CONTEXTUAL FACTORS WHICH INFLUENCE CREATIVITY IN REQUIREMENTS ENGINEERING

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Abstract

In many disciplines, creativity has been recognised as an important part of problem solving. In business, creativity enables generation of better solutions and provides opportunity to gain competitive advantage. In Information Systems (IS) creativity assists developers in finding solutions to difficult problems, it helps them in efficient utilisation of the available resources, and allows more effective planning and running of complex projects. One of the most important aspects of IS development is Requirements Engineering (RE), the development activity aiming at understanding the needs and wants of IS customers. While previous RE researchers suggested that creativity is crucial in building high quality information systems, fostering creative outcomes in RE is difficult as it is affected by the multifaceted socio-organisational context within which IS development commonly takes place. This paper reports findings from an empirical study into creativity in RE. Specifically, it reports various contextual factors which we found influence creativity of individuals and their teams.

Keywords: Requirements Engineering, Creativity, Case Study.

1 INTRODUCTION

A traditional view of requirements engineering (RE) has been that it is a structured, systematic and repeatable technique (e.g. Kotonya and Sommerville, 1998). Models of the technique have supported this view and suggest that if the techniques are followed consecutively, a satisfactory outcome will be achieved. However, an emerging view of RE has recently suggested that the process of the development of a requirements specification is not smoothly incremental but instead involves a series of increments with an occasional reorganisation of the requirements specification following a creative insight (Nguyen, 2000).

Earlier authors such as Guindon (1990) and Khushalani et al. (1994) explored the impact of creativity on software design process and suggested that designer behaviour was not pre-planned but rather opportunistic. Carroll and Swatman (1999) further postulated that opportunism occurs in RE where the requirements engineer's adapt their activities in response to the stakeholders and by reacting to their movements between different problem areas. Nguyen and colleagues (1999; 2000) offer a new understanding of the RE process as consisting of catastrophe cycles of building the requirements model and restructuring it as a result of reconceptualisation insight. The catastrophe cycle process supports Wallas' (1926) creative process model. Nguyen and Swatman (2003) further argued that managerial actions might be required to promote and support creative problem understanding and solving in RE by monitoring and promoting reconceptualisation crux points.

In recent years, the role of creativity within RE has been further expanded. Maiden and Gizikis (2001) view creativity as a central part of RE and call for a recognition of the importance of creativity in the RE process. Maiden and Gizikis (2001) and Robertson (2002) further state that in the future creativity will be central to economic and market trends. This view of the importance of creativity was further tested (Pennell and Maiden, 2003) by applying creative techniques such as brainstorming, analogical reasoning, storyboarding and Combinational Creativity to facilitate informed creative thinking about requirements and opportunities for novel software applications. The approach taken was useful and demonstrated that some creative techniques were more effective than others in providing better outcomes (Pennell and Maiden, 2003). Maiden et al. (2004) continued this approach of applying creative techniques within RE workshops and uncovered several problems or barriers to creativity, for example the lack of expertise in the creative technique, the lack of time available for undertaking some components of the creative process, the loss of the original rationale behind ideas, people's reactions and frustration to change, lack of "champions" of the workshop process and more.

Debating and discussing about creativity with a group of RE practitioners, Cybulski and colleagues (2003) strongly emphasise the importance of creativity in the RE process. As a result of their study, C/RE (pronounced sera) - an initial conceptual framework for understanding creativity within RE emerged. The conceptual framework involves the following elements in RE creativity:

- Context: The socio-organisational context that the problem solving occurs in within RE. The context element of RE creativity includes both individual and social dimensions. Barriers to creativity are also raised including lack of experience, organisational politics and cultural barriers.
- Outcome: Issues that concern promoting, assessing and accepting creative RE problem solving solutions.
- Process: The characteristics of the process. The patterns undertaken by participants and their place within the psychology of problem solving and theories of creativity within the RE process.

This framework reflects Pohl's (1994) views of the three dimensions of RE: the reaching of agreements between stakeholders in a social context, the specification process, and various presentation formats of the outcome. Furthermore, the C/RE framework also reflects the people, process and context aspects of creativity of general problem solving discussed in the literature. For instance, person, process, product and environment have been suggested as four common elements that form the basis for many understandings of creativity (Taylor, 1988). Tying these elements together, Jonathan Plucker, an associate professor of learning, cognition and instruction, described creativity as "*the interplay between ability and process by which an individual or group produces an outcome or product that is both novel and useful as defined within some social context*" (IU Home Pages, 2003). In fact, the Context element in C/RE framework can also be related to "person" and "field" in Csikszentmihalyi's (1988) systems view on creativity.

The recent tutorials on creativity in RE held at RE'02 and RE'04 (IEEE International Requirements Engineering Conference 2002, and 2004) have demonstrated a growing interest in developing a further understanding of the role of creativity in RE. However, the reactive response to the new interest in creativity, held by researchers and practitioners, has been rather slow in RE education (for example, Nguyen et al., 2002; Armarego, 2004).

In response to the need for further understanding creativity, this paper offers an examination and further refinement of the C/RE conceptual framework by extending its Context element, and identifying individual and socio-organisational factors which influenced creativity exercised by students undertaking RE in their major University projects.

2 RESEARCH APPROACH

A qualitative-interpretive multiple case study (Benbasat et al., 1987; Yin, 2002) was adopted to explore and identify individual and socio-organisational aspects of creativity in RE.

The study took place over the period of approximately twelve weeks at an Australian university in 2004. Two case studies involved two student groups, referred to as Group A and Group B, engaged in a final year project concerned with the design and implementation of a system for an external client. Each student was assigned a specific role in the project, which included the role of a systems analyst involved in aspects of requirements engineering.

The researchers tracked the teams' progress, observed the teams' meetings, conducted interviews, and analysed produced documentation. The C/RE framework was used as a lens to focus the researchers' observations and to guide the interviews with individual research participants. Closing interviews were conducted with the majority of the participants of both groups at the completion of the project. RE artefacts such as diagrams, assignment submissions, agendas, etc. were collected and subsequently examined to clarify the issues emerging during data analysis.

Meaning condensation technique was used in the analysis of the collected qualitative data (Kvale, 1996). In the process large "chunks" of data (answers to interview questions, meeting notes, etc.) were condensed into shorter sentences or statements that kept the main meaning of the original data. Reading, questioning and contemplation was undertaken to think and ask questions in order to reflect on these short statements. Questions like why? Or what is it about? This was done to also find out the relationships between the short statements and the research question. Themes were identified through these relationships. Descriptive meanings of the themes were then developed by looking further at these themes (Kvale, 1996). Therefore, the meaning condensation technique supported inductive data analysis by allowing new concepts to emerge, in the form of meanings and relationships between themes.

3 RESULTS AND DISCUSSION

The client for Group A was Redcorp[1], a small, family-owned retailer that is a home-based business. The project entailed replacing Redcorp's existing website. The owners desired a more professional website for their business. After several meetings with their client, Group A developed a specification for the required system. The website specification offered marketing opportunities for the company and a content management system for the client to update product descriptions.

The client for Group B was Healthsmart, a health care provider. The project entailed converting part of Healthsmart's paper-based system to a computer-based database. This was to be completed as part of a quality improvement process the business were undergoing and involved the conversion of three paper-based forms. Greater efficiencies and access to data were expected by making these forms electronic.

Our observations show that while both groups provided solutions that were accepted by their clients, they demonstrated different levels of creativity while undertaking RE. Both groups utilised some creative idea generation techniques (Harrington et al., 1997) and both creatively combined known solutions to produce the innovative ones (Boden, 1994).

The following sections (3.1 and 3.2) identify some of the contextual factors observed to influence creativity exercised during the teams' requirements engineering tasks. The individual and socio-organisational dimensions of the identified factors are discussed aspect by aspects to illustrate their potential in extending the Context element of the C/RE framework (Dallman, 2004) and to cross-reference the findings with the RE and creativity literature.

3.1 Individual dimension

3.1.1 Motivation

Motivation appears to have played different roles in the creativity performance of the individuals in the two groups. There are different factors involved in motivations observed: financial rewards and positive comments.

Financial rewards emerged as an important aspect for some of the teams and their members when a prize of $1000 for the best project had been announced. A clear contrast in the groups' attitudes was observed between members of Groups A (affected) and B (not affected). Our observations show that the role of the monetary reward on the individuals across both groups varied, ranging from highly motivating, competition-driven motivating, not motivating at all to even a source of disappointment (also see Fisher, 2004).

In terms of feedback, reaction to positive recognition of project quality by mentors was quite mixed. The positive comments from Group B's mentor were construed as an incentive. However, with Group A receiving continual positive feedback, the value of that feedback as a motivator decreased. Members of Group A expressed that their mentor's repeated positive comments did not provide incentive. While our examination of effects of rewards does not negate Harrington et al's view (1997) that recognition is important to encourage creativity, it tends to support Eisenberger and Shanock's (2003) view that rewards for novel solutions increase creativity, while rewards for the conventional solutions actually decrease it.

3.1.2 Personal Agenda

Personal agenda reflects the importance that individuals place on a project due to their individual motivations. While all of the interviewed individuals viewed the project as very important, their personal agendas slightly varied and had impacts on their performance. A

[1] For the purposes of anonymity all organisations and individuals are given pseudonyms

common agenda held by the final year students was to increase their employment prospects, i.e. the project could offer them valuable experience when seeking future employment. Some individuals had additional agenda in undertaking the project. For example, one student was concerned that his academic performance would impact his immigration issues if he failed a subject. For the same reason, another student considered the project as her number one priority:

> "*It's always here, the first one [priority] that's the project.*"
>
> *– Tania (Group A)*

As a result, a clear majority of students aimed at achieving a High Distinction (80% and above) result and invested a lot of effort, emotion, and time into achieving this common goal.

> "*This unit, I chose the course to do this unit … It's starting to rule my life at the minute … I've just invested so much emotional … time and effort into this.*"
>
> *– Erin (Group B)*

It is worth noting that some members from Group A expressed their concern that one particular person would be happy just to pass the subject or to receive a lower mark. Although the effect of having different agenda was minimal in this case, this is an indication that personal agenda that requirements engineers bring to a project may affect their personal performance and trust and group dynamics in complex organisational situations. Especially, trust and morale of team members have been seen as important in RE creativity according to the C/RE framework..

3.1.3 Self-Perception of Being Creative

One-to-one interviews with students revealed that they have a common understanding of the concept of creativity. It was interesting to note that all students saw themselves as creative. Surprisingly, a single participant, who believed not to be a creative person, still admitted her own creative potential.

> *"I don't think I'm a creative person until this subject actually ... I'm a bit of a text book follower I think. Yeah I don't think I'm creative, but I can be.*"
>
> *– Vanessa (Head Analyst Group B)*

Tardif and Sternberg (1988) explain this that perception of others or the self as creative may in fact be very difficult as creativity is comprised of many character traits, some of which may not be part of any particular creative individual or which could only be demonstrated within a specific domain of individual activity.

3.1.4 Perception and Knowledge of Creativity

Students demonstrated they had some good understanding of creativity. They generally identified creativity with the elements of novelty, divergent thinking, concept recombination and formulation of conceptual relationships, the issues well understood by creativity researchers (Torrance, 1988; Boden, 1994). Interestingly, students' individual perception and knowledge of creativity seemed to impact their ability to recognise creativity as an important part of their RE outcomes and processes during their projects.

3.1.5 Creativity Education

It was not entirely unexpected that the students reflected on the relative disregard for the value of creativity in RE education. In fact, students from both groups had little or no formal creativity education in RE:

> *"Honestly it only covered one lecture so I don't think there was great emphasis on it … I've read it in text books but it wasn't part of what I was supposed to read … As*

yet I haven't come across creativity … in terms of requirements or software engineering … in any other subject [except for Advanced Systems Analysis and Design]."

– Erin (Group B)

"[The lecturer in the project unit we are undertaking] has being stressing a lot on creativity and trying to be different from the others if you have to make a mark in the industry."

– Liam (Group B)

In fact, it was the lecturer's personal industry experience and reflection of creative undertakings, rather than the subject curriculum, which had a more direct and long-ranging impact on some of the students to approach their RE problems creatively when working on their project work.

3.1.6 From Experience to Design Bias

Both groups A and B brought into their projects their individual development assets, i.e. their members' experience and education, and fragments of their past projects and work-products. Design decisions were consequently based around programming solutions that individuals had studied previously and felt comfortable using. The heavy reliance on reusable information and components, however, did not in any way discount the value of their creative outcomes. It is in fact recognised that combinational creativity commonly occurs where old solutions and their elements are combined together to produce new creative outcomes (Boden, 1994).

3.1.7 Conformance vs Dogma Breaking

The students in both groups A and B expressed a desire to conform to previously acceptable solutions by preferring to follow set tasks and showing clear reluctance to take risks. For example, Group A chose to adopt a particular solution because it was used by other students in this unit before.

"Everybody *is doing that now, all of the other teams, even I asked my friend … all of the other teams last year … [used] …MYSQL and PHP. First I wonder[ed] whether it is one of the criteria to use that or [whether] we can use a different language … because we know before from the other teams, for sure MYSQL and PHP has worked.*"

– Tania (Group A)

Vanessa (Group B) supported this view and relating it to creativity. Doubts that individuals have over entering uncharted waters can be difficult to overcome.

"When using creativity, if you [are] not using creativity and you've just got like the assignment in front of you, do this, do that. It's straight forward and the answer is easier, whereas creativity is sort of taking a risk. Is it right? You don't even know if it's right."

– Vanessa (Group B)

This sentiment is reflected somewhat more vehemently by Dean (2001) in his unorthodox non-conformist book, The *Aesthetics of Incorrectness: The freeing up of thinking by the arseholing of academic wankers' tyranny and monopoly of what is correct*. In his critique of academia, Dean (2001) postulates that creativity is being "*castrated by correctness*" as thinking and believing are cast into acceptable or non-acceptable social norms. Vanessa's fear of the risk associated with not having the structured academic assignment placed in front of her reflects a constraint that has been placed around her problem solving skills through her experiences with academia. This view is also supported by Armarego (2004) who says that students expect definitive solutions to their problems in the mode of science and mathematics.

The conformity and risk avoidance as shown by these individuals could be compared and contrasted to previous discussions on risk taking in creativity. Traditional dogmas form standard practice, procedures and solutions. People prefer to conform, are taught to conform and believe they risk embarrassment or ridicule by straying from the norm (Harrington et al., 1997). The students to some degree have reflected these behaviours. However, innovative and creative outcomes require thinking out of the box and are therefore often non-conformant to dogma. Creative requirements engineers should take risks and stand up for their dogma-breaking ideas (Cybulski et al., 2003). Therefore, conformance and risk avoidance could be construed as barriers to creativity in RE.

In a wider context of problem solving, Harrington et al. (1997) further added that the barriers to creativity are risk avoidance, lack of education and the lack of use of an individual's creative ability.

3.2 Socio-organisation dimension

The *Social* dimension of the C/RE framework represents the groups undertaking the project, organisational influences, cultural issues, external forces and stakeholders. With an exception to the culture aspect, other aspects, specifically, Group, Management, Organisational and Stakeholders, have been examined in this study.

3.2.1 Group

From the group aspect, there are two factors which influence the RE creativity – group leadership and group dynamics.

In terms of *team leadership*, both groups A and B experienced difficulties with their project managers, who were appointed by the lecturer prior to the commencement of the project. This process may have contributed to the leadership problems.

In Group A, the members clearly took the responsibility for solving their own leadership issues as a team, even to the extent when in one incident the group turned on the leader and demanded for her to learn more about some areas of the project.

In Group B the leadership issues were clearly linked to the gender-related conflict. This eventually lead to the unexpected problem resolution when the Group B fractured into two sub-groups, with a female project manager and her male assistant separating the tasks between the subgroups with the project divided around two distinct project sub-goals.

In a broader context, the Moore III (2000) study of small groups raises an interesting point about the effect of appointed leadership versus democratically elected leadership in small groups. Moore III (2000) found that when combined with other creative variables, creativity decreased in appointed leadership groups as compared to democratically elected groups. The difficulties faced by Group A and B may therefore have affected the creative output of the group. This also questions the effectiveness of pre-appointment of leaders.

Group dynamics, on the other hand, had a very different impact on the creative performance in both groups. Group A clearly asserted the group setting as enabling creative outcomes. With members' differing inputs they could fuse their ideas together with recognisably higher quality results. This also lead to the recognition of good listening skills as important part of working in a Group A. Both of these issues proved a problem in the fractured Group B. The assistant project manager Liam felt that members of the group (before the separation) were not always prepared to listen to and respect others' opinions.

> *"If there were certain ideas he didn't like, he would just, just go 'That's just, that's just bullshit, it's just not going to work' … He just didn't want to listen and next time when you come to that stage you think to yourself is there any point me putting up that idea?"*
>
> *– Liam (Assistant Project Manager Group B)*

His view was supported by two other members, for example:

> *"Yeah, I think that affects your creativity … why do you want to open your mouth?"*
>
> *– Vanessa (Head Analyst Group B)*

Members of Group B believed that they worked well in their subgroups when they debated with each other and argued over ideas. They saw both positives and negatives in the creative output that could be achieved in groups and believed that their creative output had been somewhat curtailed by the fracturing of their group. Nevertheless, they seem to have recognised that splitting their group created a barrier to their team's creativity.

The above observations tend to confirm previous studies (Mamykina et al., 2002: 99; Cybulski et al., 2003) that team size, trust and morale have a clear influence on team creativity.

3.2.2 Management

In this study, management aspect can be examined from the mentor role which provided each group with performance monitor and control as well as assistance and support. The mentors of the two projects differed and had different effects on creativity in the two groups.

Group A's mentor provided constant positive support and feedback for most of the process and was personally liked by members of the group. He was described as being more like a friend and on the same level as the group members. As mentioned earlier, the effect of repeated positive comments on conventional performance was diminishing during the project. Group B received both positive and negative advice from their mentor. Only one member acknowledged that he took negative feedback defensively and viewed it as a personal attack. Overall, both positive and negative feedback had been well gauged and perceived as motivation to succeed.

Interestingly, Group B's mentor appeared to provide a source of creativity for Group B. He was seen as approachable and was used as a sounding board and for technical advice. This was particularly useful when the group struggled with modelling issues. It was felt that if Group B were totally stuck and had reached a crisis point; their mentor would have a solution or provide them with new insight. The mentor of Group B also helped to surmount the "lack of champions" barrier to creativity proposed by Maiden et al. (2004).

3.2.3 Organisation

The organisation in this study is the educational institution. There are two organisational factors observed– time constraint and consequences of decision making.

Both groups operated under *time constraints* that were placed on them through undertaking the project as part of a tertiary unit. They felt that time was a large constraint with the imposed deadlines of the deliverables in the subject. In addition, the students have commitments to other subjects as well.

> *"I have to concentrate on … so many subjects and it does took [sic] away my time … [from] putting creativity and effort into this project."*
>
> *– Brian (Group A)*

Time is an interesting constraint as it can also be seen as a trigger for creativity (Cybulski et al., 2003). Harrington and colleagues (1997) also believe that time outside of the norm is required to develop a creative solution. Maiden et al. (2004) also see a lack of time available for undertaking some components of the creative process as a constraint. The design and timing of the unit deliverables (that fit the waterfall model) acts as a barrier to creativity. The structure of deliverables following one after the other does not allow a requirements engineer the flexibility to develop both a full understanding of the problem and to solve it at the same time by extensively exploring the problem space (Nguyen, 2000).

In both projects, the *consequences of decisions made* reflected the altered reality of the situation. The clients of the groups did not have to pay for the products produced by the two groups so therefore had a different view of what was acceptable. The mentors also were more flexible than in a real world project. Both groups were reassured when they were having difficulties finishing (for either time reasons or expertise issues) that a lesser solution or a later time would be acceptable.

> *"He told us that if we can't do it, if we can't do the CMS [Content Management System] it doesn't matter because we have done [a] very good website … He encouraged us to just try … [and said] if you can't do it you still have done really very well."*
>
> *– Tania (Project Manager Group A)*

While it is uncertain whether and how the above response had on the creative output, it does however raise an issue regarding the effectiveness of capstone projects. Students may be able to get a more realistic experience by working with real world commercial project in work placement scenarios. Holt et al. (2003) suggest that work placements provide a good way for students to learn by experience in real industry projects under guidance of experts.

3.2.4 Stakeholder

The project stakeholders with expectations and conflicts had effects on the students' creativity.

In terms of *stakeholder expectations*, the client of Group A, had and constantly communicated their very low expectations of the project outcomes. The client was subsequently satisfied with any solution provided as long as it was not too complex or removed from their organisational dogmas (Cybulski et al., 2003). Not surprisingly, these low expectations were considered as a barrier or constraint to the team's creativity. By setting a simple project the client also removed the discomfort that is often required for creativity to happen (Pennell and Maiden, 2003).

Conversely, the client of Group B, was more open to the group's creative suggestions and was prepared for a change of direction. The clients also played an active role in shaping the boundaries of the team's problem space through team / client negotiation. This well contrasted with a more conservative client approach constraining Group A.

It appears that Group A responded mainly to their client's needs and wants in the development of the specification. This may have occurred due to sociological factors such as their youth, national culture and social position in relation to the clients or their inability to break through the business's established dogmas (Cybulski et al., 2003).

Conflict between stakeholders was an interesting phenomenon not uncommon in student projects, and observed in Group B's project. While the team's client had an existing IT service provider, Group B experienced difficulties accessing its information systems resources.

> *"He wasn't helpful at all … Probably, he just had this feeling that we were just going to take over and he was going to lose his job … He would answer calls … but he wouldn't just [sic] help us."*
>
> *– Liam (Assistant Project Manager Group B)*

Experience was withheld by the operator and his lack of co-operation hindered students to explore possible creative options.

The conflict experienced by Group B parallels the political forces identified in the C/RE framework. The politics within the stakeholder's extended organisation may have acted as a barrier to creativity.

4 CONCLUSION

In summary, this paper reviewed the current understandings of the notion of creativity in RE, demonstrated the emerging interest in this topic by the RE community, and suggested that further understanding of the nature and context of creativity is required to promote and encourage creative RE practice.

Through two laboratory studies, this paper identified contextual factors which influence creativity exercised by student groups undertaking RE in their major University projects with external clients. The paper examined and extended the context element suggested by Cybulski et al's (2003) in their C/RE framework, an earlier conceptual framework for understanding creativity in RE (see Table 1).

Individual dimension		
Motivation		The personal motivations offered to individuals by the organisation that affects their performances.
Personal Agenda		The importance that individuals place on a project due to their own motivations.
Self Perception of Being Creative		The belief that one holds about one's own innate creativity.
Perception and Knowledge of Creativity		What an individual understands of the meaning of creativity.
Creativity Education		The level and influence of formal creativity education in RE on an individual.
Experience and Design Bias		The desire to use past knowledge and solutions that have been previously developed by oneself or others.
Conformance vs. Risk Taking		The desire that an individual has to conform to dogmas and to avoid risk.
Social dimension		
National culture		Different cultural backgrounds in groups may have some effect on creative outcomes but this study has not proven this.
Project Team Behaviour	**Leadership**	The effects of the leadership of a group on its creativity.
	Team/Group Dynamics	The effects of group behaviour (team size, trust, morale) on creativity.
Management		The effect of a management style on students' creativity.
Organisation	**Constraints**	The constraints, such as time, placed through the requirements engineer's organisation.
	Consequences	The "buy in," reality or importance that is set by the organisation on the project.
Stakeholder	**Expectations**	The effect of the stakeholder's expectations on creativity.
	Conflict	The effect of conflict with stakeholders on creativity.

Table 1. Individual and social dimensions of creativity in RE

Having offered an extension to the conceptual framework to understand and study creativity in RE, this paper suggests future research into the further examination and application of the extended framework in organisational and commercial settings.

The various human and organisational technological aspects and factors described in this study will assist project managers in the identification of possible areas of project performance and process improvement. This is especially useful in RE projects and business situations, in which creativity and innovation are highly desired. Organisations will also

benefit if they take into account the findings from this study in running graduate training programmes and in promoting a creativity culture in their organisations.

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