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THE INTERACTION OF RESEARCH METHODS FOR SYSTEM EVALUATION AND THEORY TESTING: A NEW VISION OF THE BENEFITS OF MULTI-METHODOLOGICAL INFORMATION SYSTEMS RESEARCH

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Extended Abstract

A number of multi-methodological Information Systems research frameworks have been proposed to guide research in the IS field. In this paper, we describe a three-year program of research evaluating a computer-based training system for deception detection (Agent99 Trainer) using one such multi-methodological IS framework. The process and results of this research program clearly demonstrate the benefits of combining and triangulating multiple research methods. Moreover, through the experiences in the Agent99 Trainer study, we discover two different types of interactions between the research methods that were applied in this study. One of the interactions is between the results from different methods, while the other is between the results and the methods themselves. Hence, we propose an extended interpretation of multi-methodological IS research frameworks to incorporate these two types of interactions between research methods. We argue that this extended interpretation will provide a more specific explanation for why the triangulation among multiple research methods can provide benefits to IS research.

Keywords: Multi-methodological, IS research frameworks, research methods, interaction, benefits

Introduction

Although many empirical research methods traditionally used in social science have been applied to Information Systems, more than 80 percent of individual IS research studies reported in the 1990s used only a single research method (Nandhakumar and Jones 1997; Walsham 1995). This single-method approach, although defended by some researchers as more rigorous (see Mingers 2001), often results in a limited view of a specific research situation. In the research presented here, we have demonstrated that

combining different research methods may yield convergent validation and a richer understanding of the phenomenon under investigation. In particular, we propose an extended interpretation of multi-methodological IS research frameworks to incorporate two different types of interactions between research methods. Furthermore, we argue that such an extended interpretation will better explain why triangulation among multiple research methods can benefit IS research.

Multi-Methodological IS Research: Existing Frameworks

A number of multi-methodological IS research frameworks or guidelines have been proposed to guide the combination of multiple research methods in IS research. Nunamaker et al. (1991) proposed a framework for multi-methodological IS research in which they advocate IS research on system development that includes the complementary strategies of theory building, systems development, observation, and experimentation (Figure 1) and argue that triangulation of the results has the potential to lead to more powerful and insightful findings.

Recently, Hevner and his colleauges (Hevner and March 2003; Hevner et al. 2004) proposed a functionally similar framework for IS research that operates in a different way (Figure 2). They define the *environment* as a problem space where phenomena of interest reside, and the *knowledge base* as a collection of IS research foundations and methodologies. This framework focuses on application of those foundations and methodologies from the knowledge base that are appropriate to the business needs of a particular environment. These researchers argue that superior IS research can be achieved through the combination and integration of two paradigms: behavioral-science and design-science. They specify that such integrated IS research should be conducted in two phases: (1) develop theories and build artifacts, and (2) justify theories and evaluate artifacts. Furthermore, they claim that incorporating multiple research methods in these IS research phases can result in better refinement and reassessment of a theory or an artifact.

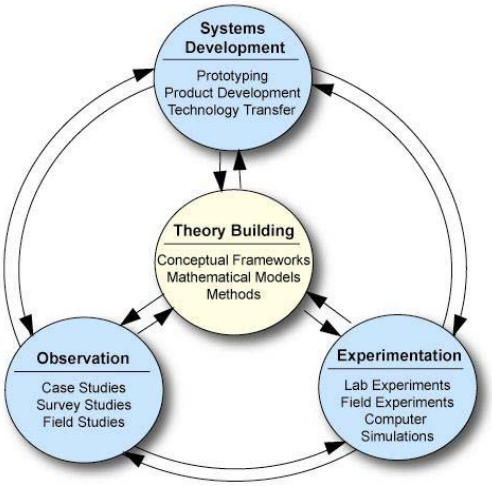

Figure 1. Multi-Methodological Approach to IS Research (Figure 1 in "Build and Learn, Evaluate and Learn," J. F. Nunamaker Jr., *Informatica* (1:1), 1992, p. 4. Copyright © 1992, Business & Educational Technologies; diagram updated in later presentations and used with permission.)

A New Vision of the Benefits of Multi-Methodological IS Research

Although the aforementioned frameworks suggest that the results from multiple research methods can complement each other, they did not provide concrete examples of research studies to illustrate the real need for and benefits of such a multi-methodological approach. Moreover, little is known about how the different research methods relate to each other or if the potential benefits outweigh the costs of time and effort invested in a multi-methodological approach.

Our experience in a recent research study based on Nunamaker's (1992) multi-methodological IS research framework provided a possible answer to these questions. In this paper we present a new vision of the benefits of multi-methodological IS research with a focus on interpreting different types of interactions among various research methods.

In this recent research study, we developed Agent99 Trainer (A99), a computer-based, multimedia system for deception detection training (George et al. 2004b). From 2001 to 2003, we iteratively developed system prototypes, evaluated system usability using questionnaires, and tested the theoretical hypotheses using field experiments. The iterative process of the A99 research is summarized in Table 1.

During the execution of this research study, we discovered interesting interactions between different research methods. First, the results from the usability survey not only helped us refine the system, but also helped explain the results from the experiment for theory testing. This type of interaction, in which the results from one research method complement the design of another, has been described in the existing multi-methodological IS research frameworks as a major benefit of combining multiple research methods. Therefore, our A99 study provides strong support for existing multi-methodological IS research frameworks. In addition, the usability survey also helped us identify weaknesses in the experimental design, and thus helped us refine the experimental design for better theory testing. This type of interaction, in which the *results* from a research method complements the *design* of another

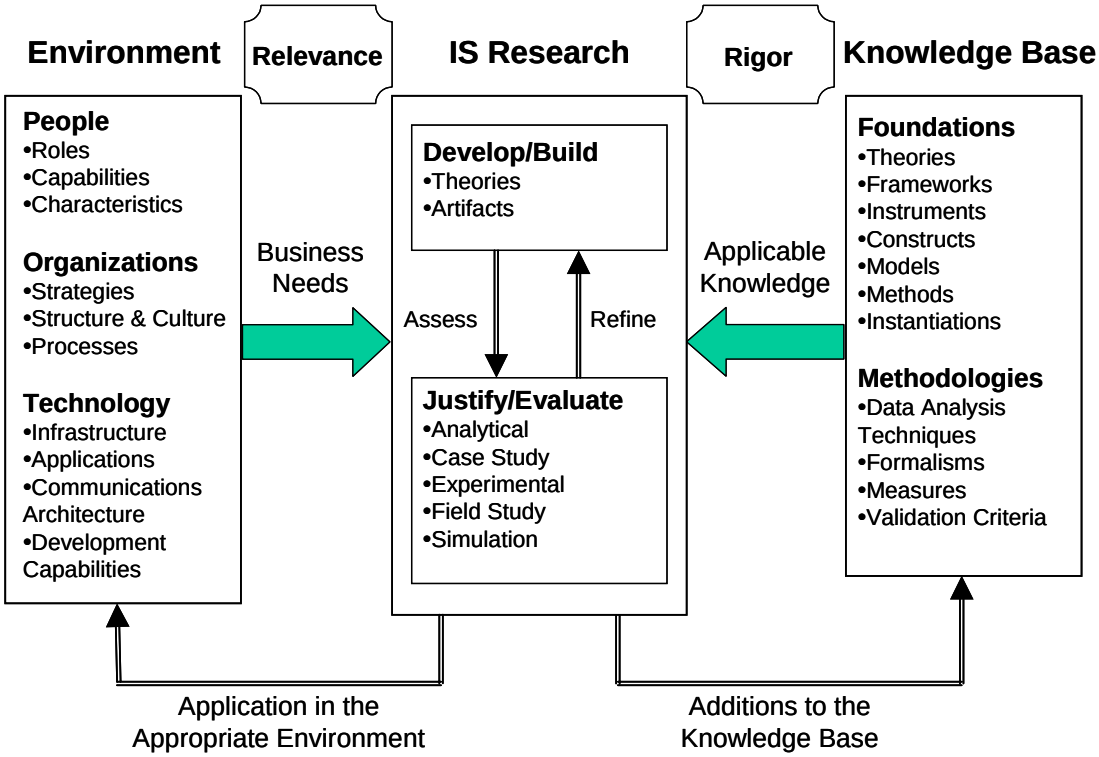

Figure 2. IS Research Framework
(Figure 2 in "Design Science in Information Systems Research," A. R. Hevner, S. T. March, J. Park, and S. Ram, *MIS Quarterly* (28:1), 2004, p. 80. Copyright © 2004, Regents of the University of Minnesota; used with permission.)

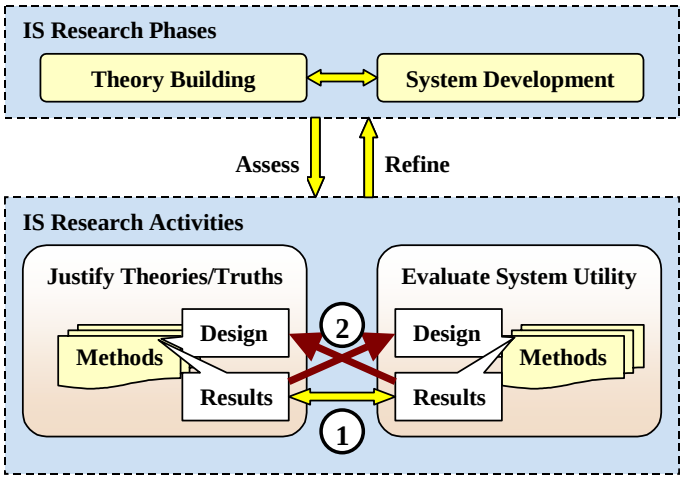

Figure 3. A New Vision of the Benefits of Multi-Methodological IS Research

Table 1. Agent99 Trainer (A99) Research Studies

Research Goals		(1) to justify that training using reliable cues or indicators of deception can improve humans' capability of detecting deceptions; (2) to build a computer-based training system to implement such DD training programs, as a more efficient and cost effective alternative of traditional classroom training.	
Phases		**2002**	**2003**
System Development	***Version***	First prototype (designed in 2001)	Second prototype (designed after 2002 study)
	System Features	• Two modules ○ Watch Lecture: explicit instruction in video ○ View Examples: real life examples and feedback • Synchronization of lecture video, PowerPoint slides and notes • Navigation button and pull down menu allow jump between topics	• Professional lecture and example videos with high video/audio qualities • New delivery method: CD-based • Two new modules: Search Tools (e.g., *Ask A Question*) and Assessment tools (e.g. *Quiz*)
Experiment for Theory Testing (George et al. 2004a; George et al. 2004b)	***Design***	Field experiment with 1 control group and 3 treatments (lecture only, A99 only and combination) **Hypotheses:** H1: Training helps people better detect deception H2: Training through A99 is better than traditional lecture-based training **Procedure:** Pretest (DD accuracy and knowledge) + training + posttest (DD accuracy and knowledge)	Field experiment with 5 treatments groups (1: video only, 2: linear A99, 3: A99+AAQ, 4: A99+ AAQ+content, 5: A99+AAQ+content+Quiz) **Hypotheses:** H1: Training helps people better detect deception H2: A99 with more functionalities delivers better training **Procedure:** Pretest (DD accuracy and knowledge) + training + posttest (DD accuracy and knowledge)
	Results	**H1:** significant improvement for all three treatment groups with DD knowledge; but no significant improvement with DD accuracy **H2:** no significant differences between A99 and the other treatments	**H1:** overall significant improvement with DD knowledge & accuracy: **H2:** treatment 5 is better than 4, treatment 1 is worse than the others; but no significant differences among the treatments 2, 3, and 4, for both DD knowledge & accuracy tests.
System Usability Testing (Observation) (Cao et al. 2003; Cao et al. 2004)	***Design***	Questionnaire with close and open-ended questions	Questionnaire with close and open-ended questions (more questions added)
	Results	• Overall positive: easy to use, good learnability, system features preferred include synchronization, self-controlled navigation, view examples… • **Identified problems**: system functionality problems, e.g. lack of interaction…	Overall positive: most system features useful, quiz very helpful… **Identified problems**: users had no time and were not forced to use search tool, so treatments 2, 3 and 4 became the same condition.

research method, has not been discussed previously. Therefore, we propose an extended interpretation of the existing multi-methodological IS research frameworks, as illustrated in Figure 3. In this extended interpretation, we assert that, in addition to bolstering the research findings, a multi-methodological approach to IS research which integrates different research methods from different research paradigms has the potential to improve the research methods themselves.

As Figure 3 illustrates, research methods used for different research goals (justifying theory and truth or evaluating system utility) can interact in two ways. In interaction 1, the *result-result* (R-R) interaction, the results from one method can help in the interpretation of results from another method and vice-versa. The R-R interaction usually results either in better understanding of the theory or in better improvement of the system design, or both. For example, our 2002 usability testing results helped us understand why there was no difference between the treatment groups in the experiment. As identified in Table 1, there were a number of problems with the system implementation. R-R interaction is a commonly recognized benefit of multi-methodological research.

On the other hand, in interaction 2, the *result-design* (R-D) interaction, the results from one method in one paradigm may interact with the research design of another method in another paradigm, providing potential to result in a better research design. For example, in the A99 study, the 2003 usability testing results revealed that, because users were not given enough time to complete the training, three different treatments became essentially one treatment in the experiment. This finding not only accurately explained why there were no differences among these treatments but, more importantly, highlighted that modification of the experiment design was needed (see Table 1). Without this R-D interaction, the same experiment could have been conducted repeatedly without finding the real truth, which was that the users did not actually use the system in the way that the researchers expected. This indicates that R-D interaction between multiple methods is critical to IS research.

We emphasize that it is better that the interactions occur between methods from the two different research paradigms. As Hevner and his colleagues stated, "An artifact may have utility because of some yet undiscovered truth. A theory may yet to be developed to the point where its truth can be incorporated into design" (Hevner et al. 2004, p. 80). For researchers doing behavioral-science IS research on a given IS system, it is recommended that they also choose a method to evaluate the system usability. The results from this complementary study could permit deeper understanding of how the information system is used in the experiment, and thus enhance validation of their research design and results. On the other hand, researchers doing design-science IS research to meet certain business requirements and/or evaluate system usability might also want to choose a theory testing method designed to find which "truth" affects the usability of the system. Overall, such a multi-paradigm, multi-methodological IS research framework will result in better IS theories and/or better information systems.

References

Cao, J., Crews, J. M., Lin, M., Burgoon, J. K., and Nunamaker, J. F. "Designing Agent99 Trainer: A Learner-Centered, Web-Based Training System for Deception Detection," in *Proceedings of the 1st NSF/NIJ Symposium on Intelligence and Security Informatics* (ISI 2003), H. Chen, R. Miranda, D. D. Zeng, C. Demchak, J. Schroeder, and T. Madhusudan (Eds.), Tucson, AZ, 2003, pp. 358-365.

Cao, J., Crews, J. M., Nunamaker, J. F., Burgoon, J. K., and Lin, M. "User Experience with Agent99 Trainer: A Usability Study," in *Proceedings of the 37th Annual Hawaii International Conference on System Sciences* (HICSS 2004), R. H. Sprague, Jr. (Ed.), Big Island, Hawaii, 2004 (available online at **http://csdl.computer.org/comp/proceedings/hicss/2004/2056/00/2056toc.htm**).

George, J. F., Biros, D. P., Adkins, M., Burgoon, J. K., and Nunamaker, J. F. "Computer-Based Training for Deception Detection," in *Proceedings of the 2nd NSF/NIJ Symposium on Intelligence and Security Informatics* (ISI 2004), H. Chen, R. Miranda, D. D. Zeng, C. Demchak, J. Schroeder, and T. Madhusudan (Eds.), Tucson, AZ, 2004a.

George, J. F., Marett, K., Burgoon, J. K., Crews, J. M., Cao, J., Lin, M., and Biros, D. P. "Training to Detect Deception: An Experimental Investigation," in *Proceedings of the 37th Annual Hawaii International Conference on System Sciences* (HICSS 2004), R. H. Sprague, Jr. (Ed.), Big Island, Hawaii, 2004b (available online at **http://csdl.computer.org/comp/proceedings/hicss/2004/2056/00/2056toc.htm**).

Hevner, A. R., and March, S. T. "The Information Systems Research Cycle," *IEEE Computer* (36:11) 2003, pp 111-113.

Hevner, A. R., March, S. T., Park, J., and Ram, S. "Design Science in Information Systems Research," *MIS Quarterly* (28:1) 2004, pp. 75-105.

Mingers, J. "Combining IS Research Methods: Towards a Pluralist Methodology," *Information Systems Research* (12:3), September 2001, pp. 240-259.

Nandhakumar, J., and Jones, M. "Too Close for Comfort? Distance and Engagement in Interpretive Information Systems Research," *Information Systems Journal* (7), 1997, pp. 109-131.

Nunamaker Jr., J. F. "Build and Learn, Evaluate and Learn," *Informatica* (1:1) 1992, pp 1-6.

Nunamaker, J. F., Chen, M., and Purdin, T. D. M. "Systems Development in Information Systems Research," J*ournal of Management Information Systems* (7:3), 1991, pp, 89-106.

Walsham, G. "The Emergence of Interpretivism in IS Research," *Information Systems Research* (6:4), 1995, pp. 376-394.