Considering place and problem solving in the virtual world

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ABSTRACT

This paper examines the interplay between the person and their environment throughout the problem solving process.

Although there are endless opportunities to electronically access information and knowledge the concern is that, rather than strengthening, building upon and enhancing an individual's knowledge, these systems do not support and allow for further losses of previously acquired knowledge.

While there are a myriad of contributing factors that impact knowledge capture and transfer, this paper is concerned primarily with tacit knowledge and the role of the surrounding environment during the problem solving process.

Of core concern is the role of the location in tacit knowledge acquisition and retrieval and whether access to prior situations in a tacit form allows for a richer access to tacit knowledge.

Categories and Subject Descriptors
H. Information Systems, H.1.1. Information theory, H.1.2. Human factors, human information processing

General Terms
Documentation, Performance, Design, Human Factors

Keywords
Problem solving, place dependence, tacit knowledge, situated knowledge, 3D virtual worlds

1. INTRODUCTION

This project aims to examine the role of the surrounding environment in facilitating access to and the transfer of tacit and situated knowledge for the purposes of human problem solving, both individual and collaborative. This focus on the surrounding environment or *place* is relevant in an era where human communication is increasingly becoming a remote, distributed and dislocated activity. This research is concerned with the relationship between place and knowledge and how virtual systems may support this relationship.

It is the contention of this research that when collaborative activities are attempted via remote access there are negative implications for tacit and situated knowledge in particular. The research postulates the absence of a persistent place is an impediment to accessing tacit and situated knowledge, for both the individual as he/she tries to access his/her own tacit knowledge and for teams whose members attempt to communicate their own tactic knowledge and to gain access to their colleagues' tacit knowledge.

Knowledge and the capacity to access it is intertwined in the surrounding place. This research argues that the co-located place, in addition to being the ideal platform for the social process, is important for the externalisation of internal representations. It also acts as a storage buffer allowing access to previous meta-learning states.

The broader aims of the research are to examine the surrounding environment and its role in tacit knowledge transfer within the collaborative process. This paper focuses solely on the individual as he/she engages in the problem solving process, gains tacit knowledge and transfers it (or not) to subsequent processes. The main objective is to determine whether the surrounding environment plays a role in this process.

This paper discusses an experiment designed to test the acquisition of tacit knowledge and the relationship with the surrounding environment during the problem solving process. The value of capturing the actions carried out during the process (tacit entities) and the evolution of both the problem solving process and the surrounding environment will be examined.

2. TACIT KNOWLEDGE, SITUATED KNOWLEDGE AND THE EXTENDED MIND

Much of the context for this work is derived from research on the current understanding of tacit knowledge and how it defines professional knowledge and experience. Tacit knowledge encompasses the informal craft or skill demonstrated by an expert in addition to a cognitive dimension consisting of schemata, belief systems and mental models that are so embedded they are taken for granted [17]. This knowledge includes expertise, comprehension and professional insight formed as a result of experience [22] and domain immersion. Therefore tacit knowledge, unlike explicit knowledge, does not yield as readily to capture and distribution by electronic media. Experiences are unrepeatable in terms of detail and individuality.

Professional knowledge depends heavily on the reuse of ideas, experience and knowledge [15, 2, 8, 4]. Professional know-how is derived from history and the evolution [20] of improvements on and refinements of previous experiences.

"In important problems, we almost always need to bring old knowledge to bear upon the solution of new problems, and to relate new knowledge to old knowledge" [19].

This history and evolution effects and shapes present events. Problem solving approaches are subject to the situation, the context and the dynamic world in which they operate [12, 11]. Thought processes are in a state of flux. Each memory that is constructed is an addition to the experience, so that the experience is augmented by memories of it. The concept of *situatedness* is concerned with locating everything in a context so that the decisions taken are a function of both the situation and the way the situation is constructed or interpreted [12, 5]. The current state is of thought is derived from both historical and current processes [18]. *"The mind is a dynamic system changing over time as new experiences are accumulated. Therefore, our interpretation of the same external artefact will be different each time we look at it."* [16].

Problem solvers create external representations to communicate and express their internal thoughts. These representations are produced based on the projected meaning of the situation and allow for interpretation of situations. Knowledge is related to the place where it originates and to its application. Johnson claims that experiences derived within an inhabited place have a permanence that can be recalled more vividly as a result of being in that place. *"The permanence of a place in contrast to the changes daily life undergoes provides a means of accessing memories associated with the place"* [13].

Proponents of the situatedness perspective all give significant to the "where" of design in terms of context. Several consider the coupled system of agent and environment [3, 10], acknowledging the interactions between agent and environment. However the focus is on the human, who is viewed as the active participant in the situated process. Less research relates to the physical "where" and the surrounding environments role as a dynamic entity, in and off itself, in the situated problem solving process. The surrounding environment and the artefacts that reside in it also have their own history and evolve over time through interactions.

The Clark and Chalmers hypothesis of the *extended mind* argues that cognitive processes are not bounded by *"skin and skull"* but may be grounded in the individual's external physical environment. The Parity principal put forth by Clark and Chalmers states:

"If, as we confront some task, a part of the world functions as a process which, were it to go on in the head, we would have no hesitation in accepting as part of the cognitive process, then that part of the world is (for that time) part of the cognitive process" [6].

If, as is argued here, the surrounding environment facilitates better access to previous knowledge, on which all problem solving processes are ultimately dependent, then what are the effects on the problem solving process when individuals engage in a problem solving process remotely? What are the implications when we losing the physical surroundings and the "*indefinable tacitness of being there"* [9]?

3. PLACE AND PROBLEM SOLVING

Technology has provided the means to access expertise that is rare, unique and invaluable and to extend enterprises. Explicit knowledge is reducible to digital media and available ubiquitously. However tacit knowledge, due to its elusive nature, remains less readily captured and transferred. As it is this knowledge that makes expertise individual and unique, how best to support it is of concern. This paper suggests that the surrounding environment plays a role in an individual's ability to recall previous knowledge. If problem solving tasks are carried out remotely using technology (that is without a persistent physical surrounding environment) then what implications does this present? If those implications are significant then what can be done to overcome the deficiency of the physical surroundings in supporting tacit knowledge?

While current technological systems cannot directly interpret and derive meaning from the tacit knowledge and rationale that is part of a problem solving process, it is possible to better support access to this knowledge.

3D virtual worlds may be used as simulated real world representations. While they may not provide the same level of presence as real physical surroundings, they can support the experience of being in a place, allow for the creation of knowledge in that place and allow the place to evolve over time and build its own history. Additionally the transitions, meta-learning, and evolution that an environment undergoes as a problem solving process progresses and is revisited can be stored, tracked and measured in its native form. This is not as feasible in a physical environment and as a result processes tend to be documented as a means of capturing them. Documenting and recording decisions and experiences does not integrate well with the problem process and burdens problem solver with additional tasks. In cases where documentation is available it is still an explicit entity trying to explain a tacit one - ill formed and not readily accessible, it requires the patience and time to search through [2].

While virtual worlds originate from the computer gaming industry and many rely on game engine technology, their focus is different. *"Games are primarily designed to foster accumulating points or reaching new levels and the like"* [Schroeder 2008]. They do not involve following pre-defined narratives and aim to allow for individual autonomy within the world [1]. It is possible to build and incorporate the computer applications that are used in the virtual world so that the problem solver is one with the world and the knowledge that he/she generates and creates.

To examine how the surrounding environment, physical or virtual, impacts the ability to recall and reuse tacit knowledge an experiment that involves the acquisition of tacit knowledge is necessary. Once this knowledge has been acquired it is then necessary to test it in both physical and virtual surroundings.

For the purposes of this experiment a puzzle is used as the means of acquiring tacit knowledge. The puzzle is sufficiently intricate to ensure that the solution is not readily recalled when the problem solver makes subsequent attempts, having disassembled and assembled it once. The physical version of the assembled puzzle is shown in figure 1.

Figure 1: real puzzle assembled

Figure one shows a twelve piece puzzle which has eleven identical parts. The puzzle is solved through a series of movements involving the key piece. Disassembling the piece is easier than re-assembling it which involves moving parts back and forth or individual and collective parts so that these can interlock correctly. The task is a

tactic on as it involves acquiring a practical hands-on knowledge that is difficult to articulate.

This puzzle will be used in a physical setting whereby problem solvers will be asked to solve the problem. Individuals in this group will be informed that they will be asked to complete this task again at some point in the future. They will be encouraged to use the surrounding environment in any way they wish to assist them to re-solve the puzzle at a future date. They may make drawings, notes, place the pieces in a certain order or placement and so forth.

The 3D version of the assembled puzzle is shown in figure 2.

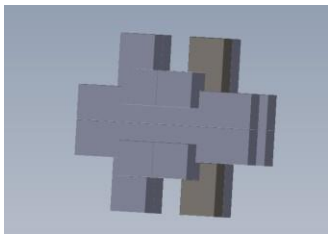

Figure 2: 3D puzzle assembled

The same puzzle has been developed as a 3D assembly with 12 separate parts within a 3D game engine. Individuals may solve the puzzle using the same steps as the physical puzzle by interacting with the individual pieces via the computer keyboard and mouse.

The 3D environment will have two user test groups. For one of these groups a timeline application will exist within the environment which will capture the intermittent problem solving steps. This timeline will be available to each individual on his/her subsequent attempts which will allow the individual to revisit their own previous meta-learning processes to assist them with the current one.

The other users using the virtual environment will not have access to the timeline application or any information other than the puzzle itself. It will be conducted in a different location for each attempt, devoid of the same environmental cues.

The three groups will be analysed qualitatively through observational analysis and a post self-analysis survey. The productivity of each group will be measured quantitatively by carrying out a time study to calculate the basic and standard time of each individual. Time study is a work measurement technique for recording the times of performing a certain specific job or its elements carried out under specified conditions, and for analysing the data so as to obtain the time necessary for an individual to carry it out at a defined rate of performance.

The calculations will be compared at the individual level between initial subsequent processes and collectively so that productivity at individual and group level can be determined and analysed.

According to Wilson *et al.* an improvement in performance demonstrates tacit knowledge [21]. For the purposes of this test, demonstrating access to *"tacit knowledge"* constitutes an improvement in performance in subsequent attempts. Improved performance constitutes a speeder solution or an alternative (more efficient) approach in the subsequent attempt. This will demonstrate whether tacit knowledge has been gained and successfully transferred from attempt to attempt.

4. EXPECTED RESULTS

It is anticipated that this experiment will lend support to two of the hypotheses put forth by this research. These are:

1) Recreating the situation in which a problem solving process takes place enables the problem solver to access his or her own tacit knowledge in a way that is superior to referring to his or her documentation about the process.
2) Tacit knowledge is partially location dependent.

If the experiment yields results that are supportive of the hypotheses it will contribute towards a greater insight to the relationship between place and knowledge and how technological systems may support this relationship.

Furthermore it will examine the value of capturing the meta learning states in their tacit form as a means of assisting recall rather than relying on the final solution.

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