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ABSTRACT

Tailorable technologies are technologies that are modified by users in the context of their use and are around us as desktop operating systems, web portals, and mobile telephones. While tailorable technologies provide users with limitless ways to modify the technology, as designers and researchers we have little understanding of how this should affect design. In this paper we present principles from four designers to strengthen inquiry into tailorable technologies. We then apply the principles to the case of the design of a web portal. We conclude that designers need to more consciously build reflective and active design environments and gradients of interactive capabilities in order for technology to be readily modified in the context of its use.

Keywords

Information systems, tailorable systems, human-computer interaction, information systems design.

INTRODUCTION

Tailorable technologies enable end users to select and integrate functions in the ongoing creation and recreation of unique information systems. They exist as ERP systems, operating system desktops, and word processing software. These technologies are generally tailorable within the confines of the functions provided by their designers. They allow for a certain amount of user expressiveness around such things as computing style, program preferences, and aesthetic layout. Designers have less control over how tailoring occurs as applications move toward user-defined assemblages of distributed, Internet-based services that support the exchange and sharing of data and processes.

Among definitions of technology tailoring, Morch and Mehandjiev (2000) describe it in its simplest terms—the user-defined design of a technology in the context of its use. So in addition to the work of the designers, the user is engaged in a design process. This suggests that designers must support not only their own design processes, but those of their systems' eventual users. In order to better understand how to design tailorable technologies, we will look in this paper at the theories of several designers, albeit in other contexts. Alexander has been engaged in the development of a pattern language "that allows its users to create an infinite variety of [artifacts]" (Alexander 1979, pg. 186). Gargarian's (1993) theory of interactive design attempts to balance a designer's attention between the creation of the artifact of interest and the creation of the tools used to realize the artifact. Pask (1971) used cybernetics to theorize about how to make systems genuinely engaging. Finally, Madsen (1989) argued that metaphor could serve as a vehicle for making tools understandable and accessible.

In the next section we identify some of the most important features of tailorable technologies. With the features in hand, we articulate questions that warrant investigation. Using a case study we examine those questions. Finally, we draw conclusions and make recommendations.

TAILORABLE TECHNOLOGY FEATURES

A large literature in human computer interaction and information systems examines the relationship between human cognition and technology and tells us that users often play an integral role in the modification of a technology, in the context of its use. This is largely a consequence of the fact that it is "impossible to design systems which are appropriate for all users and all situations" (MacLean, Carter, Lovstrand and Moran, 1990, pg. 175). Several features seem important to the success of such systems. These include user engagement, a dual design approach, recognizable components, and reliance upon component architectures.

User Engagement

It is a part of the very essence of tailorable technologies that they be modified in use. So their success is not defined only by meeting particular technological criteria. To be successful, they must engage users. "Man is prone to seek novelty in his environment and, having found a novel situation, to learn how to control it" Pask (1971, pg. 76). In the symbolic domain, control comes through problem solving, explaining, and relating to an existing body of knowledge. Pask argues that humans enjoy this process, particularly when the systems they are using have been designed to support it. He calls those systems which are so designed 'aesthetically potent environments.' They are characterized by having sufficient variety to provide novelty, forms that can be interpreted, cues to guide learning, and enough responsiveness to engage users.

Alexander notes that users employ functional components in the production of a larger whole and through the integration of these components technology takes on desired states for end users. However, a technology that does not provide the technical functionality or an engaging environment for the utilization of components will not be tailored (Alexander, 1979).

Dual Design Approach

A unique characteristic of tailorable technologies is their support of two distinct design phases. First is designing the initial, primary, or default state. Prior to the use of any technology, whether tailorable or not, a default state is designed. Second is the act of tailoring, or the user defined design of the technology during its use.

Gargarian's theory of design, with its emphasis on balancing two kinds of design seems particularly relevant to the design of tailorable technologies. Gargarian argued that in any design process, designers must ultimately attend to two aspects of design: the development of the design environment and the production of the artifact itself. In doing so the designer must balance two tasks, managing design complexity and insuring the expressive utility of the resulting artifact. It is not enough to make it technically possible for users to tailor a system; we must also manage *their* design complexity as well.

To achieve this, designers must recognize that when new artifacts are designed, they alter the design environment leading to new ways of thinking. When the environment is altered, needs for *new* tools are identified. These new tools shape a new design environment and so on. Gargarian calls this method *learning by designing* and artifacts are produced through the cyclic and discursive relationship. User engagement and utility is built into the artifact based on the interplay between the design environment and the artifact. In order to promote engagement and utility, the artifact must support variety and responsiveness and be composed of features that the user is generally familiar with. Tailoring is encouraged through recognizable conventions that regulate and moderate the ambiguity a user might encounter with the artifact. The Gargarian framework, then, emphasizes a process for designing systems that support, and even promote, multiple interpretations of the technology being tailored. Tailorable technologies represent the apex of this dual-design paradigm. Tailorable technologies are not just *expected* to be modified; they are *intended* to be modified.

Components, Conventions, and Metaphor

Through recognizable components, recognizable conventions, and metaphor, people are capable of understanding one thing in terms of another. If users are going to be effective in building things up out of components, designers must pay attention to what they and their audiences know (Alexander, 1979; Gargarian, 1993). Users can induce the rules that define their relationships as with language, where words are the components and rules create the conventions used to connect them. Tailorable technologies then get created by users through the *ad hoc*, opportunistic, and unpredictable application of recognizable components and conventions.

Madsen (1989) argues that we create and tailor workspaces through metaphor. Metaphor "may be used to perceive a situation in a new way and hereby to provoke invention" (pg. 45). Metaphor moves ready-at-hand technology into present-at-hand. It moves unreflective use into reflective use. It involves the user in creating new domains in the use of technology (Madsen, 1989). Users can modify technologies that support metaphor to create new and unanticipated uses, to reflect on their uses of technology, and to restructure their own perceptions of how a technology is used. Metaphorical systems are capable of supporting multiple and conflicting interpretations, and open-ended use patterns.

Component Architectures

Designing any system starts with a collection of components; these components must be partially autonomous so that they can adapt to the local conditions of their use (Alexander 1979, p. 163). For Alexander "design is a process of synthesis, a process of putting together things, a process of combination" (pg. 368) where components are described first and the whole later. Design is ultimately a sequence of increasing complexity where components are added and the whole emerges.

Tailorable technologies are based on the principles of component architecture where users are able to select from a set of components during use (Hummes and Merialdo 2000). Reusable components, located at various nodes, can be integrated by users to form unique configurations (Baldwin and Clark 2003).

Component architectures are a collection of loosely coupled, independent components that can be aggregated in the formation of larger systems (Baldwin and Clark 2003). As users perform new tasks, form new groups, or develop new processes, the technology must support these changes (Wang and Haake 2000). As these uses are flexible, technology must be able to support them and not strictly represent a set of anticipated user actions. Flexibility relies on a component model and the evolution of component relationships during the use of a technology (Domingos and Martins 2000; Wang and Haake 2000).

Tailoring will not occur based on functional characteristics of a technology alone; both the technology and the environment must support and promote modifications in the context of its use. Artifacts, whether a building or software, can be architected to encourage modification, thereby producing unforeseen states derived from the original artifact. The ideas of Alexander, Pask, Gargarian, Madsen, and others support the design of tailorable technologies through the promotion of design environments that supports end user modification.

RESEARCH QUESTIONS AND METHOD

From the four approaches to design thinking that we examined, we identified recurring factors. This approach provides some grounding for the factors while retaining theoretical flexibility (Eisenhardt, 1989). A factor that appeared in all four approaches was about designing technology that is analogous to currently used systems. Nine factors were present in at least two of the approaches. The nine factors served as a basis for a synthetic strategy of process theorizing (Langley, 1999) and allowed us to identify patterns of interaction that can be altered and made actionable through testing and validation (Romme, 2003).

The factors represent proposed, not governing, principles in designing tailorable technologies. They are intended to produce a design process that controls the complexity of designing as well as creates usable technology. Taken together the factors operationalize two design environments: the reflective and the active environments. The reflective environment describes how knowledge and content are used in the *service* of action. The active environment employs the knowledge and content in the *form* of action (Romme, 2003). Table 1 shows the relationship of the factors to both environments.

Reflective Environment

Problem Setting	The technology supports variable tasks and problems.
Recognizable Components	The technology supports components of existing systems.
Recognizable Conventions	The technology supports use patterns from existing systems.
Outward Representation	The technology represents the context which it will be used.
Metaphor	The technology supports symbolic representation.

Active Environment

Tools	The technology relies on existing design tools.
Method	The technology relies on existing design methods.
Functional Characteristics	The technology relies on functional requirements.
User Representation	The technology is designed through representation of users.

Table 1. The Nine Factors Contribute to Design

In the model both the reflective and active environments contribute in the design and production of tailorable technologies. Designing is process driven where outcomes are both future and solution oriented and the reflective environment acts as a set of constraints on the active environment.

Three research questions motivate our theorizing about designing tailorable technologies. First, *which of the aforementioned factors are evident in projects where tailorable technologies are being designed?* Second, *how can we further refine the factors' conceptualizations?* Finally, *what are the patterns of interaction among the factors?*

These questions support theorizing from process data of a single case study (Langley, 1999; Eisenhardt, 1989). We followed the methodology of Langley (1999) and Eisenhardt (1989) to theorize about designing tailorable technologies. Our purpose was to improve the overall grounding of the factors identified through prior literature, to ground our theorizing through the triangulation of evidence, and to build internal consistency by explaining relations among the factors.

Research Setting

As organizations expand computer capabilities, islands of computing form. Integrating these computational islands is one motivator in the development of a web portal. At the case site, the portal was highly integrated with numerous other computing services including email, scheduling, and legacy systems. The web portal provides an interface through which users access data in an integrative and personal way.

The design team consisted of three administrators, three design team managers, and 20 off-site programmers. The test community was defined by the project designers and totaled roughly 220 individuals. The test community was identified independent of our research project, based on their association with prior university computing projects, membership in various associations, and employment within university computer support facilities. The test community included undergraduate and graduate students, university staff, and university administrators.

FINDINGS

The portal technology was intended to provide configurable information portlets ranging from the local news and weather to university-based calendaring and email (D1-I).[2] A goal of the designers was to support unhindered tailoring so users could pick and choose the display and use of any portlet. Restrictions on how users tailored the technology were avoided and the technology was intended to provide anything users demanded, the ability for users to filter any information, and a self-service, user-centric technology (D1-I; D1/3/4-O).

The initial roll out of the technology was considered a working prototype (D2-I). Functionality was continually extended through the addition of new portlets.

During the year-long project, all nine proposed factors were observed. In the remainder of this section we identify the five factors that comprise the reflective environment, refine them, and then illustrate patterns

[2] The first letter indicating **D for a member of the Design Team** and **U for a member of the User Test Community**. Numbering following the D or U indicates different members. Following the hyphen an **I for an Interview**, **O for Observation**, and **D for Documentation**.

between them. We then provide the same for the four active environment factors.

Problem setting has to do with how broadly the technology can be used in support of varied problems. The portal technology supported variability through a design split (U1-I) where functionality was designed into the system yet user portals were individually unique (D3-I). The designers rarely prescribed when or how to use the technology (D1-O; D1-D); instead, they provided flexibility (D2-I; U1-I; U2-I; U4-I). Problem setting was accomplished using functional characteristics (U10) and outward representations of the technology to augment spaces where people were otherwise incapable (D3).

Outward representation is the context in which the technology is used. Both the designers and users recognized that the portal could be used to change existing practices and systems into desired ones, even when these ideals were imprecise. The technology was understood to support changing work practices (U1-I), the evolution of departmental communicative structure (U1-I; U2-I), and cost savings for a department (U6-I). How these changes in practices were to be accomplished was less important than the belief that they could be. The tailorable technology was understood as a significant agent for social change, mirroring an existing environment or context and possibly surpassing it (D3-I).

In order for problem setting to occur and outward representations to be realized, the technology must support **recognizable components**, or components from existing systems and environments. In a retrospective assessment by designers, it was argued that each component of the technology had been selected so as to be approachable and usable (D1-D). Clearly recognizable components included communication tools (D3-I; U9-I; U15-I; U1-I), scheduling (U2-I), access to legacy applications (U2-I), and contact management services (U4-I). The portal followed widely-employed aesthetic conventions of web forms and pages with respect to windows and navigation (D1-I; D1-O).

The technology also supported **recognizable conventions** or use patterns from existing systems. Like recognizable components, this factor was assessed through retrospective looks by designers. Generic conventions were employed by the design team based on patterns of conventional web usability (point and click, hyperlinking) (D4/D5/D6-I). The design team provided conventions by designing the technology to support the addition, removal, and rearrangement or portlets similar to other web technologies (D5-I; D1-O). Other conventions included single login (U2-I; D1/D2-I) and repetitive use patterns throughout the technology (D4-I).

Metaphor was frequently used in describing the technology, acting as a discursive tool in representing the technology. From a user perspective, the technology was symbolized as desktop like (D1-I), an intelligent agent (D1-I), a marketplace (U6-I), and a communication device (U12-I). From an outward perspective, metaphor included the paperless office (U1-I), a tool to reduce organizational silos (D3-I), and a mechanism for porting information from one application to another (U15-I).

These five factors described the reflective environment. The factors were identified and refined, with patterns among the factors beginning to emerge. Recognizable components and conventions supported problem setting. Problem setting along with the use of metaphor, in turn, enabled users to describe how technology was contextualized and subsequently tailored (Figure 1).

With respect to the active environment, tools, method and user representation were all present. Designing the tailorable technology relied on **tools**. The design team used a small portion of the available tools from a software toolbox (D1/D4/D5/D6-O). No formal method for selecting tools was employed; instead they relied on physical proximity of the small team to relate who used which tools for which tasks (D4/5/6-I). There were instances where tools lead to new designs which, in turn, lead to new tools and so on (D1/D4/D5/D6-I).

The learning by designing **method** was used by the team. How tools were used and how management responsibilities were shared were informally determined (D1-O). Every designer worked differently and setting common practices for accomplishing work was considered impractical. The informal approach to sharing common practices pushed each designer to personally select tools, frame their personal design environment, and reevaluate new tools within their own design environment. The management of the design environment was an individual task within the larger group context of producing the tailorable technology (D1/D4/D5/D6-O). The evaluation of when to use particular tools was informal (D1/D3-I) and there were no common practices specified (D1/D4/D5/D6-I). Although the tools were prescribed and the method appeared *ad hoc*, neither seemed to hinder designing the tailorable technology. Instead, the design team worked in cycles, focused on knowing functional characteristic outcomes, designing the solution from their tools and method, and repeating this process (D1/D4/D5/D6-O).

There was no doubt about the perceived importance of **user representations** in the design of the technology (U7-I; U9-I; D1-I), of training users on its use (U1-I; U2-I), and getting their feedback on the technology (U2-I; D1-I). However, in this project, communication between designers and users was limited and users played a limited role in the design of the technology.

Finally, the technology adhered to specific **functional characteristics** in support of technical flexibility. The technology provided an integration of legacy systems (D1-D), mandates on certain components (D1-I), and data sharing (U9-I; U15-I; D1-I). The design team treated functional characteristics as the target to which they aimed their design tools and methods. The functional characteristics, in turn, defined the use of new tools and new methods. Figure 1 shows discovered relationships.

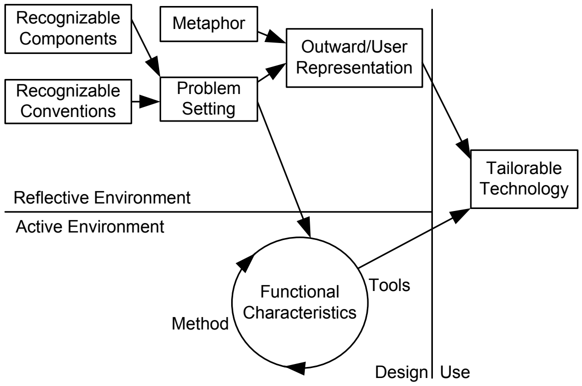

Figure 1. Discovered Relations Between Design Factors

CONCLUSIONS

Designing tailorable technologies consists of two parallel processes with a reflective environment constraining an active environment. The balance between the two environments comes through problem setting, supported by a functionally flexible technology. In the design of a web portal, the designers gave a great deal of attention to the functional requirements and maintaining the flexibility that was the *raison d'etre* of the system's design.

Following the design of a tailorable technology for a year, it became clear that instead of the design team building a singular, functionally tailorable artifact, they were building a framework upon which tailoring can occur. The team focused on building a capable foundation on which users can tailor through the selection, rearrangement, and removal of components based on changing contexts and user expectations. Our model highlights that designing tailorable technologies is the result of two processes: one reflective and the other active. How to maintain the balance between the two is not clear, and it would appear that in this project the active environment received attention at the expense of the reflective.

Our findings lead us to wonder whether technology intended to be tailorable is tailored in practice and if technology that was not intended to be tailorable can be made so through user improvisation. For instance, if non-tailorable technologies are, in fact, modified in the context of use, how should IT professionals respond? Should they prescribe mandates on use, accommodate the changes through software versioning, or let users alter it freely?

Further studies are needed to develop more specific tactics that can be adopted in designing tailorable technologies. Such efforts should explore the relationship sand interaction among factors and environments as well as the mix of research methods needed to study these systems in practice. More effort is needed to contribute to this diversity by strengthening the position of tailorable technologies as unique information systems.

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