ABSTRACT
In the field of education, multimedia courseware development can be viewed as a process of system development. In this process, two major phases are system analysis and system design. In the phase of system analysis, the structure of the courseware is determined (structuring); in the phase of system design, the details of each screen are determined (storyboarding). This paper will present a study that investigated the effects of different methods and tools for structuring and storyboarding on multimedia courseware design in two sections: (1) Structured Modeling, and (2) Storyboarding.

INTRODUCTION
Multimedia courseware development is a process of system development (Liu, 1999), and Burch (1992) described a traditional system development life cycle (SDLC) that consisted of seven phases and was widely applied in commercial and industrial fields. The seven phases are: (1) systems planning, (2) systems analysis, (3) General (or conceptual) systems design, (4) systems evaluation and selection, (5) detailed (or functional) systems design, (6) systems implementation, and (7) systems maintenance. In the field of education, especially for the purpose of developing interactive multimedia instructional applications for classroom teaching/learning, Beasley (1998-99) modified the traditional SDLC into four major phases: (1) systems analysis, (2) systems design, (3) systems implementation, and (4) systems maintenance. In the systems analysis phase, the major problems are identified (Grabowski & Drons, 1994; Henderson, Gold & Tindall, 1996; McDeniel & Liu, 1996), the scope of the system is determined (Burch, 1992; Beasley, 1998-99), and task/concept analysis is performed (Fankhauser & Lopaczuk, 1996; Vrasidas & Harris, 1995). In the system design phase, output layouts are designed for all screens, special forms, and printed reports. All inputs are specified and formats, both screen and paper forms, are also approved. Based on the output and input designs, specific processes are designed to convert the input to outputs (Burch, 1992; Henderson, Gold & Tindall, 1996). According to these designs, detailed tasks of the system are implemented. The system is developed and converted to operation (Burch, 1992). Then the system is maintained until next life cycle.

There are different methods that have been used to perform the tasks in each phase. In the phase of system analysis, the structure of the courseware is determined (structuring); in the phase of system design, the details of each screen are determined (storyboarding). This paper will present a study that investigated the effects of different methods and tools for structuring and storyboarding on multimedia courseware design in two sections: (1) Structured Modeling, and (2) Storyboarding.

Section I: STRUCTURED MODELING
Multimedia in the field of education is defined as computer controlled interaction among several media such as texts, graphics, sounds, videos, etc. (Reed, Ayersman, & Liu, 1995; Stier, 1994). Research has shown that the capabilities of multimedia learning environments to store, interconnect, and provide access to a wide range of knowledge represented with all the media provide significant affordances to enrich student learning (Bagui, 1998). A multimedia learning environment can be viewed as a multimedia system, and its system analysis can be implemented with the modeling tools to deal with the complex interactive relationships among all the media—when, what, and how to link them together.

The questions are: when using the modeling tool, for example, structure chart, how should we develop a model that best fits the purposes and requirements of the system? What is the appropriate way to structure the chart? A literature suggests that it is easier and more effective to use graphical tools or concept mapping tools to organize knowledge and create diagrams to navigate through instructional hypermedia program (Chavero, Carrasco, Rossell, & Joes, 1998; Chou & Liu, 1998). Also, Paivio (1986) proposes a dual-coding hypothesis that if information is resented in both visual and verbal formats, stronger learning should result. In system analysis, the verbal format may be an outline analysis, and the visual format may be a structured diagram analysis. Does Paivio’s (1986) hypothesis support the information representation in the system analysis? Does verbal analysis present a model as effective as diagram analysis does? Or are the relationships (links) of a multimedia application produced from verbal analysis more interactive than from diagram analysis? Few studies have addressed the above questions.

Purposes and Research Questions
Specifically, the purpose of this study was to investigate the effectiveness of three methods of...
system analysis in designing the links of a multimedia application. The three methods of system analysis were: (a) free style method, (b) outline method, and (c) structured modeling method.

The following research questions were examined in this study:
1. Is there any difference between the link designs of a multimedia application produced from free style system analysis method and with structured modeling system analysis method?
2. Is there any difference between the link designs of a multimedia application produced from outline method and with structured modeling method?
3. Is there any difference between the link designs of a multimedia application produced from free style method and with outline method?

It was hypothesized that the differences would exist.

Methods

Subjects The subjects of this study were 45 teacher education students enrolled in a basic computer technology course in an eastern state university. The subjects' ages ranged from 18 to 42 (the average age was 22.36), including 11 males and 34 females. Around 90% of them had no previous computer skills, beyond using a word processor.

Procedures The task of this study was to develop a multimedia application on certain teaching topic they chose. The software used for this task was HyperStudio, a multimedia program with which a set of Cards can be created and linked linearly or non-linearly. Each card can contain text, graphics, and sounds. The buttons in each card performs the links.

The students were randomly assigned into three groups. Before the students worked on their HyperStudio cards, they were required to do the system analysis, that is, to make a plan to determine how many cards they were going to create, what would be in each card, and how these cards would be linked together. Three system analysis methods were employed: (1) Free style method. This was not a particular analysis method. The students started to work on the first card, and thought about what would be in the next card. After they created several cards, they decided the way to link them. (2) Outline method. This was a verbal presentation of their application. They wrote an outline about what would be in each card and how the cards would be linked. (3) Structured modeling method. This was the diagram method. They created a diagram, or structure chart to present a visual structure of their application. A concept mapping tool Inspiration was used to draw the diagram or chart. Each group applied one method to plan their application.

The system analysis method was the independent variable for this study, with three levels indicated by the three methods described above. The links they created in their Hyperstudio stack were compared.

Measurements of Link-Designs

The link-design scores were the sum of three link-measurements. (1) Linear links. This was the lowest level of links—the cards are linearly connected, from one card to the next card, from first card to the last card in one direction. Linear links would be scored 10 points. (2) Layers of links. This was the medium level of links—the cards are connected in several layers. Each layer would be scored 4 points. (3) Interactions. This was the highest level of links. Two kinds of interactions were measured: (a) interactions among cards in one layer scored 5 points; (b) interactions among cards across two layers scored another 5 points, and across three layers for another more 5 points . . .

Research Method and Data Analysis

This study employed an experimental method. This was not a completely random design, the subjects were an existing group of students. However, they were randomly assigned to the three groups. Therefore, it was assumed that all other conditions were under control and different system analysis methods would result in the differences of the link designs.

According to the design of this study, one-way mixed model ANOVA was the appropriate method for data analysis. A SAS macro MIXANOVA (Fernandez, 1997) was used to perform the data analysis and assumption checking. The plots obtained from this macro showed that the assumptions of normality, equal variance, and extreme influential outliers were not violated. The significant level for these analyses was set at $\alpha = 0.05$.

Results

First, the results of descriptive analysis showed that the mean of free style group (group A) was 9.93, the mean of outline method group (group B) was 22.36, and the mean of structured modeling method group (group C) was 36.70.

Second, the results of analysis of variance are shown as in Table 1. As shown in the results, significant differences among the three groups were found ($F_{2.42} = 55.34, p < 0.0001$), indicating that the treatments—the three system analysis methods—did make difference in the response variable, the link designs.

Third, a comparison analysis was performed to determine where the differences were. The results are shown in Table 2.
### Table 1. Results of Analysis of Variance

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
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<td>1118.80000000</td>
<td>26.63809524</td>
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<tr>
<td>Corrected Total</td>
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<td></td>
<td></td>
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</table>

### Table 2. The Results of Comparison Analysis

<table>
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<tr>
<th>contrast</th>
<th>DF</th>
<th>Contrast SS</th>
<th>Mean Square</th>
<th>F Value</th>
<th>Pr &gt; F</th>
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<tbody>
<tr>
<td>a vs b</td>
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<td>b vs c</td>
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<td>874.80000000</td>
<td>32.84</td>
<td>0.0001</td>
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<tr>
<td>a vs c</td>
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<td>2940.30000000</td>
<td>2940.30000000</td>
<td>110.38</td>
<td>0.0001</td>
</tr>
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</table>

The results in Table 2 show that all the three $F$ ratios are significant, indicating that (1) significant differences were found between free style group and outline group ($F_{1,28} = 22.81, p < 0.0001$); (2) significant differences were found between outline group and diagram group ($F_{1,28} = 32.84, p < 0.0001$); (3) significant differences were found between free style group and Structured modeling/diagram group ($F_{1,28} = 110.38, p < 0.0001$).

The comparison plots obtained from the analysis also show that (1) the measurement mean score of the diagram group is higher than that of free style group and that of the outline group; (2) the measurement mean score of the outline group is higher than that of free style group.

**Conclusions**

The findings of this section suggest that using structured modeling tool in the system analysis of a multimedia application development will produce more interactive links with more layers than using outline method or free style method.

When using Inspiration to perform system analysis, students may benefit from the visual effect of the structured chart or relationship diagram. The chart or diagram can provide the structure of existing relationships, based on which students can add more links. Although, Inspiration has the function to switch between diagram view and outline view, the structure (the concept map in Inspiration) is created first in a diagram view, then it can be switched to outline view. If the structure is started from an outline, the situation will be different. An outline is a verbal information presentation. When working on an outline structure, students need to first mentally convert it into a graphical structure, which requires certain cognitive abilities. Some may not be able to perform this cognitive process; they may stay with the verbal format that will not stimulate their imaginations of complex relationships.

Another suggestion derived from the results is that the use of Inspiration is not limited to concept mapping. Inspiration is also an efficient tool for system analysis and for multimedia application development. Further studies may be conducted, with a larger sample size, to investigate the differences among linear links, layers of links, and the interactions of links.

The findings also provide evidence that it is necessary to integrate the knowledge of system analysis into the multimedia design or instructional design courses for teacher education students. Also, system design can be applied to numerous applications—such as database design, courseware design, and Web application design. It is believed that there are many potential problems in this field that need to be explored.

**SECTION II: STORYBOARDING**

Storyboards contain all the information that will be placed on the screens (in the screen templates), in addition to information that will assist the programmer and production specialists in development of the media components. Storyboards serve as the blueprint for the program. The detailed storyboards contain all the descriptive information required to produce the text, graphics, animations, audio, and video. Also, the links for each button or interaction are specified.

Traditionally, storyboards are written on 5 by 7 index...
cards. One card is one screen, all the elements designed for that screen should be on the card. In the index card, the exact information should be displayed. For example, the screen number, the text content, and questions. The Graphic should be in the right position. The background colors and designs should be specified...

Another traditional method of writing storyboards is using some paper forms. This is similar to index card except the size of the paper. In the screen component form/table, all elements are listed and there left the space for detailed explanation.

With more and more multimedia applications available for the courseware applications, evidently, neither index-card nor paper-form storyboarding can “tell” all the detailed information to the designer. Therefore, some methods, based on the idea of taking the advantage of technology to solve problems, should be adapted. Considering the format, properties and purposes of storyboarding, we found PowerPoint has the potential to be a useful tool for creating storyboards. PowerPoint slides can contain the same components as in index cards or paper forms, as well as many visual components, such as graphic object, colors, and so on. However, there is no evidence in the literature to show the use of PowerPoint as a storyboarding tool. There is no other experience to show either positive or negative of this method. In our technology courses, our students are the designers of multimedia applications. The issues are whether our students could learn multimedia design more effectively with this tool, whether this method would work well, whether using PowerPoint as a storyboarding tool would be better than the traditional storyboarding methods.

Purposes and Research Questions:
The purpose of current study was to determine a better storyboarding method among the three methods: index card, paper form, and PowerPoint, so that our students could effectively learn multimedia instructional designs. Considering the different learning experiences, styles, and knowledge background between undergraduate students and graduate students, we examined two research questions in this study:

1. Are there any differences among the evaluation scores of multimedia designs created by undergraduate teacher education students who used different storyboarding methods (index card, paper form, and PowerPoint), regarding to the quality of screen design, interaction, orientation, and navigation?
2. Are there any differences between the evaluation scores of multimedia designs created by graduate teacher education students who used different storyboarding methods (index card and PowerPoint), regarding to the quality of screen design, interaction, orientation, and navigation?

Methods
Subject and Sampling This study was undertaken from two dimensions with two groups of students: undergraduate and graduate teacher education students. The subjects were from the College of Education in an eastern state university, including 87 undergraduates from six technology classes, and 72 graduates from four technology classes. The undergraduate classes used HyperStudio to create a multimedia instruction segment, and the graduate classes used Toolbook and HyperStudio.

Instrument Instrument used to evaluate students multimedia instructional design was a criteria list consisted of 10 items that have been used in many studies (Ivers & Barron, 1998):
1. Content
2. Language
3. Screen displays
4. Visual images
5. Interactions
6. Orientation
7. Navigation
8. Input, response analysis and feedback
9. Help, evaluation & record keeping
10. Technical consideration

Under each item, there was a detailed checklist. Each quality item was scored from 1 to 10, where the score of 10 was the best. We selected four quality items—screen displays, interactions, orientation and navigation—for the purpose of this study. Because, the quality of storyboarding would directly influence these four design qualities.

Design and Data Analysis In this study, we used existing classes as the convenient sample. However, in each of the six undergraduate classes, students are randomly assigned into three groups using different methods (Index card, paper forms, and PowerPoint); and in each of the four graduate classes, students were randomly assigned into two groups using different methods (Index card and PowerPoint). We sorted the undergraduate students’ scores of the three groups cross six classes, and the graduate students’ scores of the two groups cross the four classes. This was not a completely random design; we only focused on the interested levels of the quality criteria—screen display, interaction, orientation, and navigation. According the purpose of the study, repeated measures were employed for data analysis. For each group, the four quality criteria were repeatedly measured.

SAS system was used for the data analysis, and assumptions for repeated measures were checked. The two sets of data did not violate the assumptions of equal variance, normality, and extreme outliers. Therefore, we consider that the statistics results of the repeated measures explain the situation of the data well.
Table 3. Test of Fixed Effects (Undergraduate Groups)

<table>
<thead>
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<td>Score</td>
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<td>Method* Score</td>
<td>6</td>
<td>264</td>
<td>30.66</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Results The results of the data analysis shows that significant differences were found among the three groups of undergraduate students' multimedia application design quality scores (see Table 3). As shown in Table 3, the differences are significant among the quality scores of multimedia application design created with different storyboarding methods ($F = 452.72$).

Also, as in Figure 1, quality scores of PowerPoint method group is significantly higher than that of paper forms group ($t = 25.70, p < 0.0001$), and that of index card group ($t = 26.41, p < 0.0001$). There is no difference between the paper form group and index card group ($t = 0.71, p < 0.4784$). From the mean score plot, we can see the quality scores of the four criteria in PowerPoint group are higher than those in paper form group and index card group.

Table 4. Test of Fixed Effects (Graduate Groups)

<table>
<thead>
<tr>
<th>Source</th>
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<th>Pr &gt; F</th>
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</thead>
<tbody>
<tr>
<td>Method</td>
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<td>0.0001</td>
</tr>
<tr>
<td>Score</td>
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<td>218</td>
<td>22.09</td>
<td>0.0001</td>
</tr>
<tr>
<td>Method* Score</td>
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<td>218</td>
<td>56.65</td>
<td>0.0001</td>
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</table>

The results of the data analysis shows that significant differences were found among the two groups of graduate students' multimedia application design quality scores (see Table 4). The differences are significant among the quality scores of multimedia application design created with different storyboarding methods ($F = 607.07$). Figure 2 shows where the differences are:

Conclusions

In conclusion, as the answers to the two research questions, for both undergraduate and graduate teacher education students, using PowerPoint as the storyboarding tool will produce better design in a multimedia application. The screen display, interaction, orientation, and navigation designs were significantly different (higher scores) from the designs using index card or paper forms in storyboarding. The PowerPoint group showed the high quality of design in the for area: (1) The screen frames were properly designed to achieve balance, harmony and simplicity; color and text styles were used appropriately; and special effects were used properly. (2) Interaction possibilities were maximized and properly designed. (3) A natural sense of
dialogue was created with the user; users could control the pace or sequence; screens were properly labeled so users could easily find out where they were—orientation. And (4) Users could easily get where they wanted to go—navigation.

The findings also suggested that although undergraduate and graduate students are different in their learning experience, knowledge background, and thinking skills, the results of the two groups are similar. Figure 3 and 4 showed the same pattern of the differences. This indicated that this method worked well for both groups, and could be used in the technology courses for both groups.

One interesting question was why this method made the differences. When students used index card or paper forms, they only could imagine and put in something that was to be created. However, when using PowerPoint, the storyboarding process is a pre-design process. They could visually arrange the screen, for example, they could put the exact object (buttons, cliparts, or pictures) on the right position. This made the implementation process much easier and they could sense visually. The author of this paper ever conducted a study (Liu, 1999), using a visual tool—Inspiration—to structure multimedia application that enabled students to create flowchart that visually showed the structure of the courseware. That study found out it was more effective using Inspiration than using paper flowchart in designing the interactions cross several layers of the structure.

The findings from Section II also alerted the idea that technology can be used as a tool not only for improving our daily work but also for developing other technology applications. More and more new technologies are available now. We would not only think about how to use them to solve old problems, but also think how to use them to create new applications.

REFERENCES


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