

Journal of
EDUCATIONAL
MULTIMEDIA
and
HYPERMEDIA

Journal of Educational Multimedia and Hypermedia

Volume 11, Number 4

2002

UNIVERSITY OF
WISCONSIN
MADISON

School of Education

Center for Instructional Materials and Computing

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The *Journal of Educational Multimedia and Hypermedia* (ISSN 1055-8896) is published quarterly by the Association for the Advancement of Computing in Education (AACE), an international, educational, nonprofit organization. Annual US membership/subscription rates: \$95 individuals; \$130 schools, libraries, and other institutions. Annual non-US membership/subscription rates, add: \$15 per journal for postage. US funds, international money order, VISA, MC, AMEX, or Discover.

Publisher: AACE, PO Box 3728, Norfolk, VA 23514-3728, USA 757-623-7588

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An Evaluation of the Learnability of the *Justice Bao* Button-Less Interface

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The learnability of a software user interface is an important aspect of software design. This study evaluates the learnability of an instructional game entitled *Justice Bao*. It attests issues related to "button-less" interface that uses an object on screen as a "clickable" object for various functions. It also highlights some issues with regard to the use of text labels to instruct users on the functions of a "clickable" object. Some guidelines in the design of button-less interface are suggested.

The interface of instructional multimedia plays an important role in framing students' learning experience because it instructs the learner how to behave within the created environment (Lohr, 2000). It delimitates its use and thus the user experience (Mardsjo, 1996). The interface has significant impacts on the way the user thinks and works (Rheingold, 1990). Thus, researchers (Kuittinen, 1998; Pham, 1998) have suggested that the evaluation of user interface is one of the important components of the research and development cycle of instructional software.

This study evaluated the learnability of the interface of an instructional game entitled *Justice Bao*, designed to motivate students in doing Chinese language drill-and-practice questions at the primary school level. Learnability is defined as the ease with which new or occasional users may accomplish some task using the interface. It is commonly measured by the number of

trails, that a new user needs to complete a task without being trained (Linggaard, 1994).

The motivation for evaluating the learnability of the *Justice Bao* interface is threefold. First, as instructional software, its interface should not be difficult to learn and not interfere with the learning of the subject matter (Lee, 1996). Second, as a game, its interface design should be easy to learn or the player may abandon it quickly (Crawford, 1990). Third and most importantly, the interface of *Justice Bao* adopted an experimental design format, the "button-less" interface. We are particularly interested in exploring how users perceive this button-less format. Chen, Wong, and Hsu (2002) posited that the interface design of instructional software should use objects on screen, as much as possible, as "clickable" objects to activate various functions and interactions. They argued that the usual design of buttons and icons are metaphorically inappropriate and objects on the screen that are more contextually meaningful could replace them. Consequently, the button-less design format may yield a more learnable interface. The present evaluation attests issues related to the "button-less" interface. Findings of this study will advance our understanding of learnability of the button-less interface design format and provide practical suggestions for designing more usable interface.

The *Justice Bao* Instructional Game

Justice Bao is divided into two inter-related components: (a) the study of the case that is carried out in the courtroom (Figure 1) and (b) the investigation process that is carried out in the town (Figure 2).

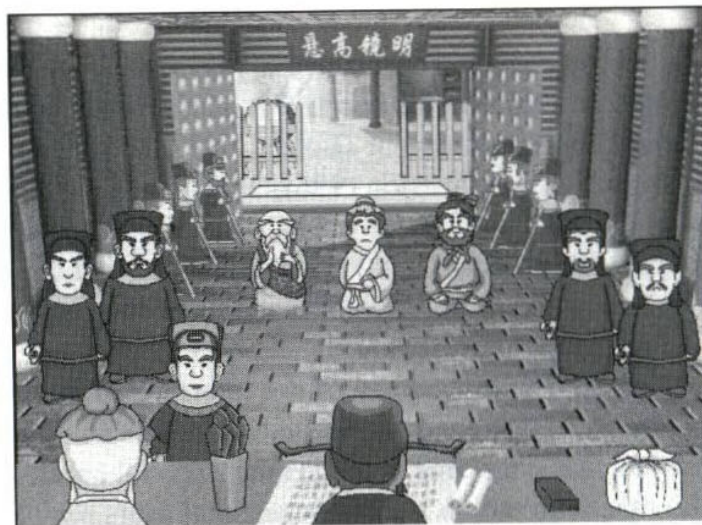


Figure 1. The courtroom

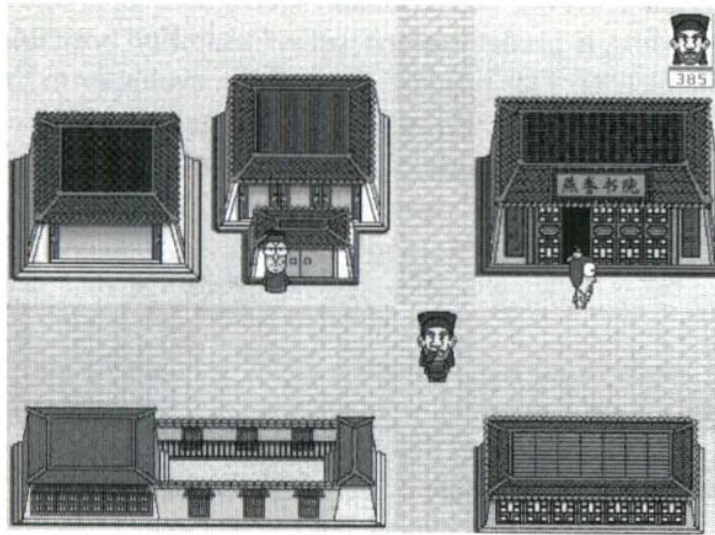


Figure 2. A section of the town

The story opens with an animation of a crime in progress. A thief has stolen some valuable that was hidden in a temple. A monk discovered the crime and brought it before Justice Bao. Justice Bao then summoned the three suspects to the courtroom to give their statements. The three suspects are the monk, a carpenter, and a scholar.

In the courtroom, the user plays the role of Justice Bao. He or she activates the statements by clicking the suspects in turns. After listening to the suspects' statements, the user sends a detective into the town. In the town, the user assumes the role of the detective. To solve the case, the detective navigates through the different areas of the town, interacts with the people to gather information and answers numerous questions posed by the system. The detective is rewarded with different magical objects that help him to solve the crime each time he answers a question correctly.

METHODOLOGY

This study was conducted in two phases. The first phase was to focus the evaluation by identifying potential problematic areas and determine the evaluation methods. The second phase was to carry out the main evaluation.

Phase 1: Focusing the Evaluation

Phase 1 consists of reviewing the design documents, interviewing the designers and participating in the internal reviews (Seels & Glasgow, 1998).

During the internal reviews, the evaluator performed heuristic evaluation (Nielson, 1993) using a predetermined set of usability principles adapted from Lee and He (1998). This process allowed the evaluator to gather background information of the design approach and gain experience with the program to facilitate the identification of potential problems.

Results of phase 1 suggest that the evaluation of the user interface should be divided into two parts: (a) the courtroom interface, and (b) the town interface. This is because potential problems for the two parts are quite different.

In the courtroom (Figure 3), because some functions do not have a direct logical link to their respective activating objects, text labels were provided as additional aids. These text labels will appear only when users move the mouse over those objects. There is a concern whether the text labels adequately inform the users of their functions. In the town, potential problems lie in assigning the detective icon to house all system related functions (e.g., save, exit, help). Figure 4 shows a screen shot of the different objects housed in the dialog box after the detective icon is activated.

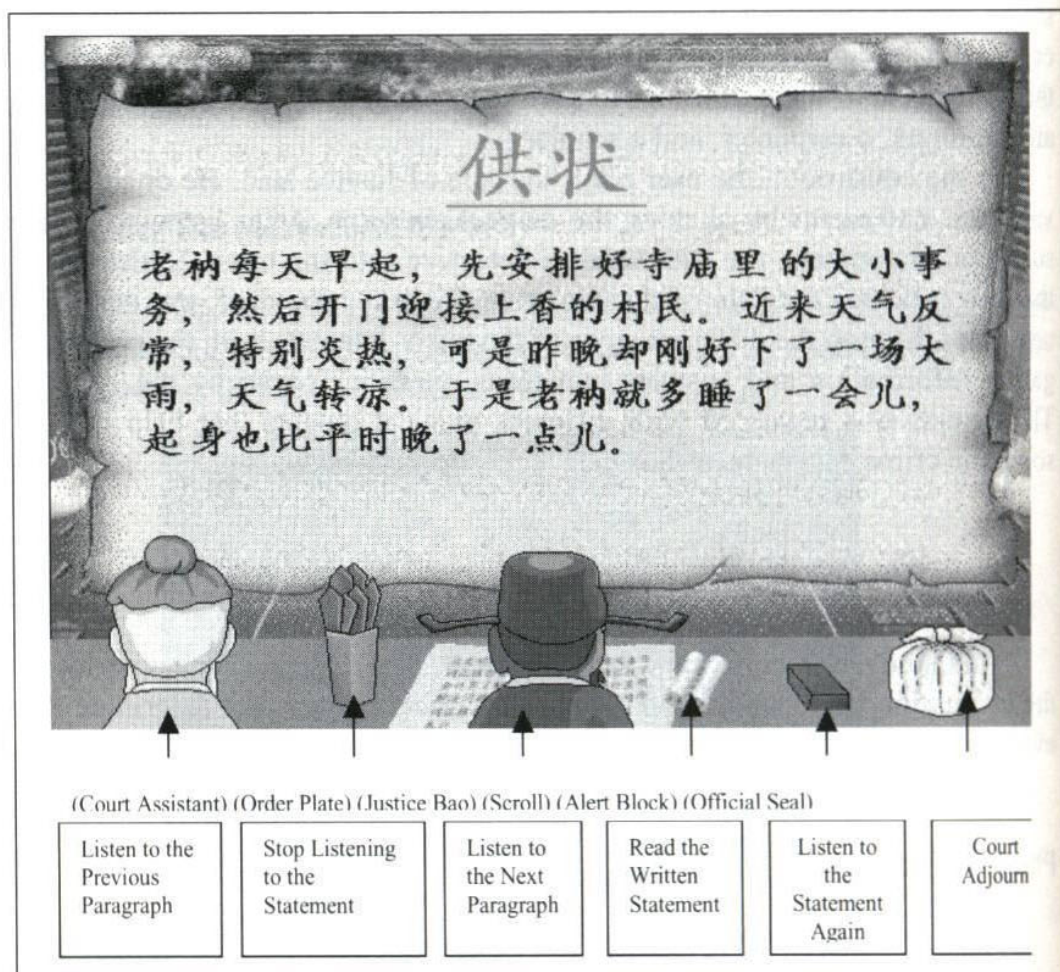


Figure 3. Screen shot of the courtroom and the clickable objects

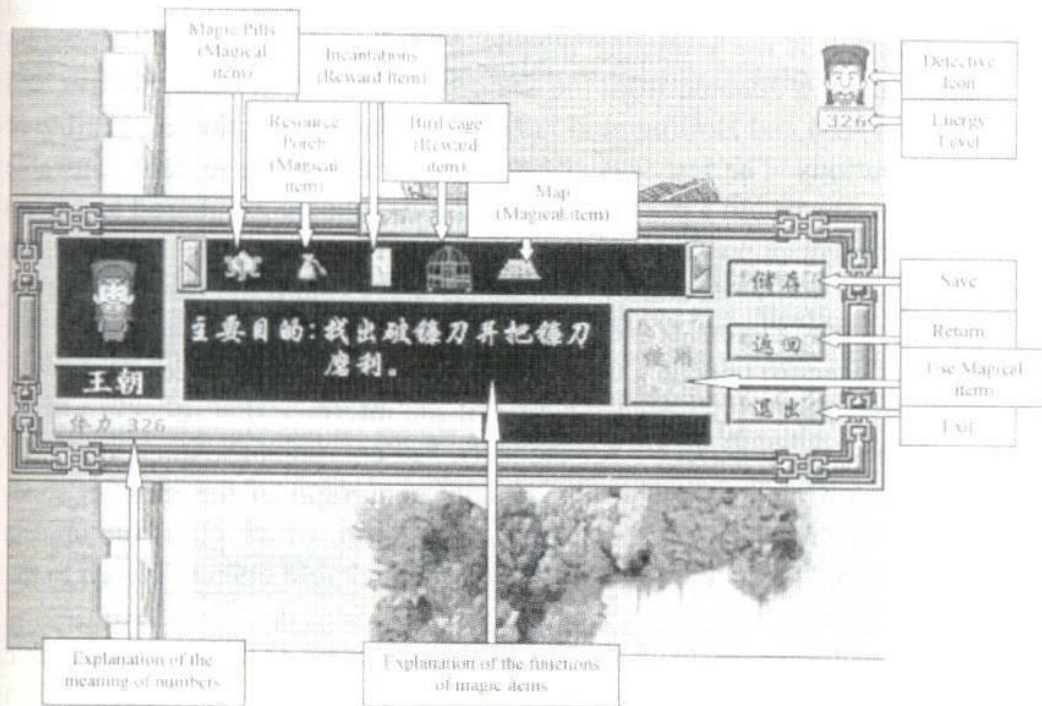


Figure 4. Screen shot of the dialog box

Phase 2: The Evaluation

The relevant evaluation methods and method of data collection were chosen based on the evaluation focus. Table 1 gives an overview of the evaluation methods and method of data collection.

Table 1
Evaluation Questions, Evaluation Methods Means of Data Collection

Evaluation focus	Evaluation Method	Means of Data collection
The Court	Scenario-based Prediction and Constructive interaction	Multiple Choice Questions (MCQ) Test Observation, video recording
The Town	Constructive interaction	Observation, video recording

The first evaluation method was scenario-based prediction. It evaluated the learnability of the clickable objects in the courtroom. Scenario-based prediction is a test adapted from the design of Bewley, Roberts, Schroit, and Werplank (1983) and Boiling et al., (1998) for measuring the learnability of icons and buttons. The test was constructed by assigning to each clickable object in the courtroom a number. An additional choice numbered as "0" indicated that there is no such clickable object. The courtroom interface, together with the numbers, and the text labels that explain the functions of the clickable objects (Figure 3) were shown to the users. Simple scenarios that required the users to choose a clickable object were constructed. They were chosen from a list of possible scenarios of the interface that users are likely to encounter (See Appendix 1 for the test). For example, the question "Suppose you have finished listening to the 3rd paragraph of the monk's statement and you wish to listen to his statement again, which clickable objects will you choose?" tests the learnability of the clickable object "Listen to the Statement Again."

Based on the scenario in the question, the users identify the clickable objects and fill in the respective number to indicate their predictions. Two scenarios were created for each task to check that the users' responses are consistent. The responses would be considered to be in agreement if they were both correct or both incorrect. Two extra pairs of scenarios without an applicable clickable object (i.e., the correct answer should be 0) were created because the heuristics evaluation revealed possible misinterpretations of these scenarios. A total of 33 test users were recruited to perform the test.

The second evaluation method was constructive interaction. It is a form of usability test that requires a pair of test users to discuss aloud while performing some tasks together. Constructive interaction is especially suitable for the present evaluation because the software is most likely used for pair-work in the classroom setting. At the same time, as the test users are young, asking them to follow the instructions for a standard think aloud test and verbalize their intentions and actions is too demanding (Nielsen, 1993). It will be more natural for them to verbalize their thoughts while discussing with a familiar companion.

The constructive interaction required the one pair of test users to complete two test tasks without any training. The first task was to listen to and read all the statements given by the three suspects in the courtroom. This is to evaluate whether or not users have any problem with the courtroom user interface (Figure 3). The second task was to obtain the scythe, which is the first key object for solving the crime in the town. Again this was to evaluate the learnability of the detective icon and the various functions as shown in

Figure 4. Two pairs of test users participated in constructive interactions. The constructive interaction was followed by an interview to clarify the evaluator's observation and interpretation of the interaction.

RESULTS

Results of the Scenario-based Prediction are shown in Tables 2 and 3. The agreement between the responses for each pair of questions was used as a means to check the trustworthiness of the responses made by the subjects. Table 2 shows that the agreements of all question pairs was at least 70% indicating that the test results for all questions were acceptable.

Table 2
Agreement of the Scenario-Based Prediction

Question No.	Total No. of responses	No. of responses that were in agreement	Agreement (%)
Q3 & Q7	33	24	73
Q5 & Q10	33	24	73
Q2 & Q4	33	26	79
Q9 & Q15	33	23	70
Q8 & Q11	33	23	70
Q13 & Q16	33	25	76
Q1 & Q14	33	32	97
Q6 & Q12	33	25	76

Table 3 summarizes results of the scenario-based prediction. Three of the six clickable objects were able to convey their functions satisfactorily (with at least 80% accuracy). The other three clickable objects are confusing to the test users (less than 10% accuracy).

The constructive interaction showed that users did not activate the detective icon; they did not show any sign of understanding of the rewards and the magical items; and the users did not make use of the magical items. When students were asked to predict what functions those magical items might be, the responses were not even close.

Table 3
Summary of Scenario-Based Prediction

Question	Clickable Objects Tested	No. of responses that were in agreement	No. of correct responses	Correct response in percentage (%)
Q3 & Q7	Listen to the Previous Paragraph	24	20	83
Q5 & Q10	Stop Listening to the Statements	24	1	4
Q2. & Q4	None	26	0	0
Q9 & Q15	Listen to the Next Paragraph	23	20	87
Q8 & Q11	Read the Written Statements	23	2	8
Q13 & Q16	Listen to the Statement Again	25	2	8
Q1 & Q14	None	32	0	0
Q6 & Q12	Court Adjourned	25	21	84

DISCUSSION

Based on the results of the evaluation, two issues stand out vividly. The first issue is the learnability of the text labels and the second issue is related to the button-less interface. These two issues are discussed in detail.

Text Labels

Boiling et al., (1998) found that employing text labels enhanced the learnability of buttons. However, in the present study, we cannot make such a straightforward conclusion. Based on the results, three out of the six text labels in the courtroom were able to depict their functions satisfactorily to the test users. They are "Listen to previous statement," "Listen to the next statement," and "Court Adjourned." Their high learnability is perhaps due to the fact that they corresponded to the usual functions (previous, next, and exit) that can be found in most instructional multimedia. However, the other three were low in learnability. It seems that the learnability of text labels cannot be taken for granted. Some thoughts are needed before text labels are employed. Three areas of consideration are proposed.

First, the text label must represent as accurately as possible the function of the object. The three text labels with low learnability showed a possible confusion due to differences in interpretation between the user and the designer. For example, activating "Listen to the statement again" would allow the users to replay the animation (questions 13 & 16) and listen to the statements embedded in the animation. However, the label chosen does not indicate that the animation can be replayed. As a result, most of the test users were unable to choose the correct clickable object if they want to replay the animations. This affects the learnability of that particular text label. Confusion may also arise when the use of words is not precise in meaning. For example, the text label "Read the Written Statement" (tested by questions 8 and 11) was confusing because the Chinese word "read" fails to differentiate the automated read aloud function from the one showing the written statement for silent reading. If "read" had been changed to "read silently" or "re-examine," the user would be able to understand it better. Furthermore, when more than one function is associated with an object, it may be better to choose the most important function to describe. For example, when activating "Stop listening to the statement" (tested by questions 5 and 10), it would not only stop the user from listening to statements but also send the user back to the courtroom interface. Since going back to the courtroom is cognitively more remote than stopping listening and therefore will need to be made known to the user more explicitly, it would be clearer if the text label had been "Go back to courtroom."

A second consideration for text labels is that they must minimize misinterpretations that might occur due to possible user actions. That is, considerations should be given to possible intentions of users when they interact with the program. For example, if the user's intention was to do silent reading, he or she might mistake the text label "Stop listening to the statement" as the function they need. Another example is the "Court Adjourned" function. In the scenario-based prediction where the users were given the task to exit the program (Questions 6 and 12), 84% of the subjects chose "Court Adjourned." However, with the same object, in the constructive interaction, when the users intended to go into the town, they also chose "Court Adjourned." The above two examples show that users will interpret the interface according to their intentions even though sometimes the function may not exist. Understanding the users' intention at decision making points help the designer choose more appropriate text labels that can minimize misinterpretations.

Third, the vocabulary of the text labels must match the literacy level of the target users. For example, because test users in one group were unable to

pronounce the words that appeared in some text labels, they were unable to understand the functions of these text labels correctly. Thus, it is important that when designing the text labels, the designer should choose words appropriate at the literacy level of the target users. This is especially crucial when the software is intended to be used by children.

To choose text labels that avoid all of the previously mentioned problems may be too idealistic. All languages have within themselves elements of ambiguity. However, the designer should strive to minimize confusion by avoiding possible ambiguity in the choice of language. The key to achieving this probably is to adopt a user-centered design approach where user interface issues and technical considerations are both the focus of the design activity. The user-centered design approach involves users and takes their needs into account throughout the design process (Preece, Benyon, Davies, Keller, & Rogers, 1993).

Button-Less Interface

Results of this evaluation have raised some issues related to the button-less design. Although both groups of test users were able to complete the test tasks, none of them realized that the detective icon is clickable. None of the test users realized that they could make use of the objects, which they obtained from answering questions correctly, to expedite the completion of the game. As a result, none of the test users made use of any magical items to help them to complete the tasks faster. These findings, together with the data collected through scenario-based predictions, point to the following issues of the button-less design format.

First, button-less interface requires the users to locate the clickable spot or objects and thus may reduce the learnability of the program. Interface design using buttons provides the user with a set of easy to locate buttons. Users do not have to spend time learning where the buttons are. Button-less interface, on the other hand, hides its functions behind objects on the screen. The user may fail to locate the clickable spots and this creates usability problems. For example, from results of the study showed that failing to notice that the detective icon is clickable caused the users to miss important information such as what the number below the icon represents. The users were also unable to learn how to use the magical items. To inform the users where the clickable objects are, the designers have to find ways of making the clickable objects salient. Examples of such design include highlighting the object when the mouse moves over, use contrasting design (e.g., sizes or

color schemes) so that clickable objects are distinctly noticeable from other contextual objects.

A second issue of the button-less design format is that it requires the user to relearn the interface each time he/she uses a new piece of software. Buttons that represent functions such as forward, previous, replay, and stop are almost standardized features in most educational software. They, in general, require little effort to relearn and thus have high learnability. For button-less interface, the designers have to make use of objects available in the scene. This means that different software may have different objects that represent the same function (e.g., previous or next). The users will have to familiarize themselves with a new set of objects if they use a different program. From the constructive interaction, it was observed that both groups of test users were trying out some objects to learn their functions. This would presumably be unnecessary if "standard" navigational buttons were used.

Third, users of different background may interpret the function of the same object differently. An example is the use of the magical porch in *Justice Bao*. To the ones who are familiar with the specific historical background of the Chinese culture, it denotes help. To the test users, however, such connotation did not exist. Another example is the scroll on Justice Bao's table. By clicking the scroll, it denotes opening it for reading. Unfortunately, such connotation did not exist to the user either.

Finally, button-less interface appears to require more effort to design. The previous discussion has highlighted the need to provide additional functions to enhance the learnability of button-less interface (e.g., highlighting the objects or using text labels). In addition to the design efforts in preventing user errors, it is equally important to proactively inform the user of the various interface features. One way could be to incorporate instructional animation at the beginning of the software. Again, this requires additional design effort. Furthermore, a button-less format also requires more effort in the analysis of the virtual environmental that the interface creates. This is illustrated in the design of the courtroom. The arbitrary assignment of functions to different objects and characters in the courtroom posed problems in selecting metaphorically compatible objects. To create a seemingly integrated button-less interface for the courtroom may require the selection of a new setting with enough natural objects in it for the assignment of various functions. To ensure that the objects chosen are metaphorically appropriate, an in-depth analysis of the metaphor (e.g., using the POPIT framework: Properties, Operations, Phrases, Images, and Types; Cates, 1994) is necessary. Also, while buttons can be easily grouped together in a designated area on the screen, objects, on the other hand, have to be placed where they naturally belong in a setting. For example, the objects found on Justice Bao's table

cannot be shifted to some other location in the courtroom where they do not belong. In other words, location of objects of similar functions (e.g., navigational) may be distributed in a button-less interface. Again, more effort is needed to tackle this design issue.

CONCLUSION

This study evaluated the learnability of an experimental button-less design format. Results of the evaluation suggest that button-less design format has the potential to present the interface in a cohesive and learnable manner. However, it is not without extra cost. More effort appears to be required to design a learnable button-less interface.

On the other hand, although this evaluation has discovered a number of learnability problems of the *Justice Bao* button-less interface, most of them can be overcome with careful thoughts of the implications. The fact that the users were able to complete the two test tasks without being taught, suggests that it is possible to design button-less interface with high learnability. However, the designers have to make an effort to ensure that possible problems are minimized. Adopting a user-centered design paradigm through incorporating usability activities such as cognitive walkthrough (Wharton, Rieman, Lewis, & Polson, 1994) and Scenario-based Prediction may help reduce these learnability problems. Although at the present moment it seems that button-less interface requires more effort to design and learn, it would be too precipitant to rule out this design format. To date, this design format is still in its experimental stage. When the designers accumulate more experience in designing button-less interface, better guidelines will be developed and the accumulated knowledge base may in the future reduce the design effort. This may also be the same in terms of learning the button-less interface, if users are more used to the idea of interpreting interface using contextual clues on the screen. Apparently more research is needed in this rather unexplored ground.

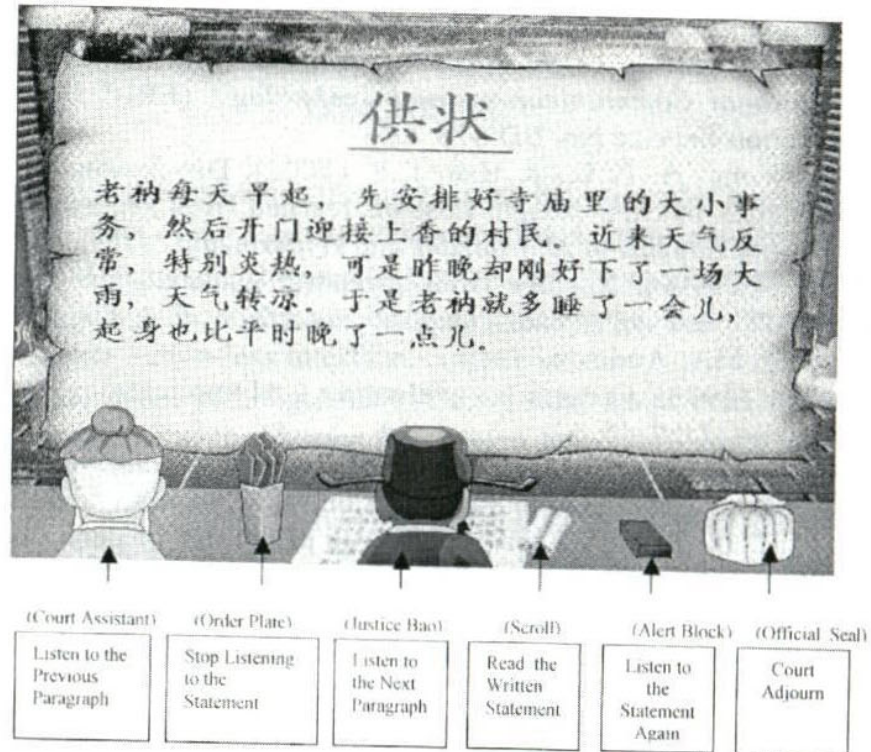
References

- Bewley, W.L. Roberts, T.L., Schroit, D., & Werplank, W.L. (1983, December). Human factors testing in the design of Xerox's 8010 "Star" office workstation. In *Proceedings of ACM CI'83 Conference*, Boston, MA, (pp. 72-77).

- Boiling, E., Beriswill, J.E., Xaver, R., Hebb, C., Kaufman, D. & Frick, T. (1998). Text labels for hypermedia navigation buttons. *International Journal of Instructional Media*, 25(4), 407-422.
- Cates, W.M. (1994) Designing hypermedia is hell: Metaphor's role in instructional design. In *Proceedings of Selected Research and Development Presentation at the National Convention of the Association for Educational Communications and Technology*. (ERIC Document Reproduction Service No. ED 373 706)
- Chen, D., Wong, A. F. L., & Hsu, J. F. (2002). Dimensions of metaphor consistency in CBL design: Lessons learned from Project Justice Bao. *Journal of Education Multimedia and Hypermedia*, 11(3).
- Crawford, C. (1990). Lessons from computer game design. In B. Laurel (Ed.). *The art of human-computer interface design* (pp. 103-113). Reading, MA: Addison-Wesley.
- Kuittinen M. (1998). Criteria for evaluating CAI applications. *Computer & Education*, 31, 1-16.
- Lingaard, G. (1994). *Usability testing and system evaluation: A guide for designing useful computer systems*. London: Chapman & Hall.
- Lohr, L.L. (2000 January/February). Three principles of perception for instructional interface design. *Educational Technology*, 45-52.
- Lee, S.C. (1996). Evaluation of the user interface for Chinese instructional multimedia programs. *International Journal of Instructional Media*, 23(3), 219-227.
- Lee, S.C. & He, Z.H. (1998). *Educational software interface design* [Computer software]. Taipei: Liwil Publishing.
- Nielsen, J. (1993). *Usability engineering*. Cambridge, MA: AP Professional.
- Mardsjo, K. (1996). Interface technology. *Computers and Composition*, 13(3), 303-315.
- Pham, B. (1998) Quality evaluation of educational multimedia systems. *Australian Journal of Educational Technology*, 14(2), 107-121.
- Preece, J., Benyon, D., Davies, G., Keller, L., & Rogers, Y. (Eds.), (1993). *A guide to usability: Human factors in computing*. Wokingham, England: Addison-Wesley.
- Rheingold, H. (1990). An Interview with Don Norman. In B. Laurel (Ed.), *The art of human-computer interface design*. (pp. 3-10). Reading, MA: Addison-Wesley.
- Seels, B., & Glasgow, Z. (1998). *Making instructional design decisions* (2nd ed.). Upper Saddle River, NJ: Prentice-Hall.
- Wharton, C., Rieman, J., Lewis, C., & Polson, P. (1994). The cognitive walkthrough method: A practitioner's guide. In J. Nielson & R. Mack. (Eds.), *Usability Inspection Methods*. New York: John Wiley and Sons.

Scenario Prediction of Clickable Objects for *Justice Bao*

Number:



According to the scenario given below, choose a 'clickable' object that you will use. Indicate your choice by filling the number that denotes the clickable object that you have chosen in the box given. Please take note that 0 denotes that there is no such 'clickable' object, i.e. the software does not provide this function.

0	1	2	3	4	5	6
No such clickable object	Listen to the Previous Paragraph	Stop Listening to the Statement	Listen to the Next Paragraph	Read the Written Statement	Listen to the Statement Again	Court Adjourn

1. Suppose you have finished listening to the 3rd paragraph of the monk's statement and you wish to listen to his statement again, which clickable objects will you choose?

Ans

2. Suppose you wish to read the statements by yourself and do not want the computer to read aloud for you, which clickable objects will you choose?

Ans

3. Suppose you have finished listening to the 3rd paragraph of the monk's statement and you wished to listen to the 2nd paragraph again, which clickable objects will you choose?

Ans ☐

4. Suppose you wish to read the statements silently, which clickable objects will you choose?

Ans ☐

5. Suppose you wish to go back to the courtroom to choose another suspect to give his statement, which clickable objects will you choose?

Ans ☐

6. Suppose you wish to quit from the program, which clickable objects will you choose?

Ans ☐

7. Suppose you have finished listening to the 6th paragraph of the scholar's statement and you wished to listen to the 5th paragraph again, which clickable objects will you choose?

Ans ☐

8. Suppose you have finished listening to the 7th paragraph of the monk's statement and you wish to read the statement silently before viewing the animation, which clickable objects will you choose?

Ans ☐

9. Suppose you have finished listening to the 2nd paragraph of the carpenter's statement and you wish to listen to the 3rd paragraph, which clickable objects will you choose?

Ans ☐

10. Suppose you wish to go back to the courtroom, which clickable objects will you choose?

Ans ☐

11. Suppose you have finished listening to the 2nd paragraph of the carpenter's statement. The animation has started automatically but you wish to read silently the statement again before you view the animation, which clickable objects will you choose?

Ans ☐

12. Suppose you wish to stop using this game software, which clickable objects will you choose?

Ans ☐

13. Suppose you wish to view the animation again, which clickable objects will you choose?

Ans ☐

14. Suppose you have finished listening to the 2nd paragraph of the carpenter's statement and you wish to listen to his statement again, which clickable objects will you choose?

Ans ☐

15. Suppose you have finished listening to the 4th paragraph of the scholar's statement and you wish to listen to the 5th paragraph, which clickable objects will you choose?

Ans ☐

16. Suppose you want the computer to replay the animation, which clickable objects will you choose?

Ans ☐

Thank you very much for your precious input.