2008

Using Design Research to Improve Data Modelling Performance among Novice End Users

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Abstract

As a first foray into the design research area, the study described in this paper was designed to improve novice users' understanding of data modelling. The paper commences with a brief description of design research, then continues with an explanation as to why design research might be a successful methodology to use in information systems. What follows is a description of the genesis of this research project, with reference to the first iteration of the design research project. The paper then proceeds to describe the development of the various components of the experiment, including the evaluation scheme and the artefact, and concludes with brief comments as to the implications of the results.

Keywords

Data modelling, design research, end user computing, novice users, training

INTRODUCTION

This paper describes research designed to solve the following problem. End users have available to them a rich array of personal computer software applications, including database management systems. In addition, a majority of knowledge workers are faced with working with database applications in organisations both small and large. In order to use these systems efficiently they need to understand how to produce and interpret data models, a skill which few find intuitive. This problem gains importance from the fact that database applications are ever more prevalent, at the core of most information systems, and correct data models will improve the accuracy of these information systems. An initial study using traditional empirical methods in pursuit of ways to improve the data modelling performance of novice end users proved unsuccessful. The main reasons for this came down to the use of an incorrect methodology together with volunteer behaviour. A new approach to this project, the use of experimental design research methodology, was suggested as a possibility, and this paper is a description of that project.

BACKGROUND TO DESIGN RESEARCH

The emerging science of design has its origins both in engineering as elaborated by Simon (1996) in his description of design research, and in education (Brown 1992; Collins 1992), where they describe their design experiments. Nunamaker et al. (1991) succeeded in integrating design as a major component of research in information systems, and design research was introduced into the information systems literature by Walls et al. in 1992. In recent years several researchers have succeeded in bringing design research into the IS research community, successfully making the case for the validity and value of design research as an IS research

paradigm (Hevner et al., 2004; March et al., 2000; Peffers et al., 2006; Walls et al., 2004).

Brown (1992) stated that her research programme was devoted to the study of learning in "the blooming, buzzing confusion of inner-city classrooms" (James 1911. pp. 141,). Here she conducted what Collins (1992) referred to as design experiments, modelled on the procedures of design sciences such as aeronautics and artificial intelligence. As a design scientist in the education field, she attempted to engineer innovative educational environments and simultaneously conduct experimental studies of those innovations.

It was noted by Collins (1992) that the evolving methodology of design experiments began as a reaction against traditional psychological experimentation, which had dominated education research about teaching and learning. The methodology of psychological experimentation was based on notions of controlling variables in order to determine precisely what caused different effects. Researchers thus conducted experiments under laboratory conditions according to carefully defined procedures. Collins stated that, in contrast, design experiments attempted to carry experimentation into real-life settings in order to find out what worked in practice. This meant giving up the notion of controlling variables and necessitated the development of a new methodology to carry out research.

Simon (1996), in his book entitled "The Sciences of the Artificial", considered the various types of science. He described natural science as knowledge about natural objects and phenomena, and then asked whether there should not also be an "artificial" science – knowledge about artificial objects and phenomena? Simon uses the word "artificial" in as neutral a sense as possible, as meaning man-made as opposed to natural. The engineer, and more generally the designer, is concerned with how things ought to be – how they ought to be in order to attain goals, and to function. A science of the artificial would be closely akin to a science of engineering, according to Simon (1996).

Historically and traditionally, it has been the task of the science disciplines to teach about natural things: how they are and how they work. It has been the task of engineering schools to teach about artificial things: how to make artefacts that have desired properties and how to design. Everyone designs who devises courses of action aimed at changing existing situations into preferred ones. Design is the core of all professional training; it is the principal mark that distinguishes the professions from the sciences. Schools of engineering, as well as schools of architecture, business, education, law, and medicine, are all centrally concerned with the process of design. The natural sciences are concerned with how things are. Design, on the other hand, is concerned with how things ought to be, with devising artefacts to attain goals. Simon (1996) questioned whether the forms of reasoning that are appropriate to natural science are also suitable for design.

In concluding this section it is important that the nomenclature in use in this paper is clarified. What is described as design research is from a scientific or engineering background (Simon, 1996), quantitative and objective in its measurement and evaluation. Design experiments on the other hand, from an educational perspective, focus on the efficacy of the intervention in authentic and real settings. Thus, as will be demonstrated in the remainder of this thesis, design research methodology was used on the area in question, namely the improvement of the understanding of the relational concepts of data organisation by novice users; and a design experiment was conducted in order to substantiate the efficacy of the intervention proposed in the application of the design research methodology.

INFORMATION SYSTEMS AND DESIGN RESEARCH

According to Edelson (2002), an important characteristic of design research is that it eliminates the boundary between design and research. In the traditional theory testing paradigm, design and research are distinct processes that happen sequentially. Design takes place first as the implementation of the theory, followed by the evaluation-oriented research. The design process is not regarded as an opportunity for learning. In contrast, design research explicitly exploits the design processes as an opportunity to advance the researcher's understanding of systems. Design research may still incorporate the same types of outcome-based evaluation (design experiments) that characterise traditional theory testing; however, it recognises design as an important approach to research in its own right.

As elaborated by Hevner et al. in their 2004 paper, design is both a process (set of activities) and a product (artefact), that is, both a verb and a noun. It describes the process involved in designing the artefact, and the product of that process, the artefact itself. This view of design research supports a problem-solving paradigm that continuously shifts perspective between the design process and the designed artefact for the complex problem under consideration. The design process is a sequence of expert activities that produces an innovative product, the design artefact.

Illustrative of the combined use of the design research methodology and design experiments, a design experiment is then used to evaluate the artefact. This provides feedback information and a better understanding

of the problem in order to improve both the quality of the product and the design process. The evaluation is itself subject to a design process, which is an intrinsic part of the design experiment. This build-and-evaluate loop, for both artefact and evaluation processes, is typically iterated a number of times before the final design artefact is produced. During this creative process the design researcher must be cognisant of evolving both design process and the design artefact, together with the evaluation of each version of the artefact by means of a design experiment, as a part of the research. This model is widely recognisable to information systems practitioners as "prototyping".

Also identified as being produced by design research in IS are two design processes, build and evaluate. The artefacts are concrete prescriptions that enable IT researchers and practitioners to understand and address the problems inherent in developing and successfully implementing information systems within organisations. Design research creates and evaluates IT artefacts intended to solve identified organisational problems. Such artefacts are represented in a structured form that may vary from software, formal logic and rigorous mathematics to informal natural language descriptions. The further evaluation of a new artefact in a given organisational context affords the opportunity to apply empirical and qualitative methods. The rich phenomena that emerge from the interaction of people, organisations and technology may need to be qualitatively assessed to yield an understanding of the phenomena adequate for theory development or problem solving (Klein & Myers, 1999). The process of constructing and exercising innovative IT artefacts enables design researchers to understand the problem addressed by the artefact and the feasibility of their approach to its solution.

This is reinforced by Hevner et al. (2004) when they assert that framing research activities to address business needs assures research relevance. Behavioural science addresses research through the *development* and *justification* of theories that explain or predict phenomena related to the identified business need. Design research addresses research through the *building* and *evaluation* of artefacts designed to meet the identified business need. As Hevner et al. (2004) have stated, the goal of behavioural science research is truth; the goal of design research is utility. In both cases, research assessment via the justify/evaluate activities can result in the identification of weaknesses in the theory or artefact and the need to refine and reassess. The refinement and reassessment process is typically described in the section on future research directions.

The knowledge base is composed of foundations and methodologies. Prior IS research and results from reference disciplines provide foundational theories, frameworks, instruments, constructs, models, methods and instantiations used in the develop/build phase of a research study. Methodologies provide guidelines used in the justify/evaluate phase. Rigour is achieved by appropriately applying existing foundations and methodologies.

Hevner et al. (2004) noted that the fundamental principle of design research is that knowledge and understanding of a design problem and its solution are acquired in the building and application of an artefact. That is, design research requires the creation of an innovative, purposeful artefact for a specified problem domain. Because the artefact is *purposeful*, it must yield utility for the specified problem. Hence, thorough evaluation of the artefact is crucial. Novelty is similarly crucial since the artefact must be innovative, solving a heretofore unsolved problem, or solving a known problem in a more efficient manner. Thus, design research is differentiated from the practice of design. The artefact itself must be rigorously defined, formally represented, coherent, and internally consistent. The process by which it is created, and often the artefact itself, incorporates or enables a search process whereby a problem space is constructed and a mechanism proposed or enacted to find an effective solution. Finally, the results of the design research must be communicated effectively both to a technical audience, and to a managerial audience.

The evaluation methods are reinforced by Cobb et al. (2003), who suggest that design experiments are pragmatic as well as theoretical in orientation, in that the study of function is at the heart of the methodology. This emphasis on function in a realised context holds for all design experiments, even though they are conducted in a diverse range of settings which vary in both type and scope. These settings include for example:

- One-on-one design experiments in which a research team conducts a series of educational sessions with a small number of participants. The aim is to create a small-scale version of a learning ecology so that it can be studied in depth and in detail (Cobb & Steffe, 1983; Steffe et al., 2000).
- Classroom experiments in which a research team collaborates with a lecturer (who might be a research team member) to assume responsibility for instruction.

The guiding principles that Peffers et al. (2006) developed were crafted from the guidelines articulated by Hevner et al. (2004). Peffers et al. (2006) suggest that the conceptual process model should be consistent with design research processes in information systems and other disciplines, should provide a nominal process for conducting the research, and should provide an understanding for what design research output should look like. The components of the Peffers et al. (2006) synthesis of prior research and their sequential order form the basis for their design research process. The result of this synthesis is a process model consisting of six activities in a

nominal sequence.

1. Problem identification and motivation
2. Objectives of a solution
3. Design and development
4. Demonstration
5. Evaluation
6. Communication

BASIS FOR ORIGINAL WORK AND FOR CHANGE OF DIRECTION

The research methodology used in the original experimental treatment was the traditional empirical method often used in disciplines such as psychology. The original hypothesis was that, given a conceptual model, novice users would perform better than those not given a conceptual model on a prescribed set of tasks. A literature review indicated that various experiments had been conducted along these lines, with results which showed that the use of a conceptual model might be beneficial. There was also a suggestion that individual differences between participants might be a factor in the level of improved understanding measured.

The consensus of various authors (for example Schlager & Ogden, 1986) was that two types of training were important, one based on concepts and the other based on procedures. Conceptual training required the learner to discover the rules underlying specific instances of more general concepts. With procedural training on the other hand, the learner had little choice but to follow a sequence of instructions step by step. In contrast to conceptual training, procedural approaches present information in discrete packets, not clearly linked as an integrated whole.

This information concerning the two different approaches to training, conceptual and procedural, suggested a hypothesis and consequent experimental treatment. As the experimental participants were expected to demonstrate their understanding of relational database concepts by building a database using Microsoft Access, it was decided that the non conceptual model (or control) group should at least be presented with some procedural instructions as to how to go about this task. The consequence of these two considerations was that the control group, instead of being given no model, was given procedural instructions to help them with their task. The final hypothesis was thus a comparison between the experimental group with a conceptual model, and the control group with procedural instructions. Thus the experiment was designed to determine whether the conceptual model was more beneficial to the novice end users in question than the procedural instructions.

The experiment proceeded as follows. There were 37 participants on the experimental group and 66 in the control group. The only significant difference in quantitative measures between the groups was found with regard to the assessment task used (the assignment) in which the control group (who had been given procedural instructions) performed significantly better than the experimental group (who had been given the first artefact (conceptual model)).

The empirical methodology used in this preliminary study was not suited to, and proved inappropriate for, the environment; the number of volunteers and the ethical restrictions on the experimental treatment mitigated against a successful outcome. Further, the methodology did not require or even encourage the development of the experimental artefact (the conceptual model) to reinforce any particular set of principles or objectives. It moved generally towards a goal of understanding how a database was developed and implemented. The use of the design research methodology specifically implies that theory underlies the design of the artefact, and the design of the evaluation method used in the design experiment itself.

Following the disappointing and inconclusive results of the preliminary study a reappraisal of the situation took place. At the viva following submission of the original thesis (the preliminary study), two alternatives were proposed. Either the preliminary study would have to be repeated with different or larger samples, or an alternative approach would have to be adopted.

As far as repeating the original work was concerned, there would have been difficulties. Due to the ethical constraints imposed, the experiment would have to have been conducted in exactly the same manner, and there was no indication of the possibility of different volunteer behaviour and more volunteers. Further, any possibility of redesigning the experiment to use different participants from outside of the University, and the further possibility of training those participants separately was remote. This was because it would have entailed using existing training establishments, or setting up a new one from scratch. Preliminary enquiries suggest that this would have been both difficult and time-consuming, and this would not have fitted into the tight time frame

imposed for the completion of an amended thesis (a period of eighteen months was allocated).

As far as an alternative approach was concerned, the suggestion was made that the design research methodology might prove to be a possible alternative. After consideration, this methodology gave evidence of suiting this investigation very well.

RESEARCH DESIGN

The process adopted for this research is shown in figure 1, an instantiation of the general scheme proposed by Peffers et al. (2006). This research adopted a problem-centred approach, because the idea for the research resulted from observation of the problem, combined with the outcomes of the preliminary study. Peffers et al. (2006) called it a Design Science Research Process, of which evaluation is one part. The steps to be undertaken during the course of this research process are as follows.

Step 1. As part of the problem identification and motivation, an in depth analysis of the data modelling literature was undertaken. This ensured an understanding of the difficulties novice users have with the task of data modelling. The problem definition contributed to the artefact design process. Justifying the value of a solution ensured the motivation of both the researcher and the audience of the research, in order that they may pursue the solution, and accept the results (Peffers et al., 2006)

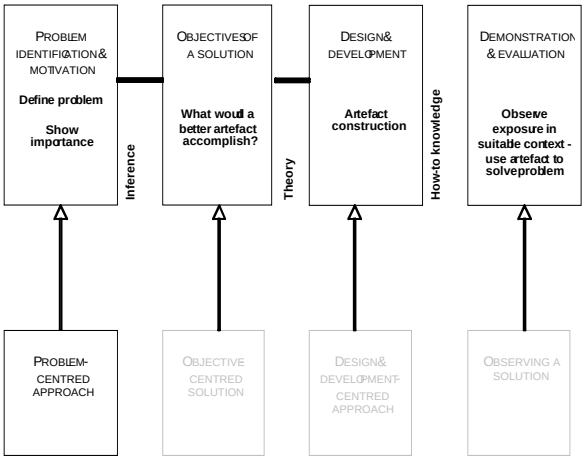

Figure 1: Research Design (Peffers et al., 2006)

Step 2. The objectives of this solution, and the better artefact arising from it, will ensure a better understanding of the relational concepts of data organisation and hence better usage of personal computer relational database software by novice end users. These objectives can be quantitative or qualitative, terms in which a desirable solution would be better than the current ones, or where a new artefact is expected to support solutions to problems not hitherto addressed.

Step 3. The design plan for the new artefact, resulting in part from improvements to the artefact used in the preliminary study. Very broadly, there were proposed to be two design processes. The first re-examined the first process, which was undertaken in the preliminary study. Then the second design process combines lessons learnt from the first iteration (preliminary study) with further information gleaned from external sources. The new elements resulting from these two investigations were combined into an amended artefact to be used in the main study design experiment.

Step 4. This step is a combination of the demonstration and evaluation steps proposed by Peffers et al. (2006), as these both are regarded as contributing to the evaluation of the artefact in the proposed environment. The design experiment provided the framework for the actual exposure which took place during the main study. This evaluation scheme operated broadly as follows. The participants first undertook some preliminary assessment tasks, to ensure that they were novice users with little previous knowledge of relational database concepts, and to determine the level of that knowledge. They were then exposed to the artefact, following which the effectiveness of the exposure was evaluated by re-assessing the level of the participants' understanding of the relational concepts of data organisation, using a different assessment task.

EVALUATION SCHEME

In line with the evaluation alternatives offered in Hevner et al (2004), a field study was used, with a carefully selected group of 10 or so people, undertaking the tasks as shown in table 1. The use of 10 or so participants offered the possibility that there would be differences. The purpose of the first assessment task was to screen participants for their previous knowledge of relational database concepts. The purpose of the second assessment task will be to allow the participants to demonstrate their improved understanding. Further, the purpose of the interview was to clarify the participants' interaction with the artefact, and to elicit the timeline of the developing understanding.

The participants were selected from the large group of administrative general staff at a New Zealand polytechnic. These people are truly end users, using personal computer hardware and software in the pursuit of their functions as personal and administrative assistants, secretaries, etc., but not being computer professionals or expected to be knowledgeable in the use of such things.

Timing of the various tasks was as follows. On the first day the participants undertook the pre-exposure first assessment task. This was estimated to last 30 to 60 minutes, with all of the participants in one group. In the early afternoon of that day, the participants were exposed to the artefact. This was done according to a script administered by a facilitator – took about 1 to 2 hours, with all participants in one group. The following morning the participants completed the post-exposure assessment tasks. Once again this took between 30 and 60 minutes, with all participants in one group. Finally, in the afternoon of the same day, individual structured interviews took place, lasting up to 30 minutes.

Table 1: Evaluation scheme (Hevner et al., 2004)

1. Pre-exposure tasks	To ensure participants have no previous knowledge of relational concepts of data organisation	1. Assessment task – to be used to screen participants for their relational data modelling knowledge 2. Also to establish the level of relational data modelling knowledge, for comparison with the post-exposure task
2. Exposure to artefact, including interaction with administrator and other participants	To improve participants' understanding of relational concepts of data organisation. To capture relevant questions, thoughts, observations, suggestions from participants, while they are being exposed to the artefact.	1. Script administered by independent third party, include steps along the way for the artefact. 2. Recorded observation
3. Post-exposure tasks	To evaluate the effectiveness of the artefact by assessing the participants' improved understanding of relational concepts of data organisation.	1. Assessment task – to offer the participants a chance to exhibit their improved understanding 2. Individual structured interviews – artefact rigour will be demonstrated by participants' comments relating to the exposure task, and the timeline of their developing understanding

ARTEFACT DESIGN

In figure 2 is depicted the process used in the formal design of the artefact. The steps in this process are as follows. Firstly there was a brief re-examination of the design process used in the first iteration, which was the necessary precursor to one major part of the second design process. A literature survey as part of the first iteration reported that novice end users have trouble with data modelling and database concepts. These problems extend throughout this research, from the preliminary study (the first iteration) to the second iteration, which is the focus of this paper. The most useful part of this first process was the use of a textual representation of the data modelling metaphor. The second design process was considered in two major blocks. These were, lessons to be learned from the first iteration and further lessons to be learned from external sources. These two jointly contributed to all of the ideas which in turn fed into the design of the new artefact used in the second iteration.

The lessons learned from the first iteration may be summarised as follows. The experiment used in that iteration was conducted as an empirical psychological experiment. As such, there were fixed hypotheses and, more

particularly, a single measure was used. No account was taken of any possible interaction between the various participants, or any other similarly confounding factors. The design research section contains a description of the design research methodology, and its greater suitability for this type of research. Under the circumstances that this study was conducted, it is likely that the design research methodology was far more appropriate.

The lessons learned from external sources can be described as follows. In order to develop an artefact that fitted the needs of this project, the final successful strategy was a combination of experience, a knowledge of the requirements, and serendipitous occurrences. The first thing that was done was to detail the concepts which need to be illustrated and reinforced by the participants use of the artefact. The concepts were then to be used as the framework on which to build the artefact. It was further decided that there would need to be a practical and familiar example used to introduce the concepts, making them easier to absorb. In casting around for an example on which to base the data modelling artefact, it was recalled that a motel which was used for accommodation might provide a fruitful example.

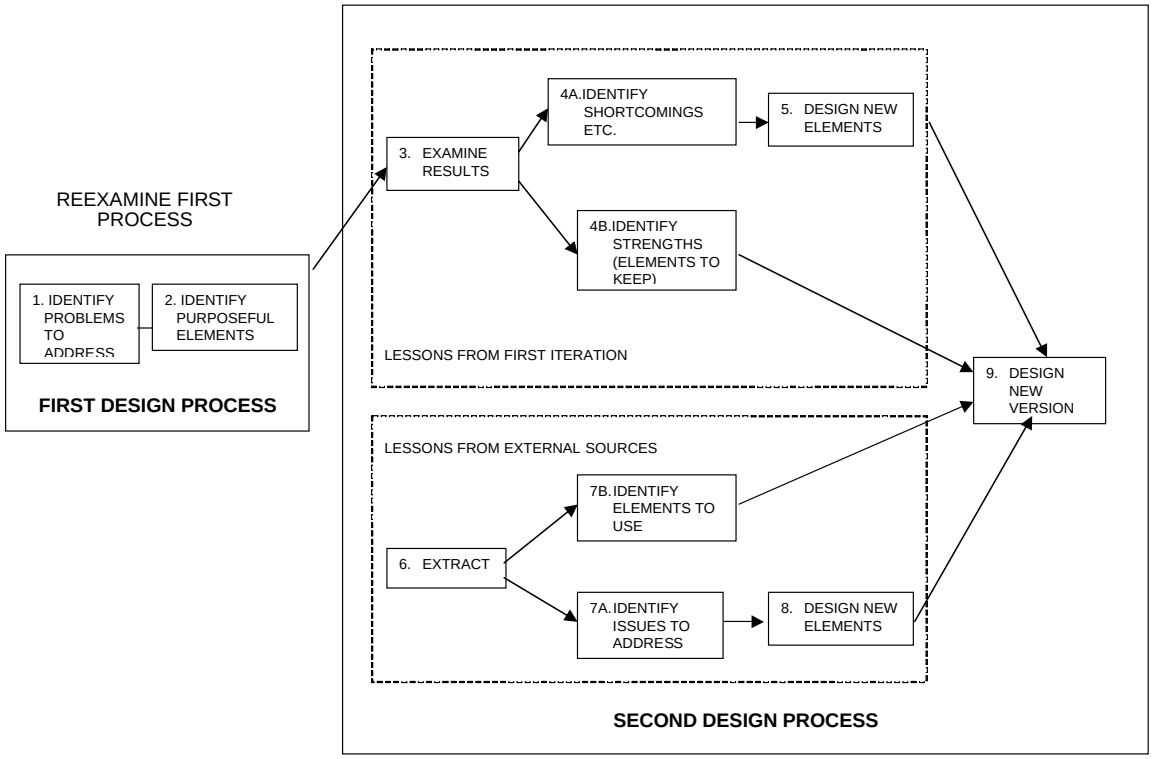

Figure 2: Artefact design process

Step 9 in figure 2, was the culmination of the whole artefact design process, with the combination of the results of steps regarding designing new elements and designing purposeful elements for the new artefact, with the steps on identifying the strengths of the original artefact and identifying the elements to use in the new artefact, to end up with the form of the new artefact. The artefact is described in the next section.

ARTEFACT

Having arrived at the objectives, the concepts and the metaphor to be used, it only remained to develop the artefact in its hard copy form for use in the exposure. The artefact had the following form and contents. It was a 16 page document, describing the scenario of a motel, and leading to an understanding of how the owner might use data, obtained from guests' business cards, to build a data model in anticipation of building a database from which they might gain information.

The artefact was designed for ease of use in the exposure session, with a facilitator introducing the details in a structured manner. The artefact introduced ideas, called Important Concepts, of which there were eight. In the process of introducing these concepts the experimental participants were asked to perform various activities, highlighted in the artefact. There were fourteen activity blocks.

At the beginning of the artefact exposure the participants were each given two packs of cards, one a set of regular business cards from a variety of people, and the other a set of cards containing details of the organisations for which these people worked. The early parts of the artefact exposure directed the participants to work with these cards, sorting, matching and otherwise manipulating their contents. Thereafter, the exposure consisted of reading text, answering questions posed by the facilitator, and discussion both between facilitator and participants, and among the participants.

The exposure process took about 90 minutes, with a useful amount of discussion taking place. Participants were asked to keep in step with the presentation, mainly because answers to questions in the activity blocks appeared on later pages. At the conclusion participants were able to take the artefact away with them. (*A copy of the artefact is available from the first author.*)

IMPLICATIONS OF THE RESULTS

The results of this main study will be discussed in two parts, namely the success of artefact exposure in improving the understanding of data modelling concepts by novice end users; and the use of an experimental design research methodology in conducting this study. Firstly, a discussion of the quantitative results. In the pre-test all of the participants achieved a level of understanding which indicated that they were in a category that could be described as novice users. Although some participants did have some previous knowledge it was considered very limited and would not interfere with their interaction with the artefact.

Of the thirteen participants three answered none of the eight questions correctly, and a further five were able to answer only two of the questions correctly. On average, the group were able to answer less than one quarter of the questions correctly, and their answers indicated a negligible understanding of the principles of data organisation. These judgements are based on the answers to the individual questions, which were designed to discover an understanding of the basic objectives as specified in the artefact design specifications.

The first objective requires an understanding of basic normalisation, which was canvassed by questions 1 to 3 in this task. Five of the participants recorded correct answers for none of the questions, a further four recorded one correct answer for these questions, and the other four responded with two correct answers. The second objective requires an understanding of the use of primary keys, for which questions 4 and 5 in the pre-test were posed. Of all of the participants five were unable to answer any of the questions correctly, five answered two correctly and the remaining three managed one correct answer. The third and final objective required the understanding of foreign keys, for which questions 6, 7 and 8 were asked. There was almost a complete lack of correct answers here, with only three participants recording one correct answer.

In the second assessment task the participants achieved considerably better results. The total scores themselves might be enough to convince the reader that exposure to the artefact had effected a considerable increase in the levels of understanding of almost all of the participants. A detailed analysis shows the pleasing result that all participants gave correct answers for questions relating to all three of the objectives listed.

Once again, the discussion will focus on the detailed objectives, and the related questions. The first objective requires an understanding of basic normalisation, which was canvassed by questions 1 to 3 in this second task. All participants answered at least part of every question correctly, of which three participants answered them all correctly. The second objective requires an understanding of the use of primary keys, for which questions 4 and its constituent parts in the post-test were posed. All of the participants managed at least two out of the three parts of the answer correctly, with two having completely correct answers to all parts. The third and final objective required the understanding of foreign keys, for which questions 5 and its constituent parts was asked. All of the participants bar one managed partial or completely correct answers. There were four participants in the latter group. Understanding of the question relating to the third objective, that relating to foreign keys, was the most noteworthy and in sharp contrast to the performance in the pre-test, which was remarked upon above,

With the possibility of partially correct answers, there was a variety of correct understandings being exhibited. For the post-test, the overall mean performance of the group of participants who completed the entire set of tasks was seventy-two percent.

Indications from this design research experiment were therefore that, while participants on average understood less than a quarter of the concepts illustrated in the pre-test, after exposure to the artefact the group were on average able to exhibit an understanding of about three quarters of the concepts tested. This would indicate that the participants on the whole had considerably improved their understanding of these data modelling and database concepts. This is a considerable increase in the level of understanding displayed by the group, a resounding success for the artefact through the exposure process, which was the catalyst for this increased understanding.

There was a marked increase in the understanding exhibited by the participants. This suggests that within the time frame used (exposure in the middle of one day, checking for understanding at the beginning of the next day) understanding of concepts was increased. This suggests that the type and contents of the artefact, and the exposure process were between them successful in developing and improving the understanding of concepts. For novice users this was a positive achievement, because by the very nature of novices they commenced this process with very little understanding of database in general, and data modelling in particular.

A number of questions might be posed at this point. The first relates to whether the concepts as identified were the right ones. It is considered that the concepts as identified were indeed correct. An exhaustive literature review combined with the plumbing of the depths of many years of shared personal experience revealed that these objectives underpinned the production of an effective data model. They provided a simple yet thorough introduction to the required concepts of data organisation,

Another question might relate to whether anything was missing from the artefact. Some concepts were more effectively imparted, because lessons can always be learnt from the implementation of any metaphor, and the one used in this research, that of the business card bowl, is no exception. It is most likely that the use of a metaphor reinforced for the participants the important elements of the scenario.

Finally, it is illustrative of the fact that such improvements in understanding are possible, and holds out hope for all novice users that they too might greatly increase their understanding of the relational concepts of data organisation.

Secondly, a review of the success of the use of the experimental design research methodology. The use of design research allowed the conduct of this experiment to proceed in a realistic setting. The details of the design research methodology, described above, have made clear the utility of such a method in this discipline. The realistic nature of the setting, the helpfulness of the small group evaluation and the ease of understanding of the design of the artefact, its exposure and the evaluation of both artefact and exposure were beneficial to the successful conduct of this experiment.

More importantly, this methodology provided a robust transition between the preliminary study with its empirical laboratory-based experiments, characterised by hypotheses and fixed parameters, and the more realistic nature of the present and any subsequent iterations of the design research process, with its attendant interaction and feedback.

The strength of this methodology is its freedom to structure each iteration using the strengths and ignoring or replacing the weaknesses in the previous iteration. This in turn means that the research is not bound to the narrow limitations of any earlier attempt, and does not have to remain faithful to the restrictions of the parameters set at the beginning of the project. This emphasis of building on the strengths and discarding the weaknesses promises an improvement at every iteration of the process. The vital concomitant aspect of the design research methodology is the need to evaluate the success of the artefact designed and developed during the iteration. And a strength analogous to that of the previous phase is that there does not need to be a slavish adherence to any evaluation used previously. If the previous evaluation methodology used is deficient in one, some or all of its details, then this is able to be changed to an evaluation better suited to the artefact to be evaluated, or in general to the task at hand.

This factor meant that the methodology was particularly suited to this evaluation, as the previous evaluation had not proved successful, as has been discussed above. The new evaluation was much better suited to the artefact and the task, working as it did with novice users in a natural environment with a facilitated exposure process. It is likely that further iterations will use a more incrementally changed and improved process, without the need for sweeping alterations.

REFERENCES

Brown, A.L., (1992) Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings, *The Journal of the Learning Sciences*, 2, 2, 141-178

Cobb, P. & Steffe, L.P., (1983) The constructivist researcher as teacher and model builder, *Journal for Research in Mathematics Education*, 14, 2, 83-94

Cobb, P., Confrey, J., diSessa, A., Lehrer, R. & Schauble, L, (2003) Design experiments in educational research, *Educational Researcher*, 32, 1, 9-13

Collins, A., (1992) Toward a design science of education, In: E Scanlon & T O'Shea (Eds.) *New directions in educational technology*, Berlin: Springer-Verlag

Edelson, D.C., (2002) Design research: what we learn when we engage in design, *The Journal of the Learning*

Sciences, 11, 1, 105-121

Hevner, A.R., March, S.T., Park, J. & Ram, S., (2004) Design science in information systems research, *MIS Quarterly*, 28, 1, 75-105

James, W., (1911) *Some Problems of Philosophy*, Harvard University Press, Cambridge, MA

Klein, H.K. & Myers, M.D., (1999) A set of principles for conducting and evaluating interpretive field studies in information systems, *MIS Quarterly*, 23, 1, 67-94

March, S.T., Hevner, A. & Ram, S., (2000) Research commentary: an agenda for information technology research in heterogeneous and distributed environments, *Information Systems Research*, 11, 4, 327-341

Nunamaker, J.F., Chen, M. & Purdin, T.D.M., (1991) Systems development in information systems research, *Journal of Management Information Systems*, 7, 3, 89-106

Peffers, K., Tuunanen, T., Gengler, C.E., Rossi, M., Hui, W., Virtanen, V. & Bragge, J., (2006) The design science research process: a model for producing and presenting information systems research, In: *Proceedings of First International Conference on Design Research in Information Systems and Technology*, Claremont CA, 24-25 February 2006, 83-106

Schlager, M.S. & Ogden, W.C. (1986) A cognitive Model of Database Querying: A Tool for Novice Instruction, *CHI'86 Proceedings*, ACM, New York, NY 107-113

Simon, H.A., (1996) *The Sciences of the Artificial* (3rd ed), The MIT Press, Cambridge, MA

Steffe, L.P., Thompson, P.W. & von Glaserfeld, E., (2000) Teaching experiment methodology: Underlying principles and essential elements, In: A.E.Kelly & R.A.Lesh (eds) *Handbook of research design in mathematics and science education*, Erlbaum, Mahwah, NJ, 267-307

Walls, J.G., Widmeyer, G.R. & El Sawy, O.A., (2004) Assessing information systems design theory in perspective: How useful was our 1992 initial rendition?, *Journal of Information Technology Theory and Application (JITTA)*, 6, 2, 43-58

Walls, J.G., Widmeyer, G.R. & El Sawy, O.A., (1992) Building an information system design theory for vigilant EIS, *Information Systems Research*, 3, 1 pp 36-59

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