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Informing Science and Engineering: the Usefulness of the Information Systems Paradigm

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Introduction

The unclear purpose of Information Systems has brought it under attack from many disciplines of Science, engineering and even Information Systems professionals themselves, Cohen (1998). This fragmentation is further clarified in Cope *et al.* (1997). However, this unclear purpose can be used to good effect as a tool for lateral thinking and creative thinking.

This paper describes a use of the Information Systems paradigm in Science and Engineering research. In order for researchers to become more innovative and creative they must understand their own various cognitive processes. In much the same way learners must learn how to learn, for self-paced, self-instructed learning exercises, see Tan & Chan (1997). The hypothesis followed in this paper is that creativity is a process of thought as opposed to personal characteristics.

This paper details an Information Systems Transformation (IST) method, which provides the pre-programmed steps for Computer Science/Engineering professionals to follow, which yields creative solutions. The imposed structure is provided giving the theoretic foundation of the IST method is detailed, with hypotheses and evidence from Information Systems, Engineering Science and Psychology.

The paper concludes with the description of three novel solutions to Engineering Science projects using the IST [McCurdy (1999), McCurdy *et al*. (1999), and McCurdy *et al*. (1994)].

Theoretical Foundations

Many methods have been detailed in the literature to inspire creativity and innovation. Brainstorming has been used to good effect in many areas requiring creative and innovative solutions - out of the chaos a solution is found. However, a thorough understanding of the problem domain is required for rendering useful problem solutions in Engineering Science. The difficulty level of the problem complete with interactions and interconnections again adds to the chaos.

A thorough understanding of the problem domain does not necessarily provide innovative and creative solutions. Once the thorough understanding of the problem domain is achieved, the generation of alternative solutions can be used to good effect. The principle of lateral thinking, see Lefrancois (1997), can be used appropriately. The essence of lateral thinking is that processing the problem into a deeper level of cognition stops; alternative solutions are provided at each cognitive layer.

Much work has been carried out in the psychological aspects of creativity and innovation. Abstraction and transformation have been detailed throughout the literature. Many successful scientists and engineers have used abstraction and transformation throughout their careers. Abstraction removes oneself from the pedagogical train of thought. Lateral thinking, is a method of making vertical thinking more effective by adding creativity. Lateral thinking attempts to remove some of the disadvantages of the way in which theory suggests the mind works. The cognitive processes of the brain are highly effective but it does lend itself to some major inadequacies.

In McInerney & McInerney (1994), a six-stage process is cited for the conceptualisation of the creative process: realising the need, gathering information, thinking through, imagining solutions, verification and putting the ideas to work.

This paper is concerned with imagining solutions. The IST has been developed to encapsulate this area. In addition to the creative process, the paper shows how the IST fits in with a typical Research Development Lifecycle. The fact that IS is so broad, Cohen (1998); makes it useful for lateral thinking purposes. Cope *et al.* (1997) question the nature of an information system. The nature of the IS paradigm in the IST is to provide alternative problem definitions. In educational psychology a collection of tools are provided to assist in training the cognitive processes of the brain. For instance the mind-map; see Lefrancois (1997). Moreover, there are countless tools, methods and methodologies in Information Systems for controlling the production of a system.

General in Science and Engineering research the formalised structure of knowledge strictly adheres to the mathematical paradigm. This highly structured approach can lead the researcher to the solution, which has a high probability of being a well-known solution, contrariwise, is an already documented solution, this could stem from the convergent type thinking. Creativity stems from the divergent thinking.

In research it is often desirable to arrive at a novel and creative solution. Using several tools at the disposal of each individual can generate new ideas. The demand on researchers to continually produce new ideas provides the requirement of a tool-set.

The system of generating alternatives is used throughout Science, Technology and Information Systems. The Business Systems Option in the SSADM for generating alternative solutions is an example where alternative solutions would be advantages for the analysts involved. The generation of alternatives could be described as lateral thinking, or looking at things from one from amongst many different viewpoints. One way of generating these viewpoints is to use the highly used brain storming method. Although the brainstorming method realistically has infinite possibilities, most will be useless; some have the capability of becoming novel and creative solutions. See Hargrave (1996).

The methods reported in this paper have been collected over many Engineering research projects undertaken by the author. The model has been used for many projects, only the projects, which have been recently published, are detailed in this paper. The method has been extracted from Educational Psychology, Information Systems and Computer Engineering & Science.

Information Systems Transformation

The Research Development Lifecycle (RDLC) is provided to framework the method. The method is derived from [Creswell (1994) & Britton & Doake (1993)].

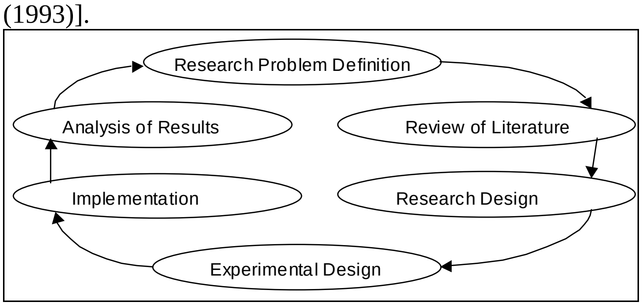

Figure 1 - Research Development Lifecycle

The RDLC is shown in figure 1. The Research Problem definition defines the area of study, reason for the study, research questions, any hypotheses, theoretic, definitions of terminology, limitations of the study and the international significance of the study. The review of literature provides the researchers with the global picture of the subject areas under investigation.

The research design stage begins the focus of the study and which elements are to be used from the literature. The experimental design stage takes the design further. The required instruments, data gathering techniques and data analyses techniques are identified.

At the implementation stage the experiments are initiated, controlled, and also well documented. The data gathering techniques are used. The data is then analysed and the conclusion and findings of the research are determined. These either confirm or deny the research question. The implementation stage then spawns other research projects, which can now refocus the researcher onto a new macro or micro level research. A new stage is incorporated into the RDLC. This is called the IST stage, which is detailed above. The IST stage is a collection of techniques derived from the educational psychology literature.

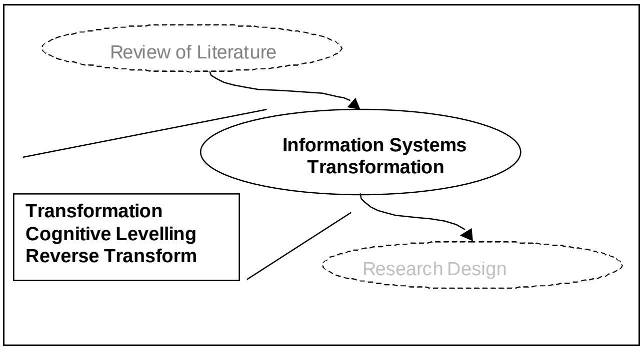

Figure 2 – IST stages of RDLC

The first method is the transformation method. The engineer or scientist must abstract from the pedagogical approach. This is achieved by representing the knowledge in terms of its information content.

The definition of IS will help in the conceptualisation process required for alternative description generation. The definition of IS can be used as described by Cohen (1998). There are many alternative descriptions: Information Systems is the field of inquiry that attempts to provide the business client with information in a form, format, and schedule that maximises its effectiveness. Again derived from Cohen (1998), to understand what is information to the researcher one must understand the research project. This is the essence of the IST, understanding of the research project, understanding what outcomes are required (from an information systems perspective).

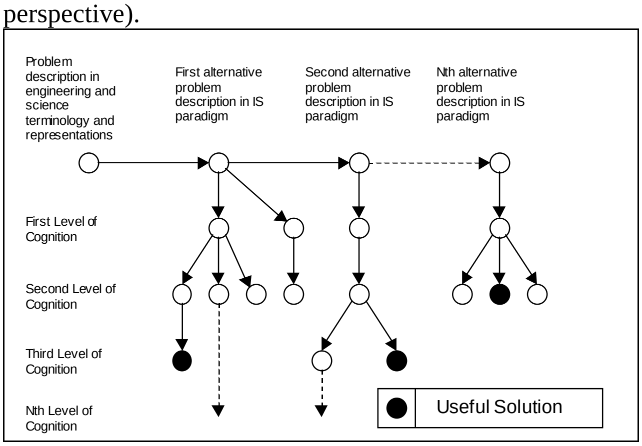

Figure 3 – The FIST

The Forward IST (FIST) similarly, takes the science and engineering terminology and transforms the details into the Information System paradigm. In this new domain processing of the information may render an alternative view upon the problem which, when transformed back using the Reverse IST (RIST) will produce an innovative & creative solution.

The FIST process is shown in figure 3. The first stage is the transformation stage, detailed above. The second stage is called cognitive levelling. The alternative description is processed further until a possible alternative solution is found. If an alternative solution is not found, the researcher proceeds to the previous node and processing begins again. In much the same way as the depth first search algorithms in imperative programming. Many possible solutions or representations of solutions may be produced. At each cognitive layer another alternative representation of the problem may be produced which is added to the top layer of the tree. Additionally, alternative problem solutions may be found, which may be useful. Remember a possible problem solution may spawn other possible problem solutions. Cognition and analysis does not end with the possible problem solutions. The RIST process is shown in figure 4. Processing in the more quantitative paradigm of science, mathematics and engineering requires a more structured approach than the FIST process.

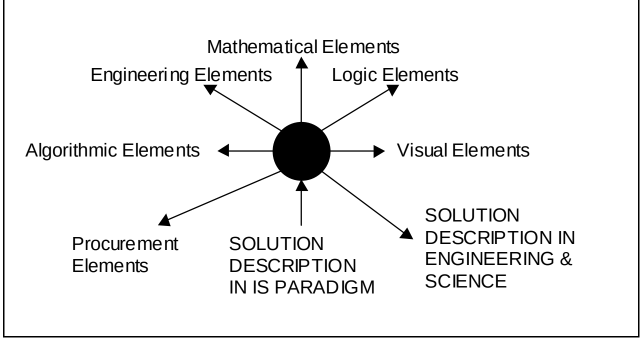

Figure 4 – The RIST

The RIST process shown in figure 4 provides the researcher with a structure information extraction technique from the given conceptual solution. Each alternative solution must be confirmed as soon as possible; the solution must be useful or appropriate, otherwise it is scrapped. Or from the McInerney & McInerney (1998) description above, verified. The researcher could assess quality of a solution using the criteria detailed by the same authors or an extension of the method provided by Hobbs *et al.* (1998)

Engineering Science Research Subject

The research subject of three-dimensional computer vision was used to investigate the use of the FIST and RIST. The pedagogical approach is that of the propagation of waves through space represented as a sine-wave interferogram. This is used in PSP Creath (1992), FTP Takeda (1982) and Moiré Asundi (1993). This pedagogical approach has brought about many useful solutions to the 3D-vision research subject. Researchers have increased the speed of execution of the algorithms, decreased the number of captured interferograms to render speedier calculations, and tested the technique on many application areas. These application areas include: solder-joint analyses Pearson (1994), surface measurement McCurdy *et al.* (1994), and neuro-surgery, human body measurement Pearson *et al.* (1993), and robot vision.

Many research projects are reported as being novel if an old technique is applied to another problem. However, as suggested in McInerney & McInerney (1994), this is described as a rearrangement of existing knowledge with a small addition. The goal of most researchers is to achieve a high element of originality. As with error propagation in mathematical analyses, when an error occurs early in computation its effect is magnified in the calculated result. Analogous, with originality, if an alternative approach is used earlier (a new technique) then the novelty of the solution will be greater. The quality and originality of research could be assessed using a technique described by Hobbs *et al.* (1998). This paper looks at the ability of students to assess their own applications. This could be changed such that the researchers assess their own projects.

The originality of the techniques cited in this paper varies. However, as suggested above the research problem is questioned then manipulated and sent through the FIST and RIST processes. McCurdy *et al* (1994) suggests an alternative technique to ones published before using alternative instruments and manipulation of data. McCurdy (1999), suggests an alternative method of controlling errors, deviating from the pedagogical approach of signal and frequency domain filtering, McCurdy *et al* (1999), suggests an alternative approach to the identification of projection-code signatures. McCurdy *et al.* (1999) provides an alternative approach to phase measuring interferometry using colour phase measuring and transmission sequences. The author is currently seeking a patent for the device ARM, which solves some of the problems of interferometry and was developed using the techniques detailed in this research paper.

Conclusions

The theory and justifications of the IST processes have been discussed. The creative flare is provided through the medium of informing science. Two techniques have been detailed: the FIST and RIST. The FIST transforms the knowledge representation into the IS paradigm, whilst in this domain manipulation and cognition proceeds, using lateral thinking. When alternative problem definitions and solutions are found they are transformed back into the original paradigm.

The FIST and RIST have provided the author with many innovative and creative solutions to several Computer Science and Engineering research projects. Three publications are referenced. Additionally the author is currently seeking a patent for an invention produced using these methods.

References available upon request from the author.