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DESIGN SCIENCE I: THE ROLE OF DESIGN SCIENCE IN ELECTRONIC COMMERCE RESEARCH

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ABSTRACT

The fast-paced development of e-commerce caused many people in business to overlook key aspects of the relevant design principles for e-commerce systems. E-commerce applications that are currently being implemented and used are not necessarily the best and the most efficient that people can design and build. The result is an opportunity for e-commerce design science researchers to make significant contributions and for business schools to create and maintain a strong e-commerce design science group of researchers. However, fulfilling this need is often difficult for business schools because resources and design science researchers are both scarce. Partnering with the computer science school within the same university to set up an e-commerce research center that focuses on design science research may be a feasible alternative.

KEYWORDS: design science, e-commerce, business school, artifacts

I. INTRODUCTION

> *The function of what I call design science is to solve problems by introducing into the environment new artifacts, the availability of which will induce their spontaneous employment by humans and thus, coincidentally, cause humans to abandon their previous problem-producing behaviors and devices. For example, when humans have a vital need to cross the roaring rapids of a river, as a design scientist I would design them a bridge, causing them, I am sure, to abandon spontaneously and forever the risking of their lives by trying to swim to the other shore.* — R. Buckminster Fuller (1992)[1].

Every academic researcher dreams of producing high-impact research outputs that potentially improve the world. In business schools, most researchers focus on connecting their research to the real world, working on topics that are relevant to current managerial practice and organizational issues. Although most of the research outputs are published in academic journals, the limited readerships of these journals—mainly within the academic circle—restrict the impacts that the research can make.

Business school professors and scholars typically find the opportunity to impact the real world through their teaching and consulting. By teaching MBA students, for example, business school professors have the opportunity to introduce the latest results from their research. Other good opportunities for dissemination exist when scholars consult with companies because they usually can access top executives.

As they are normally an integral part of the business school, information systems (IS) department professors and researchers seek to enhance business management practice and organizational effectiveness through the use of systems and technology. IS scholars look into issues that relate to the use of information systems in organizations, and search for alternatives for more

[1] The quote is available on the Internet at http://www.bfi.org/designsc.htm.

successful implementations. The quest for better solutions includes not only the evaluation or analyses of existing systems, but also the development of new artifacts and methodologies. The latter permits IS researchers to focus on design science research as well as natural science and social science.

This article discusses the roles of design science research in electronic commerce, and how business schools can decide on whether to establish a strong electronic commerce design science research capability.

II. ELECTRONIC COMMERCE AS A RESEARCH AREA IN INFORMATION SYSTEMS

Electronic commerce, like all of IS, spans the boundaries of many research areas, including marketing, computer science, economics, psychology, and sociology. Both e-commerce and IS research areas focus on computer-based business application systems as the center of their domain. Most e-commerce systems, as a result, can be considered information systems with an extended reach of customers and suppliers, made possible by the Internet and World Wide Web technologies.

The larger scope of suppliers and customers that e-commerce serves also makes e-commerce a relevant research area for scholars in other fields such as marketing and sociology. Furthermore, some IS researchers use theories from marketing, sociology and other disciplines in their e-commerce research. Therefore, it is not surprising to find IS researchers who work on non-traditional IS areas, such as pricing mechanisms on the Internet.[2]

III. WHAT IS DESIGN SCIENCE?

Nunamaker et al. [1990] classify design science as applied research, or research that applies knowledge to solve practical problems. To March and Smith [1995], design science attempts to create things that serve human

[2] In this article, the term "e-commerce researchers" refers to IS researchers who do research in the e-commerce area. Other e-commerce researchers who come from other disciplines are not included in the discussion in this article.

purposes, as opposed to natural and social sciences, which try to understand reality. Design science is technology-oriented. Design is a key activity in fields such as architecture, engineering, and urban planning that may not be thought as "sciences" per se. March and Smith characterize design science products or outputs as four types:

- *Constructs*: Constructs or concepts form the vocabulary of a domain. They constitute a conceptualization used to describe problems within the domain and to specify their solutions.
- *Models:* A model is a set of propositions or statements expressing relationships among constructs. In design activities, models represent situations as problem and solution statements.
- *Methods:* A method is a set of steps (an algorithm or guideline) used to perform a task. Methods are based on a set of underlying constructs (language) and a representation (model) of the solution space.
- *Implementations:* An implementation is the realization of an artifact in its environment. Instantiations operationalize constructs, models and methods.

Furthermore, design science consists of two basic activities:

- building and
- evaluation.

IS research builds and evaluates constructs, models, methods, and instantiations. It also theorizes about these artifacts and attempts to justify these theories. Building and evaluating IT artifacts have design science intent, whereas theorizing and justifying have natural and social science intent.

Nunamaker, et al. [1990] argue that building a system, in and of itself, does not constitute research. However, the synthesis and expression of new technologies and new concepts in a tangible product can act as both the fulfillment of the contributing basic research and as an impetus to continuing

research. The system development research process that they propose consist of five parts:

(1) constructing a conceptual framework,
(2) developing a system architecture,
(3) analyzing and designing the system,
(4) building the (prototype) system, and
(5) observing and evaluating the system.

This process operates in parallel with March and Smith's description of design science described previously.

IV. ELECTRONIC COMMERCE AND THE ROLE OF DESIGN SCIENCE

EXISTING E-COMMERCE DESIGNS

E-commerce is redefining business models. Before the electronic commerce era, for example, most people did not normally participate in auctions. With the arrival of eBay and other online auction sites, people are auctioning off everything from computers to digital cameras to violins to sports memorabilia. Other novel and groundbreaking business models implemented in electronic commerce include Priceline.com—which let its customers name their own price for certain items (e.g., airline tickets, hotel rooms and rental cars), and Mobshop.com—which sold products based on demand aggregation technologies[3]. Even though many of these business models are not sustainable in the fierce competition in the e-commerce marketplace, they demonstrate a high-level of creativity and innovation on the part of entrepreneurs.

E-commerce is a common way of conducting business today. A large number of companies now allow their customers to shop and order online. The customers are more sophisticated and want access to products and services

24/7. However, developing and operating an electronic business—especially one that handles a large number of transactions—requires technical, marketing, and advertising expertise. Webcasting, interactive advertising, customer relationship management, and personalization that uses collaborative filtering and profiling are just a few examples of new techniques that companies use in trying to target their customers more effectively or improve their services.

ROLE OF DESIGN SCIENCE

Design science can clearly play a major role in designing, prototyping, and building the technologies and systems that enable these business techniques. IS design scientists not only develop the systems, but also evaluate them to make sure they are sound and suitable for the commercial world. IS design scientists are more than just technology developers who only build systems. They care about the relevance of the systems they build to business requirements.

Even though the World Wide Web infrastructure was developed as a result of industry and academic collaboration, most of Web-related technologies, as well as the business models we see in use today, were not designed and developed on the basis of academic research. For example, Yahoo was started as a hobby by two Ph.D. candidates in electrical engineering at Stanford University; eBay was designed as a weekend hobby by a computer programmer; and Amazon.com was started in a basement by a Wall Street financial modeler. Most other Web-related technologies and business models, such as the ones cited here, were developed by industry people, and not by academicians. Some academic researchers later jumped on the bandwagon and put their theories to work by founding, advising, or becoming involved in the development of dot-com startups (e.g., OpenRatings.com by an MIT professor, Commerx.com and EthnicGrocer.com by a Northwestern University professor). However, in many cases, industry has been far ahead of academia in experimenting with World Wide Web technologies and using them in productive ventures.

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[3] Mobshop.com discontinued its consumer service in January 2001, and now focuses on providing demand aggregtion software solutions to businesses and government agencies.

While Nunamaker, et al. [1990] claim that IS researchers have the unique capabilities to create artifacts, the number of IS scholars who actually do design-science type of research and build artifacts or systems is simply too few. On the other hand, e-commerce is growing too fast for the small number of IS academicians to catch up.

CRITERIA FOR VALUE CREATION

Riggins [1999] identifies three criteria that can be used to classify the value creation potential of an e-commerce system:

- efficiency improvement,
- effectiveness enhancement, and
- strategic purposes.

In addition, he recognizes five dimensions of commerce:

- time, - distance, - relationships,
- interaction, - product.

He shows the combination of the three types of value creation potential and the five dimensions of commerce in a table that he calls the "Electronic Commerce Value Grid." As shown in Figure 1, each of the fifteen cells illustrates a different Web-based application that can be used to generate new business values. The following are examples of grid elements:

1. Establishing a 24-hours-a-day Web-based customer service (strategic and time);
2. Automating tasks using software agents (potentially increases efficiency in the product dimension);
3. Achieving a global presence (strategic and distance);
4. Altering the roles of intermediaries (efficiency and relationship); and
5. Providing online decision support tools (effectiveness and product).

THE OPPORTUNITY

Despite its phenomenal growth, e-commerce is still in its early stages. Applications in all of the fifteen application types shown in Figure 1 can be further

improved or replaced by better-designed systems. For example, to make sure that data collecting agents deliver the best information by conducting exhaustive data collection within a reasonable amount time, smarter data-collecting agents

Value Creation

Dimensions of Commerce	Efficiency	Effectiveness	Strategic
Time	Accelerate User Tasks	Eliminate Information Float	Establish 24X7 Customer Service
Distance	Improve Scale to Look Large	Present Single Gateway Access	Achieve Global Presence
Relationships	Alter Role of Intermediaries	Engage in Micro Marketing to Look Small	Create Dependency to Lock-in User
Interaction	Make Use of Extensive User Feedback	User Controls Detail of Information Accessed	Users Interact via Online Community
Product	Automate Tasks Using Software Agents	Provide Online Decision Support Tools	Bundle Information, Products, and Services

Figure 1. The Electronic Commerce Value Grid
[Riggins, 1999]

can be designed and developed to accommodate the increasing number of stores and products available on the Internet. The best information includes the lowest price of a certain product, or the most relevant information about certain characteristics of the product. As Kauffman, March, and Wood [2000] point out, design considerations for data-collecting agents are essentially being ignored, even though performing complex data collection activities over an extended period of time presents major design challenges.

E-commerce applications that are currently being implemented and used are not necessarily the best nor the most efficient that people can design and build. The fast-paced development of e-commerce results in many people in business overlooking key design principles for e-commerce systems. And so, e-commerce design science researchers are afforded the opportunity to make significant contributions. However, they must act and deliver quickly because e-commerce firms move rapidly and do not have the patience to wait.

V. E-COMMERCE DESIGN SCIENCE RESEARCH AND THE BUSINESS SCHOOL

Most business school e-commerce research concentrates on evaluating, developing theory, and justifying existing models and technology implementations. For example, IS and e-commerce researchers look into consumer online buying behavior, pricing strategies of online retailers, adoption of e-commerce technologies, and competition between online and 'brick-and-mortar' businesses. Along the way, some researchers built tools such as intelligent agents to help them gather data and information about the Internet. However, after taking into account most of the efforts made to build intelligent agents, not too many instances of IS or e-commerce research focus on building or prototyping IT or e-commerce artifacts or systems. This finding is consistent with the claim (based on a review of the full set of articles published in *Information Systems Research* over the past decade) by Orlikowski and Iacono [2001] that the IS field has not deeply engaged its core subject matter, i.e., the IT artifact.

One of the reasons why IS researchers do not build IT artifacts is that most are not trained to do so, and therefore do not have the needed skills. Most IS researchers built their skills and experience around evaluating, theorizing, and justifying existing artifacts. They are capable of developing constructs, models, and methods, but not experienced at building instantiations or prototypes. Furthermore, while some IS researchers might have the necessary skills and experience, they do not receive much from their environment because few

colleagues have similar interests. Benbasat and Zmud [1999] claim that all IS academics lack sufficient exposure to current and future technological environments. They assert that many, if not most academic IS departments lag in the capability to maintain a current, let alone leading-edge, hands-on technological environment because they lack both financial and human resources.

At business schools, it would be ideal if IS researchers also built artifacts that can be implemented in business. Because business school researchers know and understand business, the artifacts that they build should reflect business needs and requirements. Such an ideal condition is usually difficult to achieve. The diverse nature of IS research [Benbasat and Weber,1996] resulted in a diversity of research interests among business school IS scholars around the world. Most of them chose to concentrate in the "non-design science" areas such as psychology, sociology, management science / operations research. Only a small group comes from, or focuses on, areas that relate to design science, such as computer science and computer engineering[4]. This small group of IS design scientists often find their work judged by colleagues in the business school who are not too familiar with the nature of design science practice. As a result, these colleagues misjudge the quality of the work, potentially discouraging the design scientists or even preventing them from receiving appointments. Consequently, there is a lack of "critical mass", limiting the design scientists' level of productivity and the number of high-impact outputs that they can produce.

Another problem is the limited supply of IS Ph.D. graduates trained in design science. Business schools that would like to create a design science center of excellence must spend extra effort to search for good faculty candidates in the area. The search often extends to computer science and

[4] Based on my recent visits to the Web sites of all the business schools at the universities on the Carnegie Doctoral/Research Universities-Extensive list, I estimate that only about 100 (or 15%) of approximately 690 tenured and tenure-track IS faculty members are involved in research that relate to design science. The observation and counts are based on the faculty profiles posted on the school Web sites.

computer engineering Ph.D. graduates who desire to work in a business school setting. However, this task is rarely easy since computer science Ph.D.'s are not normally trained in business concepts. As a result, these people are rejected by the business school (including its IS faculty) because the search committees believe that outsiders are not suitable for inclusion among business school scholars.

THE CURRENT SITUATION

Should business schools try to develop a strong IS design science group or should the schools continue to focus only on the "non-design science" area?

As a relatively new field, e-commerce needs new ideas, concepts, methods, and implementations to enhance online business practice. From the perspective of the business world—the ultimate users of IS academic research outputs—design science, natural science, and social science work are all needed. Academicians who remained in colleges and universities were left behind in participating in e-commerce development. Businesses developed e-commerce solutions at "Internet speed", trying to stay ahead of the competition. Some hired the most innovative of the IS Ph.D.'s, effectively removing them from academic pursuits. With the sharp decline in technology and dot-com stock prices, however, gone are the days when new untested business models and technologies can easily obtain funding and be launched quickly in the marketplace. Venture capitalists are much more selective in picking which new ideas they will fund. The apparent slowing of new business developments provides the academic world with a chance to catch up.

From the perspective of business schools, however, deciding to embark on design science is not straightforward. It is true that business schools would like to be strong in all areas, but just like any other organizations, they are resource limited. If a business school is not currently strong group in IS design science, it might still be possible to recruit two or three additional faculty members in this area—if the school has the financial resources and is willing to use them to attract the best talent available to build that strength. However, even

with available resources, people may not accept offers if they do not see a good fit between their areas of interest and those of faculty members currently in the school.

At the individual level, an IS researcher normally focuses on one research approach (design science, natural science, or social science), depending on interests, training, and skills. Although some IS researchers may do work in another approach from time to time, perhaps in collaboration with other researchers from that approach, it is not a simple matter for any researcher to actually switch from one approach to another. For example, when an IS researcher decides to do research in e-commerce, she will look into the problems and issues from her own research discipline perspective (e.g., economics, behavioral science, computer science or computer engineering).

AN ALTERNATE SOLUTION

E-commerce continues to create complex business issues. In firms, these issues are normally addressed by a team of people with different of background and skills. Issues and problems are brought to corporate meetings and discussed by people from different functions in the organizations. Often, consultants are hired to help find solutions to the problems. The people involved in the problem-solving processes interact with one another to a large extent.

In contrast, academic researchers tend to work by themselves. Although there are some exceptions, most academic researchers do not interact much with or seek advice from people in other areas for the issues or problems they are working on. As a result, they often come up with very "specialized" research outputs, which in many cases cannot be implemented directly. As Weber [1987] asserts, the true paradigms will not be identified if research continues to be piecemeal and localized to particular problems. The complex nature of e-commerce (and business in general) requires the collaboration of people from many disciplines, and this is true for any academic endeavors as well.

Considering the limited number of IS design science researchers and the difficulty of recruiting the best talent, in my opinion a business school should not

try to position itself as a center of excellence in design science research unless it already has the human resources or can afford to attract the best ones. Instead, the business school should try to join forces with other research groups from outside the business school. One possible alternative is to collaborate with computer science scholars in inter-departmental or inter-school research projects. For example, a business school and a computer science school within the same university can set up a joint e-commerce research center. An example of such a partnership is the Center for Research on Information Technology and Organizations (CRITO) at the University of California, Irvine.

The kind of collaboration described above is only possible with mutual interests and respects. There might be cases in which the computer science school may consider it more beneficial to partner with companies from industry than with the business school because industry normally comes with funding, and there is not much added value to expect from the IS researchers. In this case, business school faculty must convince computer science school faculty that the business school and the IS group can add significant value because they understand business better and, as a result, together they can be more attractive to the industry. Furthermore, there are many other factors (such as appropriate recognition and rewards for researchers of both groups that work in the joint venture) that need to be considered and taken care of to ensure the success of such an alliance. Strong leadership is required to make the collaboration successful.

VI. CONCLUSION

Business schools need to decide if they should build or maintain a strong IS and e-commerce design science research group. One of the main considerations is the availability of resources and the fit between current faculty and the potential design science research group that the school plans to hire.

The absence of a strong IS or e-commerce design science research group within a business school should not prevent the business school from conducting high-quality design science related research. IS and e-commerce researchers

can still produce high-impact design science research outputs by collaborating with computer science or computer engineering scholars. A business school can facilitate this effort by partnering with the computer science school within the same university to set up an e-commerce research center that focuses on design science type of research. However, this kind of partnership requires mutual interests and respects, as well as strong leadership to make it a reality.

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