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An End-User Training Software Tool for Statistical Process Control: An Information Systems Design Theory

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ABSTRACT

An Information Systems Design Theory (ISDT) offers theory-based principles that can help practitioners to build systems that can be more successful. In addition, ISDT offers opportunities for researchers. The paper describes an ISDT for a Statistical Process Control (SPC) training tool. Such a tool can be used to train the workforce in SPC instead of the traditional lecture-training approach.

INTRODUCTION

Training has impact on the overall performance in organizations. Without adequate training, employees struggle to perform their everyday activities. Moreover, a complete training program is the base for the success or failure of software implementations.

ISDT are prescriptive theories developed to provide solutions [1]. ISDT can help practitioners in developing training software tools that may deliver enormous benefits in their training programs. Finally, an ISDT for an industrial problem (training in the use of SPC) is important because it can serve as a theoretical guide for the developing of information systems for training in such environments.

We believe that the development of an ISDT is important in end-user training. Most training efforts are conducted using a traditional lecture approach, or focus on training for general tools such as word processors. Other tasks that have more complexity involved have been for the most part ignored by software training tools developers [please see note]. Thus, an ISDT can guide developers to build such tools, and as well, can initiate further research.

This paper starts by reviewing research that has been conducted on software training. It also describes the importance of training. It then defines ISDT and provides a brief description of the research approach. The specific ISDT for SPC training is outlined using a description of its components. Finally, the paper discusses some conclusions.

IMPORTANCE OF TRAINING

Organizations face challenges in trying to remain competitive and to continue to cope with new or improved requirements. Those requirements come from different sources such as: government, customers, competitors, and suppliers. Industry and researchers are challenged to create new ways to train employees [2]. Research has been conducted on learning performance tools [3, 4], low complexity tasks [3], learning styles [5], adapting training to meet user needs [6], error-based training [7], impact of training delivery and type of computer application software on end user trainee's performance [2], and training using non-richer mediums [8].

Previous research on training has examined computer-based training (CBT) versus traditional training influenced learning of software tools (e.g., Microsoft Excel). For example, one study [4] consisted in exposing two groups to the learning process of such tools. Bowman [3] examined the effectiveness of CBT at a University. Bohlen [8] tested the outcomes of lecture versus CBT teaching WordPerfect skills.

However, no previous research has been conducted in the potential that ISDT may have in developing software for end-user training. Further, in the market there are not tools to help end-users to get knowledge/skills in activities that are activity-specific. Thus, tailored training software is needed.

Technology has added new options to deliver training [9]. Information technology helps to build new tools and methods that could help to share knowledge and learning easily [10]. For example, production managers can use such tools to train the workforce before the production actually occurs reducing costs and time required for training. "The learning model of the 21st century uses the computer as the conduit of teaching and learning" [11] (p. 114). Further, she believes that the computer is the means to the end, not the end itself. Kekäle [10] argues that IT continues to produce new ways of learning. In addition, they stated that in recent literature "personnel training has been suggested to be studied as part of more strategic, systematic and holistic concepts such as human resource development or training development" (p.269).

Training has strategic impact in organizations [10]. Training itself is not the solution. A training strategy is also needed in order to be successful in training efforts [12]. Moreover, training implies a cost for organizations, but no training or ineffective training can be even more costly [13]. Selecting the right training method is frequently bewildering [12]. If people to be trained have previous skills or similar mental models this could enhance the opportunity for successful training programs [14]. Thus, previous experience is an important factor in training efforts.

ISDT

ISDT as described by Walls [1] is based on the concept of building theory. They argued that much of information systems (IS) research deals with design-related issues and many of the courses taught in IS have a focus on design. In addition, theory development is one of the major pursuits for academic research. Further, they stated that the design process is analogous to the scientific method – stating and testing hypotheses by building an artifact.

Simon proposed the contrast between substantive and procedural rationality [15]. In a goal-directed system, substantive rationality would govern the definition or selection of the best (highest utility) goal. Procedural rationality would determine the best way to achieve that goal. Using these notions, Walls stated that a design theory should prescribe both the desirable qualities of the artifact and the procedure for building it.

Walls suggested a two-tier structure that lays out the components of an ISDT (Table 1).

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Table 1. Components of ISDT

Design Product	
1. Meta-requirements	Describes the class of goals to which the theory applies
2. Meta-design	Describes a class of artifacts hypothesized to meet the meta-requirements
3. Kernel theories	Theories from natural or social sciences governing design requirements
4. Testable design product hypotheses	Used to test whether the meta-design satisfies the meta-requirements
Design Process	
1. Design method	A description of procedure(s) for artifact construction
2. Kernel theories	Theories from natural or social sciences regarding the process itself
3. Testable design process hypotheses	Used to verify whether the design method results in an artifact which is consistent with the meta-design

A design theory is prescriptive and not explanatory or predictive in nature. Walls believes that the purpose of a design theory is to support the achievement of goals. Thus, a design theory describes how to achieve that goal and not what the goal should be. Finally, an ISDT can be empirically tested and, as any theory, serve as the starting point for new research.

PROPOSED RESEARCH/DEVELOPMENT/TESTING PROCESS

The present research is based on the ISDT framework from Walls and aims to develop a system that can be used as the base to build a software tool for end-user training. Such a tool will serve to test theories and then construct the final software tool. A prototyping approach is needed for the project. Therefore, modifications will occur through the design process. The process is based on the model proposed by Walsh [16] (Figure 1).

In the model, the arrows can be considered as knowledge links between activities in the research. It is very important to maintain these links in order to succeed. If by any circumstance the links are not maintained, then studies, systems and theory will lead to results that cannot be interpreted. "The ISDT approach allows for the explicit definition of system design requirements resulting from current theory and research, maintaining a valid link between systems design, theory, and research design" [16](p. 15).

The development is composed by a three-step model. The model requires an interrelation between the steps. After completing the three-step process, important conclusions can be drawn. Thus, the overall process is composed by a waterfall-like model and it is described as follows:

1. Build the theory using the ISDT approach from Walls. This allows the creation of a theory to identify the most important attributes for the end-user training tool.
2. Develop the training software tool using the attributes identified in the previous step.
3. Test the artifact using a training experiment. It is suggested to conduct the experiment based on an established research model.

AN ISDT FOR A CBT SYSTEM IN SP

This section introduces the activities to be undertaken to build an ISDT for the training software tool. A description of each component in the ISDT is provided.

Figure 1. An Information Systems Research Approach

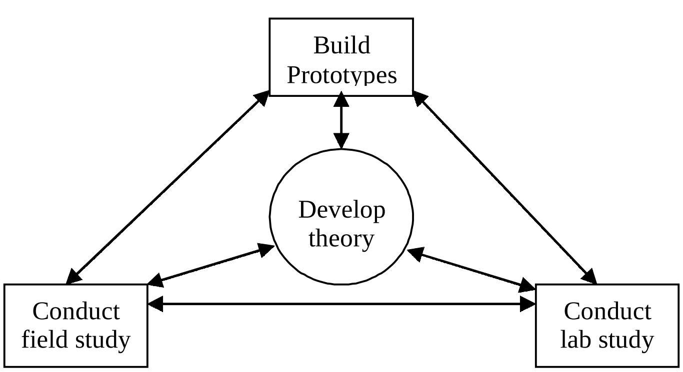

Table 2. ISDT activities for a CBT tool

Design Product	
1. Meta-requirements	1. Build algorithms to identify a set of anomalies that SPC identifies 2. Allow the creation of examples that can be solved during the training sessions 3. Interpret X-R charts
2. Meta-Design	1. Process-specific knowledge base 2. Inference engine 3. Graphical User Interface (GUI) to retrieve and build examples 4. Pattern recognition/corrective-action features
3. Kernel theories	1. SPC [17] 2. Framework for Research on End-User Training [18] 3. Assignable Cause Interpreter (ACI) [19]
4. Testable design product hypotheses	1. Training outcomes are equal or better with specific tools than using traditional means 2. Using CBT to train the workforce increases the success versus lecturer training
Design Process	
1. Design method	1. Expert systems 2. Unified Modeling Language (UML) 3. Prototyping
2. Kernel theories	1. Usability testing theory [20] 2. Systems analysis and design theory using UML
3. Testable design process hypotheses	1. A training software tool that incorporates the designed algorithms is more successful than a lecturer training approach

Design Product Phase

Meta-requirements

Build algorithms to identify a set of anomalies that SPC identifies. It is very important to include a set of algorithms that search, identify, and illustrate what anomalies are occurring as well as to describe the corrective action to be taken.

Allow the creation of examples that can be solved during the training sessions. People perform better when they enjoy what they are doing. Therefore, it is very important that trainees have the freedom to explore their own scenarios in analyzing a data set. In addition, people learn at a different pace, therefore it is important allow them to use tools at their own pace.

Interpret X-R charts. $\bar{X}$-R charts are the main element of SPC. A manufacturing process is under control when all the points on both charts are anomaly-free. If any pattern occurs, something wrong is happening in the process.

Meta-Design

The meta-design "describes a class of artifacts hypothesized to meet the requirements" [1] (p.42). The meta-design for the software training tool should include:

- A process-specific knowledge base
- Inference engine
- GUI to retrieve and build examples
- Pattern recognition and corresponding corrective action fea tures.

Kernel theories

SPC. Traditional quality control efforts have been focused on inspection of finished products by a variety of plans. The way quality control is approached presents two glaring deficiencies [21]: First, no inspection plan for verifying finished products will catch all the rejects. Second, when an inspected product is detected with bad quality, the damage is already done.

Quality control is a key issue for organizations. Industries use several techniques for quality control purposes. SPC is a tool widely used in the industry [21, 22] for this purpose. It is one of the most effective tools of total quality management and its main function is to monitor and minimize process variations [19]. SPC's focus is on producing parts with the smallest possible variation from standards. In addition, SPC techniques supervise the number of nonconformities in the production process [23].

Typically, SPC applications involve three major tasks [19]: monitoring the process, diagnosing the deviated process, and taking corrective action. Several SPC implementations have failed because a complete solution was not set in place [22]. Gaafar [22] stated that previous research has not dealt completely with the problem. Those works only focused on partial implementations, and training is a key issue in SPC implementations.

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Framework for Research on End-User Training. The framework has six major components: target system, individual differences, training methods, trainee's mental model, attitudes, and learning performance.

ACI. Guh created a model for an ES for SPC. This model is able to diagnose out-of-control situations, trigger an alarm, and give advice about the corresponding corrective action. The ACI architecture is composed of four elements: the general knowledge base, process-specific knowledge base, inference engine, and user interface.

Testable design product hypotheses

The design product phase has the following hypotheses:

H1: Training outcomes are equal or better with specific tools than using traditional means.
H2: Using CBT to train the workforce increases the success versus lecturer training.

Design Process

Design method

ES. ES present three potential benefits [24]: retain scarce expertise, train new staff, and increase the speed of response and the quality and reliability of the work. AI technologies help to improve significantly productivity and quality [25]. Some tasks appropriate for expert systems are [24]: analyzing diverse data, diagnosing and trouble-shooting, facts are known but not precisely, and expertise is expensive but available. In addition, ES are very helpful in the creation of solutions for problems such as: instructional decision making, instruction support, and job aids [26]. Hayes identified systems from manufacturing, medical, and financial as other domains for ES.

ES are useful in education and training [26]. Further, ES have been used as a training facility to train less-experienced employees or as a consulting facility to help experienced employees perform tasks [27]. ES help people to acquire skills, expertise, or knowledge they need in order to perform specific tasks. Further, ES "help us focus on our instructional development efforts on knowledge rather than procedures and to develop solutions to increasingly complex problems" [26] (p.13).

Prototyping. Prototyping provides a system very quickly for the users to interact with as well as refines the requirements during the development.

Kernel theories

Usability testing theory. The intention of designing for usability rests in the goal "that the people who use the product can do so quickly and easily to accomplish their own tasks" [20] (p. 4). Dumas' definition is based on four points: usability means focusing on users, people use the products to be productive, users are busy people trying to accomplish tasks, and users decide when a product is easy to use.

Systems analysis and design theory using UML. UML has unified many of the major object oriented (OO) information systems development methodologies. UML permits an iterative development, which is very important in the building of new systems. Provides a systematic method of planning and documenting of each prototype. Finally, OO analysis and design links well with OO development, and OO languages – although this is not a requirement. UML helps to specify, visualize, and document models of software systems. Using this approach, the structure and design of the system are included in the model. Finally, UML helps designers to meet system's requirements.

Testable design process hypotheses

Finally, the design phase has the following hypothesis.

"A training software tool for CBT that is developed through ISDT is more successful than a lecturer training approach"

CONCLUSION

It is believed that the proposed study will help to understand the role that a tailored ES may play in the research on end-user training. In previous literature, training experiments have been conducted using commercial products. None of them contains specially developed software. Thus, the proposed study will innovate in training research.

The study intends to contribute to the body of research on ISDT. There is little research available using the ISDT approach. Hence, maybe the most important contribution is related to the creation of a pioneering approach using ISDT to create an artifact to be used in the research for end-user training. The study will help researchers to understand the role that a tailored end-user training tool might play in training specific tasks. Such an outcome might increase the number of studies on using AI techniques in training settings.

Practitioners can benefit as well. Practitioners are in great demand of improved tools/techniques to train their employees. Thus, the proposed research might help organizations to explore the use of different tools and/or techniques to train their employees other than off-the-shelf software and traditional instructor based-training.

RESEARCH METHODOLOGY

In order to have a better understanding of the effect of training outcomes in the workforce, it is proposed to conduct the experiment in the population most likely to use SPC. The experiment will be run at Mexican organizations that have quality control processes in place. The sample members will include only adult individuals with similar levels of education and experience.

The study will develop an ES using ISDT and conduct an experiment in the use of the ES for measuring its impact compared to a reduced version of the system on training workers to use SPC. For the study, external validity and generalization are not intended.

For the study, an experimental design using two groups is proposed, each one having training sessions using different instructional approaches to measure the design. Using only one instructor is a requirement for the study in order to control the effects of teaching styles and to avoid compensatory coaching. The control group will use: lecture and hands-on problem solving using traditional means, and a reduced version of the system. The reduced version only will include the description and a set of solved examples of each anomaly. Thus, the instructor will serve in the traditional capacity of teacher. The experimental group will have an initial session about the basics of -R charts and hands-on exploratory study using the complete version of the expert system. For this group, the instructor will function as a consultant. Nevertheless, the instructor must participate in the construction of the rules for the expert system in order to control for differences in problem-solving approaches.

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