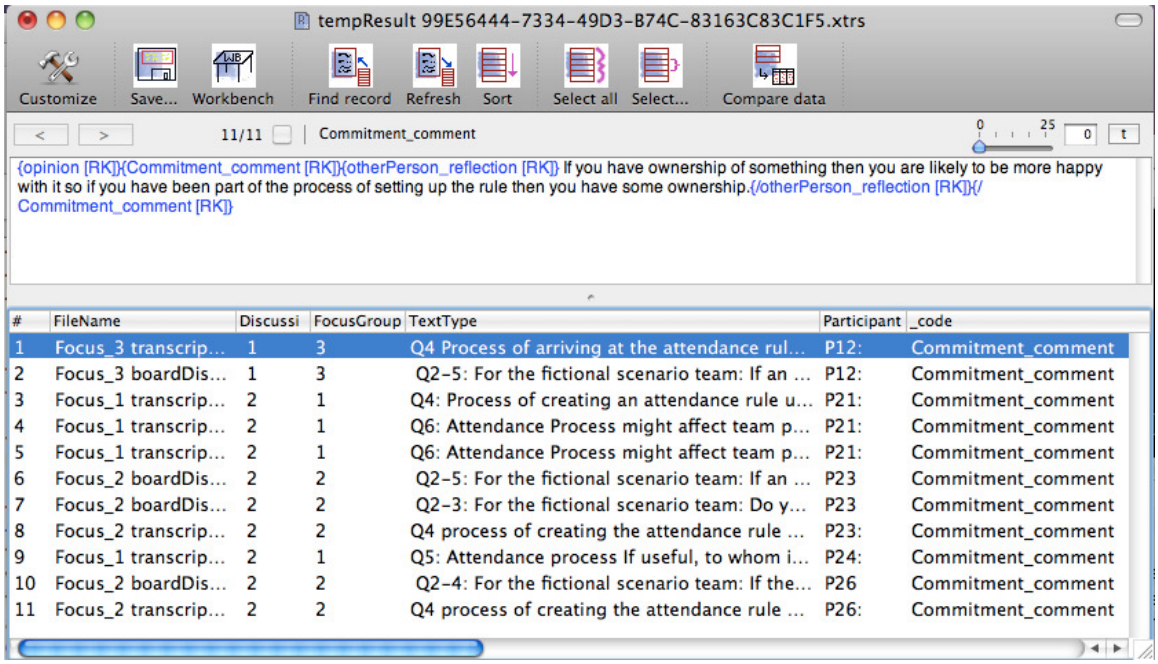

Figure 14. The TAMS Analyser search facility results for a single code associates it with all other structural tags (here "Commitment_comment"). Results are sorted here by Participant.

4.3.3 Usability study

The primary goal of usability testing is to identify whether participants can perform certain tasks. The secondary goal is to find out why they do what they do (Mitchell, 2007). Participants from a real-life group were asked to create a rule using the training material and to document the process. They were asked to use three symbols and write explanatory comments beside each symbol in a sequential logging of progress. A rectangle represented an action on the software, an ellipse any thinking processes involved in figuring out what to do and a thought cloud signified an observation about the quality of the software.

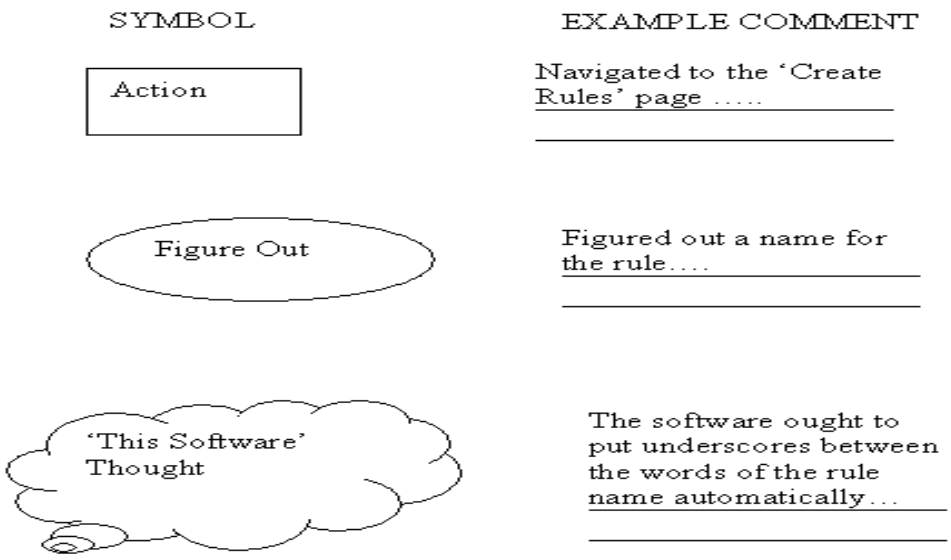

Figure 15. An extract of the usability test instructions. Participants were shown what symbols to use to classify their comments and were given examples to illustrate the use of the symbols.

The intended outcomes of the study were:

- To find out if the participants could make a rule given the training material,
- To identify areas of cognitive load and possible weaknesses in the training material,
- To identify possible areas of weakness in the usability of the interface.

Live teams then, provided several data streams for triangulating behavioural changes resulting from the rule module and allowed for iterative evaluation. Focus groups provided more direct evaluation of aspects of the rule module including the distinction between the value of artefacts and the process of creating those artefacts. Focus groups also provided textual data permitting an analysis of the reasoning behind their conclusions.

Chapter 5 Results

All data reported in this section can be found on the enclosed CD. Appendix VIII, p.213, itemises the contents of the disc.

This chapter first looks at the validity of the focus group data streams before addressing the findings for each of the research goals.

The goals are sequenced to reveal fundamental questions first, followed by the general questions of trust and finally, the questions that arose from the lack of engagement by the live teams. The recommendation engine was an important part of the theoretical design of the software. The value of recommendations is also discussed.

Focus group participants answered questions directed at the research goals. Their answers were synthesised and recirculated for validation. With the exception of single qualifications these syntheses were considered to be accurate representations of their findings. The syntheses are presented, with qualifications, when addressing the corresponding research goals.

Close reading of the data transcripts and discussion posts also led to the classification of content that extended beyond the opinions required by the set questions. Categories (code tags) such as “Research Comment”, “Software Comment”, “Question “ and “Information” were found. Participants did make comments on the research design (section 5.2.5.1) and also made suggestions for improving the software. Participants, including the researcher, often asked clarification questions or provided factual information in response to these questions. The list of relevant classification codes used in this research, are listed in Figure 16.

Comments about commitment appeared repeatedly across many questions, many participants and in all groups. They appeared in transcripts of live discussion as well as asynchronous answers to questions. This repetition indicates it was a central concept underlying the reasoning of all groups. The ideas associated with

commitment comments are explored in detail in section 5.2.4 where issues of trust are addressed.

Categories “personal reflection”, “other person reflection” and “team reflection”, emerged from the opinion data. They described the foundations of participant opinions. Reasoning was based on the personal experience of each expert in team situations (Personal reflection), imagined attributes and responses of other individuals in a team situation (other person reflection) or of the participant’s expertise of the team as a whole (team reflection). It is difficult to separate the first two of these. It is likely that the opinions given were a projection of the participant’s own personal attributes onto other individuals. Categories were established based on the grammatical person in which the text was spoken or written. First person was about the speaker/writer, while comments made in either the second or third person were considered to be speaking or writing about someone else. Comments about general team concepts were presented mainly in the third person and focused on unindividualised performance or process. The important matter here is that reflection in each focus group draws upon thoughts at the individual and the team level, demonstrating the “expert” nature of their opinions. Their reasoning was not just about personal involvement, but the implications for the team as a whole.

Social banter was plentiful, but not relevant to this research and thus omitted from the classifications.

Statements of agreement, compromise and disagreement were evident and also classified. These agreements, etc were in regard to either structured questions or open discussions. These classifications were considered important for ascertaining the quality of discussions in the focus groups (section 5.1)

TAG	Total	Group 1	Group 1	Group 3
Self_reflection	9	5	4	0
OtherPerson_reflection	29	15	11	3
Team_reflection	29	8	16	5
Agree	44	25	16	3
Compromise	18	9	4	5
Disagree	12	4	5	3
Commitment_comment	11	4	5	2
Research_Comment	2	2	0	2
Software_Comment	1	0	0	1
Total	157	72	61	24

Figure 16. The raw frequency of tagged comments appearing in textual data from each focus group. Group 3 comprised quiet, thoughtful members.

5.1 Focus group health.

Before the results from the focus groups can be believed it was first necessary to establish that the focus groups themselves were functioning properly. The three focus groups indicated clearly in their content that they were engaged in the subject matter and that they were discussing with a view to establishing their opinions. The group dynamics did not suggest undue influence of one party over another and 'group think' did not appear to be present. Groups 2 and 3 had more time to think over their answers as the second stage was, in part, conducted asynchronously.

The following 'compromise' statements come from each of the three groups when answering the question:

Q9: For the fictional scenario team: Do you think the team members would use the rule module or ignore it? Why?

P27_G1: But like most people if you are not involved at the beginning if you can avoid it you will ignore it.

P26_G2: …So that's a conditional 'Yes' I suppose.

P194_G3: I think people would use the rules if they found them useful – if they found it enabled the team to perform their task more easily, yes they'd use it but if they found it didn't really make much difference

They show signs of critical thought and an encompassing position, while 'Disagree' shows contradiction and little attempt to incorporate the prior position.

P21_G1: No I don't think it is a good idea to have the rules changeable I think they need to be static.

P23_G2: No not necessarily

P12_G3: The leader should I agree, but would they? I am not so sure. I have worked under leaders that have the attitude 'well do what I say and not what I do.

Only one participant registered 'Agree' statements only. That there was healthy debate can be seen not just from the transcript content, and individual profiles, but also from the proportion of different types of debate positions taken within each group (Figure 17). These proportions are highly idiosyncratic, but do show that debate occurred in each of the groups.

Participants of healthy focus groups also must draw on their experiences (Morgan 1997). Prior experience was built into the study by basing focus group questions on the provided experience of the `attendance` rule and on the lists of behaviours that participants identified as crucial to teamwork. Evidence of the depth of opinion formation can be found in the exchanges being based on self-reflection, the reflection of how others might behave and on how behaviour might affect the entire team.

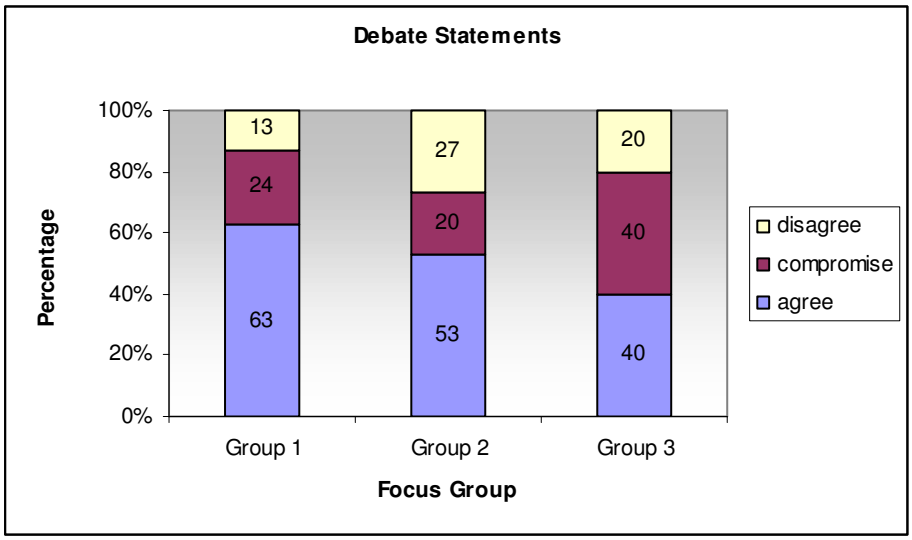

Figure 17. The proportion of debate statements that expressed either agreement, disagreement or compromise with regard to either structured questions or internal discussions.

Despite the failure of the study to record Group 3's early answers to questions that elicited responses about the participants' experiences of the attendance rule, every participant demonstrated at least one of these levels of reflection.

Self-Reflection:

P27_G1: Personally a little nudge like that is always useful to me personally because I tend to acquire lots and get side-tracked. A little nudge to get it done has worked in the past so it will probably work in the future

P291_G2: I think if we are involved in the process there is something powerful about being answerable to your peers who agree to have the rule as opposed to an outside authority or an independent authority. I think it is more challenging in a good way to think that your peers have come up with the rule.

P292_G2: and on a personal note it definitely motivated me to pull my finger out and for those of us with a competitive nature it motivates us to strive to get your log in frequency above the team average.

Other Person Reflection:

P24_G1: …they will feel some sense of ownership and being involved in the process of um creating the rules and the consequences

P26_G2: Some people just aren't good at recognising when it is better for the group to submit to authority.

P14_G3: I just thought that initially setting up the rules would be an inclusive process that everybody gets a chance to put their views forward and on that basis that is when the rule is decided. So its got to cover everybody's opinions to start with. And if it was acceptable to everyone then presumably it would help with the team performance because *they're going to be happy to work to that rule*.

Team Reflection:

P21_G1: …very democratic yes, but I think the discussion of the rules and their function should happen before we get to the stage where we start to formulate or carry out the task. I think it is too late to change the rules as you go along.

P23_G2: it also serves as a reminder to everyone that rules are important and the process can incorporate reasons why the rule is made in the first place.

P194_G3: At various times in the task one member's attendance would be more important than other people's. So to set one general attendance rule gets pretty tricky I think. Because the nature of teamwork is that the load will shift from person to person at different times depending on which stage of the process.

Mod: So its almost essential, you are saying , that the software should have the ability to break into groups?

P194: I think so.

The depth of reflection in each of the teams draws on participants' self-knowledge, judgement of the behaviour of others and understanding of team processes. All focus groups provided considered opinions and had participants exchange and develop their ideas in the group context. This indicates that the groups functioned as healthy focus groups and provided valid data.

On the other hand, the drop-out rate was high and may have affected the breadth of issues raised by the participants. Not all the principles of the design emerged from the reasoning presented. In particular, the advantages of having software rather than team members monitor the rules, was overlooked. The design also encompassed the opportunity for teams to mature and change their rules. Participants were clear that early use of the rule module was valuable, but did not cover reasons why it might be used later.

5.2 Findings

Data from focus groups as well as two live venues contributed to showing that rules can affect behaviour in a constructive manner. The first set of findings (section 5.2.1) is divided into two sections according to the experimental group from which they were derived. Focus groups informed the other research goals, primarily by means of questions aimed directly at these goals. The one exception is section 5.2.4, which uses participant reasoning found in the answers to six questions.

5.2.1 Do rules affect behaviour? If so, are the changes in behaviour constructive?

If the rules do not affect behaviour then the module has little value. In keeping with the two views of learning referred to in section 2.5, the participatory and acquisition models, research focused on both the rule artefacts, or products and the process of creating those objects. Both of these areas were examined to determine whether the rule facility was worthwhile incorporating into collaboration software. It was considered likely that, given the complexity of teams, any effects would apply to some teams and not to others, to some participants and not to others, and the nature of the effects would be idiosyncratic. The venue 4 and 5 task-related rules mentioned earlier were intended to motivate students to perform, but failed to directly affect behaviour.

Answers to research questions came primarily from the focus group study. Participants have been identified in the results as Pxx_Gx where Pxx is their unique participant number and Gx identifies the focus group to which they belong. Some live studies also contributed to research goal *b), Was the software able to result in changes of behaviour that were constructive?* Participants in live venue teams are identified as Vx_Mx where Vx identifies the venue and Mx refers to the identity of the team member.

This section is further divided into streams of results. The first stream comes from the focus group responses to questions about their experience with the `Attendance` rule artefact. The second stream, from the live venues, looks at

cross-venue experiences. This is followed by close analysis of two live venues and finally, focus group responses to questions about the value of the process of creating the attendance rule. Together they build a view that the rule module does affect behaviour and that the behaviour can be constructive for the team.

5.2.1.1 Focus Group - attendance rule artefact

The focus group participants were exposed to the `attendance` rule message. They passed comment on its effects, when answering the first three focus group questions.

When asked if they found the `attendance` rule useful accepted the following statement as a synthesis of their views.

> The attendance rule was useful for individuals despite being an imprecise and often vague statistic ("flawed", "a funny measure" "needed to be viewed in conjunction with other rules") and not representative of the quality of a user's contribution. It provided feedback on the participation of other members and served as a reminder that attendance was important to the team. It "nudged" people to keep up their attendance and to "see if they were keeping up with the level of contribution".

When asked which scenario team members, if any, would benefit from the rule, the following statement was accepted as a valid synthesis of opinions:

> The attendance rule would be useful to certain users in certain contexts and useless or detrimental in others. The team members must be committed to the team's goals or the rule will be useless.
>
> The contexts mentioned, where the attendance rule would be useful, are:
>
> - projects with tight deadlines,
> - a project where constant developments and updates are occurring,
> - projects requiring specific skills.

- projects incorporating quality control
- The people who might find the attendance rule useful are:
- over achievers and under achievers
- users who lack confidence, are uncertain
- busy people juggling many tasks who needed a reminder

> Under performers might see this rule as censure and drop out, so wording of the consequence (message) needs to be addressed carefully.

When asked if team performance might be affected by the `attendance` rule, the following statement was accepted by all participants except one. The qualification has been included.

> Team performance could be affected marginally depending on the personality and motivation of the individuals concerned. The attendance rule message could serve as a reminder to optimise attendance especially if delivered by email.

P14_G3: I think team performance could be highly affected depending on the individual responses to the rule and message.

Focus group participants felt that the `attendance` rule might have constructive or destructive effects depending upon team context and individual personalities. This agreed with prior publication (Kildare, 2004) that argued virtual teams should be considered as complex systems when designing collaborative software. Rules should be derived from the team itself. Imposed rules such as the `attendance` rule and the preset rules of the live venues were expected to provide erratic outcomes. The focus groups confirmed the failure of venue 4 and 5 rules to affect motivation when noting that the commitment to group goals must already exist if the rules are to work. Some effects of the attendance rule were reported in

discussions. The effects could be seen as beneficial for individuals and, conceivably, constructive for the team as a whole.

In answer to Q1. “Did you find the attendance rule useful?”

> **P24_G1:** I find that rule useful on a personal level it just gives me an idea of how ... it just reminds me of how often I have been logging on and um... it gives me a comparison with the average for the group so just as a just giving me an idea of my level of my involvement in logging on in comparison to the team average. I think it's worthwhile.

In answer to Q3. “Do you think that the rule might affect team performance?”

> **P292_G2:** Okay I agree with both 26 and 23 and on a personal note it definitely motivated me to pull my finger out [*colloquial for: ‘engage with the task’ – author*] and for those of us with a competitive nature it motivates us to strive to get your log in frequency above the team average.

Findings showing that rules can stimulate positive behaviour can be triangulated across live venues as well as the focus groups. Live venue analysis follows and confirms the erratic nature of the effects of preset rules.

5.2.1.2 Live Venue Overview

Computer logs were analysed for interaction with the rule module for teams both with and without preset rules. The logs were also used to trace individual participant behaviour associated with the firing of the preset `Give_Feedback` rule. The individual behaviours were set against the contextual behaviour of other team members. Participant comments that applied to the rule module or specific rules, whether in on-line discussions or survey questions, provided a second data stream. Team managers from the live venues acting as a third data source, were asked for general observations and specifically about intra-team conflicts arising from participant behaviour.

All teams’ participants were physically and culturally close to their fellow members. Venues 1, 3, 4 and 5 met face-to-face to sort out task-related problems. This was sufficient to assume that they knew what the appropriate norms of team behaviour might be. This meant that there may be no need to clarify or monitor behaviour of the virtual team, and hence no need to use the rule module.

Issues that arose within the school groups were sorted out primarily by teachers or "in the corridor" by a team member. Two issues arose that required teachers to step into the team performance, one of abuse and another of level of participation. One instance of "flaming" involving offensive language directed at another individual (venue V5) and another of verbal bullying that belittled another member's ability (venue V1). The second issue addressed in a face-to-face manner was one of irregular contribution by one member (venue V1).

A computer solution to the first of these two issues would rely on content analysis at a level of sophistication beyond the prototype rule module (but worth considering as a feature of future versions). Irregular contribution, however, could have been monitored by the rule module.

V1_M6 suggested that a rule be adjusted to accommodate the attendance behaviour of another member, and asked if any of the team knew how to create rules. V1_M6 assumed that attendance measured contribution. There actually were a number of rules about attendance, (`Poor_Attendance`, `Poor_Attendance_Tell_Me`, section 3.5.1) but none that named poor attendees to the whole team. The opportunity for creating a suitable rule, based on attendance or some other set of measures was lost, because neither the leader in this team nor the participant wanting the rule, made a request to the researcher. The existing attendance rules failed to change behaviour in this instance.

Participants from venue V1 were asked after the trial how often they were tempted to create a rule and to comment. Five of the six participants responded. All respondents reported that they were tempted to create a rule (four selecting the second choice, "1-2 times" and a fifth, V1_M6, the last option, "7+" times). They all noted not acting on this temptation, one because he would "rather decipher binary code" and three because they did not know how to do it. V1_M6 didn't know how to make rules but did make a cursory attempt to use the tutorial.

The discussion types posted by individual members were extracted and aligned with the firing of the `Give_Feedback` rule, so that changes in the posting of messages classified as "feedback" might be identified. Discussion types were also

provided for the whole team, grouped in threads. Indications of peer influences on behaviour assisted in understanding the effect that rule firing had on behaviour.

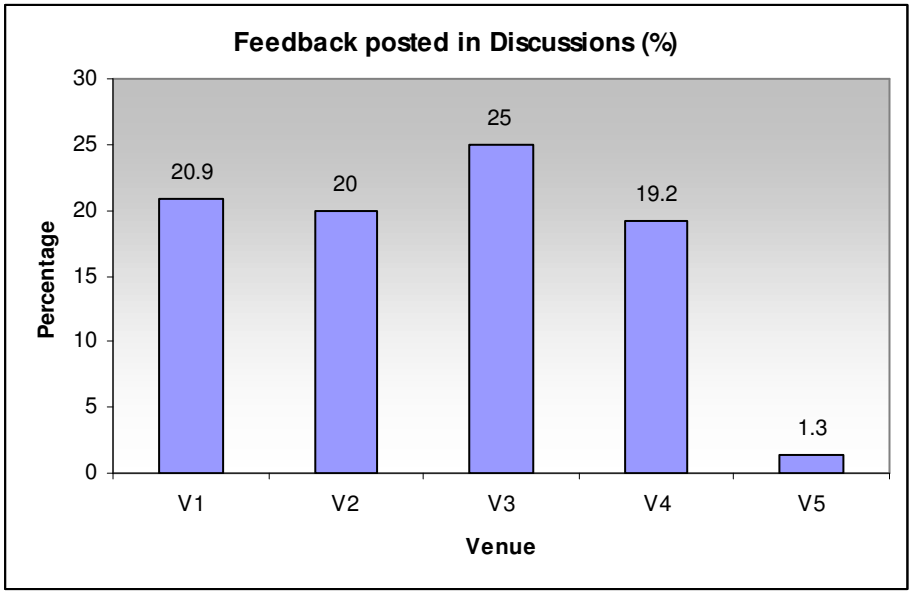

Figure 18. The proportion of discussion posts that were labelled "feedback" from each venue. Venue 5 comprised five separate teams. None of the venue 5 teams had the `Give_Feedback` *rule, while the other 4 venues did have this rule. "Feedback" was one of 8 categories available for each discussion post.*

The comparison of venues strongly supported the proposition that the presence of the rule `Give_Feedback` was responsible for the high proportion of discussion posts being labelled as "feedback" (Figure 18), although there may have been something inherent in venue 5 other than the rule, which accounted for the lack of "feedback" postings. This would have to have been at the venue level rather than the team level as 5 teams operated within the venue. Further, the probability of a post being "feedback", given random classification, should be 12.5%, rather than occurring 20% of the time. Choosing from a list of classifications will not necessarily result in a true random choice, as an individual may tend to choose from the beginning, the end or the middle. Individual tasks, general choices like "other" and team habits, all have the potential to provide variation from "random". What is notable from the result is the relatively consistent outcome from a variety of venues. The rule `Give_Feedback` appears to be the likely cause

for this cross-case result. Certainly detailed examination of another data stream was warranted. Did the rule influence behaviour at an individual level?

Behaviour change subsequent to rule firing also strongly suggested that the rule altered member behaviour. The following evidence comes from a close analysis of classification behaviour as it related to firing of the `Give_Feedback` rule for the venue V1 team. Analysis from one team at this depth is sufficient to reinforce the findings from the focus groups and the outcomes from the venue V2 team.

5.2.1.3 Venue V1

The rule `Give_Feedback` privately encouraged individuals to give feedback to their fellow team members. Figures 19, 20 and 21 show the login and discussion posting behaviour of three members in relation to the firing of this rule. Figure 22 shows an excerpt from the sequence of types of posts for the team on discussion threads where the "feedback" classification was prominent.

Member V1_M5	
Event	**Date / Time**
rule first fires:	2006-08-16 14:45:27
first sees rule:	2006-08-18 11:00:14
logs in six more times	. . .
first posts feedback:	2006-08-29 09:55:19
He next logs in:	2006-09-04 11:17:26
receives the message: *Hello V1_M5 you have not been giving enough feedback to your fellow members. Less than one tenth of your bulletin postings are feedback. [0.067]*	
He posts feedback again, along with one social message.	
He next logs in:	2006-09-26 09:57:58
receives no message	
logs in three more times without posting anything	. . .
total 16 messages, 2 feedback	

Figure 19. The association between rule firing behaviour, log in and posting of discussion posts classified as "feedback" for member V1_M5.

The rule fired for five team members. Four members (V1_M2, V1_M4, V1_M5, V1_M6) ignored the message they received for more than one day. One member, V1_M3, received the message three times more before posting feedback on the same day.

Member V1_M4	
Event	**Date / Time**
rule first fires:	2006-08-16 14:45:27
first sees rule:	2006-08-18 11:36:17
receives the message: *Hello V1_M4 you have not been giving enough feedback to your fellow members. Less than one tenth of your bulletin postings are feedback. [0.0]*	
logs in four times	. . .
posts so far are all "social" or "task content" classifications	
first posts feedback:	2006-08-24 14:34:33
logs in next:	2006-08-29 10:00:15
receives the message: *Hello V1_M4 you have not been giving enough feedback to your fellow members. Less than one tenth of your bulletin postings are feedback. 0.67*]	
posts three “task content” discussions	
logs in next:	2006-08-30 13:25:19
receives the message: *Hello V1_M4 you have not been giving enough feedback to your fellow members. Less than one tenth of your bulletin postings are feedback. [0.055]*	
posts four "feedback" discussions within an hour	2006-08-30 13:27:32
. . . posts feedback #2	2006-08-30 13:54:27
. . . posts feedback #3	2006-08-30 14:13:25
. . . posts feedback #4	2006-08-30 14:21:05
logs in next:	2006-09-04 11:10:14
receives no message	
logs in 10 more times during which he posts four more feedback messages	. . .
total 32 messages, 9 feedback	

Figure 20. The association between rule firing behaviour, log in and posting of discussion posts classified as “feedback” for member V1_M4

V1_M5 did eventually post feedback after ignoring six messages, and subsequently, on noticing a change in the message, posted again in that session. He received no `Give_Feedback` message after that.

V1_M4 logged in twice on the same day, once three days later and again another three days later, before posting a feedback message. The message altered, but still fired. The student posted different message types. The rule therefore fired again on his next log in. On logging in again, V1_M4 saw that his proportion of feedback had dropped, and posted four more consecutive feedback messages in the same session. This stopped the rule from firing thus suggesting to the member that a satisfactory proportion of feedback had been posted.

Member V1_M3	
Event	**Date / Time**
rule first fires:	2006-08-16 14:45:27
first sees rule:	2006:08:18 09:03:31
logs in six more times	
receives the message: *Hello V1_M3 you have not been giving enough feedback to your fellow members. Less than one tenth of your bulletin postings are feedback. [0.0]*	
logs in three more times	
first posts feedback:	2006-08-18 11:17:17
logs in:	2006-08-18 12:35:03
receives no message	
posts 5 subsequent feedback messages	
receives no further messages	
total 34 messages, 6 feedback	

Figure 21. The association between rule firing behaviour, log in and posting of discussion posts classified as "feedback" for member V1_M3

The exchanges classified as feedback occurred mainly in two discussion threads, one being a personal exchange where one member, V1_M3 chose to classify as "feedback" four responses to a word association game. Prior to this, the team chose "social" as the appropriate classification for this game (Figure 23, thread 34), started by V1_M3.

V1_M3: This should be a spam thread, just to get our posts up. Word association? That a nice game to play? [Social]

. . . .

V1_M3: ok, Eric – Monkey [Social]

. . . .

V1_M3: Pokemon – Digimon [Feedback]

Sender	Type	Thread	Sender	Type	Thread
V1_M3	Social	34	V1_M1	Feedback	106
V1_M6	Social	34	Teacher	Task content	106
V1_M3	Social	34	Teacher	Task content	106
V1_M6	Social	34	V1_M6	Task content	106
V1_M5	Social	34	Teacher	Task content	106
V1_M6	Social	34	V1_M5	Social	106
V1_M3	Social	34	V1_M4	Feedback	106
V1_M3	Social	34	V1_M3	Feedback	106
V1_M4	Social	34	V1_M3	Feedback	106
V1_M6	Social	34	V1_M4	Feedback	106
V1_M6	Social	34	V1_M4	Feedback	106
Teacher	Social	34	V1_M4	Feedback	106
V1_M4	Social	34	V1_M3	Other	106
V1_M4	Social	34	V1_M5	Feedback	106
V1_M6	Social	34	V1_M1	Feedback	106
V1_M4	Social	34	V1_M4	Social	106
V1_M6	Social	34	V1_M3	Task content	106
V1_M3	Social	34	V1_M4	Feedback	106
V1_M6	Social	34	V1_M4	Feedback	106
V1_M3	Social	34	V1_M4	Feedback	106
V1_M6	Social	34			
V1_M3	Feedback	34			
V1_M6	Social	34			
V1_M3	Feedback	34			
V1_M2	Social	34			
V1_M6	Social	34			
V1_M1	Social	34			
V1_M3	Feedback	34			
V1_M1	Social	34			
V1_M3	Social	34			
V1_M3	Other	34			
V1_M3	Other	34			

Figure 22. Venue 1: the sequence of response types for two threads of discussion featuring the use of the "feedback" classification by the team. The teacher intervenes in thread 34 due to teasing.

The use of "feedback" classifications by V1_M3 suggested that he was in fact learning about the rule module rather than actually providing feedback. There is

little difference between the content of his "social" and "feedback" posts. The content of his initial post clearly indicates he is thinking at a meta level; about his perception of the software usage requirements rather than the task itself. The rule is most likely to have changed his behaviour.

The second discussion thread (Figure 22, thread 106), where feedback figured prominently was centred on the distribution of topics between members for completing the team task. This thread was driven by the teacher and extended over about a month with posts made on six different days. The team appeared to be in agreement as to the appropriate usage for the term "feedback". The following is an example from V1_M4, which, although not reflecting the author's idea of feedback, certainly reflected the usage of the rest of the group. Feedback was considered loosely to be sorting out anything to do with the work allocation:

V1_M4: Guys I'm doin the privacy one Ok.

The rule itself may not have been the cause of the behaviour. It is plausible that any posting of "feedback" was as a result of there being an opportunity to post it – that the task rather than the rule was the stimulus to post feedback, particularly for V1_M4. In this instance, the changes to the message sent by the rule (see Figure 20) may have signified the rule adapting to the task via the member, rather than the member responding to the rule. V1_M4 may have learnt that the team meaning for the responses he posted was "feedback" and changed his post classifications accordingly. The rule module detected sufficient posts of feedback and stopped firing. V1_M4 may not have responded to the promptings of the rule (when it was firing) asking for more "feedback" posts.

Other possible reasons exist for classifying a post as "feedback". The students might be responding to idiosyncrasies of the collaborative environment or learning how to refine their classifications (such as distinguishing "feedback" from "decision making", for example) They might be randomly classifying a "feedback" discussion posting, or learning how to manipulate the software. The latter appears to be true in the case of V1_M3. V1_M5 registered "feedback" in the session immediately after being prompted to do so by the rule, when his prior attempt only altered the message rather than preventing it from being delivered.

Some learning was taking place, which is likely to be of indirect benefit to the team. The student could be learning the importance of feedback, or perhaps the team's meaning of the word. If the student was just experimenting with the software, then knowing how it works would ultimately benefit the team, although this meta-learning is only indirectly linked to the content of the rule. Because teams are complex systems, it is difficult to be sure that any change in behaviour will end up being constructive (i.e. that the rule module is in fact useful). Evaluation of perceptions of usefulness via the surveys was limited because teams from live venues did not construct or edit rules.

5.2.1.4 Venue V2

More direct evidence of the positive effect of rule products on behaviour came from venue 2. The rule `Morale_Slipping` fired suggested to the entire team that a 'virtual barbecue' be held as a way of addressing the weakness in morale. Morale was measured via polls that asked members to rate their levels of motivation and satisfaction (section 3.5.5). One member commented in the discussion forum:

> **V2_M1:** I must admit to being a little skeptical about the automated rules and the messages they generate. However, the ones that are presented today (Fri 13th) really seem to hit the spot (for me anyway).
>
> My hesitancy stems from the fact that I thought participants would rapidly tumble to the realisation that the messages are machine-generated, and automatically disregard them... (That would be my tendency). However, I now appreciate their value as triggers for human intervention...

V2_M1 had noticed the `Morale_Slipping` rule fire for the first time. This was followed by an attempt by another of the members, V2_M5 to organise a face-to-face social event (a non-virtual barbecue) as a means of solving the morale issue.

Rule products then, do appear to have an effect on team behaviour over-all, but the effect on individuals may or may not exist. There were team members from venue V1 and other venues who totally ignored the rule artefacts. For those participants who were affected, the effect intended by the rule may not have been the eventual effect. For example V1_M4 may have been exploring the way the

software behaved rather than having any concern for the amount of feedback he was providing to his fellow team members. Effects can be positive, as the evidence from focus groups and some live venues show. A number of the focus group participants stated that the mirrored attendance figures kept them logging in regularly. The value of the rule module is only truly understood, however, if team members are involved in the process of establishing these rules. They will have the best understanding of which behaviours are "positive" and "negative" for their team. They will also better understand the intent of a rule, and whether the effects satisfy that intent.

Finally, it should be noted that there were different degrees of control exerted by the managers of the live venues. The manager of V1 had a legal obligation to intervene in the case of particular behaviours such as bullying or verbal abuse. The manager of V2 really only had to provide opportunities for participants to discuss resources. The managers did not exercise power directly with regard to any of the behaviours studied. Establishing indirect influence on the specific behaviours studied, is beyond the scope of this research.

5.2.1.5 Focus Group – attendance rule process

Focus group participants, after being shown how the module could create rules, were asked three questions about whether the process of constructing the attendance rule might be valuable. The answers were synthesised by paraphrasing repeated opinions and listing unique comments. The synthesis was then circulated amongst participants who attested that their views were not omitted or misrepresented. Additional comments were permitted.

The synthesised statements and any final qualifications follow.

Attendance Rule Process: Do you think that the process of arriving at the rule would be useful?

The process of setting up the attendance rule was seen as crucial. With one exception participants agreed that having team members involved in setting up the rule would be central to a sense of ownership or "buy in" to the behaviour rule and thus result in compliance. The rule could be tailored to the specific needs of the team and changed over time. Being involved in establishing the rule would make its application less confronting and antagonistic.

The dissenting participant took the view that commitment to behaviour was not so important as commitment to team outcomes. [Implicit in P22's comment was the notion that people could look after their own behaviour as long as they were committed to team goals.]

P14_G3: P22 makes a valid point but I feel the rule is a statement by the team members of their commitment to the team and it's goals.

Attendance Rule Process: If the process is useful, to whom might it be useful?

The process of rule setting would be useful for the whole team because:

- it helps the members take ownership in an egalitarian and democratic fashion (promotes inclusion)
- it focuses the team on the behaviour needed for optimal outcomes
- it allows for adaptation of rules to meet specific team circumstances and changes.
- it lets everyone know why the rule is important (its intent) and how it functions.

Attendance Rule Process: Do you think that the process of constructing the rule might affect team performance?

> The question is poorly worded. Team performance must be affected because being involved in any team process is part of a team's performance.
>
> That aside, interaction between team members will be positive if the process is handled well, and negative if handled poorly. A clear template for discussion is necessary. A well handled rule-making process has the capacity to empower and motivate members and to remove the potential for misunderstandings / conflict further down the track. If handled badly the rule-making process can result in participants disengaging from the team.
>
> The software needs to be able to make rules for sub-groups within the team in case rules apply to some and not to others.

The answers, although based on the process of constructing the `Attendance` rule were, quickly generalised to the process of arriving at any rule. There was an overwhelming sense that knowing what behaviours were important to each other and taking part in setting up behavioural guidelines were valuable and vital for a team. While the value of the rule artefact was viewed with many qualifications, the response to the process questions was strongly positive. As Morgan notes, changes in focus group participant behaviour can be observed (Morgan 1997). The sound of the recorded responses indicated very definite enthusiasm when the topic changed from the rule itself to the process of creating the rule. Responses were far more animated.

The concepts presented for valuing involvement in the rule-setting process (as shown in the syntheses of the three questions above) confirm the concepts central to the design principles of the module. The focus group participants valued the democratic and adaptive features of Phreda as well as its ability to capture and share vital team knowledge. They saw the knowledge as valuable for team well-being – for maintaining commitment and avoiding potential conflicts. The experts noted that team members *learned* what was considered important by the rest of the team from the process of rule making?.

The respondents did point to the fact that a facility or template is needed to handle the rule-setting decisions as there is a risk of failure at this point. This was not addressed in the design and would be worth pursuing when developing the prototype further.

It has been shown that the rule module does affect behaviour and that the behaviour may be constructive for the team. The focus group responses to the preset `Attendance` rule artefact were mixed, some positive and others highly qualified. The idiosyncratic responses to preset rules were further demonstrated by the responses of real-life participants in venue V1 whose behaviour, while seemingly related to what the Give_Feedback rule addressed, could be attributed to a number of motivations. The rule artefact could cause a change in behaviour directly, indirectly or not at all. Two venue V2 participants responded constructively to the `Morale_Slipping` rule, which happened to be most suitable for their team's circumstances. The rule module's overwhelming constructive effects would come, according to the focus group experts, when the members participated in the rule-making process. These benefits resulted not just from understanding a rule, its purpose and then behaving accordingly, but also by changing member attitudes. Attitude issues will be explored in the results for research goals concerning trust (section 5.2.4)

The research shown so far has explored rules based on attendance, discussion posting and voting behaviours. For which behaviours might the rule module be useful? Research goals c) and d) aimed to investigate whether the rule module was suitable for behaviours identified as critical for on-line teamwork.

5.2.2 The behavioural norms for which rules might or might not be useful

The focus group participants were asked, while in one of the two asynchronous discussion board environments, to identify specific behaviours that might be destructive to a team and then those that might optimise its performance. These lists of behaviours were then presented to the participants when in their synchronous focus groups. Having seen the way the rule module worked, they

were asked if the list of behaviours accurately represented their previous discussions. The two lists were unanimously accepted. Participants were then asked to indicate if they thought the module's rule product would be useful for each behaviour in the list and to give their reasoning. This question directly addresses research goal *c). For which behaviours are rule artefacts valuable?* The answers provided were typical of those commonly found in the literature on features of problem and effective teams such as those mentioned in the team-building training materials of the Indian Ministry of Defence (CGDA, 2004). This confirmed the expertise of the participants.

The categories of behaviours considered as crucial to optimal team performance were grouped as either common to both discussion board lists or unique to one only.

The key concepts of the three common categories were "respect", "communication behaviours" (as distinct from communication content) and "group focus".

Behavioural statements to do with respect were:

- respect for the efforts of others,
- respect for the contributions of others,
- politeness.

Behavioural norms to do with communications were

- openness
- contributing to discussions.

Behavioural norms to do with group focus were:

- aiming for consensus in decision-making and team direction,
- being adaptable and receptive to new ideas,

- exerting an appropriate level of domination of decision-making only [once everyone has had input to the decision and if skilled or authorised to make decisions.]

Caveats to these generalisations were evident in discussions, but the behaviours considered important were clear.

Two norms of behaviour appeared in only one of the lists:

- encourage participation in others,
- be time conscious.

These were closely linked in discussions on the attendance rule.

Four of nine respondents ticked all choices. The remaining five felt the module artefacts were not useful in some cases. The value of the rule product for encouraging the positive forms of the behaviours listed was rather mixed. One could think of many circumstances where the products might or might not work. This was in keeping with the highly qualified response to the `Attendance` rule product (section 5.2.1.1) and further confirmed virtual teams to be complex systems.

BEHAVIOUR	**RULE ATREFACT SUITABLE**		**EXTERNAL VALIDATION**
Category	**YES/TOTAL LISTINGS**	**%**	**No. Focus Groups**
respect	9/16	56	across 3 groups
group focus	17/26	65	across 3 groups
communicate	8/9	89	across 3 groups
encourage	4/4	100	across 1 group
punctual	6/6	100	across 2 groups

Figure 23. Focus group evaluation of the usefulness of a rule artefact for key types of behaviour. Categories and contributing specific behaviours were all validated by the participants. The interpretation of results was also accepted by participants.

The following interpretation of the answers to the question was sent to all participants for validation. Eight of the nine participants responded, agreeing with the interpretation. One qualification was received and has been included below.

> The rule module was considered to be less effective for behaviours based on users' attitudes to each other and the team as a whole.
>
> "Rules are generally not able to gauge the intent behind postings and therefore are not suitable for points 4 and 5" [Behaviours: 'Be open to new ideas', 'respect others and their contributions' - author]
>
> "'rudeness' could be managed more fluidly by the team than with a rule."
>
> "I think some norms are easier to test with a rule than others"
>
> "Should I respect the effort of someone who isn't performing up to scratch. I think in this case you need to get along side someone and encourage them to perform at a higher level while respecting their person."
>
> *[? Mechanical aspects of communication and attendance can be tracked easily, whereas content and intent cannot?]*
>
> **P14_G3:** Rules may not unduly influence the behaviours during spontaneous interaction between team members. It is hoped that working towards a common goal will tend to moderate less helpful tendencies.

Participants concluded that the rule module artefacts would be more useful for the mechanical, readily measurable aspects of communication and attendance and less suitable for behaviour understood in terms of content and intent. The implication for software design is that recommended rules, in particular, should focus as much as possible on behaviours that were easily identified via system measures. Rules that were about behaviour more abstracted from the system measures would be more likely to fail.

When asked to rate the usefulness of the process of constructing the rules for these same key behaviours, the response was far less qualified.

5.2.3 The behavioural norms for which the process of constructing rules might or might not be useful

This question was designed to address research goal *d). For which behaviours are the processes of constructing rules valuable?* The mechanism for exploring the question was the same as for research goal c). Because the nine participants overwhelmingly felt that the process of setting up the rules was useful for encouraging behaviour of all sorts, this section will focus only on the qualifications provided by the participants both from the raw data and after validation of interpretation. 7 of 9 participants ticked all choices. They felt that the module process was good for all behaviours and hence behaviour categories.

One participant did not tick three choices. His reasoning as presented to participants for validation follows:

> P26 felt rule process was inappropriate for 'respect others opinions' (what if opinions were no good), 'shifting focus of team' (could be beneficial to shift) and 'dominating discussions' (team may need one person who knows what to do).
>
> [**P26_G2:** Interpretation confirmed]

One participant ticked all but one choice. Her reasoning is as follows:

> P21 felt that rule making process would not help with being adaptable? (because this is an individual trait that cannot be changed)
>
> [**P21_G1:** Interpretation confirmed]

Participants accepted the following interpretation, with two qualifications about the initial reasoning presented by P26.

> Participants felt that the process of rule creation was more important than the rules themselves – at least for those behaviours that were less mechanical and more about human attitudes (those abstractions for which behavioural indicators would be unreliable).

P12_G3: The only area of disagreement is with the comments you have ascribed to P26 concerning respect for others. I interpreted "respect for others opinions" as meaning others were expressing opinions in good faith and therefore their ideas should not be dismissed out of hand; even if you philosophically disagree with them.

P14_G3: There must always be some flexibility in coping with different personalities and interactions between team members. While some suggestions (by any one of the team) on any subject, may be deemed "no good", on a different subject, that same person (if confident enough and encouraged) may be able to contribute a whole new dimension.

The final qualifications by both P12 and P14 provided further support for the view that the rule module process was useful for all types of critical teamwork behaviour. This followed on from the tendency to generalise the benefits of team involvement in the attendance rule process (section 5.2.1.5). By participating in the process of construction, rules would be understood and endorsed, behaviour critical for the team would be kept in mind, participants would be more likely to comply with rule consequents and there would be a reduced chance of future conflict. The benefits stemmed from team members collaboratively learning about each other and the nature of the team itself.

The attitudinal reasons why the module process was found to be valuable were evident not just from answers to this question, but across the entire study. The coding of all transcripts, discussions and quiz answers yielded insights based on increased commitment. The link between trust and commitment further confirms the suitability of Phreda's design principles. Research goal a) identifies trust as the key variable for improving on-line teamwork.

5.2.4 Can we design software to further develop levels of trust in on-line teams by emulating societal structures of behaviour regulation?

Team members risk some investment in a collaborative venture. This is based on the assumption that other parties will do likewise, and with a view to a long-term goal, success that is of greater value than the risk. Can initial trust (Hertel, 2004) more recently termed predispositional trust (Black, 2008) be nurtured through the use of the software? Social rules act as a contract. A set of behavioural

expectations are articulated and agreed upon. It has been shown that focus group participants have identified the value of Phreda in setting down the behaviours considered to be important to the team. Does using software that allows the creation and administration of these rules, further develop the levels of trust between individuals in the team?

The theoretical framework predicted that the rule module would be valuable because, via improvements in team trust, performance would benefit. Finding and surveying risk-taking behaviour (increased risk-taking implies increased trust, if the reward from participation remains constant) was not possible in the real-life venues. Given the limited value of the real-life studies, was there any indication in the discussions of the focus group participants that linked the rule module to the levels of trust in the team?

From the literature discussed in section 2.4, initial trust has been seen to occur

> "when there is a common belief that others will make good-faith efforts to behave in accordance with commitments (explicit or implicit) and act honestly in negotiation of those commitments" (Hertel, 2004).

and that sustained trust emerges from team members witnessing behaviour that demonstrates that commitment. While trust was not addressed directly in the 12 questions set for the focus groups, key notions related to conflict, commitment and ownership were part of the reasoning given by the participants. These comments were coded.

Commitment was mentioned by five participants across all three focus groups. One other participant agreed directly that building the rules would encourage both ownership of and commitment to the process. All mention of commitment was in the context of the process of creating rules. Three of the questions addressed the process and the attendance rule (questions 4, 5, 6), the other three questions concerned whether the module would be used (questions 9, 10, 11). The words "committed" and the purchasing metaphors "ownership", "accountable" and "buy in" were indicators of the concept under discussion. Commitment was seen to

lead to “endorsement”, “accepting responsibility” “submitting to rules”, being “mindful” of rules and trusting. Five examples follow, from three members of different groups.

P21_G1 Q6: … I think it would be essential to be part of the process it would provide some endorsement of the rules people would understand where the rules had come from and why being part of it provides ownership, they are more likely to be mindful of those rules and apply them.

P26_G2 Q4: it all works well if people have bought in to the process so if people don't buy into the process it doesn't work so I think the actual thing is um The team creating its own rules you are more likely to get people buying in and if you like submitting to those rules.

Q 10: I think a good leader would [use the rule module], particularly if the rules had been decided upon by the group. If they didn't it would essentially be a violation of the group’s trust.

P12_G3 Q 4: If you have ownership of something then you are likely to be more happy with it so if you have been part of the process of setting up the rule then you have some ownership.

Q 11: Groups tend to respect and use rules which they have had a part in developing. This is because of a sense of ownership and because in developing the rules they have had a chance to tailor the rules to their own context.

The discussions recognised the value of the democratic design of Phreda in having participants obey the norms of behaviour set for the group, because the authority for setting the norms’ formalisms (the rules) came from every member of the group. The comments spoke of “peer pressure”, “democratic responsibility” and “submitting to those rules”.

One participant reasoned that it was likely to diffuse conflict that might arise further down the track.

Greater commitment by individual team members to the collective project implies greater trust between those members as work on the task progresses. Black’s findings indicate that as the project matures and commitment is demonstrated, benevolent trust (or affective, emotional trust) will increase, although trust in the skills (the abilities) of other members does not necessarily increase. Greater trust within supply-chain partnerships, is demonstrated by managers investing less in checking up on whether other partners have met their commitments (Black,

2008). Greater certainty of shared behavioural expectations and commitment to those expectations should also increase trust, since acceptance of rules is really an agreement binding team members in the same way that agreements bind parties in a supply chain. The checking task can be relegated to the Phreda software rather than the managers of a supply chain, and the rules can be disabled as soon as it is felt that checking is no longer necessary.

Another viewpoint on loyalty, akin to commitment, is presented by Murphy (2004). Murphy's argument is that virtual teams owe loyalty to design only, whereas face-to-face teams are loyal to each other and workplace teams are loyal to corporate goals. Sharing authority for a behavioural rule is a means of setting a teams' corporate goal and the holders of loyalty (commitment) to this goal are the individuals who set it up. The software enables a process that extends the loyalty of members to more than the shared design of the task. The loyalty is to each other as individuals on an institutional not just an emotional level. It was considered by one participant that this institutional sharing was also tied to trust.

P26_G2 felt that, should a leader not use the module when formal rules had been created by the team members, that this would constitute a breach of trust. A willingness to be vulnerable to the uncontrolled and unmonitored acts of another party is going to operate at an emotional level (i.e. Black's benevolent trust), not just an institutional one. The rule module can then be seen as a mechanism for extending loyalty and hence trust beyond the boundaries set by current on-line collaboration where allegiance is expected to be just to design. It extends loyalty to institutional and interpersonal levels as well.

What makes sharing this rule making process different from sharing the construction of any other virtual process then? (Murphy's boundaries could break down with any democratic decision-making.) Agreed process templates, such as the sequence of tasks and the format for a document, are just a series of steps in a design. Rules can be set to describe how these templates are used, to monitor how steps are actually taken. It is other team-member's behaviour that provides the risk and in which an individual trusts. Having defined a template for a team

process is no statement of commitment on how that template will be used. Trust is about behaviour and Phreda is for democratically administering behaviour.

Increased commitment to behavioural norms leads to increased trust. Focus group participants see the process of using Phreda as increasing commitment, if the process is well managed.

5.2.5 Why did the real-life studies produce such limited results?

The lack of use of the rule module during the live venue trials led to an iterative search for reasons. A number of possible causes were identified.

- The tutorial materials and introductory sessions may have failed to effectively explain the purpose and mechanics of the module.
- The preset rules may have been a perfect fit for the teams and no further intervention was considered necessary.
- There may have been a need for a leader to start the process.
- The teams may have shared a common culture of behaviour prior to the task.
- The teams may have had faster, face-to-face ways of solving the problem. In other words they were not virtual enough.

Of course these causes may have applied to some teams and not to others, and also may have contributed in combination. The tangle of possibilities could quickly take over the research, so an attempt was made to eliminate easy candidates and then use the life experiences of experts.

High school students were asked to create rules and could do so (see Appendix VII, p.210, for the usability exercise). The training materials and interface design were sufficient, therefore eliminating this as a reason for the lack of engagement with the module. Teams without preset rules and with different preset rules still did not use the module. This eliminates the notion that preset rules were perfect and hence did not need changing. This left three identified possibilities unexplored. Was there a need for a leader to initiate the process of rule creation?

Would an ad-hoc team that already shared a common culture need to use the rule module?

The behaviour of team members in venues V1 and V3 (see Appendix VII) suggests that face-to-face options will be sought out in preference to virtual problem-solving. The degree of 'virtualness' of the team is a likely contributor to the lack of engagement with the rule module.

The focus group experts were asked a number of questions to explore the likely use of the module, given a specific scenario. They were asked if the scenario provided in the research was realistic. Their opinions of leadership and rule recommendations were based on this scenario.

5.2.5.1 Do you think that the scenario was realistic?

The scenario was generally considered to be realistic with one participant actually involved in a similar leaderless team of loosely-bound, remote individuals.

The criticisms of the scenario's realism revolved around the lack of clarity about the way different members interacted and worked with each other. In particular the distinction between intentional and unintentional destructive behaviour was not addressed in the scenario. Since these would likely be key parts of the discussions about those behaviours that participants would be asked to identify, pre-empting conflict was best avoided.

There was some confusion between the scenario task and the task of the focus group experts in the actual research. This was a methodological problem that was addressed, but still caused confusion. Below are two of the eight responses to the question.

> **P14_G3:** a. The confusion was between what contribution was required toward the scenario task as opposed to the setting of the working group modus operandi
>
> b. As in 'a', the confusion could have led to unintentional consequences when members tried to get other members back "on track" especially if they themselves were off track.
>
> **P26_G2:** Yes. Sounds like a typical UN project to me.

With minor qualifications unrelated to the design principles, participants considered the scenario to be realistic. In this realistic situation, would people use the rule module? They certainly did not in the real-life situations tested.

5.2.5.2 Would scenario members use the rule module?

The following synthesised statement was circulated to participants for validation and the single qualification to the statement is appended.

> Opinions about whether the scenario team would or wouldn't use the rule module varied.
>
> The general view was that it would vary according to the personality of the team member, their motivation and the context of the team.
>
> It was felt that users were more likely to engage with the rule module if they participated in an effective process of developing the rules.
>
> Scenario team members are likely to ignore the rule module if they are distracted, lack emotional security or social maturity and have weak or destructive interpersonal relationships with other team members. Weak interpersonal bonds stem from a lack of personal knowledge of each other.
>
> The more successful the relationships the more likely members will follow the rules.
>
> [reiterating relevant content from previous questions]
>
> Sharing in the development of the rules will encourage strong relationships by sharing expectations and developing consensus positions. It will provide ownership of the rules and thus help commitment. Members will understand not just each other, but what the rules mean and why they are important.
>
> Other reasons offered for not engaging with the rule module:
>
> - Like-minded members may not need the rule module because they already share common beliefs / norms of behaviour.

- Over time the rules will be used and may be ignored or need changing.

- Once the norms have been established as a result of the process of developing the rules, the rules may become redundant.

> **P26_G2:** Yes I do[think that scenario members would use the module – author], particularly if the rules have been established as a consensus. They would use it because I think at level most people recognise that we need some social / ethical boundaries to work effectively together in an environment that is 'safe'. If they have had input into the development of the rules, they are also more likely to 'own' and subscribe to them.

The importance of process was emphasised as motivating scenario members to use the module. It was interesting to note that focus group experts felt it was likely that the rules, once agreed upon, would fall into disuse because the norms were now shared. It was noted that if the rules were already understood scenario members would be unlikely to use the module, for example, P194's contribution to focus group 3's discussion.

> **P194_G3:** Basically I think people would use the rules if they found them useful – if they found it enabled the team to perform their task more easily, yes they'd use it but if they found it didn't really make much difference ...

This confirmed the author's suspicion of one reason for live venue participants not engaging with the module. The rules would not be useful if they already knew them. This would be the case if members shared a culture prior to the formation of the team.

5.2.5.3 Would a scenario team leader use the module?

The following synthesis of focus group opinion was circulated to participants. They agreed that it neither omitted nor distorted their views. One qualification was added.

> Whether a leader does or does not use the module can not be definitively answered. If the rest of the team ignore the module the leader may be tempted to do so, too. The leader's personal disposition and skills may also lead to the module being ignored.

> It would be advisable, given the scenario, for the leader to use the module to maintain group focus without appearing dictatorial. Any leader should consider using all tools available.

> **P26_G2:** I think the leader would use the rule module if they were any good at it. Most people would lose respect for leaders who say one thing and do another. The only exception to this would be when the outcome of the rule is clearly detrimental to the group or task, in which case it might be more appropriate to break the rule on a case by case basis.rules might have inhibited the construction of rules in real-life venues.

There was an assumption by some participants that the existence of a team assumed the existence of a team leader. This could have resulted from a bias in participant selection (experts in teamwork were likely to have taken leadership roles). It is plausible that leadership emerges from teams of independent members, perhaps as a result of personality, perhaps as a result of expertise. It is also plausible that this role rotates among members as circumstances dictate.

5.2.5.4 Would a set of recommended rules encourage the scenario team to use the module ?

The question on recommended rules was pertinent for two reasons. Firstly, providing recommendations was a design principle that was considered important, but not implemented. Would it be worth implementing? Secondly, there may be some connection between the lack of use of the module in live situations and the use of preset rules. Did the opinions of experts confirm live venue indications that neither the presence nor absence of recommendations (preset rules) was necessary for the rule module to be used.

The synthesis of expert opinions from the focus groups follows, with the additional comments received in the validation process.

> It will be helpful to have an initial set of rules as a suggestion to help guide users in creating rules that are appropriate for their context, provided the process does not bog them down in activities incidental to their main task. But the rule module will be ignored for deeper reasons than just the absence of recommendations (such as low level

of commitment, personality and skills, an already shared understanding and trusting relationship).

P14_G3: With the wider view – there will always be differences in the personalities in the makeup of any team and whether any rules will be obeyed or ignored is dependent on the individuals and their commitment to the task.

P26_G2: Yes. I think it would be helpful to provide an initial set of rules. Many of these would be common to different groups or projects. Having suggested rules would also minimise the amount of input required (e.g. Be more efficient).

The findings imply that recommended rules should be optional. The finding supports the observation that preset rules might or might not produce positive effects on behaviour and also that they played little part in explaining the lack of use of the rule module. If a recommendation engine were built, it should 'learn' to more accurately predict which rules would produce positive effects for a particular team.

The research findings described the value of a rule module in collaboration software, how better to design the module and how to use it. Results from live venues were disappointing, but when aggregated with the results from the focus groups, provided a clear indication that the theoretical underpinnings of the module design were sound. In particular, the module was seen as important when team members participated in the process of rule construction. A democratic approach to rule construction allowed team members to establish what behaviours were important and to articulate their expectations. Focus group participants, although couching their reasoning in terms of strengthening commitment, were dealing with the same domain as theoretical discussions of trust. Rule artefacts alone (i.e. without member participation in rule construction) were less strongly valued as they may or may not be important to the members and their meaning was less clear. Responses to pre-set rules in live teams were mixed. Some members responded and others did not, some responses were positive others not, and responses did not necessarily align with the intent of the rules. This corresponded to the theoretical expectations of a complex system.

Chapter 6 Conclusion

This chapter reiterates the problem addressed by the research, a description of the software developed, the questions that were tested, a summary of findings and thoughts on work that might follow from this study.

The research recommends that developers of collaborative software should integrate an interaction rule management tool in their software. It is likely that team members collaborating virtually will be unclear of each others' behavioural expectations. Using a rule module will nurture trust between members, which is essential for optimal performance.

6.1 Problem Space

On-line teamwork has unique difficulties that arise from its remote nature as well as those difficulties confronted in face-to-face teamwork. In particular, when working asynchronously there are no voice or visual queues to inform our understanding of the behaviour of other team members. Trust and norms of interaction are slow to develop in these circumstances. This may lead to sub-optimal performance. In face-to-face teams it is easy to address expectations and misunderstandings. No mechanism exists in existing groupware for managing behaviour, other than providing process templates for specific acts of production. Little consideration has been given to team well-being processes. The literature of virtual teamwork and its deeper psychological and sociological roots suggested that a facility for the democratic creation and monitoring of rules of interaction, akin to contracts and other governance structures might address this.

6.2 Software development

The author developed a software design that covered the most extreme case of remote teamwork – where an asynchronous team is put together in an ad-hoc fashion and members may be unknown to each other.

A prototype rule module (Phreda) was created and set in a simplified, 'essential', collaborative environment. The environment allowed members to:

- manage their own profiles and read the profiles of other members,
- manage time through a calendar,
- manage activities through a task allocation system,
- vote on questions of well-being,
- communicate via a threaded discussion board.

The entire software was served on the internet from a University of Tasmania web server. Apache server ran PHP to access both the server-side Java application and the mySQL database. Rules of interaction could be created through a web interface. The module defined team and member behaviour using 96 measures of member interaction with the collaborative environment. Some of these measures checked individual behaviour, others aggregated team behaviours such as averages and total frequencies of aspects such as the average login rate for the team and the average size of discussion post contributions.

The rule module application accessed the environment's database, ran the measures (SQL queries) and wrote these as facts to an expert system script. Any active team rules were also written to the script. An instance of the JESS expert system shell was passed the script and the output from the shell was written to two files. These files were the basis of consequences and were managed by the web server's PHP code. The PHP code delivered the output back to the collaborative environment home page to greet each participant as they logged in.

Rebuilding the fact base on each log-in was not the most efficient configuration for the system, but did allow for the gathering of research data. Individual behaviours could be cross-referenced against the firing of rules by re-running each script.

This body of rules was treated as a repository of team knowledge and open to democratic change by its members. The responsibility of monitoring these rules was delegated to the software, rather than an assumed leader.

6.3 Research Goals

Five research goals were established in an attempt to determine the value of the rule module, Phreda, and both real-life virtual teams and virtual focus groups of experts were used to explore these goals. The over-arching question, "*Can we design software to further develop levels of trust in on-line teams by emulating societal structures of behaviour regulation?*", spawned more specific goals.

Could these rules affect behaviour in a constructive way and if so what behaviours would the software module suit best? The module was considered to be both a tool for storing knowledge of expected behaviours and a tool for enabling the process of constructing this knowledge. Collaborative learning of this knowledge was considered pivotal for the success of the module. Both the participative and the acquisition models of learning were pursued in the research goals. Questions about behaviour were divided into questions about the rule artefacts and the process of constructing these.

The final research goal was developed as part of the review of iterative trials. It was clear that the teams available for the study did not engage with the tool as expected. A number of hypotheses were generated, some eliminated and the theory refined as to how and when the rule module should be used.

In addition to the research, software design requires that an iterative approach be taken. Prototype software must be repeatedly altered to reflect user responses. Suggestions for modifying the software were also noted.

6.4 Contribution

While the live tests were unable to demonstrate sustaining or increasing the levels of trust, the expert focus group discussions revealed a strong belief that the rule module would enhance commitment (and hence trust), provided team members were involved in a successful process of establishing the rules.

It was demonstrated that rule artefacts changed behaviour and that these changes could be constructive for the team's well-being. Experts identified that the module could be used for a range of key behaviours. The process of construction

was considered useful for all key behaviours but the artefacts in isolation would be less effective for the most abstract and difficult to measure behaviours. In particular the benefits of the module were seen to be:

- that all team members shared and understood what behaviour was important to the team

- that being involved in a successful process of establishing rules of behaviour increased the commitment of members to those rules and therefore to team goals.

The module should be used early in the team's time together. Consolidation of team expectations and commitment would capitalise on initial trust and not interfere with task performance later in the team's project.

The focus group did not recognise as important the ability of the software to be responsive to changes as the team matured. At a practical level, the author felt that repeated unnecessary consequent messages would be annoying. The rules should at least be disabled. While this was tangentially referred to by one member of the live studies, no team member acted to do so.

The inactivity of the live venue participants could have been due to the constraints of venue contexts, limitations of the software's decision-making interface or a lack of a leader. It was not due to the cognitive load required to produce the rules or the quality of the training provided. Participants could generate rules.

If a team leader chose to use the software, as was strongly recommended by the focus groups, then it should be done using democratic decision-making processes. One emergent (but informal) team leader, a participant in the venue 3 team, drove the collaborative tasks. He commented that he didn't think it was his place to set rules. It was not automatic that he seek consent and invent some decision-making process to establish rules. He was also reticent because the members all knew each other, knew what to expect, shared the university culture and could meet face-to-face to solve problems. Having a decision-making template and software interface may not have been sufficient to guarantee the use of rule module, but may have assisted, if the need to use the module existed. It would have been of

little help if the team members knew what behaviour was expected and could by-pass virtual communications.

Two other improvements in the prototype software emerged from the research. The first was that members of the group might be treated differently, so a facility for sub-grouping the rules should exist. The module should not just act at either an individual or a whole team level. Secondly, the software should have some content analysis capacity. The forced classification of discussion posts into a few categories was used as a convenient way of constraining the size of the research project. This constraint made it impossible to create behaviour rules based on the meaning of the actual text in discussion posts. Specifically, 'flaming' and bullying could not be detected. A form of latent semantic indexing could be used help in this challenging area of language understanding.

Finally, the focus group experts saw the use of recommended rules as a practical way of starting the rule-making process, but of little sustained value. It was evident from focus group discussions that the recommendations should be available as an option for the team.

The design principles identified by this research have greater scope than social units the size of virtual teams. Virtual communities of practice and interest have much larger boundaries. Behaviour is central to all governance – identifying it and responding to it. While these are primarily human issues, the software structures, like court houses and parliament houses, are essential tools for humans to use. Humans interacting virtually are the same as humans interacting face-to-face, but what they can do is far more constrained. This does not change their needs, just how these are allowed to be expressed.

The experts did not comment on the fact that responsibility for checking rule compliance was delegated to software, rather than an individual, which was a motivating factor in the research. They also did not distinguish between contextual and intra-team sources of knowledge. Both leaders and recommendations are means of bringing pre-existing, contextual knowledge into the team. One possible explanation for these omissions is that some biasing factor or factors existed in the process of selecting experts.

It is possible that, as teamwork experts, they have often been placed in and accepted a role of leadership. There may be an assumption that exercising power and drawing on prior experience are normal in teamwork, and that leadership will always be present. The questions asked of the experts did not test whether it was possible to have a team without a leader. The scenario they were given gave no indication of leadership and was accepted as realistic by the experts. However, they may have assumed that leadership (shared, rotated or otherwise) would emerge from the scenario team. Further research into the nature of leadership may help in determining how to stimulate the use of the module and provide training.

6.5 Further work

A number of areas of further work stem from the experience gained by this research. Some suggestions come from participants of the study, others were anticipated in the software design process, while a third area applies the software to broader applications.

According to the focus group experts, using the module in a democratic way is valuable, provided the process is successfully conducted. An interface with a rule-setting template should be useful for team leaders and may improve the uptake of the module by team members generally. Such a template should take users through the decision-making processes required to create the rule, not just guide the user through rule creation mechanics.

Although the experts considered a recommendation engine as optional, an agent-based recommendation engine should be useful, if many teams operate within a single or multi-tiered organisation. Rule recommendations, if created without an engine, should rely on behaviours that are closely tied to the mechanical measures available. Understanding measures of human intent or analysis of meaning may fail without the input of team members, whereas matters of attendance and contribution frequency are most likely to have shared meaning.

Apart from the feedback mentioned by participants, potential exists for the building of an interface to adapt the rule module to many different collaborative environments. The system has been adapted successfully to work with the TRAC

wiki and ticketing software. This required analysis of the TRAC database table structures and the writing of specific SQL queries. There is scope for developing an interface to assist with this initial configuration of the module. Advanced rule development may require control over what facts are recorded by the system.

The prototype allowed for two types of consequents, messages to individuals and messages to the team as a whole. The capabilities of the system could be expanded, not just to sending messages to sub-groups, but to performing many different functions. The system could, interface with an email client, mobile device, etc and manage a rewards system. The key issue with teamwork appears to be commitment. Uncommitted individuals really do not belong to the team. The software could temporarily or permanently exclude access to individuals by mediating the log-in process.

The theoretical model is very general and more specific designs (perhaps more workable designs) could be explored. There may be benefits in looking at types of communities such as political groups, guilds, enterprises and hobby groups. There may also be different formats for rules, such as rules for division of labour, rules for arriving at decisions and rules associated with particular roles.

Finally, the consequents of rules should be expanded to send messages through more than the collaborative environment's message facility. Email, social networking linkages and mobile device applications are possibilities. The messages do not need to be limited to text, either.

In terms of further research unrelated to software design, Phreda could be used to teach potential virtual team members, including leaders, critical skills. In other words its potential for education about a range of expected team behaviours could be investigated. It could also be used to provide the foundations for research into ergodic and non-ergodic rules. Are rules about some critical interaction behaviours predictable and how might they be represented? Finally, the ultimate test of whether Phreda does impact on the degree of creativity and learning that occurs within a team could be examined. Trusting behaviours could be noted in sufficiently remote and virtual venues and conclusions drawn about performance.

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Appendix I

Collaboration Environment including Phreda Software

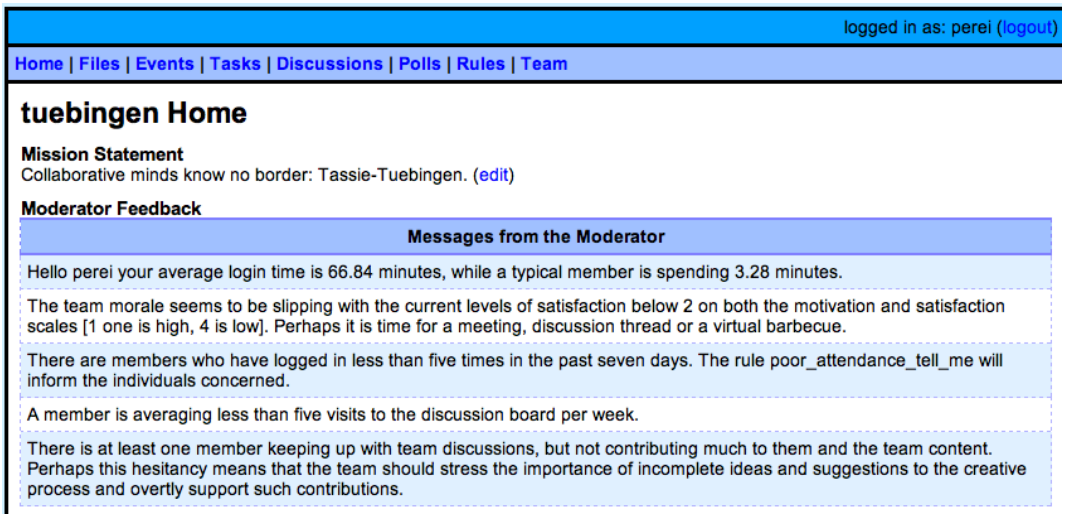


Figure 24. Home Page: Messages from Phreda.

Phreda checks measures of resource usage against the rules and sends messages customized for the team member.

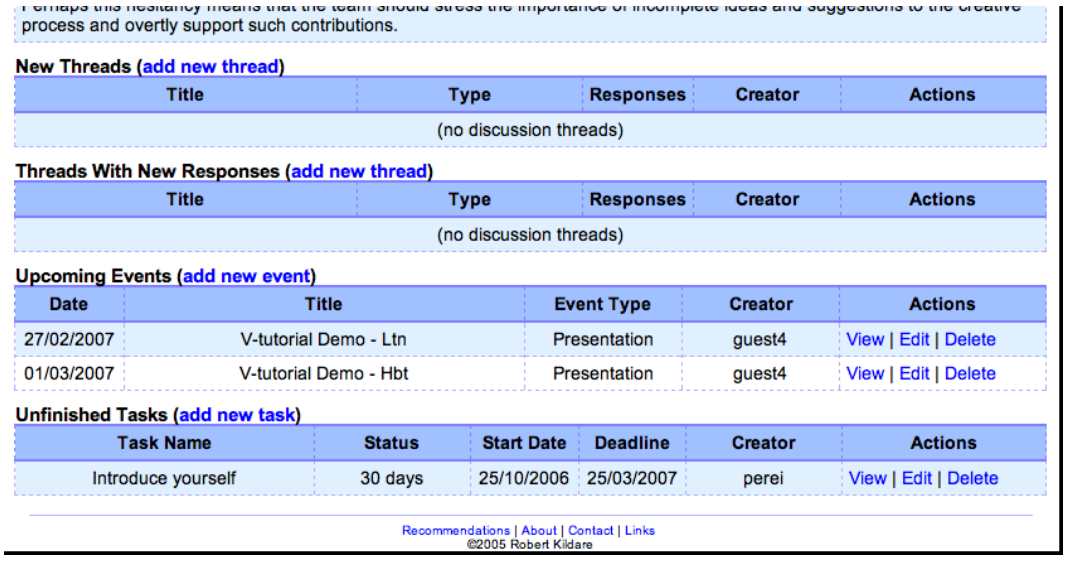


Figure 25. Home Page: Messages from the team, events, tasks.

Any new messages from the team are displayed on the home page as well as upcoming events and outstanding tasks.

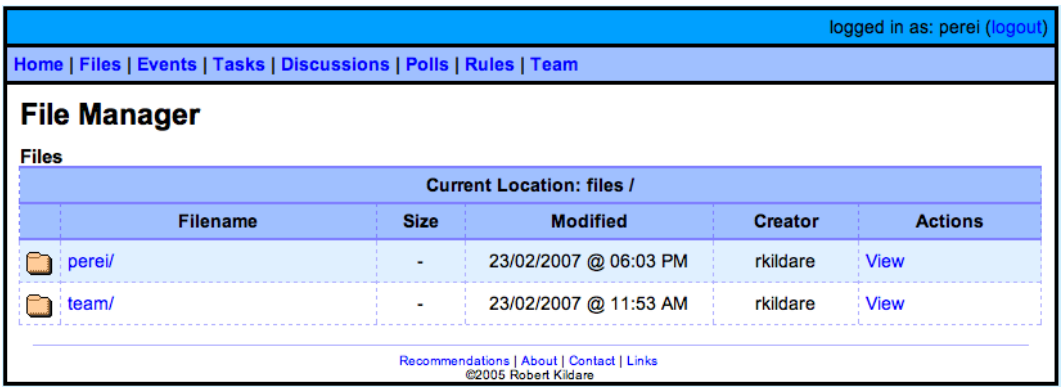


Figure 26. File Manager: Personal and team files.

The file management system allows for storage of both private and team accessible files.

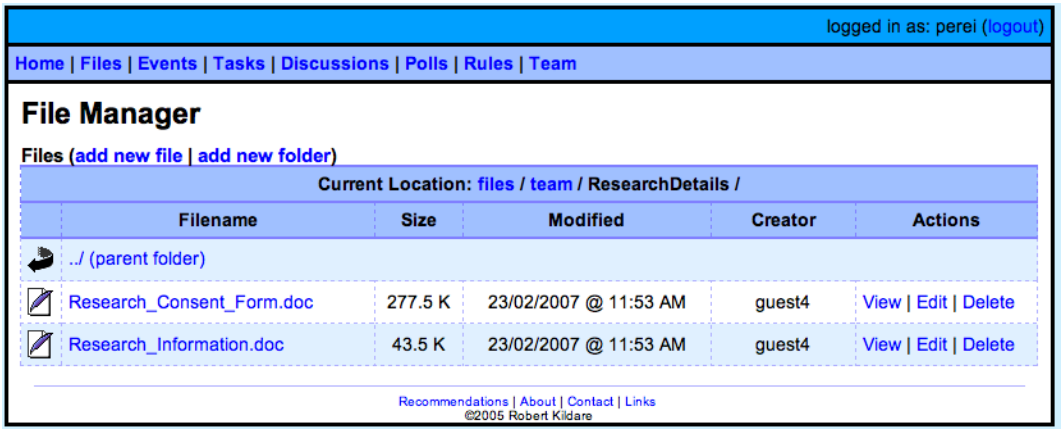


Figure 27. File Manager: Contents of the team/ResearchDetails subfolder.

The prototype is not designed for large multimedia files, but can store files as large as 50MB.

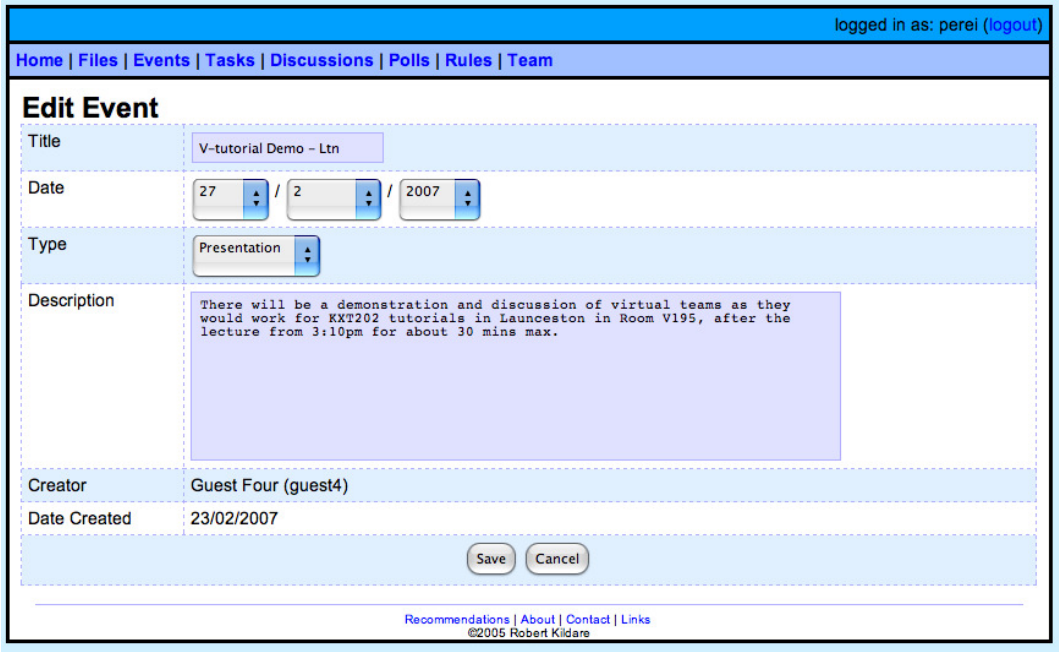


Figure 28. Event Manager: The "edit" function.

Events and tasks can be created, edited and deleted by all members of the team.

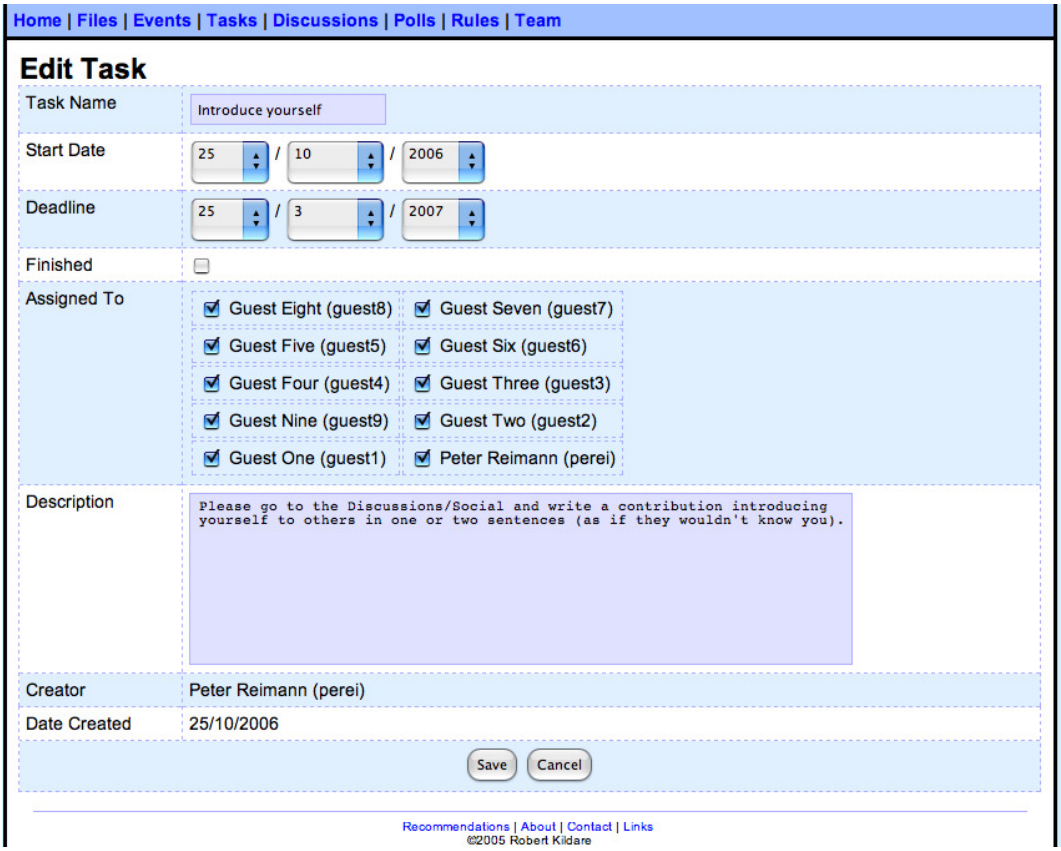


Figure 29. Task manager: the "edit" function.

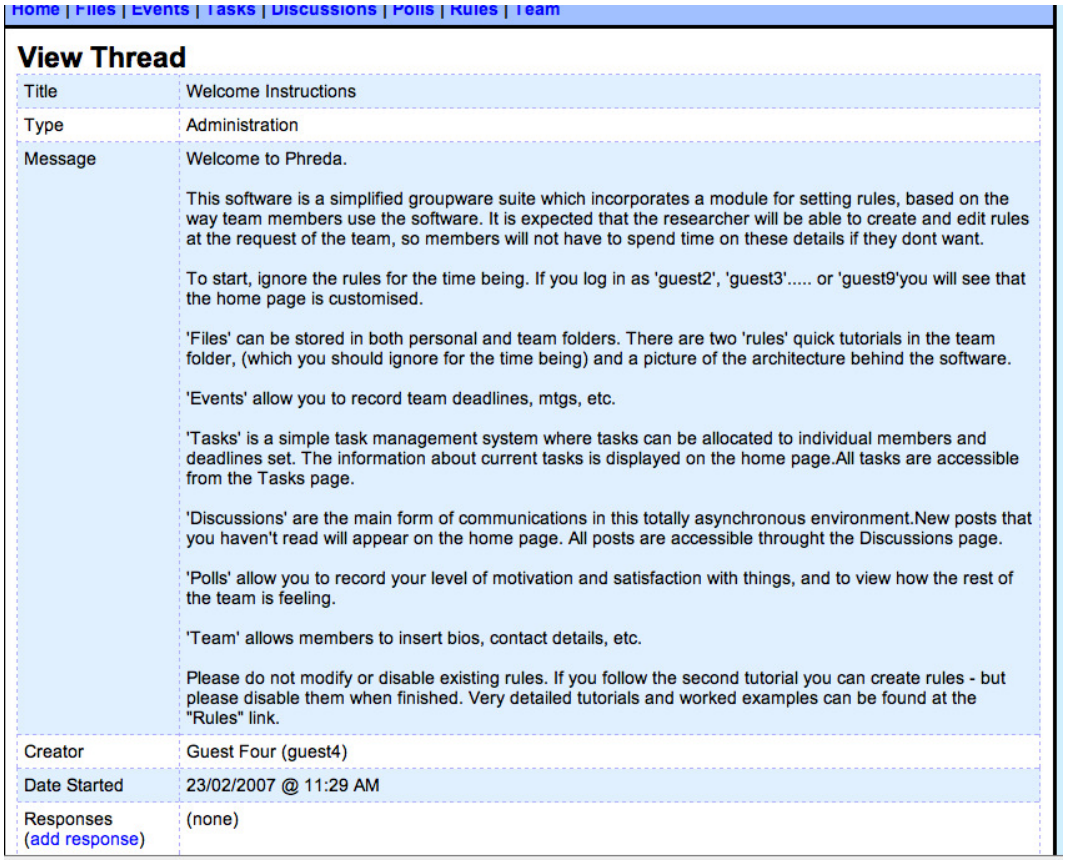


Figure 30. The Discussion Manager: A discussion thread.

Responses are added to the bottom of the thread with the most recent first. The members classify their posts affixing a term describing the main purpose of the post. This mechanism, although having problems, is a way of representing the same sort of output as a similarly fraught tool for content analysis.

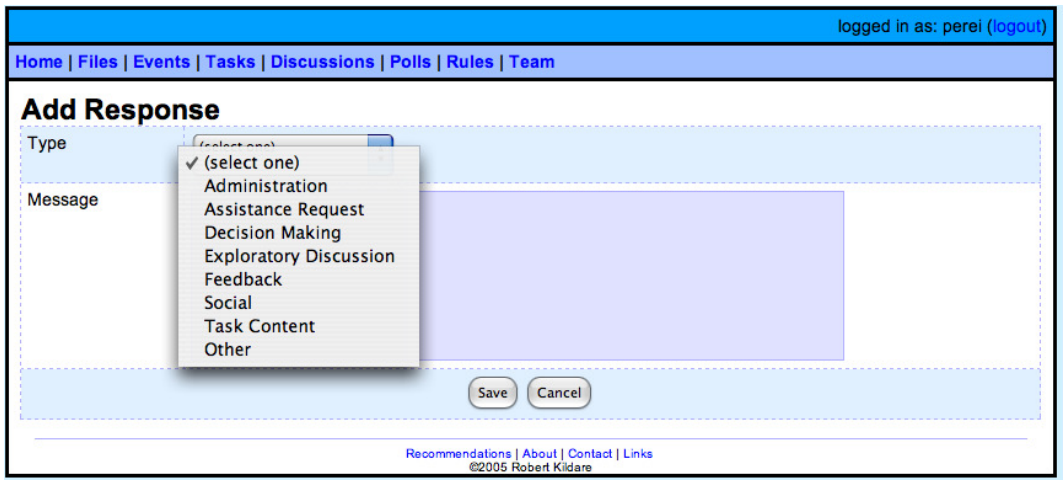


Figure 31. Discussion Manager: classifying a response.

Discussions cannot be edited or deleted unless the system administrator agrees. They represent an archive of team communications. Email between members over issues concerning the rest of the team is likely. Participants were discouraged from doing so and asked to either copy external communications to the discussion board, or to post a summary. This eliminated the extra complexity of adding an email client to the prototype.

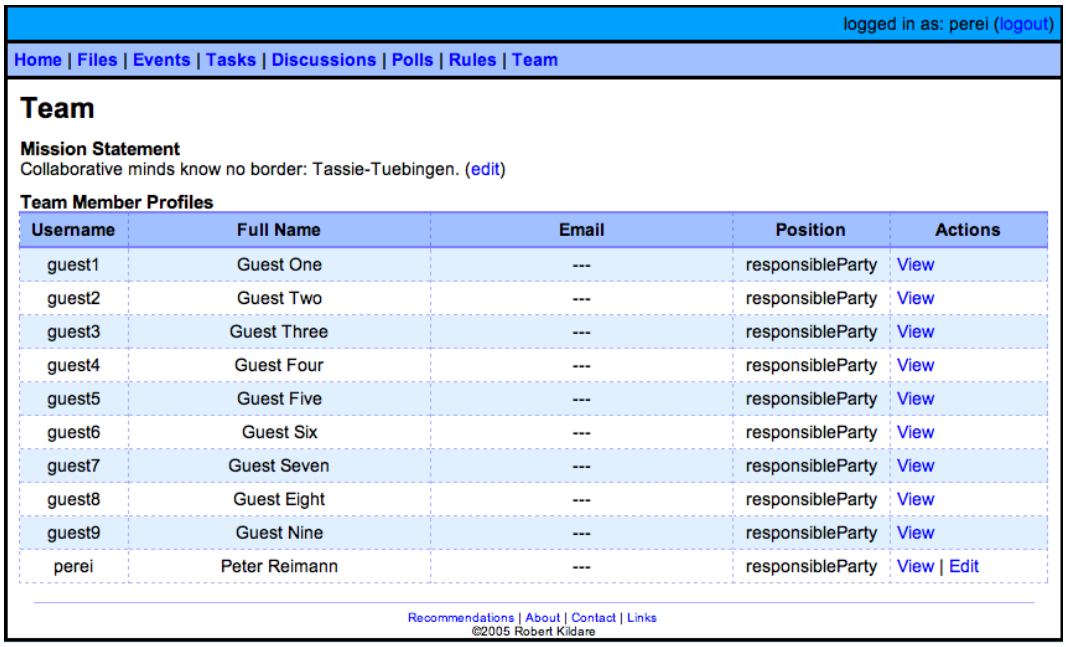


Figure 32. Team Manager: Members may see each others' details and edit their own.

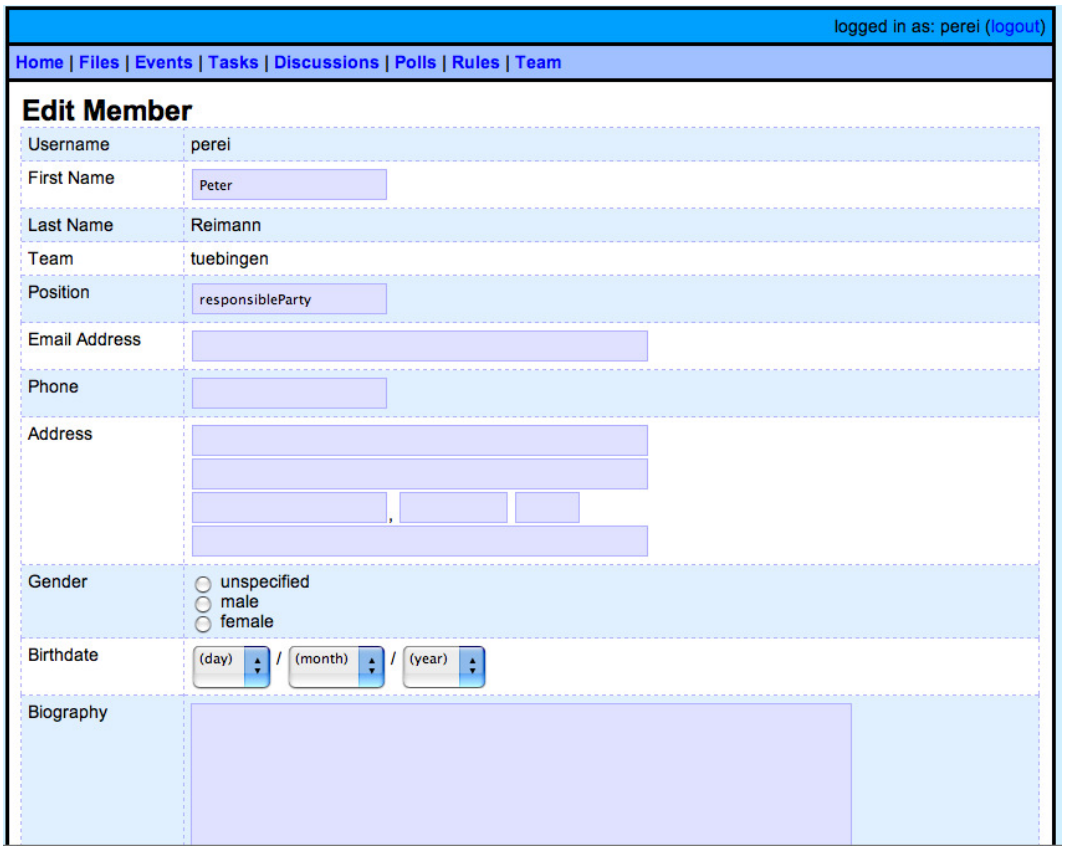


Figure 33. Team Manager: Members can edit their details at will.

The team management tool allows the free editing of the team's mission statement and the member's own profile. Members can only be added or deleted by the system administrator, who also sets and changes the passwords.

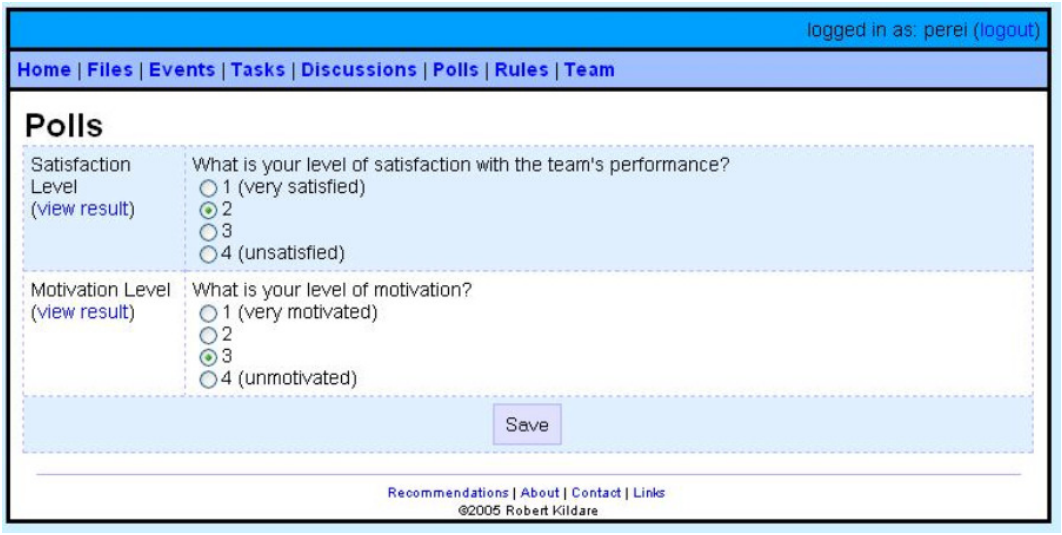


Figure 34. Well-being Polls: Members can offer their current feelings.

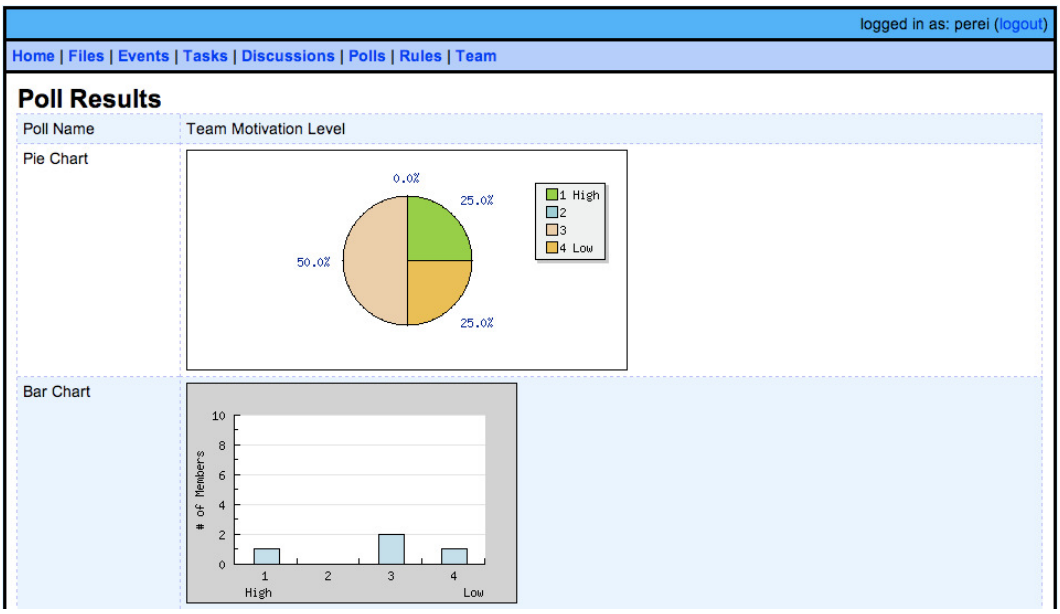


Figure 35. Well-Being Polls: Members can check on how everyone is feeling.

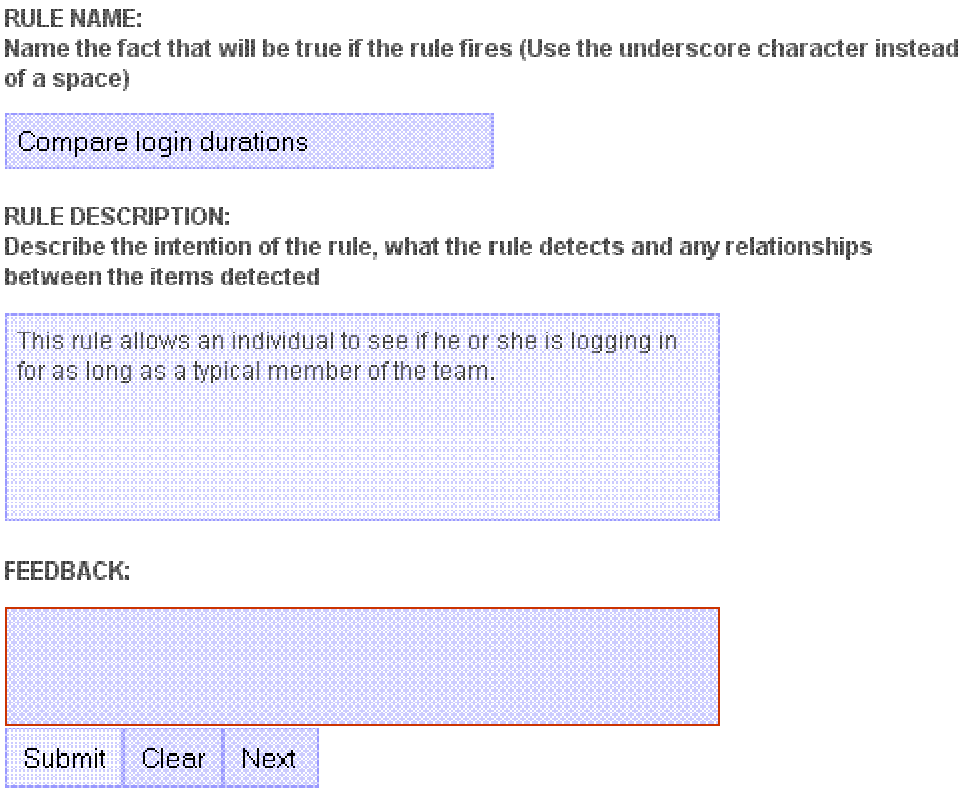
Appendix II

Quick Tutorial - AvLogin Time

- Navigate to Rule/Create

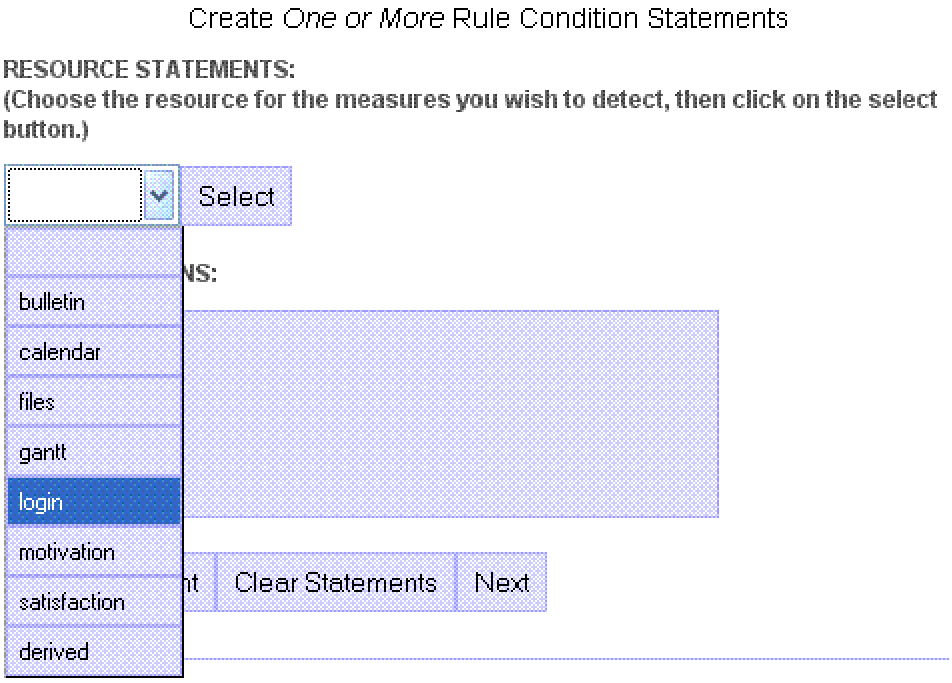
Step 1.

- Type in the name of the rule and the description of its function.
- Click ‘submit’, and when successful click ‘next’

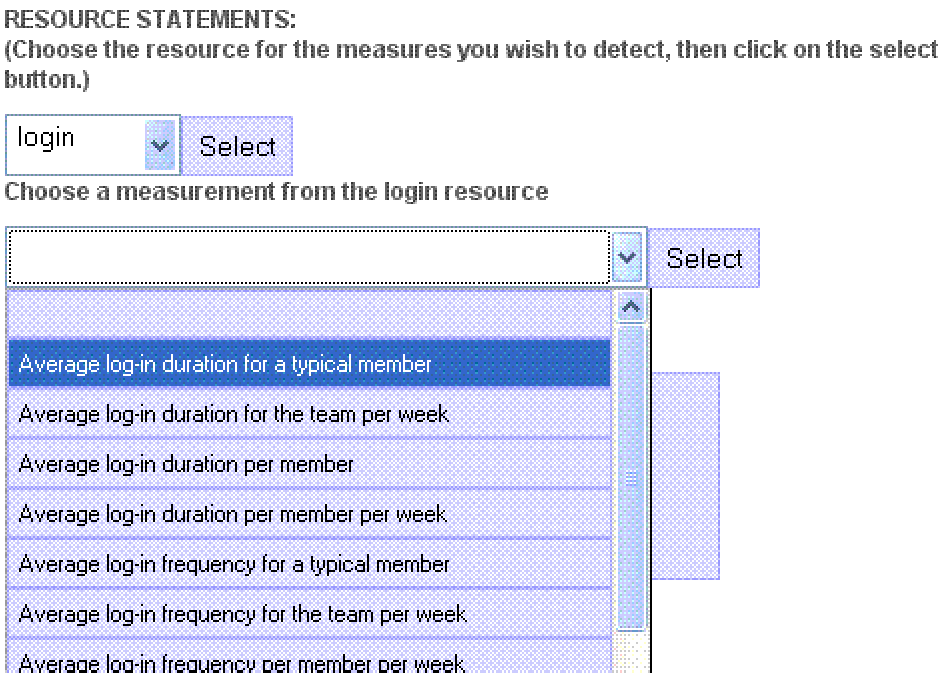


Step 2

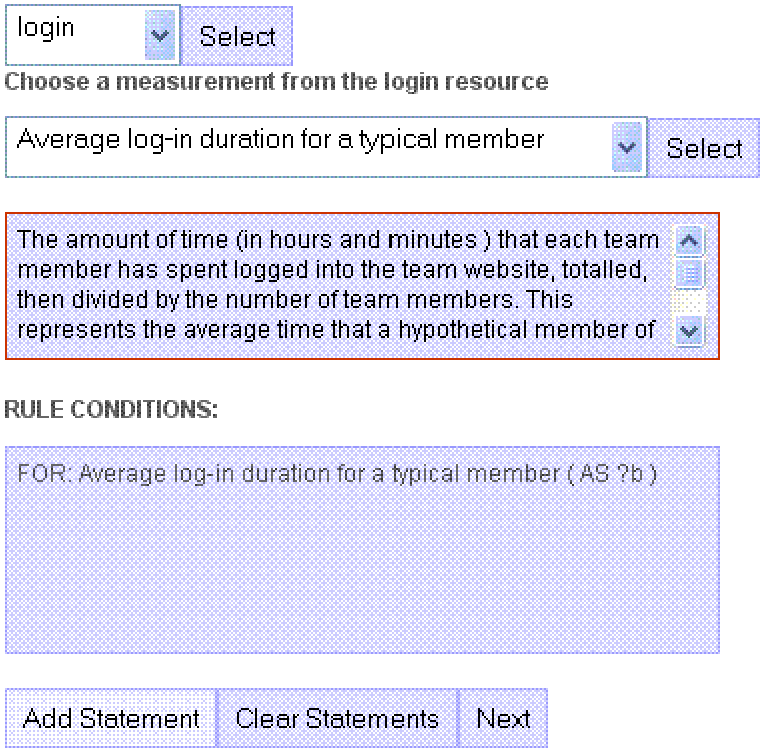
- Choose the `login` resource



- From the list choose the measure: `Average login duration for a typical member.`
- Click 'Select.'

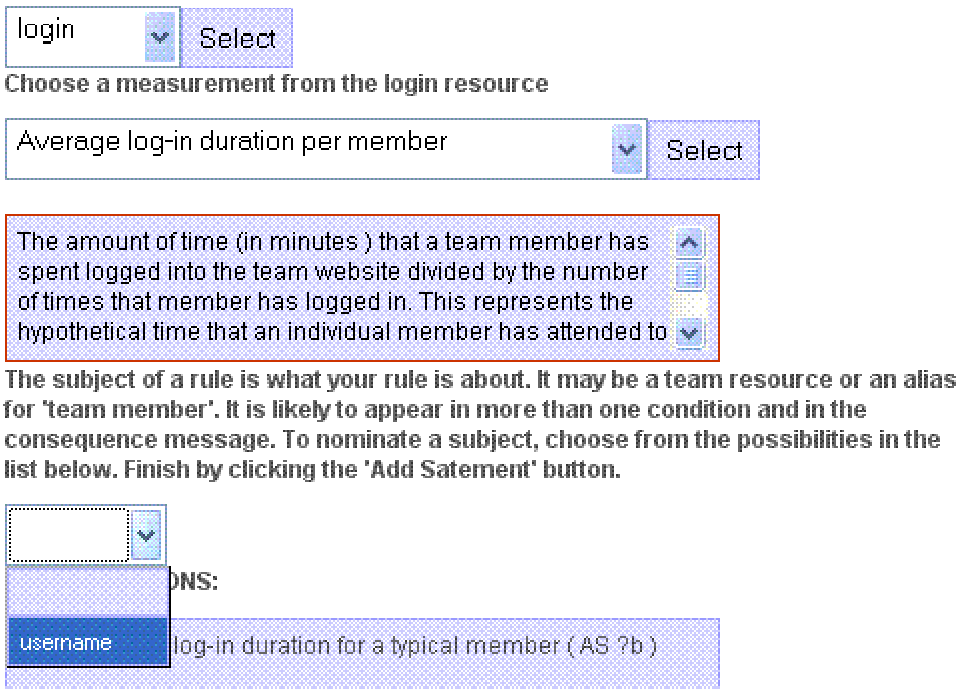


- The measure's description will appear and if there are no other select boxes, go to the end of the page and click on 'add statement'.



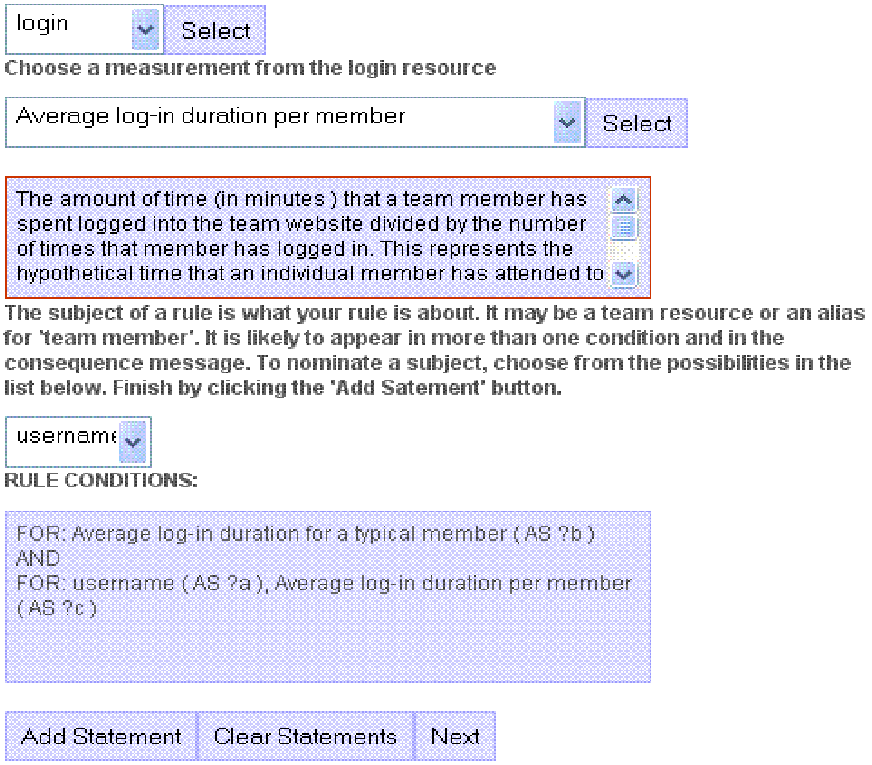
- Repeat the process by going to the "choose a measurement…." Select box and selecting `average login duration per member.`

- A selection box letting you choose the subject of the rule (the username) will appear. If you want the username to appear in the message or if you wish to send a personal message (to just the user named) then select the subject (in this case 'username')



- Click on the Add statement button. You have now chosen the two measures that will be the conditions of your rule. A consequent will fire if these variables have certain values or have some relationship to each other.

- Click next to set up these constraints and move to the next step.

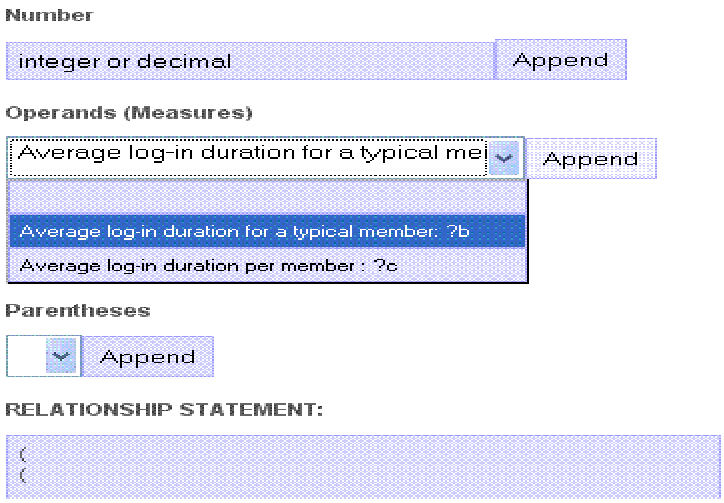


Step 3.

- Here the conditions for the rule firing will be that the measures are greater than zero

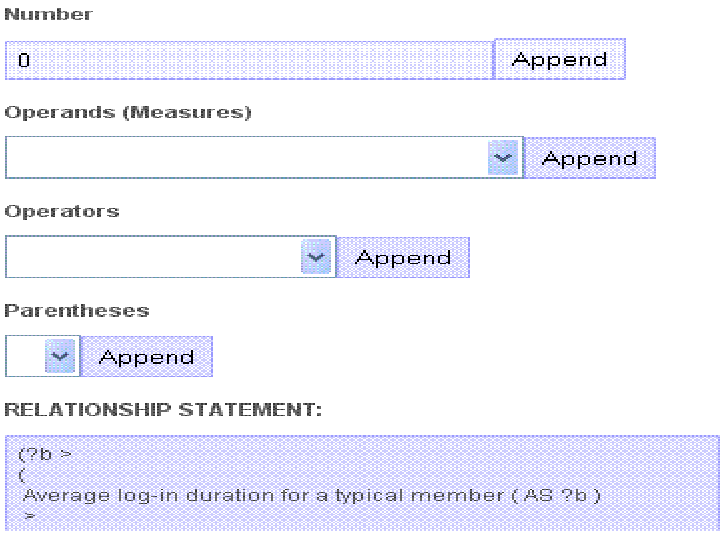
- Select operand `?b` and click the ‘append’ button. You will see it is added to the relationship statement we are building.

- Next select the ‘>’ operator and click the operator ‘append’ button You will see it is added to the relationship statement.

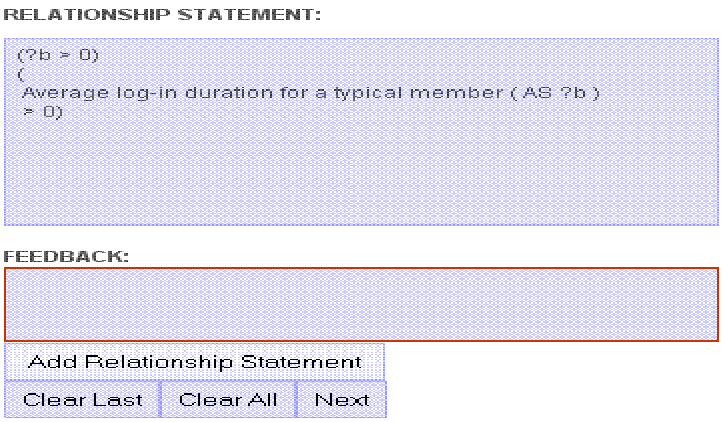


- Then clear the Number field of "integer or decimal" and type in a zero. Click the number field's append button.

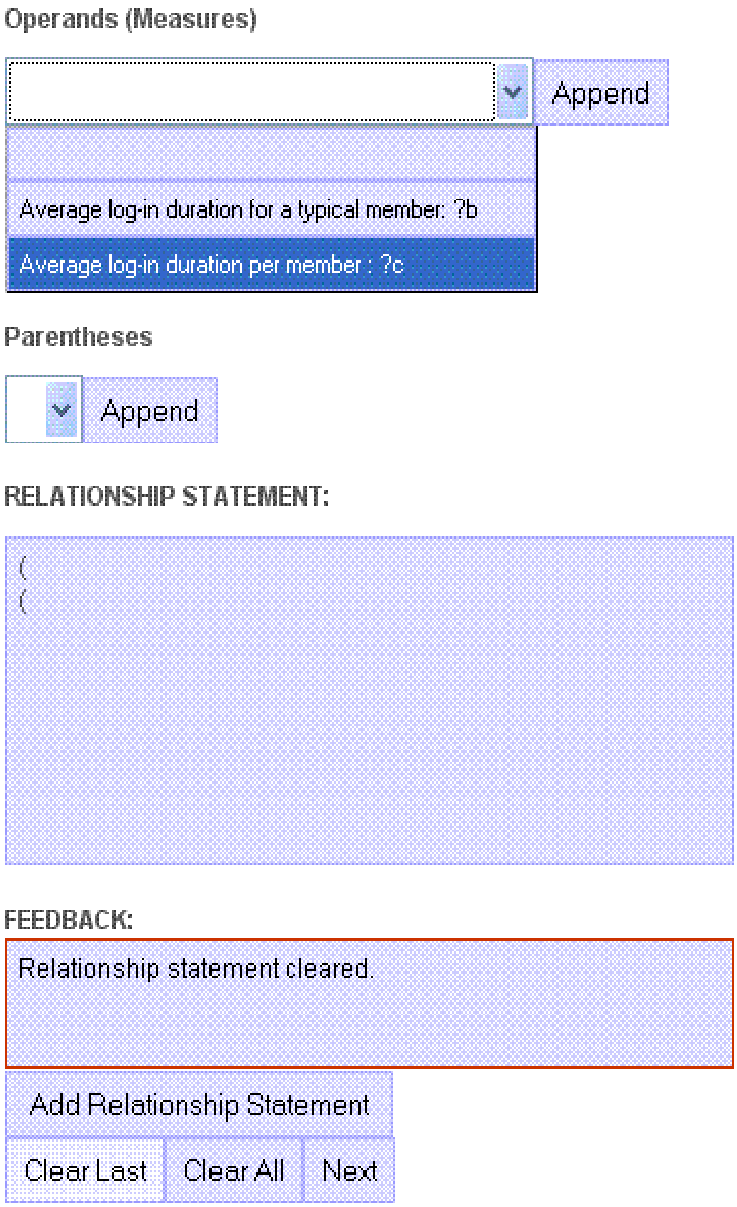
- Finally append a closing parenthesis to complete the expression.



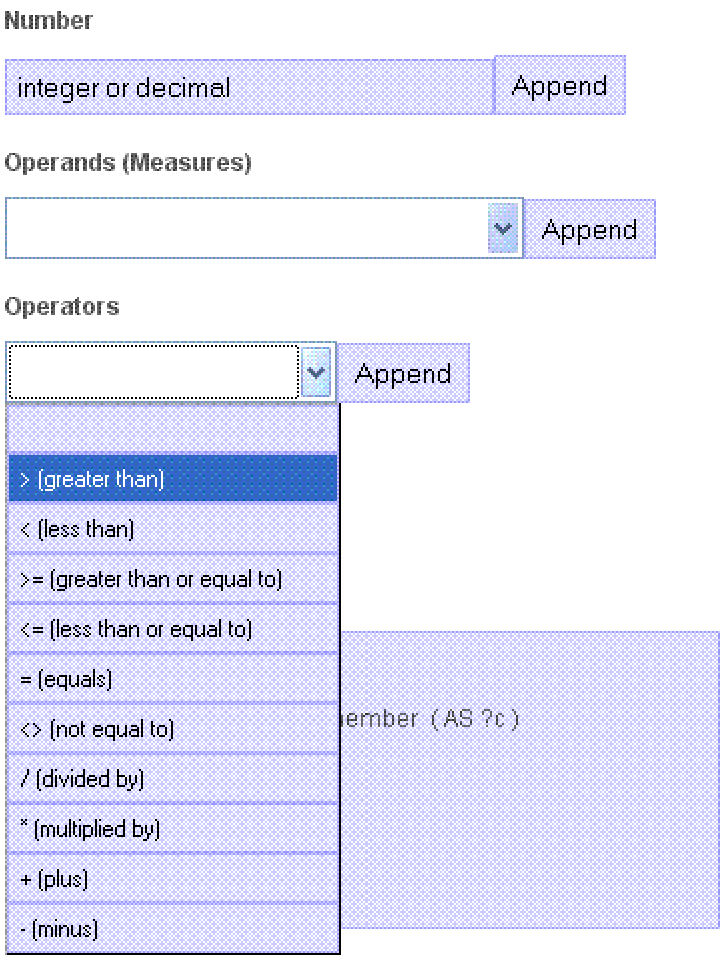
- Click on the ‘add relationship statement’ button below the feedback box. Because we are going to add another statement we will clear this one out of the work area – click the ‘Clear last’ button.



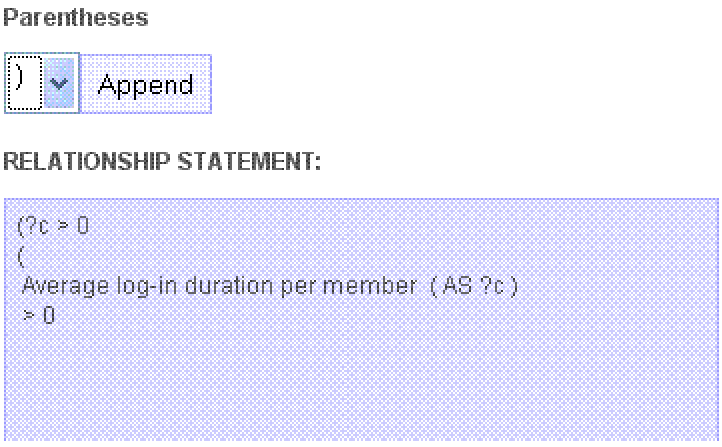
- Repeat the process for the member’s variable `?c`.



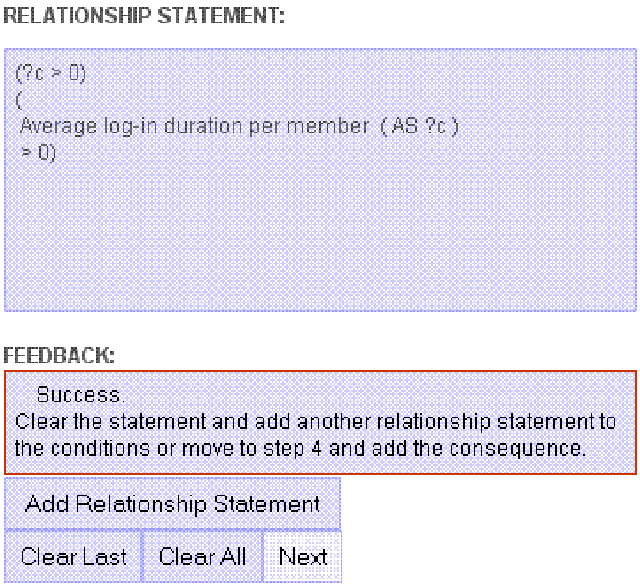
- Appending the operator, below.



- Appending the final parenthesis, below.



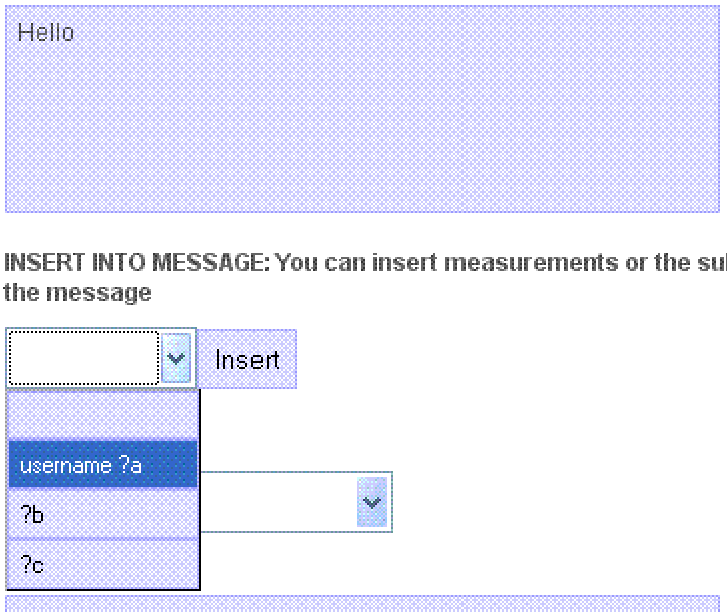
- Because this is the last relationship statement we will add, click on the “Add relationship statement” button then click the ‘Next’ button.



Step 4

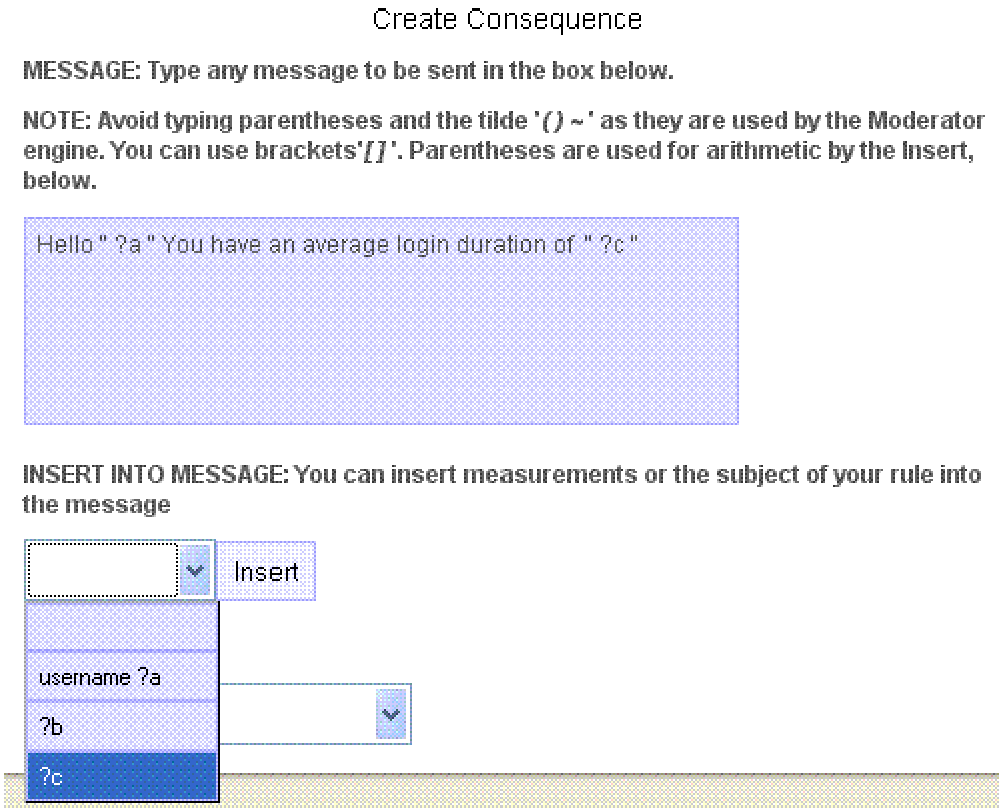
- Type without the angle brackets <Hello > into the message text box – don’t forget the space after the word.

- From the insert box below, select the ‘Username ?a’ variable and click the ‘insert’ button you will see it added to the message in the message textbox.

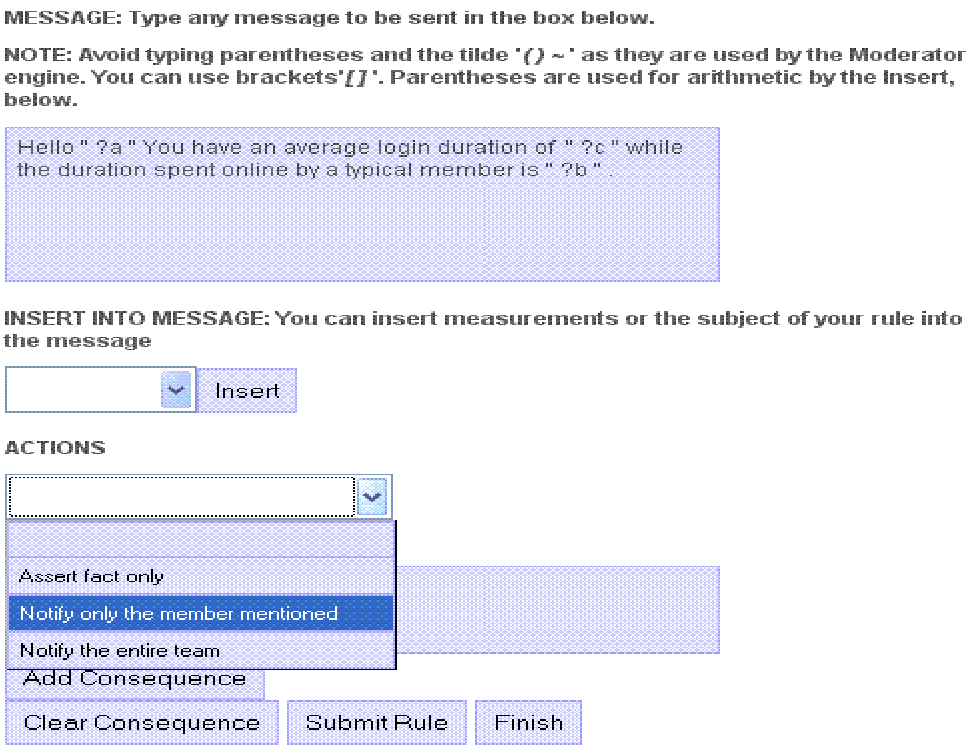


- Complete the message as shown below (the software will insert the quotation marks <“”>). Remember not to type the angle brackets.

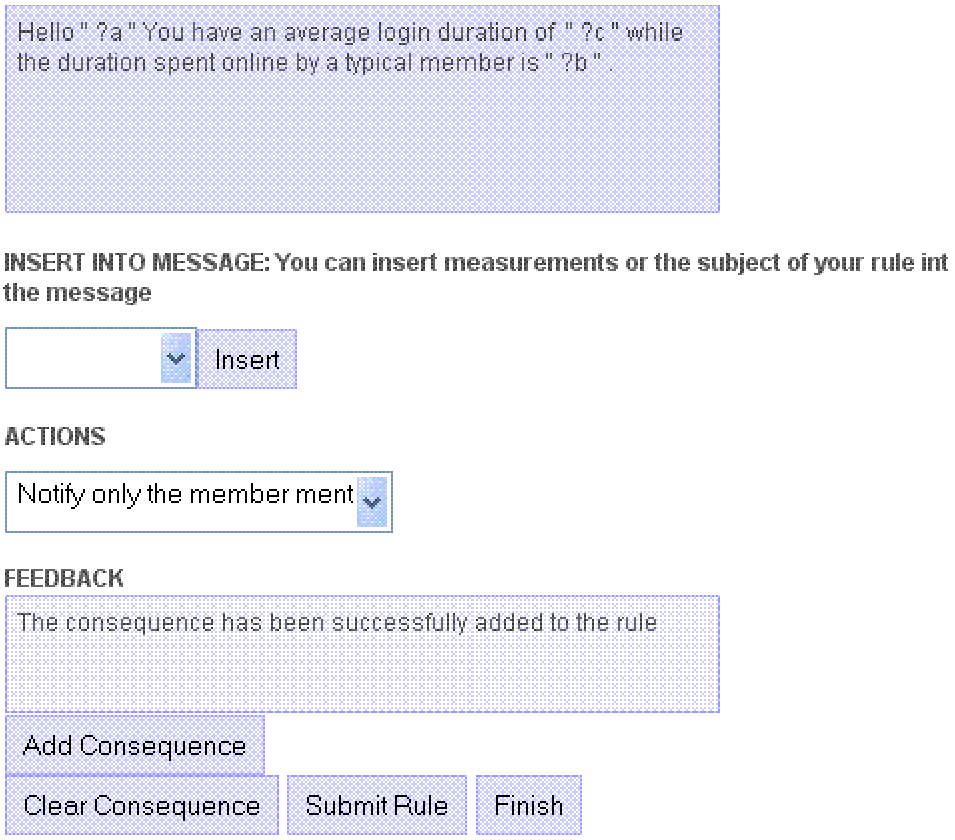
  <Hello “ ?a ” you have an average login duration of “ ?c ” minutes, while the duration spent on-line by a typical member is “ ?b ” minutes.>



- From the actions field, select `Notify only the member mentioned`.
- Then click the 'Add Consequence' button.

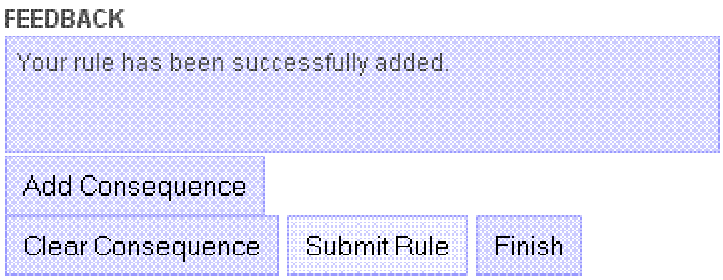


- Upon getting the success notification click the submit rule button



- When the rule has been successfully added you can click 'Finish'. The rule will be visible at the end of the Rules list on the first page of the rule facility, as will the details should you wish to revisit them.

- When next a team member logs in, they will get a personal message about their average login duration.



- If you wish to make the rule fire only when the personal login duration (?c) is less than the average for a typical member (?b) then you will only need one relationship statement at step 3.

- Append operand (?c)

- Append operator (<)

- Append operand (?b)

- Append closing parenthesis

- Click ‘Add relationship statement’

- Click ‘Next’ You will have the same variables available to build your message.

Appendix III

Real-Life Venues

The process of finding real-life venues for testing the value of Phreda was in itself revealing. Venue managers such as teachers or organisational management staff were approached in order to embed the research. The team managers were potential users of the software and some found it of value. At the point of expressing interest, the value that managers saw in the software was naturally hypothetical until after the trial. Managers requested rules.

In keeping with both Action Research (McKay 2005), Grounded Research (Corbina and Strauss 1990), and Multiple Case Study (Yin 2003) methodologies, re-evaluation of the theoretical and experimental framework occurred regularly after each trial, with a view to refining research questions, existing theory and assessing the research context.

The real-life studies attempted to identify changes of behaviour associated with changes in the rule set or associated with the firing of existing rules. The associations identified by the researcher between behaviour and rule activity were validated using participant perceptions.

The Five Venues

Brief descriptions of the five live venues follow. Venues 1 and 2 were primarily pilot tests for the software whose participants did not change or request changes to the initial rule set. Venues 3 and 4 were attempts to refine the experimental process and to discover whether the teams had a pre-existing understanding of the appropriate behaviour for the team. A shared culture of behavioural norms would obviate the need for setting up behavioural rules. The fact that participants knew each other and shared locations as well as circumstances would be enough to expect this to be true. Survey questions were constructed to confirm this. Usability was also tested. Venue 5 was the final iteration of the live venues where teams with and without preset rules were set up. The preset rules were different to

those of venues 1-4, being rules considered important by the venue 5 co-coordinator.

Venue 1

This venue was very much a pilot to test for the functionality of the software environment. It was a secondary school team comprised 6 students and their teacher. The students knew each other well and were co-located, although the task they had been set was to be conducted on-line. Class time was allocated so some on-line activity occurred during a timetabled slot. Each student was free to structure his own time and to use the software asynchronously. The students were male, aged 17-18 years and attended a private Christian school. The extent of their commitment and the students' lack of experience with teamwork suggested that the interaction rule module might be useful for completion of their task.

The teacher was particularly interested in the teamwork aspect, feeling that the software might help them to develop collaboration skills. He was not interested in constructing a study to demonstrate improvement in skills. The teacher's intention was to be part of the team, but not participate unless it was required to set aspects of the task. The teacher did, however have legal responsibilities via government regulations to the school, and the parents of the students. Bullying, for example, would require that the teacher become involved. It was decided that the computer-logged data presented be generated by the students themselves. Any logged data including the teacher's behaviour would clearly identify the teacher's contribution. The teacher also acted as an observer of behaviour for the purposes of this research.

Venue 1 Activities

The school students were given two months to complete a joint assignment on e-commerce. The exercise involved subdividing the topic, researching and providing individual contributions to a common, pooled product. They were shown how to use the software and encouraged to contact either the researcher or their teacher if they wanted to add, remove or alter the rules in any way. Students were also encouraged to answer the poll questions about their level of satisfaction

and motivation. They were directed to a page of recommendations for virtual teamwork, to be used as a guide for working on-line, and shown how to access the rule-making tutorials. A software demonstration included the explanation of interaction rules and the construction of an example rule.

Venue 2

The second team comprised a group of seven academics who were part of an initial cohort of twenty. They used the software as part of a four-week short course in collaborative, web-based learning, conducted by three members of a collaborative learning research group, including the author. There were five active participants using the software, excluding the course conveners and two members with minimal involvement. The aim of the course was to explore current theory, techniques and uses for different forms of on-line collaboration. The role of the course conveners was to give an introduction to the course and to provide background knowledge and software resources to the participants. The conveners also administered the on-line collaborative process. Leadership of the team was confined to administrative direction only. However, the work undertaken during the second half of the course contributed little to the aims of project. It was expected that the participants would spend at least one to two hours per week on-line after the one-day workshop. Difficulties with the technical infrastructure prevented the synchronous component from being undertaken in week three. The chat port being used remained blocked by the client university's IT department, preventing any asynchronous discussion of the experience. End of semester marking pressures prevented participation in week four.

The author was able to act as observer, being one of the course conveners.

Venue 2 Activities

The team of academics completed a one-day workshop on collaborative learning, including an introduction to the software. They were encouraged to request that the author add to or alter the seed rules provided. It was expected that they would be provided with short readings and would respond in the discussion forum with questions or exploratory posts.

The failure to complete the course, the drop-out rate and the use of discussion posts for commenting on issues relating to rules and the rule facility made the use of a questionnaire redundant, and so it was removed from the study.

Venue 3

This venue was within the University of Tasmania's School of Computing. The second year undergraduate course centred on the teamwork associated with software engineering projects. The course creator felt that the option to use collaboration software would be desirable for her students. She was curious to see if the interaction rule facility was useful in diffusing typical team interaction issues.

The course dealt with the non-code aspects of the software engineering cycle as a means of preparing students for the third year capstone project. The teams all had to find solutions to a common problem presented by a common client. They were required to elicit requirements, produce a requirements document, requirements trace matrix, prototype design, release schedule, risk analysis and project schedule. Each team was expected to divide the workload amongst the members, have members review each other's work and then integrate aspects of member documents into a final team item.

The subject was taught across two campuses with lectures delivered by two lecturers.

Students were given the option to volunteer to carry out the tutorial work virtually. It was envisaged that the arrangement would be appealing to students who were also employed. For consistency of delivery the researcher, who was also a tutor of face-to-face teams, would act as the tutor for all virtual teams.

Interested students were given a demonstration of the collaborative environment and told that they did not need to learn how to use the rule facility, just request changes from the researcher. From the outset the two roles were kept separate. The tutor role did not involve any discussion of the rule facility with the students. The tutor role was administrative and was confined to setting out methods for

completing the tasks using the collaboration environment and for informing students of associated deadlines. Content tuition and assessment was the same for on-line and face-to-face tutorials.

Venue 3 Activities

Only seven of the 150 students volunteered to use the collaboration software for tutorials, sufficient for one team. Of the seven, two students found it impossible to work and study at the same time and dropped study. The remaining five managed well. Unfortunately for this research, members were all from the same campus, had been in the same classes and knew each other. The same seed rules were provided as for previous teams. Virtual team members agreed to complete any questionnaires associated with the research.

One of the members was approached to describe any offline interaction. The team met face-to-face within the final hours prior to milestones such as the interview with the client and the presentation of their design. Conversations were predominantly task related (the member cites 90% as the proportion), due to members experiencing time pressures. They mainly defined task related activities such as “content, schedules, presentation delivery, next meetings, responsibilities, deadlines, etc”. The rest of the time was spent getting to know each others’ backgrounds and providing information for allocating roles and work.

In keeping with grounded research validation techniques, the members of the team were asked to comment on the findings of the researcher.

Venue 4

The second team in this iteration of the research was a senior secondary school team studying the pre-tertiary subject of “Computer Science”. The teacher in charge of the students felt that the use of the collaboration software with a previous class was sufficiently constructive to justify its use with another class (see section 1.2.1.1).

The team comprised five students and the teacher. Their task was to produce an assignment on networking as a shared document. The team had five months

available for the assignment to be completed, including two three-week vacation periods where any work would have to be done virtually. During school time the students were encouraged to work virtually, but could meet face-to-face. Students were given other activities to deal with and were relatively free to organise when they were to undertake these activities. The first vacation was early in the exercise, so was considered to be a period of orientation, where students accustomed themselves to working on-line. The teacher used rules to encourage this process of orientation. Further aspects of the school venue context were addressed in section 1.2.1.1.

Venue 4 Activities

Students were given a thorough introduction to the rule module and the software, providing a demonstration of how to create a rule and showing the available tutorials.

After these lessons, the teacher created a rule which reminded individual students, if they hadn't logged in for a total of an hour, that they hadn't yet reached their target. Two further rules were requested reminding students to post at least one discussion and upload one file. The intention of these rules was to have students use the collaborative environment during the three-week vacation period. The rules were subsequently disabled. In addition, the standard set of seed rules was provided. Towards the end of the assignment, 12 weeks after the demonstration, the already documented usability study was conducted (section 1.1).The same questions as those surveying undergraduates (identifying behavioural expectations) were also asked during the session. Three of the five students in the team attended.

Venue 5

Venue 5 promised the ability to provide multiple teams of 15 and 16 year-old secondary students. These participants were younger than the previous teams and (from the author's twenty years of teaching experience) closer to the beginning of the developmental stage of reasoning about social behaviour and norms of social interaction.

The teams were part of a wider study in on-line learning where classes from schools in different regions of Australia were to engage in a social computing study, arranged by the SiMMER research group (SiMERR, 2007). The end product for the team of students would be some type of team artefact or "collaborative document". Arrangements were expected to be finalized by the end of July 2007 and completed by November 2007, including time for an end of school term vacation and an early end to the year for the Grade 10 students who would be completing their High School education. Two schools would work together using the Phreda collaboration environment.

One teacher involved with the venue 5 study was interested in researching the effect of rules intended to encourage participation in particular on-line activities. The leader of a project for The National Centre of Science, Information and Communication Technology, and Mathematics Education for Rural and Regional Australia (SiMERR) (of which venue 5 was a part) was interested in the way social computing could be fitted into school curricula and as such was interested in the way Phreda performed.

Venue 5 was potentially able to provide multiple teams of remote members allowing a research design which eliminated face-to-face interaction and permitted a comparison of teams using and not using seed rules. The investigation of prior shared expectations would be necessary if they did not engage with the rule facility.

Venue 5 Activities

The first school, Sc_A, was not able to start the study until early September 2007 and negotiations for the two schools to integrate did not take place until the beginning of November. Cross-school teams did not carry out any tasks before the students left school for the year, although the teams were formed and some members briefly communicated. This scuttled any attempt to answer research questions that required remote team members. Despite this, training sessions were carried out with students from both schools. Five teams, of 4 or 5 members each, were created with a small number of students from the second school blended into these teams during November. Most students were highly unmotivated,

particularly from one of the schools where commitment to school in general was very poor.

Students at Sc_A were asked to create a set of trivia quiz questions about the local area and exchange these with another team for review purposes. Ultimately the quiz questions were likely to be part of the inter-school activities to follow. A lack of enthusiasm in some groups and the need to practice the skill of collaborative on-line document editing saw the exercise changed. A team story was written, with members progressively adding to a single creative writing piece. Students worked predominantly in class time, with the exception of an injured student, who worked from home. The course consisted of two sit-down classes run on different timetable blocks. The asynchronous nature of the collaboration environment was able to join members of these two classes into the one activity. Students were able to fraternize outside class times and shared a common culture at the regional school. A degree of anonymity did exist when pseudonyms were used for the creation of the story.

Questionnaires were conducted prior to use of the software environment and after its use. During the training session for both schools, interaction rules were clearly explained and the students were familiarised with the collaborative environment. Few students were interested in participating from the other school, Sc_B, but they were also given the same training and preliminary surveys.

Expressions of interest – context of teams

Tasmanian organisations, both government and industry bodies were approached via email for an initial expression of interest. Any interest was followed up with a personal visit from the researcher and an information pack containing previously published academic papers (if appropriate), a description of the problem and proposed solution, documentation on the conduct of the research, contact details, etc. approved by the ethics committee.

Detailed planning of the actual task, use of the software and clarification of the roles of both the manager and researcher followed agreement to participate.

Organisation	Position of Contact Person
Rural Clinical School	Head of School
Westbury Community Health Centre	Sister In Charge
Beaconsfield Community Health Centre	Sister In Charge
TAFE Tasmania, Burnie	Campus Leader: Manager, Staff Teams
UTAS School of Computing	Lecturer in charge Software Engineering
UTAS School of Computing	Lecturer in charge Introduction to Systems
* UTAS School of Computing	Lecturer in charge ICT Management
UTAS Centre for Learning and Teaching	Director
* UTAS Faculty of Education	Dean
IBM (Aust)	Manager of Research
Australian Computer Society	Secretary
Minerals Council of Tasmania	Chief Executive Officer
Farmers and Graziers Association (Tas)	Chief Executive Officer
* University of Sydney CoCo Research Lab	Associate Professor
RMIT Media Studies	Lecturer in Charge Capstone Project Course
Monash University	Senior Lecturer Information Technology
Edith Cowan University	Dean Graduate Research
Wilderness Society	Secretary
Timber workers for Forests Inc.	Secretary
General Practice, St Helens, Tas.	General Practitioner
Department of Tourism Arts and Environment	Director
Department of Health and Human Services	Manager Disability Services
Department of Health and Human Services	Manager IT Services
*Marist Regional College , Burnie	Senior Teacher Computer Science and Information systems

*Figure 36. A list of the contacts made in search of venues. * Indicates a venue that participated in the study.*

A number of venues that expressed interest failed to participate for a range of reasons.

Appendix IV

Survey Questions

This questionnaire in five parts is intended to provide information on the value of the prototype rule management component of the teamwork software.

The first part of the questionnaire is intended to provide an understanding of your circumstances, the second to is to understand your use of the rule facility, the third is to look at the role of the rule facility in influencing the team's interaction (this involves distinguishing between the process of team members making rules and the actions of the software in administering the product - the rules themselves). The fourth part of the questionnaire looks at your opinion of the general worth of the concept behind the rule software and the fifth as for your thoughts on the usability of the software.

Part 1 Context:

The following questions will help to understand the nature of your team and the context in which in which the experiment is running.

- What is the name of your team [Will not be published!!]? …….
- How many weeks has your team worked together on this project?

……..

- Describe the task that your team intends to complete:

…….

- How **experienced** are you at working in on-line teams? Choose the alternative that best describes your prior experience. (A team is a group of people working on a *specific* task or problem. A type of team can be defined as one that has members with the same or similar roles and tasks – such as a

sports club committee or a construction team. Exclude your family from the definition of a team for the purposes of this study.)

☐ Rarely a member of a team of any sort.

☐ Often a member of the same type of team only – never an on-line team

☐ Often a member of many types of team – never an on-line team

☐ Often a member of the same type of team only – including on-line teams

☐ Often a member of many types of team – including on-line teams

- How many times did the team meet synchronously on-line (eg: by tele-conference, video conference, chat)?

☐ 0-5

☐ 6-10

☐ 11-15

☐ 16-20

☐ 21+

- Comment on when these meetings occurred during the project….
- How often did the team meet face-to-face?

☐ 0-5

☐ 6-10

☐ 11-15

☐ 16-20

☐ 21+

- Comment on when these meetings occurred during the project and if you attended all meetings…….

- Were the meetings called due to the needs of :

  ☐ The Team?

  ☐ Forces external to the team?

- Comment briefly on the reasons for these meetings:……...

How many emails did you send to other team members, while working on this project?

☐ 0-10

☐ 11-20

☐ 21-40

☐ 41-60

☐ 61+

- Comment on changes to the nature and distribution of these emails over the length of the project:

…….

- Can you identify critical periods in the team's interaction? Typically (but not exclusively) these critical periods might be due to the requirements of your project or the related to the well-being of the team.

☐ Yes

- If so, how many times critical periods were there?

  ☐ 0

  ☐ 1-2

  ☐ 3-4

  ☐ 5-6

  ☐ 7+

- Comment on the **nature** and **duration** of these critical periods and **when** they occurred:

……

Part 2 Rules

The following questions are designed to understand your use of the rule-making facility.

- How many times were you tempted to create a rule?

  ☐ 0

  ☐ 1-2

  ☐ 3-4

  ☐ 5-6

  ☐ 7+

- How many times did you create a rule?

  ☐ 0

  ☐ 1-2

  ☐ 3-4

  ☐ 5-6

  ☐ 7+

- How many times did you help another team member to create one?

  ☐ 0

  ☐ 1-2

  ☐ 3-4

  ☐ 5-6

  ☐ 7+

- If you were tempted, but did not create a rule (or assist in its creation) what prevented you doing so?

…… ……

- How **satisfied** were you with the result of rules you created or helped another team member to create.

1 2 3 4 5 6 7

Totally Dissatisfied |_____|_____|_____|_____|_____|_____| Totally Satisfied

Comment:.....

- How **satisfied** were you with the result of rules created by other members of the team and not including your input.

1 2 3 4 5 6 7

Totally Dissatisfied |_____|_____|_____|_____|_____|_____| Totally Satisfied

- Comment:.....

Part 3 The team environment:

Did you feel that the other team members had similar expectations of how the team should operate?

1 2 3 4 5 6 7

Different Expectation |_____|_____|_____|_____|_____|_____| Identical Expctn

- In what way were the expectations of members of the team either similar or different to your own?

....

- Did you find expectations of how the team should operate to be:

1 2 3 4 5 6 7

Not a problem |_____|_____|_____|_____|_____|_____| Major Problem

- In what way?

…… ……

- Conflicts within the team were resolved **constructively**:

1 2 3 4 5 6 7

Never |_____|_____|_____|_____|_____|_____| Always

- How were conflicts resolved?

……

- Did rule creation assist conflict resolution?

1 2 3 4 5 6 7

Never |_____|_____|_____|_____|_____|_____| Always

Conflicts in the team were mostly **personal** in nature rather than about ideas or processes:

1 2 3 4 5 6 7

Entirely personal |_____|_____|_____|_____|_____|_____| Conceptual or procedural

- What were the main issues?

……

Indicate the extent of your opinions by circling a number between 1 and 7.

- Were you prepared to admit your mistakes publicly to the team

1 2 3 4 5 6 7

Not at all |_____|_____|_____|_____|_____|_____| Always

- Were you prepared to suggest unusual ideas to the whole team that had not been fully thought through

1 2 3 4 5 6 7

Not at all |_____|_____|_____|_____|_____|_____| Always

- Were you prepared to admit to the whole team when you didn't understand something

1 2 3 4 5 6 7

Not at all |_____|_____|_____|_____|_____|_____| Always

- Were you prepared to make a plea for assistance in front of the whole team

1 2 3 4 5 6 7

Not at all |_____|_____|_____|_____|_____|_____| Always

- Did you consider the level of support provided by the team for each other to be:

1 2 3 4 5 6 7

low |_____|_____|_____|_____|_____|_____| high

Rules governing the way the team should operate may have been created by the team separate to the Moderator software. If so can you describe these? Were they prompted by the existence of the Moderator software? Was the software ignored because the rule could not be created by the software (eg: no measures existed in the system)? .....

Part 4 Meaningfulness:

The following questions focus on the difference between the value of the act (or process) of making the rules and the value of the product – the rule set itself.

To what extent do you think the rule making *process* and *product* contributed to the team's trust? The number one will equate to causing the total destruction of trust the number 4 will equate to no contribution at all. The number 7 will equate to fully contributing to increased trust in the team.

- Did you feel the act of making rules changed the development of trust within the team?

1 2 3 4 5 6 7

Decreased trust |_____|_____|_____|_____|_____|_____| Increased trust

- Did you think moderator *feedback from the rule* changed team trust?

1 2 3 4 5 6 7

Decreased trust |_____|_____|_____|_____|_____|_____| Increased trust

Did rule making contribute to improving team interaction – more general than trust alone?

- The ***process*** of generating the rules was:

1 2 3 4 5 6 7

Not at all useful |_____|_____|_____|_____|_____|_____| Useful

The process of generating the rules was:

1 2 3 4 5 6 7

Not at all useful |_____|_____|_____|_____|_____|_____| Useful

- The moderator's *feedback from the rule* was:

1 2 3 4 5 6 7

Not at all useful |_____|_____|_____|_____|_____|_____| Useful

- Generally the team found the moderator:

1 2 3 4 5 6 7

Not at all useful |_____|_____|_____|_____|_____|_____| Useful

- How effective was rule making in uncovering expectations?

1 2 3 4 5 6 7

Not effective |_____|_____|_____|_____|_____|_____| Very effective

- How effective was moderator feedback in uncovering issues?

1 2 3 4 5 6 7

Not effective |_____|_____|_____|_____|_____|_____| Very effective

- How useful was the *process* of rule making in resolving issues:

1 2 3 4 5 6 7

Not at all useful |_____|_____|_____|_____|_____|_____| Useful

Can you elaborate on why you hold these views on the process of rule-making and the moderator feedback itself?

.....

Part 5 Usability:

This section of the questionnaire refers to the worth of the prototype rule module

- Did you find making the rules:

1 2 3 4 5 6 7

Not worthwhile |_____|_____|_____|_____|_____|_____| Worthwhile

- Did you think the team found making the rules:

1 2 3 4 5 6 7

Not worthwhile |_____|_____|_____|_____|_____|_____| Worthwhile

- If you found the process of making rules to be not worthwhile, was there some non-virtual process that could replace making the rules?
- Please describe this.

……

- If only on-line avenues were available for defining the way the team operates then the Moderator software would be:

1 2 3 4 5 6 7

Useless |_____|_____|_____|_____|_____|_____| Useful

- Given your experience of on-line teamwork, which of the following methods would be the most effective method for managing the way a team operates?

Rank each choice by placing a number beside each one. Your first preference should be 1. and you least preferred method should be 5.

_____ assume everyone will behave the same as you and do nothing;

_____voice objections personally when problems arise;

_____use discussion to achieve informal agreements before problems arise and note breeches of agreements personally;

_____formalise policies in documents before problems arise and note breeches of agreements personally;

_____create Moderator rules and have problems identified impersonally;

- Circle the words that best describe your response to the rule component of the software:

Affirming Frustrating Enjoyable Intrusive

Distracting Rewarding Annoying Challenging

- Having used the prototype rule component of the software, tick all of the statements that best describe what you might do next:

☐ Recommend this component to others

☐ Avoid this component

☐ Track the component to see what improvements are made

☐ Use this component again

☐ Ignore further developments

☐ Assist others in the use of this component

☐ Discourage others from using this component

- What suggestions do you have for improving the software?

  ……...

- If you are an educator or researcher and you have comments that extend beyond your role in the team as to the usefulness of this software, your input would be appreciated: ……

Other……

Appendix V

Venue 5 Training Session

Learn about Interaction and Interaction rules

Pretest1:

What problems arise in a team?

What behaviour happens in a good team?

What do you *try* do when in a team (What would be the best habits of behaviour to adopt)?

Interaction by a team is?

Actions and responses usually have a meaning or communication attached to them.

When someone puts red ink on your assignment… when a friend takes your ipod to cash converters..

When a team member passes the ball as you make a lead…

Teams work together to achieve more than can be done by an individual – the product is more than the sum of the individual efforts… there is exchange of ideas which can lead to creative solutions to problems, there is an effect on the bigger game (one person can pass another can shoot – but the result could be win or lose- an effect on the bigger picture), it may be cheaper to have lots of individuals with fewer skills than employ one person with all the skills.

What problems can you have in a team?

Miscommunication – different understandings of meanings

Lack of communication

Misunderstanding team processes – like publishing before checking with the boss…

Interpersonal conflicts

Freeloading

Domination

Lack of commitment

Illness

Outside influences – like water restrictions on ovals, council rates, public holidays

When do you know your team is working well?

Enjoy each others company, sociable

Lots of feedback,

Lots of backup when you need it

Members reliable

Communications clear

Committed to task at hand

Interaction Patterns

Many informal patterns of behaviour exist – but they are not formally written down – like when you are trying to reverse park in Goldie St…. legal but just not done… or when someone behind you front parks into the space you were going to reverse into… Burping at the table in Japan used to be/is an expression of satisfaction with the meal – a compliment.

In society we have "rules" about theft and murder and Father of the Year, Australian of the Year. Rules don't have to be negative – most people think of them as such because they restrict "freedoms", but they also reward those

behaviours that are encouraged. Patterns of interaction are selected that suit the way the society is supposed to run and are written down as a formal statement of their importance.

Interaction rules are formal statements of what your team decides will be the appropriate patterns of their interaction.

How often it is ok to miss training,

How much socialising is good and not distracting,

How much each person should speak at a meeting (too much, not enough)..

Learn about Software

I will log in first – on the projector

Log in – takes a while

Edit team details

Discussions – types try to keep email contact to a minimum.. post copy or summary of contacts if the discussion concerns the team task.

Calendar – types

Tasks

File – upload a file, download a file, edit a file

break

Version control … filename_versionNumber_Initials.doc

Polls – vote.

(can create your own voting using an excel spreadsheet that everyone edits…. or create folders… eg: Pollys_Party_Yes PollysParty_No

Interaction Rules and Software

Refer to home page on the projector.

Every act a member makes on the software is an interaction with the team – possibly indirectly. It is possible to measure interactions with the software such as the number of times a member logs in, or the number of files downloaded, the satisfaction level of the team, the average size of discussion posts for the team, a member ….etc

These measures or combinations can be thought of as patterns of behaviour, about which we can write "rules". The system allows a user to be reminded privately or publicly praised (to the whole team). The team is free to use whatever message they want – positive, negative, neutral and to choose freely from the measures available on the system.

show detail view of a rule

show links to tutorials, (quick tutorial in the team folder)

Ms Cruse will be a member of each team and will likely want to put rules up for some teams and not for others – as part of our research.

You will be able to create your own rules and edit or disable them – but it is best if you ask me to create or edit rules – do so by email. This will save you having to learn something extra when you could be working on your team assignment. It is sensible to do so after you discuss this with the rest of your team – do so by creating a discussion thread.

pretest2

5 x 1-7 trust questions.

To do

Dependent upon time:

Either introduce the coming task OR set something they can do over the holidays to explore the software OR both OR neither.

Appendix VI

Focus Group Instructions

Asynchronous Instructions

1. Introduction:

Welcome to the collaborative research environment in which the software moderator is embedded. This environment provides the software to fulfill the fundamental requirements for collaboration: managing time, resources (files), people, tasks and communication. The environment is not intended to be a fully functional, slick commercial package. It is intended to focus on the ideas behind the collaboration process.

The aim of the research is to explore the role that rules of behaviour might play when independent team members (such as those in the scenario) are working in such an environment. When standards of behaviour are explicitly formalised (typically in writing) they are considered to be rules.

In on-line teamwork, interaction behaviour is about the way the environment is being used. Some usage can be tracked and measured. Who knows what measures of usage are important to the scenario team? Who knows what measurements become critical and what they actually mean to the team members? You as scenario members will know what is important – based on your prior experience. The measurements can be regarded as the conditions of a rule and what follows is the rule's consequence.

My research is about whether it is worth providing a tool that will enable the participants to decide what is measured and what happens when those measurements reach a certain point.

You have been introduced to the output (the consequence) of one rule – "Message from the Moderator" at the top of the list of items on the "Home" page. It gives you a personal message based on your attendance and that of the team as a whole. You only need to know what a rule is, rather than learn how the rule management works.

Your primary focus should be on working out what behavioural standards (or norms) are best for the scenario. You don't have to do the scenario task (Don't make a tourism website), just contribute to discussions.

A copy of the scenario can be downloaded from the Files/team/ folder. Discussion topics related to norms of interaction have been started. You may wish to start others. Feel free to do so. This is your

group's site to do with as you wish. I will check in to answer questions and deal with administrative concerns, but leave you to your discussions.

2. Where to Start

Click on the "Team" link at the bottom of the page header.

Where you see your username listed, click the "edit" link.

Include a bit about the real you – experience with teams, on-line activities. Try not to make it possible for others in the study to work out who you are in real life.

Then add a brief biography of the persona you would adopt for the scenario – the team you represent, the hobby or interest that is the focus of the team's tourism design, the location you have chosen in the scenario context.

Read the entries of others.

You may wish to edit the mission statement of the study group.

Click on the "Polls" link and register your levels of satisfaction and motivation with regard to the study. Look at the results for all the participants.

Look at the other links and get a feel for how they work.

3. What Can I break?

Not much is breakable except the law (copyright). Just about everything you do, you can also undo or delete **with the exception of discussion messages**. Use copy and paste to pre-write lengthy messages. Expect typos and spelling errors.

You may wish to share files that have research or stimulus material pertinent to the discussions you undertake. Try to keep file sizes small, even though the system is robust and will handle 10MB files without a problem. You have private ('username' folder) and shared ('team' folder) file storage.

4. Scenario Usage

How might your imagined scenario team members use this collaboration environment to carry out their task?

[Please list ideas and respond to them on this thread if possible. If this proves to be too restrictive then start new threads.]

5. Optimal Performance

From your experience, what behaviours ("standards" or "norms" of behaviour) make for a team that performs at its best? (Expand on each behaviour briefly).

Add responses to this thread, so that we end up with a list. Move on to "6 Expected Behaviour" when you are done with this thread.

6. Expected Behaviours

You (the group), should list the constructive or destructive behaviours that you would expect from your imagined scenario team members.

Mention what might motivate these behaviours (remember cultural differences) and how you might identify (measure) these behaviours in an on-line collaborative environment such as this one.

Describe possible rules you would like the scenario team members to adopt with regard to that behaviour.

Start a new thread for each behaviour. Put the title as the name of the behaviour and follow with three parts – the behaviour and how to identify it, possible motivation, possible rule.

It is then up for comment and your responses. Please respond to other behaviour threads as well.

Scenario

Team scenario:

Imagine you are working with a like-minded group of independent team members – ones you do not necessarily know. You are working on an on-line project being set up by UNIHCO, a United Nations organisation aiming to develop international harmony and co-operation.

The aim is to design a tourism website depicting features, facilities and means of visiting places around the world that have your interest or hobby as the common element. The attractions should relate to a particular interest that you have such as horse riding, surfing, rock climbing, fabric and clothing, etc.

The other members of your team will be from different regions in the nation and from regions in other nations. They may not be familiar to you despite sharing the same interest. You and the others have either volunteered or have been asked by their employer to engage in the project.

The project will run for three months. New members will be allowed to join for up to a fortnight after commencement. The UNIHCO agency running the project will oversee the selection of team members and limit the numbers to 12. All activities will be conducted in English. The agency will provide funds for getting participants to two video conferences, one half way through the project and another

one week before the report is due. Time-zone difficulties with these meetings will be handled as equitably as possible. Most of the process of setting up and completing the project will occur on-line using an asynchronous collaboration environment with management facilities for time (calendar) people (team page) resources (file storage and exchange) and jobs (task allocation). Communication will be via a threaded discussion board.

Some reasons to be involved

- Employment in Australian government departments of tourism is increasing and a good outcome would be an asset on your resume. The UN may also be hiring if this project proves successful and is extended.

- Your business or current employer may get valuable free advertising or access to decision-makers.

- You may be able to develop an attraction into a business.

- You may learn about existing enterprises surrounding your attraction.

- You may be able to meet new people that share your interest – possibly with a view to friendship, potential travel destinations or an exchange of ideas.

Some Risks:

- Someone may use your work or ideas in competition with your business.

- You may have to deal with people you don't like.

- A poor outcome will not be good on your resume.

- There may be little or no return for the effort you put in.

Create a scenario persona by answering the following questions:

- What is your name?

- What is the common interest you share with your team members?

- What location have you chosen to include in the tourist website?

- What has motivated you to join the team and what risks do you run?

- How would you like the interactions between you and the other team members to work? Consider task driven factors but also those interactions that serve to enhance personal and team well-being.

Appendix VII

Usability Study

The participants of venue 4 were asked to create rules using the tutorial materials available and to document their thoughts and actions as described in the methodology. Two of five students did not attend.

Of the three students, two were able to create rules successfully using the materials available. The third student had English as a second language and seemed un-able to understand the task.

The use of symbols was helpful in keeping students to the task of explaining what they did and why. It was possible to see where the student with difficulties was struggling, but the recording by the participants was very coarse-grained saying little about the interface and how it could be improved.

One of the participants, V4_M5, who successfully created a rule was particularly terse:

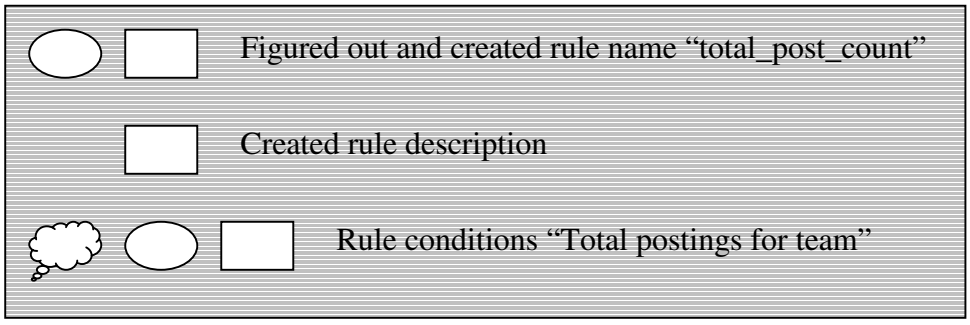


Figure 37. An excerpt from the usability comments of team memberV4_ M5.

Figure 37 includes the only software thought and annotation, which is not very informative at all. The other student to complete a rule, V4_M4, was a little more articulate, commenting on the “good descriptive names” in the on-line tutorial and help facilities and the “helpful step by step process” for making the rules.

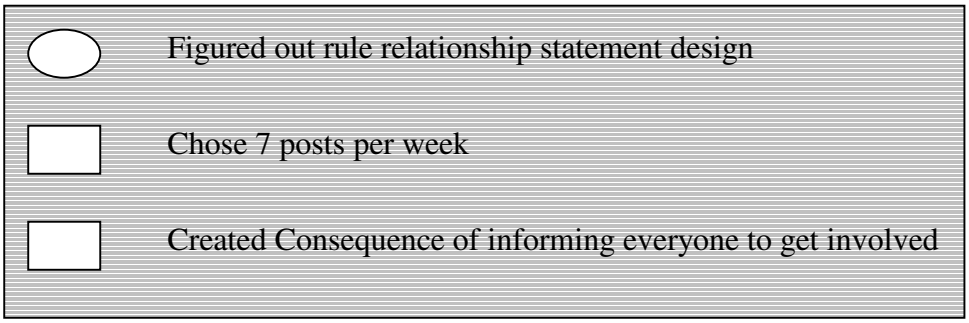


Figure 38. An excerpt from the usability comments of member V4_M4.

Respondent V4_M2 attempted to encode a poor choice of measurement for the intended purpose of his rule. He attempted to use the level of team motivation measurement to indicate the amount of task content provided by each member. It was the interface that appears to have prevented him successfully creating this rule, but the point where he failed to complete instructions is not documented in enough detail. He used the categorisation symbols erratically, as well.

Figure 39 shows how step three in the rule making process is the point of collapse for V4_M2. The symptoms he describes, however suggest that either tutorial steps one and two are also not completed, or that the step 4 page has not been interpreted correctly. Clearly the process was too complicated for this student.

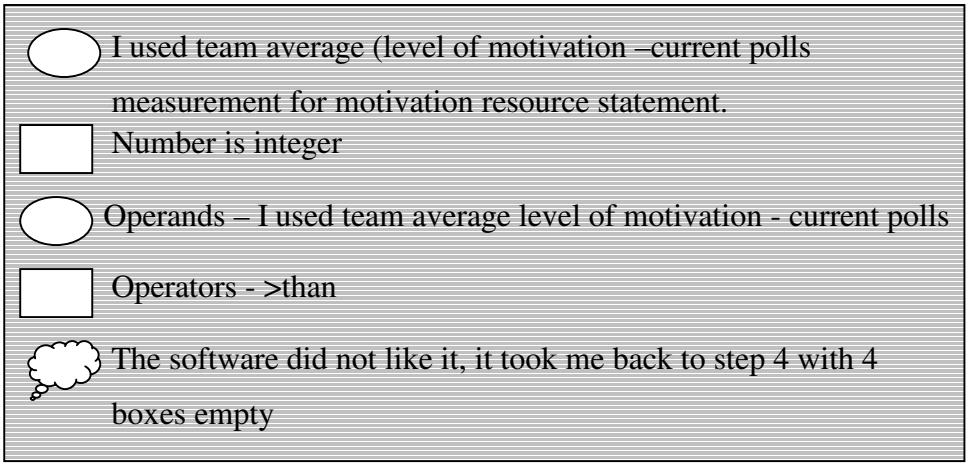


Figure 39. An excerpt from the usability comments of member V4_M2

From this outcome it was clear that the module and tutorial usability was not the reason why this team did not use the module. The students who did complete the task were typical secondary students 17 to18 years old and computer literate. Their ability to use the module and read the tutorial would be most unlikely to

differ widely from those members of teams from other venues. University students and lecturers also did not use the module.

Appendix VIII

CD Contents

The CD included with this thesis is divided into two parts, Research Data and Software. Also included are details on how to access a live web-site running the collaboration environment including Phreda. The website has a number of preset rules already functioning and sufficient mixed attendance to have the rules fire according to team 'state'.

Software

A file called "newInstanceInstructions.txt" explaining how to create a new instance of the moderator, source code for the collaborative environment and its database, source code for Phreda, basics for populating the database tables with users, temporary tables, resource constants, measures and preset rules, instructions on how to compile Phreda source code, including compiled versions of mysqlConnector and JESS.

Research Data

The data is broken into two: Focus Groups and Live Venues.

Focus Groups

The focus group data comprises discussion board threads for each of the discussion boards (the first phase of the study) and data from the three focus goups (the second phase of the study). A folder of processed data is provided. Also included are the 14 "whiteboard" slides used in the web conference and the recorded demonstration of Phreda.

Data from the first phase is presented as MSWord files showing the text of each discussion thread.

Data from the second phase is presented in a number of forms:

- Incidental Chat as text file
- Quiz answers grouped by question as MSWord file,
- Images of Group checkbox activity for questions related to identified behaviours.
- Transcript of web conference audio
- Actual audio recording of the web conference
- Any email or discussion board answers that substituted for the live "Quiz" answers as MSWord files.

Processed Data is provided in three groups:

- Pre synthesis raw answers for all groups sorted by question as MSWord files
- TAMS Analyser coded files as Rich Text Format (.rtf) files
- Validation responses from focus group participants as MSWord files

Live Venues

Sample usage of each venue is given for each venue as MSExcel files. The contents of these files vary, depending upon which idea was being tracked at the time. As much as possible, data for each teams resource usage and the types of messages posted have been included. These data have also been presented as charts.

The file "V1_RulePtputs_AllFirings.txt" is a collection of every rule that fired for Venue V1. These firings were compared against database traces that are shown in the body of the thesis. Ethical, security and practical considerations prevent all the database information from being provided. Reproducing live venue experiments will require a new installation of the collaborative environment for each new team.

A sample rule engine script from Venue V1 (“V1_SampleClips.txt”), comprising fact templates, anonymised facts of team state and rules, has been included.

Finally there is a sample of the processing done by JESS in evaluating the rules against the facts (as distinct from the output of the rules themselves). This detail is invluded in “V1_SampleRuleFactmatching,txt”.

Appendix IX

Recommendation Engine Design

If we introduce a recommendation engine, which is expert in evaluating the needs of teams, then we introduce a second adaptive component providing "personalisation" for a team.

The recommendation engine would answer the question: What rules are useful for similar teams? It would acquire its knowledge rule lists from other teams and incorporate any recommendations from human experts at the organisational level in which the engine is running. It would produce the answer as a list of rules for a containing system to deliver to Phreda.

The expanded system structure suggests an adaptive component for each complex container (or context) as an interface with its containee (Figure 40).

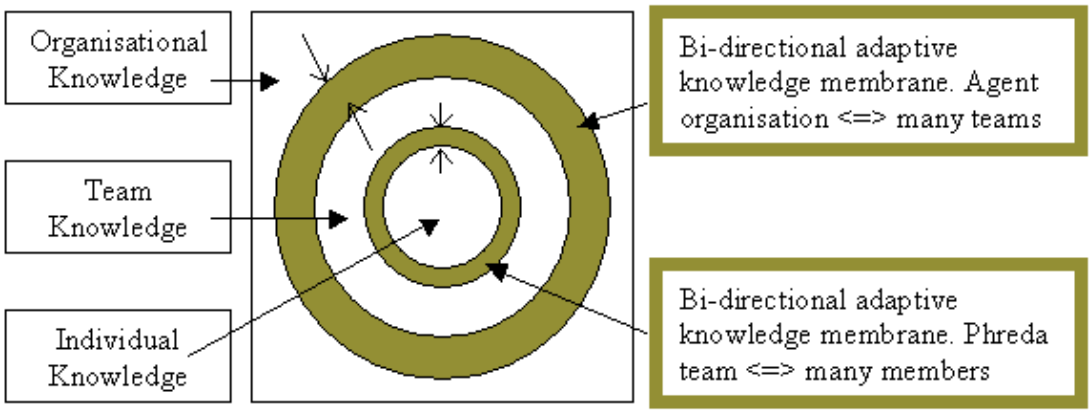


Figure 40. Knowledge inputs for adaptive systems integrated in a complex system of complex systems. The fine arrows indicate knowledge inputs. The adaptive systems act as interfaces between complex systems.

Socially speaking, this could be a recursive structure, terminating with the individual. A complex social system must have more than one individual. Each component would be able to access and deliver knowledge from either side of the interface. This is analogous to a cell membrane. Its behaviour is dependent upon both external and internal state.

Each of these adaptive “membranes” contains a user-model and question handler that act as a repository of knowledge. Just who is informed of what is determined by the manner in which the action handler is implemented. De Vrieze classifies adaptation actions as “pull” and “push” actions, where information is pulled into the user model or pushed to the user (de Vrieze, 2006). These actions describe the flow of knowledge; inputs are pulled and outputs are pushed.

In the case of the Phreda ‘membrane’, inputs would come from the recommendation engine and the team members. Outputs would go to either the team as a whole or just the individual. Team state and the associated rule set would be passed to the recommendation engine for machine learning purposes. In the case of the recommendation ‘membrane’, the inputs would come from multiple implementations of Phreda and come from the organisational level when default settings were created. Output would go to the team via Phreda and potentially to researchers and organisers at the organisational level.

Recommendation Engine

The design for implementing interaction rules requires some way of reducing cognitive load and introducing knowledge that may be pertinent from outside the team. A recommendation engine is suggested to fulfill these roles. The functions for the recommendation engine are as follows.

A set of measurements is defined for the database traces considered important for a team.

Each team will have a “ state”, S, defined as being the set of the measurements (M_i) defined by the system.

1). $S=\{M_1, M_2, M_3 \ldots Mn\}$

The semantics of a “rule” will be the same as for a production rule used in the first order predicate logic constructs of an expert system. Each rule will be a predicate based on some relationship of measurement values to an absolute value or to another measurement value as conditions for the rule. A consequent is defined by the user, based on options available within the system.

Each team will have a set, R, of rules at any time. The set may be empty.

The recommendation expert will be able to reference a list, P, of example state and rule set pairs, $S`_nR`_n$. A default set of rules should be used to initialize the system, if no states exist, $S`_0R`_D$.

2). $P=\{ S`_0R`_D, S`_1R`_1, S`_2R`_2, S`_3R`_3,\ldots. S`_nR`_n\}$

The recommendation expert will have two functions, f_1 and f_2. f_1 will find in its list (P) the state and rule set pair (P_i) most similar to the current team state (S), given as a parameter. f_2 will return a rule set (R'') comprised of an amalgamation of the rule set associated with the most similar state, and the existing rule set of the team (R), provided as a parameter.

3). $Pi = f_1(S)$

4). $R``= f_2(R, R`_i)$

To simplify, since $R`_i$ is available to the recommendation expert in pair Pi, one can represent a function f, which takes SR (a state and associated rule set from Phreda) as the parameter and returns R`` a recommendation as to what would be an appropriate rule set for use in some later request.

5). $R``= f (SR)$

Calling this update function would be the responsibility of the Phreda question handler (figure 3), which would then provide the information for the adaptation effect as shown in figure 4. The recommendation engine would have to poll teams, however, to obtain its list of State-Rule pairs before having a recommendation available for Phreda to request. Repeated usage creates structures of legitimation and recipes for interaction. It also creates structures of meaning or signification (Poole & DeSanctis, 2004). The repetition of meanings ascribed to measures creates a social dictionarywhere agency determines meaning and indicates what is valued by the teams. This is similar to Google's spelling suggestions, where the most common recent spellings are suggested before socially less prevalent ones. In addition to the rule set, some form of usage

dictionary could be returned as a list of alternate interpretations of the conditions of each recommended rule.

To begin with Phreda has no rules and no state. Once the team uses the collaboration software it will have state. The team should be able to request a default set of rules, or build their own. The team can modify any set of rules at any time. The subsequent state and rule set should be stored by the recommendation engine. A recommendation is prepared, should it be requested, the next time that Phreda runs. It would provide personalisation on request. A recommendation engine fulfils the definition of an adaptive personalisation system as defined by deVrieze (2006). The mechanisms for making the recommendation are not explored in this design and will be left for further research. There is exciting work to be done in how to detect similarity (how to data mine the list of state-rule pairs) and how to manage the transfer of meaning. This research however, focuses on the interaction rules themselves, in order to ascertain whether pursuing these questions is warranted.

Agents

The introduction of a complex system within complex systems and the provision of adaptive facilities, in this case concerned with interaction rules, suggest that this research is about the simplest, terminating case of a much larger picture. If one considered the scenario of an on-line educational delivery system, collaborative teamwork occurs at many levels. If one considered simply student collaborative learning, there could be multiple teams in a course and multiple courses in a school (intersecting with different qualifications). There are many schools, faculties and inter-university connections. Rules governing interaction (production and team support rules) are generated for many reasons. Adaptive personalisation “membranes” could exchange knowledge in a multitude of configurations. The pushing and pulling of knowledge as part of the adaptive process implies a degree of autonomy for the various Phreda implementations and their associated recommendation engines.

The single instance of Phreda, or a collection of Phredas with their own recommendation engine, could be conceived of as part of a larger system of

distributed intelligence, which would enter the realm of multi-agent systems. Agents in such a system can be units of software capable of acting in a virtual environment. These units can communicate with other agents and have their own individual objectives. The have a partial view of their environment, possess skills and offer services as well as pursuing their objectives. They may be mobile and may be able to reproduce. (Ferber, 1999). While the current design can be managed as a small program that is run by the website itself or as a web-server program (if “always on”), embedding the adaptive components in a software agent would expand Phreda’s horizon. Features of agent systems such as autonomy, reproducibility and mobility could be exploited to fully integrate interaction rule support in a larger complex organisational structure. The emergent properties of agents themselves would determine which agents had populations in the environment, the size of these populations and where they would be found, rather than being constrained to the hierarchy suggested by the concentric membrane model. Again, this research potential is only worth pursuing if interaction rule support proves to be of significant value.