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ABSTRACT

The goal of this study is to show how some concepts and techniques from disciplines outside Instructional Systems Development (ISD) have the potential to extend and enhance the traditional view of ISD practice when they are employed very early in the ISD process. The concepts and techniques employed were user-centered in design and usability, and the context was an instructional development project, Indiana University Center for Excellence in Education's (CEE) Virtual Textbook, in the earliest stages of design. One component of the Virtual Textbook is an interactive whiteboard which students will use during groupwork activities. The major goal for the interactive whiteboard study was to understand how representative virtual textbook users, high school students, would interact with the whiteboard with the fewest possible imposed restrictions of an established interface. Five groups of students were videotaped as they constructed a timeline depicting the history of rock and roll music. Findings from sessions and results from discussions with designers are discussed. Each student group employed common strategies and tactics to manipulate either a picture or text item on the simulated shared space. Each group also expressed similar social characteristics in order to manage and complete the timeline. Common strategies and tactics include types of moves; command language; students' language; shared space maintenance; item maintenance; and shared space navigation. Common social aspects include common ownership; turn-taking; strategy discussions; limited collaborative skills; and need to consult at close range. Designers had four major types of reactions to the findings and viewing of videotaped sessions: (1) proposing new and revised features; (2) reconsidering assumptions about students using the whiteboard; (3) questioning the design of the usability sessions; and (4) posing questions to be answered in future usability sessions. (Contains 11 references.) (MAS)

Title:

User-Centered Innovation: A Model for *Early Usability Testing*

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The overall goal of this study is to show how some concepts and techniques from disciplines outside Instructional Systems Development (ISD) have the potential to extend and enhance the traditional view of ISD practice when they are employed very early in the ISD process. The concepts and techniques we employed were user-centered design and usability, and the context of our study was an instructional development project in the earliest stages of design.

What are user-centered design and usability?

We will define user-centered design as a philosophy that places the eventual user of a product at the heart of the design process for that product. Usability is a key concept within the philosophy, and refers to the cluster of attributes commonly considered to determine the ease-of-use a product will enjoy; learnability, efficiency, memorability, error prevention and recovery, and user satisfaction (Nielsen, 1993). The terms are sometimes used interchangeably, and both are used frequently to distinguish product development methods and processes that facilitate the creation of usable computer products (Strong, 1995). The methods and processes associated with user-centered design are derived from multiple disciplines including, among others, human factors, ergonomics, psychology, ethnographic studies, and document design.

One of the fundamental principles of user-centered design is that users must be involved in design decisions for the products they will use. From this principle is derived an iterative approach to design, since the input of users forces designers to reconsider their own decisions and assumptions during the development process. Furthermore, the iterative approach demands use of rapid prototyping techniques to make testable products available early enough in the process that they may be altered, sometimes repeatedly, before they are delivered in final form.

Applying user-centered design and usability to instructional product development

A variety of principles and methods associated with user-centered design appear to overlap in part with elements of the instructional development process, specifically needs analysis, audience or learner analysis, and formative evaluation (Dick & Carey, 1990), but there are not direct equivalents for usability evaluations within standard ISD. Tripp and Bichelemeyer (1989) propose that rapid prototyping and testing techniques from user-centered design can be best applied in: 1) novel designs: those products that are new and/or; 2) problematic designs: those designs that present problems to the development team that have not been successfully solved previously. We chose the Indiana University Center for Excellence in Education's (CEE) *Virtual Textbook* project as a viable candidate for application of usability evaluation methodology to the development of an instructional product.

Applying user-centered design to the concept of an interactive whiteboard

The *Virtual Textbook* project, still in early design stages is defined by its developers as a "single integrated delivery environment" for "a new form of interactive learning" (Siegel, 1992). One component of the virtual textbook is the interactive whiteboard which the designers envision that students will use during groupwork activities. As it is conceptualized, students would transmit text and pictures, among other things, through their virtual textbooks onto the whiteboard and share these items with other members of their group.

There have been some references to interactive whiteboard technology in corporate settings (e.g., Weiser, 1991), but we have found no published studies on incorporating an interactive whiteboard in educational settings; hence, the interactive whiteboard is a novel design problem for this team. Consideration of the interactive whiteboard raises specific issues for the design team, for example, once an item is on the whiteboard, will it be owned by the group or by the original student? The team also faces a larger question: how should the interface between the virtual textbook and the interactive whiteboard be designed? We decided to focus on the issues surrounding the interactive whiteboard for our usability study.

Our major goal for the interactive whiteboard study was to understand how representative virtual textbook users, high school students, would interact with an interactive whiteboard with the fewest possible imposed restrictions of an established interface. We chose to simulate the interactive whiteboard, since use of the commercially-available model would require us to conform to an established interface. To simulate the interactivity of a whiteboard, we used volunteers who put up and took down pictures and text from a regular blackboard in response to students' requests. Students participating in the study were told to direct their requests to the whiteboard instead of the volunteer, and given only minimal instruction on formulating those requests.

We videotaped five groups of either three or four students as they constructed a timeline depicting the history of rock and roll music, an activity that teachers told us was representative of groupwork projects, but which did not overlap with any current projects for these students. Each student was given twenty items, both pictures of rock and roll musicians and text descriptions of these musicians, and the group was given guidelines for the construction of their timeline which they completed during two half-hour sessions. Since the goal of the usability sessions concentrated on the interactions of students with the simulated technology we did not focus on the timeline produced by each group, but on their interactions with the simulated whiteboard. Sugar and Boling (in press) give more detail on the sessions themselves.

Results of usability sessions

There were two major results from these early usability sessions: findings from the sessions and results from discussions with designers. The findings from the sessions are grouped into strategies/tactics and social issues. We presented the findings to the *Virtual Textbook* designers along with several of the usability session videotapes and recorded their reactions. The designer's reactions fell into four categories, 1) proposing new and revised features, 2) reconsidering assumptions about students using the whiteboard, 3) questioning the design of the usability sessions, and 4) posing questions to be answered in future usability sessions

Findings from the usability sessions

After viewing each videotaped session, we identified two major categories of student collaborative interactions, namely: 1) strategies/tactics; 2) social aspects. Each student group employed common strategies and tactics during both sessions. Students used these strategies and tactics to manipulate either a picture or text item on the simulated shared space. In addition to these manipulations, each group expressed similar social characteristics in order to manage and complete the rock and roll music timeline. Below, we have described common occurrences in both these categories.

Strategies/tactics

• *Types of moves*: There were three primary moves that the student groups performed: singular moves, combination moves (e.g., "Put The Beatles at 1969 and take Jerry Lee Lewis down"), and simultaneous moves (those moves that were voiced by more than one subject).

• *Command language*: Each student group use a similar command language pattern in communicating to the shared space. In the beginning of the task, students constructed their commands with a "verb/subject" format (e.g., "Put Chuck Berry in 1950"). Students gradually deleted the verb from the command format and referred to the material by the subject (e.g., "Chuck Berry in 1950"). When student groups were involved with task and not cognizant of communicating formally with the shared space, they relied on using jargon to communicate with the shared space. Examples of these type of jargon included such statements as: "*Slap on* The Byrds close to 1963" or "*Call up* Prince".

• *Students' language*: During group discussions, the volunteer simulating the interactive whiteboard could not always tell whether students wanted to put an item on the board. One student would say that they should put an item up, but another student would disagree, and the language they employed might or might not be construed as direct commands to the interface.

• *Shared space maintenance*: Since the student groups only had a limited amount of space (a maximum of 21 items), the groups eventually confronted the issuing of "cleaning up" or maintaining the shared space. The two groups employed two major strategies in dealing with this issue. Some student groups issued global commands; for example, one group asked to take *all* of the text items off the shared space (e.g., "Take all of the written statements down"). Another major strategy was to designate a certain portion of the shared space to review items.

• *Item maintenance:* Each student group employed common tactics in maintaining their work space. There was an apparent need to sort through their items on their desks. Students would sift their items to figure out which items to include on the timeline; they would put used items in a separate pile. This finding and the previous one indicate a need for a workspace to view several items. This proposed workspace could be located on student's individual virtual textbook or on the common shared space.

• *Shared space navigation*: Before students would put up a item, they checked the whiteboard. There was a constant interplay of students checking the board, their respective piles of pictures and text, checking the board again, and then deciding which item needed to be on the board. Students also needed to figure out a specific location to put their items on the shared space. Students either referred to a specific year on the timeline or referred to a existing item on the whiteboard near which to place pictures or text.

Social aspects

• *Common ownership*: A major question prior to this study was whether students had common ownership of the materials that were held in shared space. That is, if one student put up his or her picture in the shared space, would another student freely move or take down that student's picture? Overwhelmingly, each student group treated the shared space material as common property. Students moved other students' materials to other locations in the shared space and deleted those materials off the board. When there was a disagreement on the transfer or removal of a certain item, it was settled by the dominant group members in that student group, not the original "owner" of the picture or text.

• *Turn-taking*: We expected to see students establish a set of rules on how to take turns in communicating with the shared space. It appears that there were usually one to two dominant students who acted as "gatekeepers" or spokespersons for each student group. These students would direct other students moves. They would either approve or veto the group's decisions. This transfer of power originated from students' need to confirm decisions among group members before putting items on the board. These decisions were mediated through these dominant student(s).

• *Strategy discussions*: After the initial period of putting items on the board, students usually discussed on strategies on how to complete the timeline. These discussions focused on particular pictures (e.g., "who has Jimi Hendrix?") and where to place items (e.g., "where should we put Bob Dylan?").

• *Limited collaborative skills?* The student groups understood their task to be a cooperative one, since they were told that they each had part of the materials required to complete the timeline, and no one of them had everything required. However, none of the groups was observed to organize themselves in preparation for the work, choose a leader (although dominant members emerged in each group), settled on or even discuss a process for their work, or carry out any coherent effort to plan the task. Various groups were observed to spend time ineffectively, marginalize one or more members who were later discovered to have information needed by the group, and backtrack through actions due to misunderstandings.

• *Need to consult at close range?*: Even though there was a restriction on sharing items among themselves (in order to maximize observed interactions with the whiteboard, and to simulate the probability that virtual textbook screens might not be large enough to use for this kind of

consultation) and groups were reminded of the restriction, students consistently consulted with each other by holding up and passing around pictures and text items.

Results from discussions with *Virtual Textbook* designers

The virtual textbook designers had four major types of reactions to our presentation of these findings and their viewing of videotaped sessions; 1) proposing new and revised features, 2) reconsidering assumptions about students using the whiteboard, 3) questioning the design of the usability sessions, and 4) posing questions to be answered in future usability sessions. We believe these reactions gives insight into the potential impact of the usability sessions on the process of designing instructional products and the possible impact of user-centered design on the instructional systems design (ISD) process.

• *Proposing new and revised features for the whiteboard*: The designers had envisioned the functionality of the interactive whiteboard within the virtual textbook environment to the extent of representing some of its major features in a "conceptual video" mock-up, but once they were presented with findings of the usability sessions and the videotapes, they began to speculate on both new and dramatically revised features the whiteboard might have. Among other things, they discussed the development of a new command set within whiteboard interface, and designing a horizontal whiteboard instead of a vertical one.

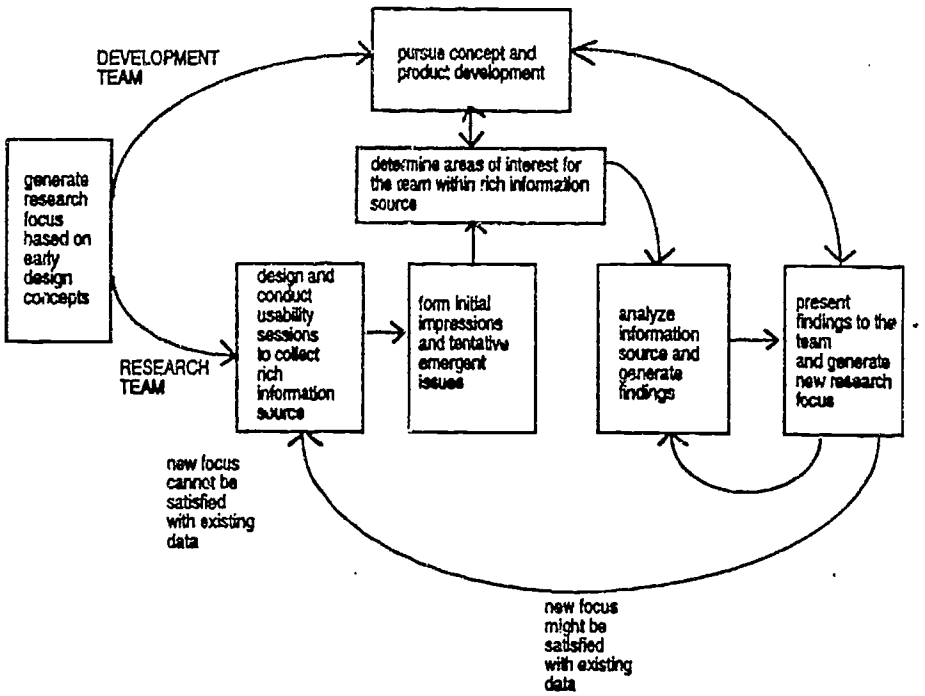
• *Reconsidering assumptions about students using the whiteboard*: The designers showed considerable interest in the findings concerning strategies/tactics and social aspects described in the preceding section and spent time discussing how to redesign and reconceptualize the interactive whiteboard in response to this more detailed view of the students who would use the technology. Should the whiteboard interface try to compensate for limited collaborative skills? If so, how? Should the whiteboard interface encourage or discourage the "gatekeeper" function observed in every group?

• *Questioning sessions' design*: The designers wondered whether students were comfortable with addressing the "simulated" whiteboard and suggested that future usability sessions should focus on students groups working without an interactive whiteboard to answer some of their new questions about how students work together and to limit the admittedly confounding effect of the simulated technology. The designers were enthusiastic about the possibility of conducting further usability sessions, in spite of their questions about the design of this one.

• *Posing questions to be answered in future usability sessions*: The designers posed a variety of questions they wanted answered through future studies: do students need to touch their documents rather than indirectly manipulating them? how should students cue their commands with the interface? what type of order needs to be imposed with a common work space? will the same social dynamics occur among students if the usability sessions were altered? what impact is the whiteboard technology having with the social dynamics? Though there were no conclusions among designers about the design of the *Virtual Textbook* interactive whiteboard interface, there was tremendous amount of creativity exhibited by the design team during the discussions of these usability sessions.

Early usability testing model

The model represented in this paper describes how we conducted usability tests in relation to the design and development work ongoing in the *Virtual Textbook* project. Although our study used two separate teams to conduct tests and carry out ongoing development, the model could as easily describe parallel activities by members of a single team. The model cycles back into itself, demonstrating the difference between usability studies and experimental research; the focus of usability studies is contained within a project and the results of the studies guide further design efforts. There is no expectation that findings from these studies will generalize outside the project for which they are conducted, although they may be of great interest to designers working on similar projects.



Some anticipated criticism of the *early usability testing* model is that this testing is simply formative evaluation. Tessmer (1993) points that the rapid prototyping technique is similar to "repeated formative evaluations." Although the evaluation techniques are similar in usability testing and traditional formative evaluation, the key difference between the two is how early in the process and how often a product is evaluated. In describing the rapid prototyping techniques of his ID2 theory, Merrill and his associates comment that the instructional systems development (ISD) approach assumes that there will be no actual product until the later stages of the process (Jones, et al, 1992). The *early usability testing* model provides designers the opportunity to assess and evaluate their concepts and assumptions during the earliest stages of a design. The model also presumes that the evaluation process will be carried out several times during the development process, giving designers the opportunity to adjust designs in situations where they have little prior experience to gauge the probable success of a product.

Implications for the ISD process

What impact does this model have for the ISD process? In our experience with this study, *early usability testing* may impact the ISD process in four ways; 1) condense ISD process; 2) refine prescriptive methods; 3) encourage a cyclical process; and 4) concentrate attention on the human elements of the process.

• *Condenses ISD process*: The results of user-centered design evaluations provide insight for the next analysis phase, and can give rise early in the process to questions that might not otherwise be asked until a product is almost ready to be implemented. Catching and considering a wider range of issues for design at the beginning of a project may reduce overall development time, especially in cases of novel or problematic technology.

• *Refines prescriptive methods*: *Early usability testing* also gives instructional designers the opportunity to test the prescriptive methods they are encouraged to develop by Reigeluth (1983). Through each redesign phase of the *early usability testing* model, designers can refine these methods with the goal of having the most effective methods for their final product. We would assert that refined methods developed using an *early usability testing* model must be more effective than prescribed methods tested only once under a traditional ISD model.

• *Encourages a cyclical process*: Dumas and Redish (1993) differentiate between two types of process models: *assembly line* and *cyclical team* models. In the assembly line process, designers develop their products in successive and separate phases. There is a dearth of feedback between each of the phases. An example of this model is where a design team develops a product during the development phase, and then, the marketing department (a different set of individuals) evaluates the same product. There is limited communication between these two groups and thus, assumptions and realizations of the design team are *not* communicated to the marketing department. In contrast, the cyclical team process, a design team performs each step of the design process (e.g., analysis, development, evaluation). The assumptions and realizations of the design are fully communicated to each member on the design team. The *early usability testing* model is explicitly cyclical, encouraging both communication between all team members and re-examination of prior decisions on each repetition of the cycle. We are *not* suggesting that all instructional designers who follow the traditional ISD process are using an assembly line process. However, the traditional ISD model presents cyclical development as a desirable option, not as a requirement.

• *Concentrates on the human element in the process: Early usability testing* seems to give the eventual user of an instructional product a consistent "presence" within the development process. Once designers have observed real people use even an approximation of their product at the earliest stages of conception, they tend to refer back to those people throughout the project to visualize the effect that future design changes might have on them.

Conclusion

Our study has only touched the surface of the issues, and we know that some of the controversies that attend user-centered design accompany its introduction into ISD, for example, the question of cost/benefit analysis for the additional effort spent conducting usability sessions and debates over specific methodological applications for one type of project and another. However, our experience suggests that the possibilities for incorporating user-centered design concepts, and specifically usability testing, in the ISD process deserve consideration and further study.

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