THEORIES, TEMPLATES, AND TOOLS FOR
DESIGNING AND DEVELOPING
INSTRUCTIONAL HYPERMEDIA SYSTEMS

by
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(ABSTRACT)

In recent years, hypermedia has been widely adopted in education. It is extolled as a highlighted medium for the coming educational reform. Although many practitioners as well as theorists support the adoption of hypermedia in instruction, some negative effects have been reported. There is not much "instruction" in most existing hypermedia systems. Also, most hypermedia courseware designs are based on the capabilities of technology, not on instructional theories or research findings.

Another issue related to the adoption of hypermedia in instruction is the exclusion of teachers in the courseware production process. Hypermedia is much more complex than traditional computer-based learning materials. A school teacher without a strong technology background has a great deal of difficulty in producing such a complex learning system. Courseware production also demands more time, cost, and effort than a school teacher can afford.

In this study, the author explored the principles and theories relevant to the design of effective hypermedia courseware. A courseware template was constructed to exemplify
the design of a complete instruction. A project template based on an instructional design model and software engineering principles was proposed to manage hypermedia production more effectively and efficiently. The author also developed a set of courseware tools to decrease the technical skill requirements and to facilitate the coordination of a production team.

These templates and tools were implemented and refined in a hypermedia production project. This project produced a courseware unit in a context with rather limited time, cost, and effort. This courseware product had also been tested in a real classroom setting. Feedback was positive and new units are under construction. The successful completion of this courseware project verified the usefulness of these templates and tools.

Reflections on the development and implementation of these templates and tools are discussed. Future work based on this study is suggested. The author expects that adopting and adapting hypermedia for education will contribute to the realization of more democratic and scientific instruction. Directly or indirectly, such instruction will help us to establish a more desirable society.
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Chapter 1

Introduction and Literature Review

This dissertation is about the design and development of instructional hypermedia systems. Although popular in industry, existing hypermedia systems have not had the expected effects on instruction. This study, therefore, reviews the problems of implementing hypermedia systems in instructional settings and proposes solutions to those problems.

This chapter begins with a general introduction and contains several literature reviews. The general introduction describes the background and problems of using hypermedia in instruction. The goal and framework of this study is addressed. This chapter also explores the historical development of hypermedia from three perspectives: concept, related technologies, and instructional contexts. A second review addresses the theoretical bases and discusses the potentials and pitfalls of hypermedia in instruction. The last part of this chapter reviews what researchers have found about the implementation of existing hypermedia systems in education.

I. Introduction

Hypermedia is a rising star in instructional media (Boone & Higgins, 1991). It has two major characteristics which make educators enthusiastic. One is the non-linear
association of information (Lee & Lehman, 1993; Marchionini, 1988; Marsh & Kumar, 1992). The informational fragments in the hypermedia environment are linked based on users’ real-time decisions, not on a predetermined sequence. The other characteristic is the use of multiple information formats (Moore, Burton, & Myers, under contract; Muhlhauser, 1992). Text, charts, photographs, animation, video, voice, and music are examples. These two characteristics have excited the imaginations of many educators. They expect that the non-linear association will put an end to arbitrary teaching styles and encourage active, individualized learning (Carr, 1988; Marsh & Kumar, 1992; Nelson & Palumbo, 1992). They also expect that the multiple information formats will not only motivate learners, but also more faithfully and efficiently represent the knowledge (Moore et al., under contract).

A. The status quo of hypermedia

Although the concept of hypermedia extends back to the 1940’s (Fraase, 1991; Jonassen, 1992b), only in recent years has hypermedia become a reality. It is now widely accepted through the computer industry, commerce, and education. In the computer industry, hypermedia is first realized by the integration of a relational data base and multimedia technology. Then, computer engineers use hypermedia systems to construct network-structured data bases and manipulate external audio-visual devices. Through remote communications, a hypermedia system can become a world-wide knowledge base. For the information industry, hypermedia systems are authoring tools or communication tools. HyperCard and Mosaic are two examples.

In commerce, many libraries, museums, and publishing companies use hypermedia systems as resource tools to dynamically link and search information. Business companies emphasize hypermedia systems’ ability to control video and sound. They use hypermedia systems to make an attractive presentation or demonstration. The application of
hypermedia in commerce is as a resource tool or a presentation tool. For instance, Grolier’s electronic encyclopedia is a resource tool, and numerous information systems in public kiosks are presentation tools.

Fascinated by the success of hypermedia systems in industry and commerce, practitioners as well as theorists of education embrace hypermedia with great eagerness. More and more systems are implemented in instructional settings (Nelson, 1990; Thompson, Simonson, & Hargrave, 1992). It is even extolled as one of the most promising media for the coming educational reform (Campoy, 1992; Dede, 1992; Tobin & Dawson, 1992).

Although enchanted by the powerful medium, educators need to be aware that most existing hypermedia systems are not intended for instructional purposes (Nelson & Palumbo, 1992; Small & Grabowski, 1992). In general, they are used as authoring tools, resource tools, or presentation tools. Only a few of them are designed for teaching or learning.

B. Hypermedia as an instructional tool

Although having no doubt of computers' role in education, we should not embrace computer technologies without knowing their relevance to instruction (Moore, Myers, & Burton, 1994; Snelbecker, 1987). Gagne, Briggs, and Wager (1992) have identified nine internal activities in the learning process: reception, registration, selective perception, rehearsal, semantic encoding, retrieval, response generation, performance, and control. They further assert that instruction is a set of external events deliberately arranged to support internal learning activities. Based on the analysis of learning process, they propose nine corresponding instructional events:

1. gaining attention,
2. informing learner of the objective,
3. stimulating recall of prerequisite learning,
4. presenting the stimulus material,
5. providing learning guidance,
6. eliciting the performance,
7. providing feedback about performance correctness,
8. assessing the performance, and
9. enhancing retention and transfer (p.190).

Sometimes, some of these instructional events are provided by learners themselves.

Nevertheless, instruction should have considered all of these nine instructional events to be complete.

In designing computer-based instruction, Alessi and Trollip (1985) further suggest that instruction should include four phases: presenting information, guiding learning, practicing, and assessing achievement. Missing any phase will cause instruction to fail.

If hypermedia systems are going to have a significant role in instruction, they must function in most elements of the instructional process. From the viewpoint of instruction, most existing hypermedia systems are not suitable media. They are not a complete, total instruction. Even those hypermedia systems which are used in schools are only aids for one or two elements of the instructional process. To fulfill the expectations most educators have for hypermedia, the design of instructional hypermedia systems must be drastically changed (Ambrose, 1991; Jonassen, 1992b).

**Problems with adopting hypermedia in instruction**

Theoretically, the concept of hypermedia has a great potential to revolutionize instruction (Muhlhauser, 1992; Nelson & Palumbo, 1992). It provides many functions which are essential to the realization of democratic and individualized instruction. Nevertheless, in practice, the effects from adopting existing hypermedia systems are far
short of our expectations. To date, there are at least four obstacles preventing hypermedia from fulfilling its promises for instruction.

1. *Hypermedia designs are not based on instructional theories or research.*

   Historically, educators have seldom invented technologies for instructional purposes. They have simply adopted outside technologies, and then developed theories to justify the adoption of those technologies. Slide projectors, televisions, computers, and videos are examples. Adopting outside technologies may not be bad for education. However, we should direct their usage to fit the needs of instruction and carefully examine their effects.

   Without theories and research we cannot assure the usefulness of technologies in education. Even if a technology does succeed in a context, without theories we cannot generalize its application to other contexts. Theories form a basis on which we can decide why and how to use technologies (Moore et al., 1994; Snelbecker, 1987). Today, unfortunately, most of the design of hypermedia systems are based on the fantasy of technologies, not on instructional theories and research findings. Once the novelty of the technology fades, these systems became trash in instruction (Clark, 1985; Moore et al., under contract).

2. *Hypermedia systems are not used appropriately.*

   There are two common situations in which hypermedia systems are used inappropriately. One is that teachers do not adopt hypermedia systems based on their instructional needs (Cates, 1992). They are excited about technologies and simply use any available hypermedia system in their instruction. These teachers will eventually find out that it fits nowhere in their courses. This embarrassing situation may also be attributed to the insufficiency of hypermedia courseware.
The second situation is that teachers do not add essential instructional elements to the existing hypermedia systems. As mentioned earlier, most hypermedia systems are not designed for instruction. They do not have all the elements critical to effective instruction. In order to make those systems useful, teachers must know how to supply the missing instructional elements (such as presenting objectives or assessing learning achievement) to those hypermedia systems.

3. Grassroots development is difficult, if not impossible.

Gayeski (1989) has pointed out that though each decade has witnessed the coming of new instructional technologies, most of them have failed. Cost, complexity, and incompatibility are the main causes for their failure. This history is repeating itself in the development of hypermedia. The cost and time of producing hypermedia courseware is beyond the reach of most educational institutions. The techniques and resources required to produce hypermedia courseware are beyond the resources of most grassroots developers (Gleason, 1991). Teachers who actually use hypermedia courseware are excluded from their production. The exclusion of grassroots producers eventually will hold back the dissemination of hypermedia systems in instruction (Grimes & Potel, 1991).

4. Both the lack of standards and the rapid change of technologies prevent the circulation of hypermedia systems.

In spite of the fact that the price of computers has dropped drastically in the last two decades, schools still are hesitant to purchase computers and courseware. The problem comes from the lack of standards and the rapid change of technologies. Without standards, computer manufacturers make products incompatible with others. Due to sharp competition, most manufacturers and their products rapidly disappear from the market. Any investment in them is lost.
Even those schools which stay with their existing products lose their investment. New products come on the market in relatively short periods of time. The purchased equipment and systems become outdated in no time. People joke: "When a computer is shipped, it is already obsolete." The continuous upgrading of computers and software is an obstacle to promoting computer-based instruction. Compared with TVs and overhead projectors, computers are not cost-efficient. They are too unstable to be promoted in a budget-tight school environment.

Need for this study

This study intends to address some of the problems mentioned above. The author believes that hypermedia can enhance instruction and help students achieve an ideal education. Nevertheless, with the deficiencies in existing hypermedia systems, we need to improve the courseware design and production in order to fulfill their potentials (Cates, 1992; Morariu, 1988; Park, 1991). The major goal of this study is to construct theory-based templates and devise useful software tools to facilitate the design and development of "instructional" hypermedia systems.

The first step is to establish the theoretical bases for the design and use of hypermedia courseware (Park, 1991). Technologies are useful in carrying out the ideal of education, but only theories can prescribe the ideals of education. Therefore, the use of technologies in instruction should not be simply for the sake of technologies themselves (Ambrose, 1991; Cates, 1992; Jonassen, 1992c; Moore et al., under contract). There must be theories and research to guide and refine the application of instructional technologies. Eventually, the theoretical bases of a technology will determine why and how it is used in instructional contexts.

In the field of instructional technology, many theories and research do exist. However, there is a wide gap between theories and applications. Theorists and researchers
explore a problem with assumptions. They set up propositions and examine the results. For them, instruction is descriptive. But, designers and instructional practitioners know the result they want. They just need to know how to reach the predetermined result. For them, instruction is prescriptive.

Theories and actions are different in nature. A template is suggested to connect the theories and applications. A template is a model or a skeleton which shows theories in pseudo contexts (Boone & Higgins, 1991). It serves as a demonstration of how theories should work. At the same time, a template is also a semi-product. As real data are added to the template, it is easily transformed into a product (Gleason, 1991). A template saves time, money, and effort in production without losing its theoretical value. It shows how action realizes theories. Theorists and researchers will learn from templates what variables need to be considered in implementations. Designers and practitioners will also get benefits from templates by giving theoretical value into their practices.

As Kirst and Meister (1985) have suggested, any innovation should involve constituencies and stay within cost constraints in order to persist in educational settings. Gleason (1991) and Gayeski (1989) also point out that any successful implementation of technology must involve the participation of grassroots users. The grassroots users of instructional technologies are teachers. They know the learning needs and they will decide how to use these technologies (Cates, 1992). Teachers are the determining factor for successful implementation of hypermedia systems. However, hypermedia is a cutting edge technology. The production of hypermedia courseware includes structuring subject content, prescribing learning strategies, computer programming, controlling external devices, and media production. Even with user-friendly authoring systems, producing hypermedia courseware still is beyond the skills, time, and available resources of the average teacher. Without easy-to-use templates, most teachers find such a complicated task
impossible to perform. Without teachers' participation, hypermedia courseware will not be appropriate and sufficient for school instruction.

This study uses theories and research findings to build a courseware template. The courseware template sketches the screen layouts and control flow of an instructional hypermedia system. It can be applied in different instructional contexts. Simply substituting the subject contents in a courseware template will produce usable instructional materials. Although not a "plug and use" system, the template can save time, cost, and effort in producing courseware (Boone & Higgins, 1991; Gleason, 1991). Teachers can use this template as a skeleton and then fill in subject content to make usable learning material. They can also use this template as a base to make their own creation. This new template represents a new approach to deliver instruction. As the number of courseware templates increases, the flexibility of instruction also increases.

To remind producers of the important instruction factors, this study also devises a project template based on an instructional design model. This project template suggests the roles of team members and regulates the procedures of producing courseware. At the same time, courseware tools are developed to ease the technical demands and facilitate team cooperation.

These templates and tools not only reflect the application of theories and research, but also simplify the effort and reduce the cost. They will make the participation of local teachers in producing hypermedia courseware a possibility.

In order to illustrate and validate the usefulness of these templates and tools, a sample of courseware is produced. This study selected an instruction unit from a real course subject and used these templates and tools to create the courseware. From this process, their functionality is examined. The production activities and result also illustrate the process of implementing these templates and tools. During and after the production,
templates and tools were refined to meet the challenges encountered. The end products also clearly explain the theories on which those templates are based.

Finally, the resolution of standardization and continuous change of computer hardware and software is beyond the reach of this study. However, if we produce hypermedia systems based on common templates, compatibility between courseware products is achieved. The burden of exporting, maintaining, and upgrading courseware can then be greatly decreased.

Framework

In this section, the framework of this study is described. To avoid confusion, terms used in this study are defined at the last part of this section.

A. Scope of this study

As the title suggests, the target of this study is limited to instructional hypermedia systems. An instructional hypermedia system is defined as a particular hypermedia courseware which contains all or most of the elements of instruction. This study is not concerned with hypermedia systems used as authoring tools, presentation tools, or resource tools. The concern of hypermedia systems here is on their use for education, not for business or industry.

The developmental platform of these hypermedia systems is Macintosh computers with HyperCard and Quicktime systems. However, the proposed theories and templates apply to all mainframe and micro computers. The ideas of the courseware tools, although based on HyperCard system, can be used with other computer platforms. For instance, Multimedia Toolbook in IBM PC has similar functions to HyperCard.

In general, the production of a hypermedia system requires teamwork. But, due to limitations of time and financial support, in this study the author plays most roles of a
production team. A unit of sample courseware is produced rather than a complete course. The graphics, video, and sound in this sample are prototypic. The accuracy of instructional content for this sample unit is of secondary importance. This sample unit is used to demonstrate how the templates and tools are used and how the product might look.

One caution about this study is that even though these templates have fully carried out the concept of this study, there is no template which can meet the needs of every course or every learner. An effective instructional design takes into account the nature of subject matter, the type of learning objectives, and learner characteristics, as well as theoretical bases. These templates represent only some of the many options which designing and developing courseware can take. Also, these templates should not be considered as unchangeable models. They should be modified as frequently as needed to reflect the uniqueness of each instructional context.

The templates in this study are a beginning point for constructing a template library. Only after more and more people are involved in the production of instructional hypermedia systems and a broad template library is established will the application of hypermedia courseware become versatile and effective. The potentials of hypermedia will then be fulfilled.

B. Methodology

This study adopts a developmental approach. Its main objective is to propose theory-based templates and tools to facilitate the design and development of instructional hypermedia systems.

As such, the first step was to review the literature on the historical development, theoretical foundation, and instructional effects of hypermedia. Then, based on the theories and research findings, rules and guidelines for designing hypermedia courseware were
developed. A courseware template was constructed to illustrate the application of these rules and guidelines.

For the purpose of managing the production of hypermedia courseware, an instructional design model was described. Then, a project template was proposed to exemplify the application of that instructional design model. This template not only proposed a way of managing a hypermedia project, but also reminded producers not to overlook the important considerations of instructional design.

In addition to courseware and project templates, some useful software tools were also constructed to integrate the design and development processes. They are intended to decrease the time and efforts demanded in producing hypermedia courseware. A courseware developers' guide describes how those tools should be used in the courseware development process. In order to illustrate the use, and validate the usefulness, of the suggested templates and tools, a unit of sample courseware was created. These templates and tools have been refined to maximize their usefulness.

The last part of this study provides feedback and reflections on the creation and implementation of those templates and tools. Directions for further studies are discussed.

II. Historical Development of Hypermedia

A hypermedia system is a computer data base which allows its users to access various types of information in a non-linear fashion. Such systems have become popular in education recently. However, the concept goes back to Bush in the 1940's. Since then there have been many pioneers who have pondered and explored the idea of non-linear, associative thinking. Their efforts became fruitful when technologies advanced to
materialize their conceptions. These inventions then found their way into education when instructional contexts were ready to accept a change.

Therefore, hypermedia's entrance into the instructional stage is based on the confluence of three important developments: concept, technology, and instructional context. Table 1.1 is a time line chart which shows the factors which influenced the development of instructional hypermedia.

Table 1.1
The evolution of instructional hypermedia

<table>
<thead>
<tr>
<th>Decade</th>
<th>Technology</th>
<th>Hypermedia concept</th>
<th>Instructional technology</th>
<th>Instructional paradigm</th>
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<td>1900</td>
<td>Information explosion</td>
<td></td>
<td>A-V instructional aids</td>
<td>Behaviorism</td>
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<tr>
<td>40's</td>
<td>Television</td>
<td>Bush: Non-linear association</td>
<td>Skinner: Teaching machine</td>
<td></td>
</tr>
<tr>
<td>60's</td>
<td>Mainframe computer</td>
<td>Engelbart: NLS</td>
<td>Instructional TV</td>
<td>Cognitive psychology</td>
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<td>60's</td>
<td>Artificial intelligence</td>
<td>Nelson: Hypertext</td>
<td>Linear CAI</td>
<td></td>
</tr>
<tr>
<td>80's</td>
<td>Personal computer</td>
<td></td>
<td>Branch CAI</td>
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</tr>
<tr>
<td>80's</td>
<td>Videodisc: CD</td>
<td>Nelson: Hypermedia</td>
<td>Adaptive CAI</td>
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</tr>
<tr>
<td>90's</td>
<td>HyperCard</td>
<td></td>
<td>IVD</td>
<td>Constructivism &amp; Situated Learning</td>
</tr>
<tr>
<td>90's</td>
<td>Multimedia personal computer</td>
<td>Nelson: Global hypermedia</td>
<td>Instructional hypermedia</td>
<td></td>
</tr>
</tbody>
</table>


Evolution of the hypermedia concept

The concept of hypermedia originated with Vannevar Bush in the 1940's (Fraase, 1990, 1991; Franklin & Kinnell, 1990). Bush was then the science advisor for President Franklin Roosevelt. He accessed numerous technical papers everyday and was deeply bothered by being unable to keep track of related information from piled up documents. Basically, Bush believed that the linear way of storing and searching information did not correspond to human associative thinking style. Therefore, in an article, "As We May Think," he promoted an envisioned medium, Memex, which adopted associative links between information to facilitate the use of information.

Bush believed that the associative links would allow us to deal with the increasingly complex information society and think more creatively. Unfortunately, the technology at that point could not realize what Bush had proposed for Memex. Memex was never built. Nevertheless, Bush's vision for Memex opened a new window for people to think about a future world full of associative linked information.

In the 1960's, Douglas C. Engelbart developed Bush's idea into a computer-based information network, NLS (oN Line System) (Franklin & Kinnell, 1990). The NLS was designed to link text segments in a database. It allowed users to connect to a central database through remote terminals and then read a filtered selection of information. Users could retrieve records from the database or send and receive messages to and from other on-line users. They could extract information and make notes, comments, or modifications from the original information. The NLS later evolved into "Augment," a hypermedia system which featured the adoption of a mouse, multiple windows, electronic mail, and computer conferencing. Bush's idea of non-linear association was first actualized through Engelbart's works.
However, Theodor Nelson is the most influential person in the history of hypermedia (Fraase, 1991; Franklin & Kinnell, 1990). He coined the term "hypertext" in the 1960's to refer to the storing and retrieving of text in a non-linear fashion. Later, he adopted the computer technologies on image and voice processing to expand the information format from text to graphics, voice, programs, and video; and so "hypertext" became "hypermedia."

Nelson was the most vigorous pioneer in promoting hypermedia. In 1960 he began work on a project called "Xanadu." He wanted to establish a universal information database which put all available manuscripts, books, and documents into an electronic format. A user could then connect to the database from anywhere around the world to retrieve various information and create a new composite document. The project is a huge, global hypermedia system.

Nelson also has a great interest in promoting hypermedia in instructional environments. As early as 1970, in an article, "No More Teacher's Dirty Looks," he said: "Let the student pick what he wishes to study next, decide when he wishes to be tested, and give him a variety of interesting materials, events, and opportunities..." (cited in Franklin & Kinnell, 1990). For Nelson, the key issues of hypermedia in instruction are the openness and freedom of information formats and links.

**Evolution of hypermedia related technologies**

The instructional use of technologies to deliver multiple formats of information goes back to the 1920's (Heinich et al., 1989; Moore et al., under contract). Audio cassettes, instructional films, slides, and filmstrips had been widely used as supplements to or substitutes for printed textbooks in training and education. The later development of audio-visual instructional aids have included instructional television, VCRs, and laser discs. Some of them provide a basis for the evolution of hypertext into hypermedia. However,
the technology most related to the development of hypermedia is computers (Moore et al., under contract).

The first generation of computers appeared in the 1950's (Alessi & Trollip, 1985). They were huge, expensive machines dedicated to number computation. They were called "number crunchers." The computers of second and third generations used transistors and integrated circuits (IC), respectively, to replace vacuum tubes as the main components of the computer's central processing units. Both the size and price of computers were greatly reduced, yet the computing power was increased. The most meaningful change was that computers were used to process textual information. Accompanying the emergence of database and networks, technology was able to support Engelbart to create his NLS. The University of Illinois at Urbana Champaign developed the first computer-based instruction project PLATO in the 1960's (Alessi & Trollip, 1985).

It was not until 1975 that the very large-scale integration (VLSI) chips became the main components of central processing units in computers. VLSI once again reduced the cost and size and increased the power of computers. It also made personal computers feasible. Shortly after 1975, the Apple II, the IBM Personal Computer, and the Macintosh appeared one by one. They were powerful and much less expensive than mainframe computers. Therefore, they were affordable for the public, not only for big companies or government institutions. More importantly, the Macintosh computers adopted a graphic-oriented interface and greatly reduced the difficulty of using computers. The power and the price of personal computers pushed schools into widely adopting computer-based instructional media. Many teachers began to make their own courseware for students.

When computer-assisted instruction (CAI) became popular in the mid 80's, practitioners felt that no matter how wonderful the computer technology was, the graphic quality of computer screens was very limited. A courseware producer had to either suffer from the poor visual symbols or limit instructional materials to text data only. About this
time, video industry was sophisticated enough to use laser technology to reproduce high fidelity images. Through the marriage of computers and videodisc players came the interactive video (IVD). Digitized audio also ushered in the arrival of the compact disc (CD).

The ability of computer systems to control various peripheral devices was significantly increased at the end of the 80's. HyperCard, an authoring tool to develop hypermedia systems, was released by Macintosh in 1987. Not until then did hypermedia become real to educators as well as industrial users. In the 90's, CD-I, DV-I, voice generators, 3D-animation, and many other advancements of hardware and software gave greater power to hypermedia (Barron & Orwig, 1993). Now, hypermedia united with the multimedia environment represent the state-of-the-art development in educational technology.

Evolution of instructional contexts

In the first half of this century, Behaviorism was the most influential theory in education. Both classic and operant conditioning theories had strong influence on the practices of instruction. Although Behaviorism conflicted with non-linear association, the popularity of Behaviorism resulted in the introduction of technology in education. Skinner, who advocated programmed instruction, designed teaching machines in the 1950's (Heinich et al., 1989). When computer technology was introduced into education, teaching machines were replaced by computers. The first computer-based instruction, a page-turner, essentially was a computerized programmed instruction (Gable & Page, 1980).

After the 1960's, cognitive psychology received more and more attention. It challenged Behaviorism by placing more emphasis on the "learners," particularly their cognitive structures. Quillian proposed a "semantic network theory" (Ashcraft, 1989) to explain how we store and retrieve knowledge from our cognition. This theory used the
computer as a metaphor and reflected well the concept of hypermedia. It gave the application of hypermedia for instruction a strong theoretic basis (Gleim & Harvey, 1992).

When the instructional paradigm gradually shifted from Behaviorism to Cognitive psychology, instructional technologies changed correspondingly. There were linear CAI and branched CAI in the 1960's and 1970's. When the instructional paradigm targeted the learner in the 1980's, the adaptive CAI was introduced to address the individual needs of learners.

In the second half of the 80's, some Cognitive psychologists shifted their emphases from the structures of human cognition to the process of constructing knowledge and the engagement of social context (Hanks, 1991). This change led to Constructivism and Situated Learning. Hypermedia was welcomed as a cognitive tool to reflect the emphasis on the constructing process of knowledge (Jonassen, 1992a).

From the preceding discussion, we can find that the introduction of educational technologies corresponds to the development of instructional theories. Skinner's teaching machines are the best example. Technologies satisfy the needs of theories, and instructional theories promote the adoption of technologies. Before 1985, we have witnessed the serial adoptions of teaching machines, linear CAI, branched CAI, and adaptive CAI in instructional settings (Gable & Page, 1980). Two strategies were used in adaptive CAI. The strategy of “system-controlled” adaptation in CAI, confluent with artificial intelligence, led to the development of intelligent tutorial systems (ITS). The other strategy of “learner-controlled” adaptation merged with non-linear association into hypermedia systems (Park, 1991). Both adaptive CAI systems adopted multimedia technology.

Since intelligence is such a complex thing, using computers to simulate human intelligence is tremendously difficult. Although promising, the intelligent tutorial system is currently not sophisticated enough to have significant influence on schools. On the other
hand, the hypermedia system allows learners to use their intelligence to decide what, when, and how to see the instructional materials. Therefore, it greatly reduces the complexity of designing individualized instruction. It is so far the most powerful and feasible learning tool.

III. Theoretical Foundation of Hypermedia

In the history of educational technology, instructors have rarely invented a technology which was driven by a theory. Most of the time, instructors have simply adopted technologies outside of education and then correlated the adoption of technologies to the needs of educational theories. The introduction of hypermedia into instruction is an example. The theories related to hypermedia can be classified into two groups: theories about multiple information formats and theories about non-linear association.

Theories about multiple information formats

Originally, educators were fascinated by the way hypermedia systems controlled video devices, especially videodisc players. They adopted video into the computer-based learning materials and attributed the adoption to the assertion of “dual coding” theory. Dual coding theory contends that visual messages can be coded into our memory by two forms: verbal strings and images (Miller & Burton, 1994; Moore et al., under contract). On the other hand, verbal messages can only be coded in one form. The importance of using video in instruction is that not only is the visual message more attractive, but it is also much easier to retrieve it from our memory due to the dual coding.

The use of multiple information formats in hypermedia also evoked the revisiting of “multichannel” research (Gleason, 1991; Moore et al., under contract). Multichannel
theory asserts a continuous and simultaneous presentation of information over two or more channels (Dwyer, 1978). It contends that the multichannel presentation provides additional cues or reinforcement for learners to interpret and organize incoming information. This ensures more complete learning.

Since the 40’s, many studies have been conducted on the comparison of one-channel and multiple-channel learning theories. The findings (Drew & Grimes, 1987; Findahl, 1971; Reese, 1983; Warshaw, 1978) were inconsistent. However, Hartman (1961, cited in Dwyer, 1978) distinguished four relationships between multichannel messages in those studies: redundant, related, unrelated, and contradictory. If multichannel messages are unrelated or contradictory, they compete with each other. This competition results in information interference. That explains why multichannel presentations were less effective in some studies. But, if messages in different channels were identical or closely related, they complement the other to form one thought and improve learning (Dwyer, 1978; Hanson, 1989; Locatis, Charuhas, & Banvard, 1990). In practice, educators seldom deliver unrelated or contradictory messages through multiple channels. Therefore, an improvement in learning is expected by adopting the multichannel presentation.

The multichannel learning theory is supported by the multiple-resource theory (Wickens, cited in Tripp & Roby, 1990) and multiple-intelligence theory (Moore et al., under contract). The multiple-resource theory contends that learners possess different pools of mental resources for various learning activities. Although each mental resource is limited, learners can evoke different pools of resources to process multiple formats of information. Provided that the incoming stimuli do not exceed the limitation of our processing capacity, better learning will result from multi-format information.

The multiple-intelligence theory suggests that learners possess multiple dimensions of intelligences. Seven distinct intelligences are identified by Gardner and Hatch (1989): logical mathematical, linguistic, musical, spatial, bodily kinesthetic, intrapersonal, and
interpersonal. Each learner shows his/her unique pattern of perceiving information. On the other hand, text, sound, graphics, animation, and video are symbolic formats of information. Each symbolic format has its own unique features and limitations. There is no one best symbolic format for all learners. Therefore, not only each piece of instructional content must be coded into its most effective and efficient format or formats, but also multiple formats are needed to fit various intelligence patterns. Since hypermedia allows multiple information formats, it can be a better tool for representing instructional content (Moore et al., under contract).

**Theories about non-linear association**

All dual-coding, multichannel, multiple-resource, and multiple-intelligence theories have addressed the features of multiple information formats of hypermedia systems; deep appreciation of hypermedia’s non-linear association came from correlating hypermedia to Semantic Network theory (Jonassen, 1988a; Marsh & Kumar, 1992).

Semantic Network theory (Ashcraft, 1989) proposes that the structure of human semantic memory is a network consisting of numerous nodes and pathways. A node is a fragment of information which can be a name, a feature, a function, or a chunk of ideas. Nodes are connected by relationships called pathways. For example, in the statement, "A robin is a bird," "robin" and "bird" are concept nodes and "is a" is a pathway describing a "robin" which is a member of the category of "bird." At the same time, "robin" can connect to several other nodes which say "red breast," "blue eggs,"...etc. These nodes are related to "robin" by pathways of "property." Also, these related nodes are grouped together to form a higher order concept. Whole knowledge is thus constructed as a networked organization. According to Semantic Network theory, information is not necessarily duplicated in our memory. When information is needed, a spreading activation
is initiated from the key nodes through their pathways to other related nodes, and the related knowledge of the key nodes is retrieved.

A hypermedia system is a networked information database which consists of numerous nodes and links. An information node is connected to others by links which represent the interrelationship of these nodes. The organization of a hypermedia database is surprisingly identical to the proposed human cognitive structure by Semantic Network theory. Nelson and Palumbo (1992) therefore suggested that using hypermedia will facilitate the construction of learner cognition.

When some cognitive psychologists shifted emphasis from cognitive structures to the constructive processes of cognition, hypermedia systems became a construction tool for learners, not an instructional aid for instructors. These cognitive psychologists are called Constructivists. Constructivists believe that learning is a process of knowledge construction (Jonassen, 1991, 1992c; Nelson & Palumbo, 1992). New knowledge should be related to personal existing knowledge. Learners are using new information to construct or update their cognitive structures.

These constructivists assert that instruction should not be designed to teach (Merrill, 1991). Instruction, rather than prescribing learning activities for learners, should be limited to providing content only. Learners then use these content materials to build up their own cognition. For constructivists, the usefulness of hypermedia is not in its formats of knowledge, but in the freedom and openness of accessing and structuring information. Hypermedia here is a cognitive tool, not a learning object.

Over the past five years, a new theory has emerged called Situated Learning. Situated Learning theory argues that knowledge is created and made meaningful by the activities and situations in which it is developed and applied (Brown, Collins, & Duguid, 1989). It criticizes the traditional schooling of teaching students abstract and decontextualized concepts as leading them to the inertness of knowledge. According to this
theory, knowledge is inextricably situated in physical and social context. It can only be learned in authentic or realistic environments. Instructional hypermedia systems can provide a rich and realistic learning environment through their high fidelity audio-visual ability. They also give learners the opportunity to freely select cues to construct their learning from the context. Utilizing hypermedia systems to implement the concept of situated learning seems promising in instruction (Moore et al., 1994; Young, 1993).

IV. Hypermedia in Instruction

Features of hypermedia systems

To date, hypermedia has become a common term in computer industry, commerce, and education. However, people still confuse it with "interactive video" or "multimedia." Therefore, a clear description of a hypermedia system is needed before further discussion. Many researchers have defined hypermedia systems from the perspective of their functionality. For example, Lanza (1991) described hypertext (hypermedia) as "a tool for thinking and communicating which.... supports a cognitive model for 'using' information" (p.18). Nelson's view (Ambrose, 1991) of hypermedia is "a system of order that allows anyone to create personal information systems without confusion, with exact accounting of each contribution" (p.51). Although these definitions are useful in understanding their purpose and functions, people still can not get a concrete understanding of the look and feel of hypermedia systems. Therefore, this study adopts a physical approach to define hypermedia systems.

A hypermedia system is a multi-format information network that enables users to gather information through a nonlinear sequence. In this definition, the study emphasizes two characteristics: multiple information formats and nonlinear accessing. When these
characteristics of hypermedia are embodied into computer systems, the physical features of that hypermedia system are outlined as follows (Jonassen, 1992b; Marchionini, 1988; Park, 1991):

1. A hypermedia system is a knowledge base. It contains a huge collections of information.

2. The contained information is represented in various formats (media).

3. The knowledge base consists of many "nodes" and "links." Nodes are small yet meaningful information fragments. They are connected by links to form higher level knowledge.

4. A hypermedia system has browsing tools for users to navigate in its "hyperspace."

5. Some hypermedia systems allow users to expand, delete, and modify nodes and links.

   Therefore, these systems also are constructing tools.

Potentials of hypermedia in instruction

Although most existing hypermedia systems are not for instruction, the features of hypermedia systems facilitate important instructional functions. These instructional functions are discussed below (Ambrose, 1991; Nelson & Palumbo, 1992; Park, 1991).

1. Providing rich and realistic contexts for learning: In hypermedia databases, various and vivid learning situations are represented. The huge amount and networked structure of an information database form a rich resource for learning. Unlike the ordinary school instruction, useful information for learning or solving problems is not explicitly expressed. It is embedded into the database, and learners have to dig it out. This process of finding and organizing information will not only give true meaning to knowledge, but also facilitate the construction of learner cognition.

2. Non-linear access to information: Hypermedia instruction breaks the classroom's arbitrary, linear teaching style. It allows learners to access randomly the stored
information based on their needs, interests, or whims. It is more consistent with our thinking style.

3. Providing multichannel learning: Hypermedia databases contain various information formats. Knowledge is represented in multiple symbolic codes. A learner can then select the most comfortable and effective format to grasp the meaning.

4. Focusing attention on the relationships of facts: The usefulness of facts is limited if they are isolated. The structure of hypermedia systems inherently helps learners focus their attention on the learning of relationships between facts. Therefore, it produces better usage of information (Kearsley, 1988).

5. Encouraging active learning: A hypermedia system is an interactive information system. Since there are always decisions about where to link, the learner must be actively engaged in the retrieving process. The more learners participate in learning, the more they gain from the process.

6. Learner control: Learners use browsing tools to navigate in hypermedia systems. They control speed, amount, and paths of learning based on their abilities and needs. Hypermedia systems thus provide an individualized environment for learners.

7. Collaboration: In some hypermedia courseware, learners can annotate, add, delete, or modify the stored information to correspond to their cognition needs. Thus, learners are not only knowledge receivers. They are knowledge contributors, too. A group of learners can also work together on the same system. The "collaborating" process blurs the distinction of instructors and learners and induces the cooperation between learners.

**Pitfalls of hypermedia in instruction**

Hypermedia systems fascinate instructors and bring hopes for the coming educational reform. However, at least four problems plague the adoption of existing

1. Too much learner-control: In most hypermedia systems, learners are granted full control of navigation without specifying learning objectives or pedagogic strategies. Should those who are novices in the subject matter, poorly-motivated, or lacking metacognitive skills take full control of learning (Park, 1991)? It is particularly doubtful if these learners are using a poorly-structured hypermedia system. Many studies (McNeil & Nelson, 1991; Tennyson, Christensen, & Park, 1984) failed to prove that learner control resulted in better learning effects. Clark's research (1983) even indicated that when learners had control over learning, they "may learn less from the options they like the most" (p.3).

2. Lost in navigation: A hypermedia system contains a huge amount of information nodes. Most nodes connect with multiple nodes. While learners have the freedom to jump from one node to another node, they are easily lost in the complex hyperspace. They will not know where they are, where to go, or how to get there (Jonassen, 1992b; Stanton, Taylor, & Tweedie, 1992).

One cause of getting lost in navigation is that the learner has no appropriate search strategy. This is especially true for young or novice learners who are easily distracted by unrelated information and then are buried in the fascinating but confusing information maze.

Another cause for disorientation is that learners do not understand the content structure. The knowledge base of a hypermedia system is too broad. Most information linkages also do not specify the nature and rationale for the connections (Nelson & Palumbo, 1992). In some systems, the linkages are arbitrary or only superficially related due to the inappropriate structuring of the knowledge base.
Therefore, learners have difficulties in integrating the nodes and links to form a meaningful organization. They become lost in the hyperspace (Park, 1991).

3. Cognitive overload: During the navigation in hypermedia systems, learners have to continuously make decisions about where to go and to make sense out of the connection. There are tremendous efforts demanded in the process. It consumes learners’ limited mental resources which otherwise can be used on learning content knowledge (Jonassen, 1992b; Marchionini, 1988; Tripp & Roby, 1990).

Another huge consumption of mental resources comes from the use of browsing tools. In order to carry out various fascinating functions, a hypermedia system requires complex manipulation, unlike those of the traditional computer-assisted instruction courseware. In a pilot study of a hypermedia courseware series, the author of this study has found that novice learners spend a great deal of time figuring out the operational functions. Mental efforts as well as learning time are wasted.

4. Missing important information: Most existing hypermedia systems are “open” environments where no learning objectives or paths are specified. It is up to the learner to decide what to learn and when to terminate the learning. The achievement of instructional objectives is not assured.

The problem with learners being confused about what to learn and when to end their study is common in hypermedia systems. The networked paths in hypermedia systems are so complex and confusing that most learners are unsure of whether or not they have completed the important topics. Also, there is no way to measure whether the learning objectives are satisfied because no evaluation or feedback is provided. Learners, therefore, either prematurely terminate the course without learning all the information or waste time repeating the same paths (Marchionini, 1988; Nelson, 1990).
V. Review of Research Findings

Although hypermedia is relatively new, there already are hundreds of reports and studies. However, most of them deal with the excitement of adopting this new technology or are envisioning its potential in education. Only a small portion of those reports are experimental studies.

These experimental hypermedia studies can be grouped into comparison studies and attribute studies. The comparison studies compare the effects of using hypermedia systems with using other media or human teachers. The researchers are looking for a better medium to substitute for traditional instructional agents. On the other hand, the attribute studies examine the effects of adopting a special attribute. The researchers are trying to find a better strategy to enhance hypermedia systems.

The purpose of comparison studies is to prove that hypermedia is an effective medium and the purpose of attribute studies is to find out how to make hypermedia an even more effective medium.

Review on hypermedia comparison studies

When people are excited by a new technology, the most frequently asked questions are "Is it good?" and "How good is it?" The same questions were asked when teaching machines, TV, and CAI were introduced. The introduction of hypermedia systems is not an exception. Researchers conducted comparison studies to examine the effects of hypermedia systems.

In these studies, some positive results have been reported. Abrams and Streit (1986) as well as Jones & Smith (1989) reported significant gains in learning achievement. Janda (1992) found a positive attitude toward the use of hypermedia systems. Higgins and
Boone (1992) reported a decreased demand on teaching time. Hardiman and Williams (1990) noted that the completion rate of the course was increased. Liu (1992) found that hypermedia instruction was very effective in the teaching of secondary language. In a review Thompson, Simonson, and Hargrave (1992) summarize that hypermedia is promising in learning contexts.

Although educators are pleased with the positive results, caution should be taken in interpreting the results. Four particular confusions are noted here.

1. Confusion of the treatments in hypermedia research

Since there is no commonly accepted definition of hypermedia, existing studies may use different terms to refer to the same concept or use the same term to refer to different concepts.

In early studies, hypermedia was often referred to as interactive video. Recently researchers have also confused hypermedia with multimedia. Although interactive video and multimedia sometimes are interchangeable terms with hypermedia, they can also be different media which provide linear, system-controlled information.

In some studies, hypermedia was only an information storing and retrieving system. There is no instructional purpose embedded in the design of hypermedia. Some hypermedia systems are group-based, some are individual-based. Some are hierarchically structured, some are unstructured. Some are tutorial, some are simulation. All these "hypermedia" systems vary so much that they can hardly be treated as identical objects (Reeves, 1986).

Therefore, it is doubtful that the subjects in these comparison studies have experienced the same treatment of "hypermedia." Since factors that affect learning are not consistent in using this particular medium, it is also doubtful whether we can generalize the results of using a hypermedia system to other "hypermedia" systems.
2. Confusion of the measurements in hypermedia research

The second caution deals with questions such as “What are the learning effects?” “How are these effects measured?” “When are results of using hypermedia systems measured?” and “Are all possible effects included and fairly judged?”

Dwyer (1978) pointed out that researchers generally used text test items to evaluate the learning of multiple formats of information, thus biasing the effects of visual materials. Also, the results were explained with total scores, and the medium’s contributions to specific learning achievements were overlooked. His comments are still relevant today as confirmed by recent hypermedia studies.

One related issue is the timing of generating effects. Since using hypermedia is a new experience for most learners, can they acquaint themselves with the new environment in a short experimental period? In an experiment, the author found that novice learners spent a significant part of their learning time in figuring out appropriate strategies to use the hypermedia courseware. Their attention was not focused on the content. Their learning achievement was negatively influenced, at least in the first several lessons.

Furthermore, the active participation in learning required by hypermedia systems conflicts with the passive attitude commonly exhibited by many learners. A dramatic adjustment in learning styles may not occur in a short time. Reeves (1993) commented that the experimental treatment is usually too brief to introduce significant learning effects on cognitive skills.

3. Confusion of the generalizability of hypermedia research

Throughout the literature of mediated instruction research, aptitude-treatment interactions have been consistently reported. A medium may be good for one particular population but not for another population. This effect also occurs with different types of subject content. A medium is suitable for language arts but not for math. A careless
generalization of the "superiority" of hypermedia systems may result in reverse effects on another practical instruction. Williams and Brown (1991) therefore reminded researchers and practitioners to be aware of the interactions between attributes of medium, characteristics of learners, types of subject knowledge, and outcomes of learning.

4. *Confusion of the explanations in hypermedia research*

The last caution entails the explanation of media effects. Salomon and Clark (1977) argued that in most mediated instruction research, media are only vehicles that deliver contents and instructional strategies. It is the content or strategies that matter in the research. Most researchers were studying "with" media rather than "on" media. Therefore, the results should not be attributed to the effects of "medium" but to the effects of contents or strategies.

Again, Clark and Salomon (1986) reminded us to distinguish between "the effects of a medium's generic attributes" and "the effects of the medium's introduction" (p.466). The effects of a medium's introduction are the effects that accompany the adoption of a new medium. They are not the true effects of media or media's attributes. The following events are typical: high quality instructional programs are produced, robust funding and organizational changes are made, and students are excited about the new medium and then study harder. However, when the medium is no longer new and learners calm down, the effects drop.

**Review on hypermedia attribute studies**

In reviewing media comparison research, Clark (1985) argues that the medium is the vehicle which delivers the instruction. The medium itself will not influence instruction, just as the truck which delivers grocery has no effect on our nutrition. Therefore, he proposed a suspension of media comparison studies. Instead, he (Clark & Salomon,
1986) suggested that we examine the attributes of a medium. The study of media attributes will shed light on the appropriate design and use of media.

Since hypermedia systems possess two most powerful attributes, learner control and multiple information formats, this study will examine these two attributes separately rather than examine the vague concept of hypermedia as a whole. Because getting lost in hyperspace is the most serious problem of using hypermedia courseware, an additional review will address the study of navigating strategies.

1. Learner control

Learner control is one of the most significant attributes of hypermedia courseware. A hypermedia system allows learners to non-linearly choose instructional content based on their personal interests. It encourages learners to actively participate in the learning process. However, learner control is not a unique attribute of hypermedia. Some other media such as traditional computer-based instruction or Keller’s personalized system of instruction also have a certain degree of learner control.

Learner control has been studied for a long time. In a study comparing "learner control" with "program control" of instruction, Campbell & Chapman (1967) indicated that in the long run, learner control strategy would produce a positive attitude toward the subject and require less study time without a loss in performance.

Tennyson, Christensen, and Park (1984) compared various control strategies in computer-assisted instruction. They found that learner control with advisement is the most effective. However, learner control without advisement was not as effective as program control. Merrill (1980) believed that learners were able to select the optimum amount of instruction they need to master lessons if appropriate information about their progress was provided. Although his hypothesis was not supported by the study result, more efficient learning was reported. Williams (1993) in his comprehensive review of learner control
indicated that the effects of comparing learner control with program control were equivocal. Interactions between treatments and individual differences were reported.

From these studies, it is concluded that learner control is not necessarily an assurance of effectiveness. It is desirable in a democratic society, but appropriate limitations of freedom and appropriate advisement to the learner are critical to ensure its usefulness in instruction.

2. Multiple formats of information

In hypermedia systems, information is represented by various formats. Each format has its unique function in communication. While visuals easily attract learner attention, verbal messages better direct learner attention. Therefore, a combination of multi-format learning experiences seems plausible in improving learning.

Researchers have examined the effects of using multiple information formats and multiple learning channels. Hsia (1968, cited in Dwyer, 1978, p.50) concludes that the simultaneous audio(A) visual(V) channel "presumably has advantages over the A and V only if... its A and V stimuli are closed identical..." Mayer and Anderson (1991) in an experiment found that supplementing verbal information with visual was more effective in problem solving than using either one alone.

From multichannel studies, there is no doubt that multiple formats of information have greater potential to enhance learning. However, Dwyer (1978) pointed out that the use of visuals to accompany audio or verbal (textual) information does not automatically improve learning. How these multiple formats of information are associated to form a better presentation of content is the key factor which generates the desired effectiveness.
3. Navigating strategies

Hypermedia systems allow learners to navigate through their knowledge bases freely. We have no doubt that they individualize the instruction (Carr, 1988; Marsh & Kumar, 1992). However, researchers have constantly found that many learners get lost in hyperspace. Here we will review some design strategies proposed to resolve this problem. These strategies include cognitive maps, hierarchical content structures, advance organizers, instructional cues, adjunct questions, and discrete tutors.

Providing cognitive maps is one of the most frequently suggested navigating strategies (Jonassen & Wang, 1991; Stanton et al., 1992). Cognitive maps are graphic representations of the content structure. They can be global overview maps which show the organization of major topics. They can also be local association maps which show the linkages between the current node and its immediate linked nodes. It is postulated that these maps will help learners understand the content. Learners match their cognitive structure to the subject organization and thus the disorientation of hypermedia is reduced.

Several researchers (Jonassen, 1988a; Kearsley, 1988; Marsh & Kumar, 1992) proposes structured content to resolve the problem of distraction in hypermedia environment. Jonassen believes that structuring hypermedia knowledge based on experts' knowledge organization and then mapping this structure onto learners' cognition will improve learning. This strategy is best realized in a hierarchical menu-driven system.

Advance organizer is another popular strategy proposed by instructional designers. It has been studied in traditional media for a long time (Tripp & Roby, 1990). Studies show that an advance organizers provide higher level conception frameworks and help learners anchor new information into such frameworks. Its use seems promising in dealing with a huge, yet unfamiliar environment.

All these three strategies provide extra structural information to the learner. However, some other hypermedia designers suggest instructional cues and adjunct
questions to direct learner attention and integrate the accessed information. Instructional cues are hints to remind the learner to view the embedded elaborated information (Lee & Lehman, 1993). Adjunct questions preview or summarize knowledge presented on the content screens. Both instructional cues and adjunct questions can be placed before or after the subject content. If being placed before content screens, they will direct learner attention to appropriate contents. If being placed after content screens, they will serve as a review of the accessed information.

A discrete tutor, also known as a computer advisor, is probably the most complex strategy of improving hypermedia performance. It relies on a monitoring tool and a prescription formula. The monitoring tool collects the progress information of each learner. Based on this information, the prescription formula will determine whether the difference between an optimum performance and the actual performance of the learner is significant. If this difference exceeds a limit, the computer tutor will interrupt the learner-controlled navigation and suggest advisement (Roselli, 1991). Artificial intelligence can be adopted to help with the analysis of difficulties and prescription of advisement.

Some of these strategies have been put into quantitative studies. The results are mixed. Reynolds and Dansereau (1990) found that knowledge maps increased the overall satisfaction of using hypermedia. Jonassen and Wang (1991) reported that providing structural information by cognitive maps reduced the time spent in reviewing the knowledge base. Stanton et al. (1992) found that the provision of content maps as navigational aids led to poorer performance and lower perceived control over the hypermedia system. They warned designers that a spatial map is not a cognitive map and we should not assume that any map will facilitate the navigation of hypermedia.

The advance organizer is effective as studied with linear text. When it was examined in a hypermedia environment, Tripp and Roby (1990) reported positive effects, although not significant. However, they also warned that if other navigational aids such as
graphic metaphors were added, the effects became negative. They attributed the negative effects to the mental conflict between two different navigational aids.

Lee and Lehman (1993) reported aptitude-treatment interactions in a study of instructional cues. They found that for passive and neutral learners instructional cues improved learning. But for those active learners, no significant difference was found.

Boker (1974, cited in Nelson, 1990) noted that adjunct questions were effective in learning from prose. However, Nelson (1990) reported that in a hypermedia environment adjunct questions were not as effective as hypothesized. The placement, number, and types of adjunct questions are critical to the effects of learning.

Several reasons may explain why these strategies did not work well in those studies. One reason is that those studies tend to use retention tests to measure learning results. Most retention tests measure the learning of facts rather than relationships or applications of facts. All the suggested navigational strategies are directed to help learners gain understanding of relationships between nodes, not the nodes themselves. The results of these retention tests may not reflect the improvement of adopting these strategies.

Another reason is that most studies are administered to students who are not hypermedia-literate. The more novel the appearance of a hypermedia system, the more adjustment a learner needs, and the more negatively the learner reacts to this system (Jonassen & Wang, 1991). Since the adjustment of cognitive skills cannot occur in a short time, Reeves (1993) suggested that a longer experimental period is needed.

VI. Summary

Within this chapter four problems of implementing hypermedia in instruction are described: (1) courseware design is not based on instructional theories, (2) courseware is
not used appropriately, (3) grassroots or local production is difficult, and (4) there is a lack of product standard. This chapter contains reviews of the historical development, theoretical foundation, and academic research of hypermedia from the instructional perspective.

Acknowledging that a great effort has been made to resolve hypermedia problems, this study proposes a broad solution. It intends to establish theoretical bases for the design and use of instructional hypermedia systems. Templates and tools are suggested to facilitate the grassroots production of hypermedia courseware. Using and sharing the common templates and tools presented may achieve certain product standards in the future.
Chapter 2

Designing and Developing Hypermedia Courseware

This chapter deals with the designing and developing of hypermedia courseware. In this study, “designing” refers to the creation of discrete screens and their linkages in a courseware. The scope of designing is limited into the courseware itself. “Developing”, on the other hand, refers to the management of a courseware production. It includes all the production activities from analysis to design, development, and evaluation. In general, courseware refers to software which delivers lessons. Although it can be tutorial, simulation, drill, or gaming programs, in this study, courseware is limited to the tutorial type of instructional systems.

In this chapter, the designing of hypermedia courseware is explored from two aspects: micro design and macro design. Theories and research are discussed to form design guidelines. A courseware template is constructed to illustrate the application of these guidelines. For the development of hypermedia courseware, this chapter proposes an instructional design model which addresses the important considerations of producing any instructional medium. This model is then combined with software engineering principles to form a project template. This project template is a model to manage the hypermedia production activities.

In order to help novice producers to create their own hypermedia courseware, this study also presents some software tools. These tools include object libraries, generation
tools, documentation tools, and functional buttons. Finally, the Courseware Developers' Guide illustrates the usage of these tools.

I. Designing Courseware (I): Micro-Design

Merrill (1987) believes that courseware presentation can be described as a sequence of discrete displays together with the interrelationships between them. When designing computer-based instruction, we are engaging in two activities: creating a series of information screens (displays) and organizing them into certain orders (interrelationships). These two activities are especially well reflected in designing hypermedia courseware which is composed of two substances, nodes and links. A node is an independent fragment of information and a link is the connection between two nodes. In hypermedia systems, a node is placed into a window or a screen. The various links between nodes form a network structure from which learners dynamically select their navigational paths. Therefore, to construct hypermedia courseware we are creating a series of information nodes and then organizing them by creating links between nodes.

For the convenience of discussion, this study will refer to the creation of discrete nodes as the "micro-design" and the creation of links as the "macro-design."

The micro-design of hypermedia courseware deals with the creation of discrete information screens. Usually, a computer screen contains multiple stimuli. The significance of each stimulus is different. Therefore, it is the main consideration of micro-design to guide learners’ attention to the important information and help them achieve the best learning effect in a short period of time.

Guidelines for the micro-design of hypermedia courseware are mainly based on the theories and studies of psychology, aesthetics, and human-computer interface. However,
in practice many aspects of micro-designing courseware have not been addressed by any theories or studies. These aspects rely on designer experience or intuition to fill in the gaps. This will leave space for personal creativity. This study classifies guidelines for micro-design into five categories: information formats, language usages, attention-getting techniques, operating directions, and screen layouts.

Information formats

In hypermedia courseware, information is represented in text, graphics, sound, or a combination of these presentation formats. Each format has its own merits for representing information. Some learners believe that text is more truthful or academic than other formats (Laurel, Oren, & Don, 1990). It also takes the least space in computer memory. Graphics provide concrete and spatial information. They attract learners' attention easily. Sound is an inseparable part of language and music learning. All these formats can be presented in hypermedia courseware respectively or simultaneously. In selecting presentation formats, three general guidelines are suggested.

A. Graphics are generally more appropriate for representing basic or concrete information

Dale (1946, cited in Heinich et al., 1989) found that in order to discover the meaning of abstract concepts, learners generally should have basic and concrete knowledge first. He proposed a diagram (Figure 2.1), cone of experience, to show the concrete-abstract continuum of various learning experiences. According to this diagram, graphical information is more concrete than text. In graphics, motion pictures or animation is more concrete than still pictures.

Nevertheless, we should not consider graphics or audio as easier media than text. Different formats are appropriate for different contexts. But, in general, graphics do provide more cues, such as spatial and transitional relationships, to help learners decode
and remember the knowledge content (Heinich et al., 1989). For example, when introducing "zebra" to novice learners, a picture of a zebra is worth a thousand words. However, when an abstract concept, such as "love", is introduced, a word may be worth a thousand pictures. Assuming that a learner already has the basic knowledge, text is as effective as graphics. Sometimes, it is more efficient.

Figure 2.1 Cone of experience

Therefore, the choice of format for representing information should be based on learner characteristics and the nature of subject contents. Dale’s assertion reminds us that concrete knowledge generally should be taught before abstract knowledge; it also reminds us that graphics are more useful than text in building concrete knowledge.

B. Multiple formats are more effective and adaptive than single format

In the section “Theoretical foundation of hypermedia” in chapter One, we have addressed dual coding, multichannel, multiple-resource, and multiple-intelligence theories
to support the adoption of multiple information formats in hypermedia systems. Those
theories held that information is communicated more successfully to learners when they use
multiple channels to process the incoming information (Dwyer, 1978; Hanson, 1989;
Moore et al., under contract).

Educational and psychological theorists have long acknowledged that learners vary
in their preferred learning styles. They receive benefits from using particular information
formats. Multiple presentation formats provides a better chance to accommodate learners' divergent learning styles (Moore et al., under contract). It is more adaptive, if not more
effective, than the single presentation format.

C. Information must be consistent in different presentation formats

Courseware studies (Alessi & Trollip, 1985; Malone, 1981) have identified at least three relationships among information presented in different formats. They are intrinsic,
related, and arbitrary. An intrinsic relationship describes the information from two
presentation formats with the same meaning. For example, if we present a video showing
the digestion process with a paragraph of description about digestion, the relationship
between these two presentation formats is intrinsic. A related relationship means that one
type of information is a parable or analogy of another type. The information in different
formats is not identical, but one type of information helps learners to better understand
another. When a text describes the sizes of elephants and whales, a drawing which uses
two circles to show the comparison of these two sizes is a related representation of the
knowledge. An arbitrary relationship means that two types of information, although
presented simultaneously, have no relevance. They can even be contradictory.

Malone (1981) claims that an intrinsic relationship is most valuable in instruction.
Research on multichannel theory (Dwyer, 1978) also shows that identical (intrinsic) and
related messages improve achievement while unrelated (arbitrary) and contradictory
messages decrease learning. Therefore, in designing courseware the information contained in different presentation formats must be consistent and integrated.

**Language usages**

A successful instruction must be an effective communication. Since most computer courseware is used without direct assistance from tutors, a carefully crafted language is critical to the effective communication (Alessi & Trollip, 1985; Thompson et al., 1992). Although the following guidelines are mainly proposed for text, most of them can also be applied to other information formats.

**A. Use language at the appropriate reading level**

The reading level of a language concerns not only the ability of learners, but also their cultural backgrounds and previous experience in the subject content.

It is widely acknowledged that educational practitioners should use language at the learners' reading levels (Alessi & Trollip, 1985). However, in producing commercial courseware content experts and computer programmers often neglect the importance of appropriate language. They understand very little about the potential learners. They place emphasis only on content expertise and programming skills. The courseware thus ends up inappropriate for the target learners.

Another concern related to the reading level is the cultural backgrounds. Modern civilization has not only transformed the whole world into a global village, but it has also created great diversity in a small community. In most classrooms, there are different cultures and subcultures. A less sensitive designer may use language which is only understandable by some cultural or ethnic groups. For example, the slang of inner-city students is different from those of rural students. The scene of the Wild West also bears different meanings for American Indians and American whites (Heinich et al., 1989). It is
difficult to eliminate the misconceptions arising out of cultural differences. However, designers should be cautious about their language in courseware.

Instructional theorists assert that prerequisite knowledge is critical to the success of learning new knowledge (Gagne et al., 1992). The content designed for novice learners should be different from that for experienced learners. A careful learner analysis will suggest the appropriate considerations about the reading levels of language in courseware.

B. Be clear and specific

The purpose of instruction is to help learners understand the content knowledge. Therefore, courseware should strive to keep language clear and specific (Alessi & Trollip, 1985; Moore et al., 1994; Thompson et al., 1992). Jargon, abbreviations, and vague expressions should be avoided as much as possible.

In each discipline, technical terms seem unavoidable. These terms are often confusing and difficult for new learners to understand (Alessi & Trollip, 1985). Nothing frustrates learners more than those technical terms. We should diminish the use of such jargon. However, if technical terms are necessary, clear explanations have to be provided before they are used. These terms also have to be used consistently through the course. We should not expect learners to remember all these terms during the instruction. It is advisable to provide a look-up index to these terms. It will help learners refresh their memory when needed.

Since hypermedia courseware allows learners to jump from node to node dynamically, it is crucial that each node is independent and self-explanatory. An abbreviation garbles communication, especially when its full explanation is not on the same screen. It can only be used when learners are familiar with it (American Psychological Association, 1983).
Positive statements are clear in expressions. However, negative mode seems necessary and appropriate some of the time. An effective information design should not use double negative expressions unless there is a strong reason to do so. Double negative expressions are vague and consume more mental efforts. Considering the following two statements: "I am not the one who will be not honest with you" and "I am honest with you." The double negative statement is wordy and puzzling.

C. Use appropriate layouts

On screens, text should be presented in appropriate layouts. Spelling, grammar, and punctuation are important in correctly communicating the content information (American Psychological Association, 1983). However, the layouts of information are also important for they arouse and maintain learners’ attention (Braden, 1994).

Top-to-bottom and left-to-right is the conventional viewing order in western countries. Indentation or blank lines signifies the beginning of a new paragraph. Upper- and lower-case text is preferred. Use fonts with serifs. Margins and line spacing are important for readability. In designing content messages, all the text layouts must facilitate the cognitive process.

The text layouts, although not related to the message content, affect learning results. Research has consistently shown that using both upper- and lower-cases in the text body is more effective than using upper-case only (Hix & Hartson, 1993; Isaacs, 1987; Knupfer, 1994). Also, text written in a "solid" manner decreases readability. Therefore, serifs, ragged margins and extra space between lines are more effective (Aspillaga, 1991-92).

D. Keep language concise and simple

For oral communication, we use redundant words to improve listener comprehension. However, this redundancy of expression is not needed in courseware
because the limited space on a computer screen allows no room for redundancy. Learners can spend as long as they like reading the information. Therefore, to make courseware efficient, the language should be lean. Say only what needs to be said; use short words and short sentences. They are easier to comprehend (American Psychological Association, 1983; Thompson et al., 1992) and more suitable for independent learning.

A lean language uses not only concise syntax, but also simple expression. It allows only one theme in each paragraph or on one screen. On a computer screen, each paragraph should be simple enough so as to decrease the burden of memory and increase the satisfaction of achievement. A lengthy and complex paragraph will “overload memory, cause confusion, and decrease interest” (Alessi & Trollip, 1985, p.75).

There is one more reason for hypermedia courseware to keep language concise and simple. Since the whole subject content is broken into many independent nodes in hypermedia courseware, if a node contains multiple themes, the flexibility of linkage between these themes is decreased.

Attention-getting techniques

One purpose of micro-design is to direct learners’ attention. There are many ways to direct learners’ attention to the emphasized information on the screen. The most frequently used techniques are: inverse, underline, bold, colors, fonts, sizes, beep, blinking, arrows, and boxes (Alessi & Trollip, 1985; Knupfer, 1994). These techniques are effective. But without deep considerations, they may backfire and annoy learners.

A. Don’t over highlight information

Highlighting techniques differentiate the important information from the general description. As human beings, learners have only limited mental resources. Miller (cited in Ashcraft, 1989) has asserted that the capacity of our short-term memory is rather limited.
Only seven plus or minus two chunks of information can be held at one time. Therefore, it is delusive to highlight a great deal of information on a single screen. If learners have to read most of the screen, highlighting too much information is equal to highlighting no information at all. Interface experts have suggested limiting the use of highlighting techniques to no more than three fonts, four text sizes, or four colors on a single screen (Hix & Hartson, 1993).

Frequent use of highlighting devices also decreases their effectiveness in directing attention. Since attention is drawn to novelty or specialty, we should highlight only necessary information to keep the effectiveness of highlighting techniques. Over highlighting will lose its effects and even become detrimental to learning.

B. Consistent with the conventional usages

There are conventions which are used to highlight information in traditional media such as printed materials or computer systems. As a relatively new medium, hypermedia courseware should conform with the existing conventions. If there is room for free defining the usages of a highlighting device, the designer should stick to that usage throughout all the course.

For example, underlining is used to indicate book names or headings; titles use larger text size; red is the color of warning and danger. All these usages of highlighting techniques have been widely acknowledged (American Psychological Association, 1983; Thompson, 1994). Violating these rules may cause confusion and decrease reading speed.

C. Use highlighting formats to provide extra information

Highlighting formats can provide extra cues to learners if they are used systematically (Knupfer, 1994; Thompson, 1994; Thompson et al., 1992). Those cues,
although not a part of the content knowledge, are useful in conveying the structural information of the content.

For example, a courseware unit uses italic text for key terms. When learners are looking for terminology, they do not have to read through the whole text to find technical terms. They just skim screens by looking for the italicized text. The highlighting formats guide learners toward what to expect. They facilitate learners searching as well as anchoring information.

Operating directions

Although computers are widely used in schools, the reality is that there still are hundreds, thousands of students who are computer illiterate. The continuous changes in computer hardware and software make the situation worse. Before computers are stabilized, we probably will see many novice users and technology phobias throughout all the schools. It is up to the design to help learners become confident and willing to use computer courseware. User-friendly operation guides can ease the anxiety and fear of learners. They will also save learning time and effort.

A. Directions should be clear and specific

Ambiguity causes uncertainty and misunderstanding (Alessi & Trollip, 1985). It is especially true for computer novices and people with technology phobias. Several years ago, the author of this study worked in the computing center of a nationwide bank in Taiwan. In bank transaction systems, users are prompted to continue by a message “HIT ANY KEY TO CONTINUE.” One day, in the pilot testing period the author was called on a telephone by a desperate employee who could not find the <ANY> key on the keyboard. Several other telephone calls also reported that they had shut down the systems by mistakenly pressing the <RESET> key.
What the author has learned is that directions should be clear and specific. Even if a system allows learners to proceed by hitting any key, it is better to tell learners to hit a specific key. The specific direction minimizes the mental effort and avoids possible troubles.

**B. Consistency of operation**

Consistency of operation means universal position and universal meaning (Kearsley, 1988; Megarry, 1991). The operating direction should always be placed in the same area, and the same operation should initiate the same function. If the operating direction is located in different places on screens, learners must spend time to look for it. Thus the inconsistency of operation causes the loss of efficiency.

An operation is frustrating if it means different things in various contexts. Therefore, it is advisable that operation conforms to a convention throughout the course or even across systems. For example, <command+Q> signifies to quit an application in most Macintosh software. We should observe the convention if the courseware is running in Macintosh platforms. However, if a designer defines <option+V> to see the video, the designer should continue the usage throughout the course unit.

**C. Accommodate learner differences**

Generally, computer courseware emphasizes the individualization of instruction. The instructional content is adjusted to meet the needs of diverse learners. This adaptation to individual difference should also be applied to the operating direction in courseware.

Learners have different levels of experience in using computers and courseware. The design of operation must meet the various abilities of learners ranging from novices to experts (Hazen, 1985; Hix & Hartson, 1993).
Usually, at the beginning of a courseware, learners will be prompted to read the operating direction. However, most learners will not read or will forget the direction. Therefore, during the navigation in courseware, learners should be allowed to access the operating direction at any time (Kearsley, 1988). An on-demand assistance is an important characteristic of a user-friendly system. It eases the memory load of learners. It is also adaptive to both novice and expert learners.

D. Optimize the operation

While novice learners need detailed, step-by-step direction, experienced learners usually feel it is cumbersome. The experienced learners want short-cuts to accelerate their learning. The focus of using courseware is to learn the content, not the operation (Morariu, 1988). Therefore, a designer should strive to keep operation simple, direct, and adaptive to learners.

For example, novice learners benefit from clicking a menu-bar to pull down a set of detailed selections. They select the desired function by a series of actions. However, experienced learners like the efficiency of using function keys or hot keys to bypass the cumbersome selections and go directly to the desired destination (Hix & Hartson, 1993). Abbreviations for input, such as type "Y" instead of "Yes", also increase performance by reducing unnecessary typing. The learners' time is better used in learning content.

Screen layouts

To motivate learners, screen layouts of courseware should be artistically pleasant. Nevertheless, being instructionally beneficial is more important. An effective screen layout should not attract learners' attention to decorations, or sidetrack learners to unimportant information. The use of courseware is for instructional purposes. Therefore, the design of screen layouts is directed to decrease the mental burden and achieve better learning effects
(Knupfer, 1994; Thompson et al., 1992). A good designer seeks both the aesthetic and instructional quality.

A. Define functional areas

Since different types of messages co-exist on a screen, it is desirable to divide the screen into several functional areas (Isaacs, 1987; Thompson et al., 1992). Each functional area should use fixed layout and location on the screen. A possible area list includes: title area, text description area, graphic area, operation area, or dialogue window. Similar messages are put into the same areas on the screen by functions. The functional areas make the appearance of screens neat and clear. The fixed locations of these areas also minimize unnecessary eye movements.

B. Standardize screen layouts

The design of functional areas is useful in organizing multiple messages on a single screen. It is more useful in organizing messages through multiple screens. If a series of screens share common functional areas, the standardized screen layout will save the designer’s efforts to create different layouts. It also facilitates the learning process by providing the structural information through its standardized formats (Alessi & Trollip, 1985; Thompson et al., 1992).

In most hypermedia systems, the common layout of a series of screens is designated as the background of these screens. In the series of screens, objects in some functional areas remain static. Only contents are changed. Therefore, the learner only pays attention to the changed areas instead of the whole screen. Efficiency is achieved.
C. Efficacy and coziness

A basic rule for designing screens is not to clutter the information. Cluttered displays increase mental burden and cause tension (Kearsley, 1988; Thompson et al., 1992). Further studies show that less than 25% of white space in textual displays degrades learning (Tullis, 1983). This rule applies to the design of each functional area. Leaving appropriate space in margins, between lines, and between functional areas will have aesthetic and instructional value.

Color also has a decided effect on learners' visual comfort (Knupfer, 1994). Red and blue text are difficult to read. A darker background reduces glare on screen. Colors in the middle of the light spectrum are preferred for text (Godin & Hacunda, 1991). Thompson (1994) even contends colors have psychological effects on people. For instance, "reds and yellows are energizing and uplifting, while greens and blues tend to be more peaceful" (p. 171-172).

Remarks

The guidelines presented in this section are better used as a check list. It is impossible to use these guidelines to "generate" effective screens. But, they are helpful after a designer has drafted the instructional screens. These guidelines are used to evaluate the draft screens and suggest necessary modifications. However, we have to admit that problems frequently occur when these guidelines are put into practice (Megarry, 1991). Personal experience and intuition is valuable in resolving these problems. Novice producers may have to learn from experienced colleagues or from their trial-and-error process.
II. Designing Courseware (II): Macro-Design

The macro-design of hypermedia courseware deals with the connections between discrete screens. Courseware is not only a collection of independent information fragments; it also contains the interrelationships between fragments. These interrelationships can be addressed from two perspectives. The content organization discusses the interrelationships on the subject matter aspect. The presentation flow addresses the interrelationships on the aspect of instructional strategies.

The content of an instructional unit usually is too complex to be delivered in a single or a few screens. Instructional activities are also not limited to presenting information. Only when these information screens are well structured and presented in a sequence appropriate for learner cognition is the learning facilitated. Otherwise, even with a good design of discrete screens, the courseware is disjointed. It is not very useful in achieving the expected results.

As a metaphor, the courseware instruction can be viewed as a basketball game. The micro-design addresses the skills of individual players and the macro-design addresses the tactics of the whole basketball team. To win a game, the basketball team must have skillful players as well as smooth cooperation between players. For courseware, both micro-design and macro-design are essential to the effectiveness of instruction.

Content organization

Two tasks are involved in content organization: slicing knowledge into independent fragments and linking these fragments into a coherent knowledge. These tasks actually are two sides of the same object. How we should slice the information is based on how we are going to link the fragments.
Instructional courseware contains a set of knowledge contents. The whole set of information usually is a composition of multiple units. An extended description of knowledge may overload memory, cause confusion, and increase the difficulty of understanding the texts (Alessi & Trollip, 1985). The comprehensive knowledge should be broken down (chunking) into many manageable fragments (Kearsley, 1988). It can be divided by the modes of information, such as video, graphics, sound, or text. It can also be divided by the functions of information such as examples, principles, applications, or questions.

Theorists have suggested many ways to conduct the content breakdown. Bloom (1956, cited in Seels & Glasgow, 1990) proposes a taxonomy for analyzing cognitive content. Knowledge, comprehension, application, analysis, synthesis, and evaluation are the six levels of cognitive content. Gagne (Gagne et al., 1992) has also proposed a learning taxonomy based on his experience in analyzing hierarchical sequence of knowledge. Both taxonomies are useful in guiding the analysis of instructional content.

However, to prescribe the design of computer courseware, Merrill's component display theory (1987) is most useful. This theory is evolved from Merrill's experience in designing TICCIT (Time-shared Interactive Computer Controlled Instructional TV) programs. He identifies four primary presentation forms (PPFs) in the practice of computer-mediated instruction: expository instance (example), expository generality (rule), inquisitory instance (practice), and inquisitory generality (recall). In the component display theory, Merrill uses a Performance-Content matrix (Table 2.1) to classify the instructional outcomes. In performance domain, four levels are identified: remember instance, remember generality, use, and find. In content domain, there are four categories: fact, concept, procedure, and principle.
When constructing instructional fragments, a designer uses the Performance-Content matrix to determine the performance level and content categories of the expected learning outcomes. Then, according to the performance level of the outcomes, the designer looks at a Performance-PPF Consistency table (Table 2.2) to find the appropriate primary presentation forms for presentation, practice, and performance. Again, according to the content category of the outcomes, the designer looks at a Content-PPF Consistency table (Table 2.3) to find the prescription for each primary presentation form.

Table 2.1
Performance-Content matrix

<table>
<thead>
<tr>
<th>Performance</th>
<th>Find</th>
<th>Use</th>
<th>Remember Generality</th>
<th>Remember Instance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Fact</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concept</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Principle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2.2
Performance-PPF Consistency table

<table>
<thead>
<tr>
<th>P/C classification</th>
<th>Presentation</th>
<th>Practice</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find</td>
<td></td>
<td>Ig.N</td>
<td>Ig.N</td>
</tr>
<tr>
<td>Use</td>
<td>Eg --&gt; Eeggs</td>
<td>Iegs.N</td>
<td>Iegs.N</td>
</tr>
<tr>
<td>Remember Generality</td>
<td>Eg --&gt; Eeg</td>
<td>Ig.P</td>
<td>Ig.P</td>
</tr>
<tr>
<td>Remember Instance</td>
<td>Eeg</td>
<td>Ieg</td>
<td>Ieg</td>
</tr>
</tbody>
</table>

Eg = Expository Generality
Eeg = Expository Instance
Ieg = Inquisitory Generality
Ig = Inquisitory Instance
N = New forms
P = Paraphrase
Table 2.3
Content-PPF Consistency table

<table>
<thead>
<tr>
<th>P/C classification</th>
<th>Eg</th>
<th>Eeg</th>
<th>Ieg</th>
<th>Ig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fact</td>
<td>N/A</td>
<td>symbol - symbol A</td>
<td>symbol - ? B</td>
<td>N/A</td>
</tr>
<tr>
<td>Concept</td>
<td>Definition: .name .super-ordinate .attributes .relationships</td>
<td>Example: .name .object, etc. .all attributes .representation</td>
<td>Classify: .new object, etc. .all attributes .representation .? (name)</td>
<td>State Definition: .name .paraphrase .? (definition)</td>
</tr>
<tr>
<td>Procedure</td>
<td>Process: .goal--name .steps .order .decision/branch</td>
<td>Demonstration: .goal--name .materials .execution .representation</td>
<td>Demonstration: .goal .new materials .response mode .? (execution)</td>
<td>State Steps: .goal .paraphrase .response mode .? (steps, etc.)</td>
</tr>
</tbody>
</table>

In addition to these primary presentation forms, Merrill also suggests secondary presentation forms. These forms do not come directly from the analysis of instructional content, but they direct learners to process the content information and thus enhance the learning results. It is suggested that the purpose of secondary presentation forms is to assist the primary presentation forms. Merrill suggests that those forms should be prescribed based on the performance levels of primary presentation forms (see Table 2.4). These secondary presentation forms include: enhancement (attention-focusing), prerequisite information, alternate representations, mnemonics, correct answer feedback, informational feedback, and others.
Table 2.4
Performance Adequacy table (Secondary Presentation Forms)

<table>
<thead>
<tr>
<th>P/C Classification</th>
<th>Presentation with Eg</th>
<th>Presentation with Eg</th>
<th>Practice with Ig</th>
<th>Practice with Jeg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find</td>
<td>enhancement, prerequisite information, alternate representations</td>
<td>enhancement, alternate representations</td>
<td>informational feedback</td>
<td>.</td>
</tr>
<tr>
<td>Use</td>
<td></td>
<td></td>
<td>alternate representations, correct answer feedback</td>
<td></td>
</tr>
<tr>
<td>Remember Generality</td>
<td>mnemonic</td>
<td>alternate representation</td>
<td>correct answer feedback, informational feedback</td>
<td></td>
</tr>
<tr>
<td>Remember Instance</td>
<td></td>
<td></td>
<td>correct answer feedback</td>
<td></td>
</tr>
</tbody>
</table>

An example is listed to demonstrate how to construct information fragments based on the component display theory.

Example:

Instructional purpose: Teach "long division."

Step 1: Use the Performance-Content matrix to classify the expected learning outcome.

Result: Since the purpose of teaching long division is to apply the skill into practical use, the performance level of the instruction is "Use." Long division is a series of steps dividing a multiple-digit number. The nature of the content is "Procedure."

Use (Performance dimension),
Procedure (Content dimension)

Step 2: Check the Performance-PPF Consistency table to determine the primary presentation forms.

Result: From the Performance-PPF Consistency table we look the third row which is labeled as "Use" in P(erformance)/C(ontent) Classification column. In that row, primary presentation forms are listed for presentation, practice, and performance respectively:
For presentation: Eg --> Eegs
For practice: Iegs.N
For performance: Iegs.N

Step 3: Check the Content-PPF Consistency table to see the prescription for each primary presentation form.

Result: From the Content-PPF Consistency table we look the fourth row which is labeled as “Procedure” in P(erformance)/C(ontent) Classification column. In step 2 we have identified three PPFs in the instruction. In the intersections of row “Procedure” and each PPF column, there is a prescription of the instructional activities for the PPFs.

Eg: explain the process of long division including goal, steps, order, decision/branch etc.

Eeg: demonstrate the executions of long division.
Ieg: ask learners to demonstrate the execution of long division in a new condition.

Step 4: Check the Performance Adequacy table to see the prescription for secondary presentation forms.

Result: In order to make instruction more effective, secondary presentation forms are prescribed to assist each PPF. From the Performance Adequacy table we check the third row which is labeled as “Use” in P(erformance)/C(ontent) Classification column. The intersections of row “Use” and column “PPF” list the SPFs for each PPF.

For Eg presentation: enhancement, prerequisite information, and alternate representations.

For Eeg presentation: enhancement and alternate representations.

For Ieg practice: alternate representations and correct answer feedback.

*******************************************************************************

When designers have constructed all the information fragments, these fragments are put into a knowledge base for future retrieval. In hypermedia courseware, there are three basic organizations for storing these informational fragments (Boone & Higgins, 1991;
Jonassen, 1988a; Locatis, Charuhas, & Banvard, 1990): unstructured, hierarchical, and network (see Figure 2.2).

![Diagram of Unstructured, Hierarchical, and Network Structures]

**Figure 2.2 Three basic organizations of hypermedia courseware**

Unstructured knowledge bases store all information fragments alphabetically, chronologically, or randomly. Learners have to type a key to start the link between screens. Those systems rely on the search function to link the screens. They give learners the maximum flexibility of association at the price of being fully responsible for the success of learning. Electronic encyclopedias and dictionaries are examples.

Hierarchical knowledge bases store information fragments in a fixed, tree-like sequence. Strict hierarchical systems allow learners to go only one-step forward or backward in the navigation. They are menu-driven information systems.

Network knowledge bases are probably the most valuable in education. In network hypermedia courseware, a node links to others based on the relationships between them. The complexity of the network structure depends on how many interrelationships between nodes exist. If each node has only a one-way relationship to connect to another, this organization becomes a hierarchical structure. If one node has relationships connecting to all other nodes, this organization works like a non-structured system.
For hypermedia systems used in computer industry and commerce, the most popular organizations are network or unstructured formats. For most traditional computer-based instruction, the content organization is hierarchical. When existing hypermedia systems are used in instruction, studies have frequently reported the loss of learners in hyperspace. Therefore, a mix between hierarchical and network structure will be appropriate for most subject contents. The complexity of content organization is based on the nature of subject matter, learner characteristics, and learning objectives.

Presentation flow

While content organization concerns the construction and organization of subject contents, the presentation flow deals with the analysis and design of the learning process.

Basically, learner control is a fundamental feature of hypermedia courseware. Hypermedia learners dynamically decide where to go, what to see, when to stop, and how to organize information. This is a plausible feature in the democratic society. But many learners are lost in navigation (Jonassen, 1988a; Marchionini, 1988a; Park, 1991). Clark (1983) also pointed out that learners' unguided strategies often are not the desirable strategies. Therefore, there is a call for "limiting" the learner control in using hypermedia courseware.

In "Review on hypermedia attribute studies" in chapter One, we have discussed strategies researchers suggested to resolve this navigational problem. These strategies include cognitive maps, hierarchical content structures, advance organizers, instructional cues, adjunct questions, and discrete tutors. Generally, they address the resolution through a better content organization. Except for the discrete tutor, these strategies only superficially touch the issue of a complete instructional process. As mentioned earlier, an "instructional" hypermedia system should address most of the instructional events during the learning process. Lacking appropriate instructional elements will cause the learning to
fail. Those navigating strategies, which only influence one or two elements of the whole learning process, are not the ultimate solution to the design of instructional hypermedia systems. A promising solution should result in the design of a good presentation flow.

The presentation flow of courseware can be viewed from two aspects. A broader view of the presentation flow concerns the whole learning process, while a narrower view concerns only the presentational sequence of content knowledge.

Gagne and his associates (1992) have carefully devised a series of instructional events to correspond to the needs of learning process. In their theory, nine internal learning needs and nine external instructional events are correlated as shown in Table 2.5.

<table>
<thead>
<tr>
<th>Internal learning process</th>
<th>External instructional events</th>
</tr>
</thead>
<tbody>
<tr>
<td>reception</td>
<td>gaining attention</td>
</tr>
<tr>
<td>registration</td>
<td>informing learner of the objective</td>
</tr>
<tr>
<td>selective perception</td>
<td>stimulating recall of prerequisite learning</td>
</tr>
<tr>
<td>rehearsal</td>
<td>presenting the stimulus material</td>
</tr>
<tr>
<td>semantic encoding</td>
<td>providing learning guidance</td>
</tr>
<tr>
<td>retrieval</td>
<td>eliciting the performance</td>
</tr>
<tr>
<td>response generation</td>
<td>providing feedback about performance correctness</td>
</tr>
<tr>
<td>performance</td>
<td>assessing the performance</td>
</tr>
<tr>
<td>control</td>
<td>enhancing retention and transfer</td>
</tr>
</tbody>
</table>

According to this theory, no matter what the subject matter and learning objectives are, the critical instructional elements remain the same. This theory has been effectively implemented in the design of various instructional media.

This study has argued that most existing hypermedia systems are not valuable for instruction. The main reason for their failure is missing important factors in the
instructional process. Therefore, to enhance hypermedia courseware, we should include as many instructional events as possible in the presentation flow of hypermedia courseware.

A proposed presentation sequence of hypermedia courseware is shown in Figure 2.3. This presentation flow begins with the title page. The title page should be artistically designed. The producer may use graphics, animation, or other techniques to arouse learner interest. The indication of course name in the title page will also arouse the mind set for learning the course content. The next page presents learning objectives. These objectives should clearly communicate the expected learning result of this courseware. It is desirable to allow learners to access this page at any time they need.

![Diagram of instructional events]

**Figure 2.3 A proposed presentation flow with instructional events**

After knowing what is expected of them, learners can select topics from the content menu. The information screens of each topic should present clear explanation, refer to previous experience, and provide suitable guidance. After tutorial screens, each topic should have a practice section and provide informational feedback.
In courseware, the tutorial, guidance, practice, and feedback are provided for each topic. When learners feel they have finished the tutorials, they then can take a performance test. This test will evaluate their achievement and provide remediation. Once the performance has reached the standard indicated in the objectives, learners can proceed to the ending. In the end page, statistical information about the learning process and suggestions for further studies are presented. They will provide reflection and recommendation about learners' cognitive strategies and future transfer.

Generally, the presentation flow is somewhat fixed for any self-sufficient instructional medium. However, since hypermedia courseware is highly interactive, the design of the presentation flow should also allow flexibility in the sequence of tutorial, practice, and performance test. We will say the proposed presentation flow is hierarchical in instructional activities while the content organization is more network structured. It may not fully correspond to the spirit of "free" and "open" in hypermedia concept, but it is more appropriate for instructional purposes.

To further explore the sequence of presenting tutorial content, we will go to the narrower view of presentation flow. Here, this study adopts a sequence based on Reigeluth's elaboration theory.

Reigeluth (1987) uses "zoom lens" as a metaphor to describe his elaboration theory. The presentation of content knowledge begins with a broad overview called "epitome." This overview contains fundamental topics of this course. It provides the scaffold for the content knowledge. Then based on learner interest, the subsequent tutorials "zoom in" on one of the topics. The provided details are called "elaborations." They fill in part of the knowledge scaffold. Once learners have explored the selected topic, they zoom back to the epitome again. The epitome will tie all the elaborations into the overall knowledge structure. The zooming process continues to other topics until the learning is completed.
Reigeluth's general-to-detailed approach shares much similarity with the advance organizer or content map we have discussed in hypermedia navigating strategies in chapter One. However, the elaboration theory systematically manipulates the interrelationships within the content knowledge. Adopted into hypermedia courseware, it allows considerable freedom for learners to select the topic sequence and depth. Accompanied by appropriate screen layouts, the elaboration theory presents a clear relational structure of the content to learners. Since it has presented an overall knowledge structure first and limited the exploration within a topic structure, learners are less likely to be lost in hyperspace.

III. A Courseware Template

For computer software, a template is a convenient and reusable model to effectively and efficiently construct system products. A template has the general skeleton, but no real content. It is a content-free framework (Boone & Higgins, 1991; Gleason, 1991). Teachers use the template as a skeleton and then fill in course content to make usable courseware. They can also use this template as a base to create new ones. A template can save time, cost, and effort in producing courseware. Its usage can be a milestone in promoting grassroots production of hypermedia courseware in schools.

We have explored theories and guidelines for the macro- and micro-design of hypermedia courseware. Based on the nature of content, objectives, and learner characteristics, courseware designers can then select or create courseware templates. To better illustrate the theories and guidelines we have discussed before, here this author proposes and develops a sample template for courseware design.

One caution about the use of templates is that there is no standard or best template for courses. The designer must frequently modify and create templates to meet various
needs. The template in this study is a starting point to build a template repertoire. Only after more and more people are involved in the production of instructional hypermedia systems and a broad template library is established, will the application of hypermedia courseware become versatile and effective.

Courseware structure

The structure of the proposed courseware template is illustrated in Figure 2.4. The course starts with a TITLE screen and is followed by an OBJECTIVES screen. After the OBJECTIVES screen, learners can select their path by clicking navigation buttons on the screen. The assistance buttons send learners to screens of production credits, operation guides, learning map, path history, and comment memo. The content topic buttons lead to TUTORIAL, INDEX, TEST, or END screens. Learners can freely select any button to link to those information screens. However, they must click "END" button to leave this courseware unit. The END screen will provide feedback about their learning activities and performance achievement.

Between the OBJECTIVES screen and END screen, learners engage in various instructional activities. They can view content screens or take the performance test. The content screens are grouped from two dimensions of the content knowledge. The hierarchical view of content knowledge contains many "tutorial" screens. It presents the "epitome" screen (overview or menu) first. "Elaborations" screens follow the selection of a sub-topic. In each sub-topic, a "PRACTICE" screen is included to diagnose the understanding of the information in the sub-topic tutorial screens. "INDEX" screens provide an index table to key concepts in this course unit. These key concept screens are horizontally organized. They can be linked to the hierarchical tutorial screens by clicking a line in the index table. Learners can also go back to where they came from by clicking the "RETURN" button on the tutorial screen.
Figure 2.4 The structure of a courseware template

The test part of the courseware presents the "TEST DIRECTION" screen first. The direction screen describes the rule of the test. Then, an answer sheet is shown on the screen. The test includes several multiple-choice questions. They are randomly selected from the test bank. Learners can pick any test item by clicking the item number on the answer sheet. They can jump from item to item randomly. They can also make any correction on their answers. Once they are satisfied with the answers, they click the "SCORING" button to evaluate their answers. The courseware also provides informational feedback. Learners can click any item number to view the explanation of the correct answers. Learners have full control of the order and speed of answering questions and reading feedback.

The courseware structure is derived from Figure 2.3. It includes all the important elements of instruction. It also allows the flexibility of non-linear association. In the
tutorial screens, the general-to-detail sequence reflects the zooming process of elaboration theory. This course structure is an example of the application of the macro-design theories we have previously discussed and used.

**Screen layouts**

To illustrate the implementation of micro-design guidelines, a pseudo content is put into each screen. The remark on the right side of each following figure explains how that screen is designed.

| Screen for title               | Figure 2.5 |
| Screen for objectives, direction, credits, etc. | Figure 2.6 |
| Screen for learning map and path history | Figure 2.7 |
| Screen for tutorial menus | Figure 2.8 |
| Screen for tutorial contents | Figure 2.9 |
| Screen for tutorial practices | Figure 2.10 |
| Screen for practice feedback | Figure 2.11 |
| Screen for index table | Figure 2.12 |
| Screen for key concepts | Figure 2.13 |
| Screen for test before scoring | Figure 2.14 |
| Screen for test after scoring | Figure 2.15 |
| Screen for ending | Figure 2.16 |
Tour of HyperCard
Virginia Tech
College of Education
April 5, 1993
* Adapted from "Your Tour of HyperCard"

**Remark**
This screen contains course name, producers, and copyright information. In addition to informing learners what the course is about, this screen also arouses learner interest by presenting a graphic or animation.

Figure 2.5 Screen for title

![](image)

**Remark**
This format is used for objectives, direction, credits, memo, or any assistance screens. If more than one screen is needed for the assistance information, use "(Card n of m)" to indicate more screens are ahead.

Figure 2.6 Screen for objectives, direction, credits, etc.

68
Figure 2.7 Screen for learning map and path history

Remark
This screen format presents a learning map or a learner's path history. In the path screen, nodes which have been visited are reversed. A flash node indicates the latest position in the course learning.

Figure 2.8 Screen for tutorial menus

Remark
Tutorial menu can be presented at different levels. This screen is a second-level menu. The top heading indicates the hierarchical status this menu represents. Clicking the heading or a menu item will bring the learner to the target screen.
Figure 2.9 Screen for tutorial contents

Remark
In the screen, tutorial information is displayed in the central area. It mixes graphic and text together. The heading indicates its hierarchical status in this course. "(Card n of m)" indicates more than one screen is used.

Figure 2.10 Screen for tutorial practices

Remark
The practice button appears only in tutorial screens (see Figure 2.9). It takes learners to this screen. The learner has two chances to respond to the question.
Figure 2.11 Screen for practice feedback

Figure 2.12 Screen for index table
Remark
This screen presents an explanation of the selected key concept to the learner. It is linked from the index table. By clicking the “link” button, the system will link to the related tutorial screens.

Figure 2.13 Screen for key concepts

Remark
On the screen there is a test sheet. The learner clicks one of the question numbers to bring in the question. The questions are randomly selected from a test bank. Not until the learner clicks the “SCORING” button will the evaluation begin.

Figure 2.14 Screen for test before scoring

72
0. In HyperCard, which object is often used to link cards?

A. a button
B. a field
C. a stack
D. a graphic

The correct answer is C.
Although fields may be used to link cards, we mainly use buttons to link cards.
(Please click an item number or a button to continue.)

Figure 2.15 Screen for test after scoring

1. You have completed the following topics:
   - Section 1.1 How HyperCard organizes information
   - Section 1.2 How to get around in HyperCard
   - Section 2.1 Card sizes
   - Section 2.2 How to start using HyperCard
   - Section 2.3 Card backgrounds and foregrounds
   - Section 2.4 Elements of a Card

2. The total learning time is 43 minutes 25 seconds.
3. Your test score is 78. (Our required standard is 80.)

Figure 2.16 Screen for ending

Remark
This screen basically is the same as test screens. It uses a pop-up window to display the informational feedback. The learner clicks question numbers on the test sheet to review feedback or other buttons to leave test screens.

Remark
This screen contains statistical information about the learner’s studying time, test score, and completed topics. It also suggests further study activities.
IV. Developing Courseware: An ID Model

Problems in developing courseware

Hypermedia is widely accepted. Schools and training institutions are eagerly developing and using hypermedia courseware to fulfill the dream hypermedia pioneers have promoted. However, there is a huge gap between the ideal and the reality (Gleim & Harvey, 1992; Nelson & Palumbo, 1992). For hypermedia users, problems such as courseware not fitting into any curriculum, schools not having the required equipment, and the structure of courseware not being appropriate for instructional purposes, have greatly discouraged teachers as well as students. For hypermedia designers, difficulties often arise such as complex techniques, continuously delayed schedules, higher and higher costs, no accountability for different job activities, and end users not being satisfied with the finished product.

Essentially, there are two problems related to the production of hypermedia courseware: the instructional design problem and the project engineering problem. Without the guidance of instructional design theories, hypermedia courseware may have little value in instructional contexts. Such courseware is merely computer software. Without practical project engineering techniques, hypermedia production becomes chaotic or even disastrous. The proposed ideas may have merit, but after the expenditure of time and money, there is no return for the investment.

Although hundreds of instructional design models exist, only a fraction of them deal with the design of instructional media. Even those instructional design models which have discussed media design principles provide no concrete procedures to carry out computer-based courseware projects. What has been learned from those instructional
design models becomes "inert" when the designer actually faces the challenge of conducting a hypermedia production project.

Books or manuals about the development of hypermedia systems have been published (Alessi & Trollip, 1985; Franklin & Kinnell, 1990; Jonassen, 1988b; Keller, 1987). They provide insights into the design of an effective hypermedia system. Nevertheless, most of these books adopt the practitioner's approach. They give detailed description of how to draw graphics, create animation, design screens, or even program system flows, but they fail to address instructional issues. The readers may have learned the programming techniques, but they may not know how to design a courseware to meet the instructional needs. They are not confident about whether their designing will fit into actual school settings.

Another problem occurring in hypermedia development books is that there is no practical example showing how production tasks will be carried out in a team approach. All the books acknowledge that multiple persons are needed for the hypermedia production (Alessi & Trollip, 1985; Franklin & Kinnell, 1990; Jonassen, 1988b; Keller, 1987). However, managerial issues are not touched by those references. How are tasks shared by team members? How much effort is needed to accomplish a job? How does one manage the resources or schedule the tasks? All these questions are essential to the success of a hypermedia project, but they have not been considered in hypermedia development books.

The computer industry has suffered from poor management on software development for the past 30 to 40 years (Utz, 1992; Wattam, 1991). The field of software engineering emerged to resolve the problems of managing software development. One systematic approach divides the development of software into a series of small steps. A precise definition is given to each step. Early quality assurance by evaluators and customers is greatly emphasized to avoid confusion and rejection of the final products (Utz, 1992).
Most principles in software engineering can be directly applied in hypermedia production projects. This study refers to those principles as project engineering. The implementation of project engineering will not only save time, money, and effort in producing hypermedia courseware, but will also ensure the quality of products. It devises a set of comprehensive yet manageable activities to complete the whole task. It emphasizes full communication between users and producers by confirming every major effort. It also ensures the responsibilities and cooperation of team members.

In the following sections, this study proposes an instructional design model for the production of courseware projects. Then it combines this model with software engineering principles to form project engineering procedures. A brief description of each activity and the roles of team members in the project are followed.

**An instructional design model**

For producing hypermedia courseware, this study proposes a Yang's model (see Figure 2.17) which evolves from the generic model of instructional design. A generic model includes at least five stages: analysis, design, development, implementation, and evaluation (Seels & Glasgow, 1990). While some models put these stages into a cybernetic loop, the author of this study found, based on the experience of producing computer courseware, that some clear-cut points of these stages are necessary to ensure the early quality assurance of products. The author has combined the essence of many instructional design models with his software management experience to form a three-dimensional model--Yang's model. This model has three stages and ten activities.
Yang's Model

I. Analysis stage
II. Development stage
III. Evaluation stage

Figure 2.17 Yang's ID Model

1. Analysis stage

The first stage of this model is the analysis stage (see Figure 2.18). It consists of three activities: goals analysis, learners analysis, and resources and limitations analysis. In practice, courseware production usually occurs in contexts where the goals are set by authorities and in which learners as well as resources are already determined. Courseware producers usually do not have much control over what to achieve, whom to teach, and what resources are available. These conditions are determined before the courseware production begins. Therefore, the first job a hypermedia production team should do is to identify useful information embedded in these particular backgrounds. Based on the information, courseware producers then design and develop the best instruction.
I. Analysis Stage

1. Goals analysis
2. Learners analysis
3. Resources analysis

Figure 2.18 Analysis Stage of Yang's Model

The objective of the analysis stage is to clearly define those background conditions. It analyzes factors like what goals the instruction strives to achieve, to whom this courseware is directed, and what resources or limitations the courseware will have. There is no fixed sequence in doing these three analyses. They can be done sequentially or concurrently. The result of these analyses will provide inputs for the activities in the next stage.

2. Development stage

The second stage of Yang's model is the development stage (see Figure 2.19). It includes five activities: construct content, select strategies, select media, select instructional settings, and design measurement.
These activities are based on the result of the analysis stage. Courseware designers should not arbitrarily alter the analysis result without redoing the analysis activities. However, these development activities are mutually influenced and should not be isolated from the others. At times, a particular activity may need adjustment based on the side effects or interrelationship of other activities. Formative evaluation is continuously ongoing during the whole process of this stage.

II. Development Stage

<table>
<thead>
<tr>
<th>4. Construct content</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Select strategies</td>
</tr>
<tr>
<td>6. Select media</td>
</tr>
<tr>
<td>7. Select settings</td>
</tr>
<tr>
<td>8. Design measurement</td>
</tr>
</tbody>
</table>

Figure 2.19 Development Stage of Yang's Model

The activities in this stage may proceed one by one or all at the same time. There is no fixed sequence of doing the development activities. However, any designing of an activity must bear the other four activities in mind. Unless all activities are completed, any activity is subject to change even at the last minute.

In carrying out the developmental activities in a courseware production project, we further divided this stage into two sub-stages: prototype design and formal production.
Since a courseware production costs a lot of money and effort, before actually spending a huge amount of these precious resources to create a real, computer-based product, we better have a simpler, paper-based prototype for confirmation and evaluation. The changes in a prototype are far easier and cheaper than those in a fully-grown product. Once the prototype is confirmed, we then can proceed to the formal production. If multiple courseware units are to be produced based on a generic prototype, this sub-stage is also called "mass production.

3. Evaluation stage

Evaluation is an endless loop. The result of evaluation should be used as the basis of refinement and further designing. Unless an instructional program is no longer to be used, evaluation should be continued. Therefore, although formative evaluation is well on the way during the development stage, a pilot test and the summative evaluation are done in this stage (see Figure 2.20).

Before release, instructional courseware should be tested. This trial process is the pilot test, a formative evaluation. A sample courseware is applied on a small-scale but authentic environment to examine its effects. Subjects are selected from the target population. All the implementing procedures are the same as they would be in the real contexts. Based on the test results, refinement is made. If major changes occur, another pilot test should be conducted after the refinement.

If the result of the pilot test is positive, the courseware products can then be distributed. The system documents are prepared for future usage. The installation and maintenance supports are provided to users. However, following the changes in subject content, learner characteristics, instructional settings, and other factors, a previously effective and efficient program may become ineffective or inefficient. Therefore,
implementation (summative) evaluation should be conducted periodically. Once again, if major changes occur, a pilot test is needed before this program is re-disseminated.

**III. Evaluation Stage**

9. Pilot test
10. Implementation evaluation

![Diagram of Evaluation Stage of Yang's Model](image)

**Figure 2.20 Evaluation Stage of Yang's Model**

V. A Project Template

Although most principles in instructional design models are similar, their applications are context-sensitive. Some of the applications derive meaning from the development contexts. It is difficult to devise a "generic" template to be applied in various production environments. Nevertheless, to demonstrate the management of hypermedia production activities, this study proposes a project template. This template includes a procedure flow, task definition, and role explanation. The procedure flow regulates the
production activities based on Yang's instructional design model. The task definition describes the scope and type of each production activity while the role explanation defines responsibilities of team members in each procedure. To illustrate the use of the project template, a Gantt chart for a hypothesized production project is constructed.

The project template is not fully transferable to other instructional hypermedia projects or other contexts. It is dependent on the particular scenario in which the template is evolved. However, the ideas presented here provide an example which is beneficial to the novice producers of hypermedia courseware.

**Procedure flow**

The procedure flow of the proposed project template is presented in Table 2.7. In the table, each row represents a production activity (procedure). The columns represent the roles of team members. If "P" appears in the intersection of a row and a column, that means the member is primarily responsible for that activity. If "s" appears in the intersection of a row and a column, that means the member will participate in this activity but is not primarily responsible for that activity.

Assuming the production of four units of hypermedia courseware, this study constructs a Gantt chart (Table 2.8) for the procedure flow. How those procedures are carried out into a practical context is demonstrated in the chart.

The Gantt chart is a master plan to control the project. It lists all the production activities in a chronological order. The length of each activity is also indicated on the chart. At the end of each activity there is a check point. The check point is critical in controlling the schedule. A delay on a check point will hold back the beginning of next activity.

In this hypothesized project, we assume that an eight-month period for the production of four instructional units. All these four units are based on the same teaching model. The project budget allows the hiring of skillful production staff. No training or
<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>S/C</th>
<th>PM</th>
<th>ID</th>
<th>CE</th>
<th>MS</th>
<th>AR</th>
<th>EV</th>
<th>TP</th>
<th>LB</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Set up working place</td>
<td></td>
<td>P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Kick-off meeting</td>
<td>s</td>
<td>P</td>
<td>s</td>
<td>s</td>
<td>s</td>
<td></td>
<td></td>
<td></td>
<td>s</td>
</tr>
<tr>
<td>2</td>
<td>Analysis stage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Define goals</td>
<td>s</td>
<td>P</td>
<td>s</td>
<td>s</td>
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**Abbreviations of key words:**

- **S/C**: sponsors, customers, instructors, or students
- **PM**: project manager
- **ID**: instructional designers
- **CE**: content experts
- **MS**: media specialists (computer programmers)
- **AR**: artists or musicians
- **EV**: external evaluators
- **TP**: typists and other logistic persons
- **LB**: librarians
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| **3. Development stage I**  
  (prototype design) |      |      |      |      |      |      |      |      |      |      |
| 3.1 construct content |      |      |      |      |      |      |      |      |      |      |
| 3.2 design objectives and test items |      |      |      |      |      |      |      |      |      |      |
| 3.3 select media      |      |      |      |      |      |      |      |      |      |      |
| 3.4 design instructional strategies |      |      |      |      |      |      |      |      |      |      |
| 3.5 select settings   |      |      |      |      |      |      |      |      |      |      |
| 3.6 evaluate prototype |      |      |      |      |      |      |      |      |      |      |
| 3.7 refine prototype  |      |      |      |      |      |      |      |      |      |      |
| 3.8 confirm prototype |      |      |      |      |      |      |      |      |      |      |
| **4. Development stage II**  
  (mass production) |      |      |      |      |      |      |      |      |      |      |
| 4.1 content writing   |      |      |      |      |      |      |      |      |      |      |
| 4.2 ID modeling       |      |      |      |      |      |      |      |      |      |      |
| 4.3 art works         |      |      |      |      |      |      |      |      |      |      |
| 4.4 media producing   |      |      |      |      |      |      |      |      |      |      |
| 4.5 system integration |      |      |      |      |      |      |      |      |      |      |
| 4.6 preparing manuals |      |      |      |      |      |      |      |      |      |      |
| **5. Evaluation & promotion stage** |      |      |      |      |      |      |      |      |      |      |
| 5.1 pilot test        |      |      |      |      |      |      |      |      |      |      |
| 5.2 refinement        |      |      |      |      |      |      |      |      |      |      |
| 5.3 documentation     |      |      |      |      |      |      |      |      |      |      |
| 5.4 acceptance confirm |      |      |      |      |      |      |      |      |      |      |
| 5.5 pack and release  |      |      |      |      |      |      |      |      |      |      |
| 5.6 summative evaluation |      |      |      |      |      |      |      |      |      |      |
| **6. Final report**   |      |      |      |      |      |      |      |      |      |      |
Table 2.8
Gantt chart for a hypermedia project (2 of 3)
( #: check point; *: work day; -: preparation day )

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* : check point; * : work day; :: preparation day
warm-up is needed for the production staff. They are also available at any time they are needed. The estimated work days is based on the author's previous CAI experience.

However, the construction of this Gantt chart is based on a hypothesized project. Real contexts may not be so simple. The chart is also a plan, not an activity log. It relies on the project manager to revise and execute the Gantt chart to make it a reality.

Roles of team members (see Table 2.7)

There are many different roles in a hypermedia production project (Seels & Glasgow, 1990). These roles are not necessarily to be played by different persons. Multiple persons may play a single role while one person may play multiple roles. The responsibilities and required expertise of nine suggested roles are defined below.

1. Sponsors / customers / instructors / students: They are persons who support the production or use of hypermedia courseware. The product of a hypermedia project must meet their demands. In the production process, they are responsible for providing necessary information to the production team. They must be able to clearly define their needs and confirm or explain why they do not agree with the result of each development stage.

2. Project manager: The project manager is responsible for the success or failure of a project. S/he also has to manage the budget, schedule, human resources, and make necessary administrative decisions. To successfully fulfill these responsibilities, a project manager must be able to negotiate with sponsors and customers. S/he has to construct a feasible schedule, control the budget, and coordinate the effort of the team members. In carrying out these administrative skills, it is very important that s/he has the basic knowledge of hypermedia and instructional design. The project manager should know what a hypermedia system can do and cannot do in instruction.
S/he should also know what his/her team can do and cannot do in producing courseware.

3. **Instructional designers:** In hypermedia projects, instructional designers have to know the strengths and pitfalls of using hypermedia in instruction. They should not only have the expertise of teaching, but also have a sufficient experience of using hypermedia courseware. In general, a middle level of hypermedia knowledge (e.g. taken 6 credit hours of study) is suggested for being able to design hypermedia courseware. However, highly sophisticated programming skills are not required. Their main responsibility in the hypermedia project is to prescribe courseware templates based on the result of learners and goals analyses. They suggest instructional strategies and cooperate with content experts to transform subject knowledge into instructional materials.

4. **Content experts:** They are experts in a particular subject domain. They should be able to clearly convey the information on the knowledge level of target learners. Teaching experience is recommended, but not necessary. In a hypermedia project, they provide the correct, precise, and up-to-date information to fit the need of the courseware.

5. **Media specialists:** They are experts in producing media. In a courseware project, their job requires computer programming skills. They must have advanced knowledge (e.g. having a bachelor degree in computer science) in controlling the computer hardware and software. Multimedia experience is essential in fulfilling their job in hypermedia courseware projects.

6. **Artists or musicians:** They supply graphics, music, video, or other artistic information for use of the hypermedia courseware. They should know the limitation and application of computers on audio and visual. It is preferable that they can create the graphic, audio, or visual directly in digit format.
7. **External evaluators:** They are experts in instruction, especially in computer-based learning media. They should also know the target learners well. In the project, the external evaluators are not part of this production task force. Therefore, they can be more objective in judging the quality of this courseware and providing useful suggestions.

8. **Logistic persons:** They help other team members with word processing, bookkeeping, document preparation, document delivery, and other chores related to the hypermedia project. General clerical skills will be sufficient to accomplish the task.

9. **Librarians:** They provide information and keep record of the system documents. In the hypermedia production process, their role is critical in establishing a standard of productivity. They register graphic files, program routines, and courseware units. Therefore, they should have the knowledge of electronic filing including backups, storage, retrieving, coping, etc. The stored documents can be used repeatedly to establish the standards for courseware products.

**Definitions of activities**

The activities listed on the procedure flow table are explained in the following.

0. **Set up working place:** Reserve work space, display schedule charts, set up tables and computers, and prepare all other supplies.

1. **Kick-off meeting:** Project manager announces the beginning of this project. Sponsors, users, and team members will meet together and share their concerns and expectations.

2. **Analysis stage:** This stage draws out information embedded in the project context.

   2.1 **Define goals:** Use general terms to define the instructional goals of this courseware project.
2.2 Define learners: Identify the characteristics of potential learners. These characteristics include ages, jobs, majors, living areas, grades, reading levels, computer experience, learning styles, learning difficulties, cultural backgrounds, etc.

2.3 Define resources and constraints: Identify the resources and constraints the target users have or will have for the instructional courseware. It should include the survey of computers, video, and other related equipment.

2.4 Confirm analysis: A written document will be sent to sponsors or customers to confirm the result of analysis. Before an approval is communicated, the next stage should not officially begin.

3. Development stage I (prototype design): This is the first part of the development stage. It’s main objective is to create a courseware prototype. Once the prototype is confirmed by the sponsors, courseware producers can proceed to develop the formal system.

3.1 Construct content: Based on goals and learner characteristics, content experts prepare the content materials which includes overview, explanation, examples, practices, feedback, and reviews.

3.2 Design objectives and test items: Instructional designers work with content experts to write down specific objectives and test items for the instruction.

3.3 Select media: Based on the nature of the knowledge content and instructional activities, instructional designers specify appropriate media (computer or video) and information formats (text, graphic, animation, video, or voice). Media specialists then create a quick-and-dirty draft of these media.

3.4 Select instructional strategies: This activity decides what strategies will be built into systems. Possible strategies include learner control, feedback, advisement, record keeping, learning path, etc.
3.5 **Select instructional settings:** Specify required equipment and setting to run the instructional system. It must be bound by the result of resources analysis.

3.6 **Evaluate prototype:** Invite external evaluators to sit in the work place and examine the prototype with instructional designers, content experts, and media specialists. At present, an articulate system may not be ready; a dry-run system (no real information included, only the link function and screen layouts with some sample statements are available) or a paper-based system is used.

3.7 **Refine prototype:** Based on the suggestions of external evaluators, refine the prototype.

3.8 **Confirm prototype:** The prototype should be sent to sponsors or customers to confirm the result of design. Before an approval to the prototype, the next stage should not officially begin.

4. **Development stage II (Formal production):** This is a sub-stage of formal or mass production based on the approved prototype.

4.1 **Content writing:** Content experts continuously construct content knowledge according to the formats of courseware template.

4.2 **ID modeling:** Cooperating with content experts, instructional designers write objectives, structure contents, organize activities, prescribe strategies, and design test questions.

4.3 **Art works:** Based on the specification of the prototype and instructional needs, artists create graphics, compose music, or suggest screen enhancements. Video specialists will shoot footage for the instruction.

4.4 **Media producing:** At the beginning, programmers work on the generic prototype. Then programmers add special routines into the generic prototype to form each courseware unit.
4.5 **System integration**: Integrate contents, programs, arts, and video into a complete system. Modify parts of the system if problems occur.

4.6 **Preparing manuals**: Write operational manual or handbooks for users.

5. **Evaluation and promotion stage**: This stage will put completed courseware units into real contexts for testing. The preparation for releasing the product is also included in this stage.

5.1 **Pilot test**: Pick up part of the completed units, install them into real environment, and test their instructional effects. The whole procedure of administrating the system should resemble the real one except for the size of users.

5.2 **Refinement**: Based on the results of pilot test, refine the products.

5.3 **System documentation**: Prepare detailed system documents for future maintenance.

5.4 **Acceptance confirmation**: A written document with the completed systems should be sent to sponsors or customers to confirm the result of development. Before an approval is communicated, the project is not complete yet.

5.5 **Pack and release**: After the courseware is accepted by the customers or sponsors, the programs, video disc, and manuals are packed into a package and sent to sponsors and customers. Register the courseware if copyright is needed.

5.6 **Summative evaluation**: The summative evaluation is conducted only after the courseware has been used for a certain period of time. A questionnaire is send to the users to collect feedback and suggestion. Maintenance records can also be used as part of the evaluation resources. If the evaluation result requires a significant change on the designing or programming, repeat related procedures as necessary.

6. **Final report**: Prepare a final report and presentation for the sponsors and customers. A discussion of the whole experience of producing courseware is useful.
VI. Courseware Tools

Even though school teachers know how to design hypermedia courseware and how to conduct a development project, the whole task of producing hypermedia systems is still overwhelming. The production needs a work force to share various duties. It also needs tools to help the work force do their jobs and coordinate the operation.

In the previous section, we have identified nine roles in a hypermedia courseware production: sponsor, project manager, content expert, instructional designer, artist, media specialist, evaluator, typist, and librarian. We have also proposed a procedural flow to manage the production activities. But two problems occur: "Will the team members effectively and efficiently utilize their talents?" and "How to synchronize their efforts?"

From experience, we have frequently seen all the production team crowded in front of a computer to watch a content expert slowly type in content or a programmer modify programs while others had nothing to do.

The tools discussed below are devised to simplify the tasks for individual members and to coordinate the team efforts. The tools are classified into four categories: object libraries, documentation tools, generation tools, and functional buttons. (For a printout of these tools, see Appendix A.) Since this study adopted Macintosh computers and the HyperCard system as the production platform, their terms are used to describe the tools. To make those terms clear, we explain them first.

Object: An object is an independent and fully functional entity of a computer software.

In HyperCard environments, it can be a stack, a background, a card, a button, a field, a graphic, or a window.

Stack: A stack is the metaphor of a HyperCard product. It is a collection of cards.

These cards within a stack are related to one another, or based on a common theme.
In general, a courseware unit is a stack.

**Background**: In HyperCard environments, each card is a composite of two layers: foreground and background. The foreground layer is the unique part of each card while the background layer is the general elements for a series of cards. These cards share that background.

**Card**: A card is the metaphor of an information screen in HyperCard environments. A card of HyperCard is like a paper index card on which one can jot information. In addition to representing information, a HyperCard card also has control functions to link cards together.

**Button**: In general, a button is a control object in a card. It contains a piece of script. When the button is activated, the contained script will perform control functions.

**Field**: In general, a field is a display area. It displays text information on screen. Some fields, such as menu items, may also act as control units.

**Script**: A script is a piece of computer program in HyperCard environments. It is embedded in an object of a stack. When that object is activated, the computer will perform the script program.

**Property**: A property is the attribute of an object. For example, a button exists in a particular location. The location, expressed in a series of numbers, is a property of the button. A button can also have a name, an identification number, or an icon format. All these attributes are the properties of that button.

In other platforms, such as Toolbook, or Authorware, those terms may vary. However, the concepts generally remain the same.

**Object libraries**

The purpose of the object libraries is to provide ready-made examples for courseware production. They not only illustrate the preferable designs of objects, but also
provide a copy-and-paste approach to facilitate the construction of courseware.

In the study, the object libraries consist of the Template Library, Card Library, Button Library, Field Library, and Script Library. Some libraries link to stacks which come with HyperCard. The users can enrich them by adding new collections. These libraries can be expanded to include a Graphic Library, a Sound Library, and a Video Library.

The Template Library (Figure 2.21) is the collection of courseware design templates. Functionally, it is a control panel with various template names. Clicking a template name will bring users to that courseware template.

Card, Button, and Field libraries (Figures 2.22 - 2.24) are the warehouse of object parts for courseware construction. They contain objects in various formats and functions. Graphic and Sound libraries are resources for special effects in producing courseware. They can also include resources for instructional contents.

![Courseware Templates](image.png)

Figure 2.21 Template Library
Card Library (Originally "Stack Templates")

Use these Templates to create new stacks. Click any line.

- Names & Addresses
- To Do List
- Calls Received
- Day Appointments
- Month Calendar
- Year Calendar
- Invoice
- Weekly Expenses

Go back to 1D Tools

Reading Buttons

You can paste these buttons into your own stacks. This stack contains buttons that ...

- Create card pictures
- Create pop-up fields
- Display traveling text
- Do various things
- Go to a specific card
- Hide and show pictures
- Locate Information
- Move cards
- Navigate through stacks

Go back to 1D Tools

Figure 2.22 Card Library

Figure 2.23 Button Library
Readymade Fields

You can paste these fields into your own stack.
This stack contains fields that...

Add numbers
Average numbers
Check input
Convert measurements
Create a card index
Display a different time zone
Display a one-month calendar
Display a two-month calendar
Display the card number
Display the date
Display the time continually
Encode text
Pop-up notes
Search and replace styles
Search and replace text
Sort lines

Figure 2.24 Field Library

The Script Library (Figure 2.25) collects program routines. Each program routine specifies a name, functions, inputs, and outputs. From the viewpoint of courseware producers, a piece of script works like a black box. The producers use the program routines and provide the needed data. The routines then perform functions and return the desired outputs.

In each object library, there is a collection of ready-made objects. The courseware producers can repeatedly use those objects without spending great efforts to create new objects. They simply copy parts from libraries to build their courseware. These libraries make the construction of courseware easier and quicker. They also are helpful in establishing standards and diminishing the load of maintenance.
Documentation tools

The documentation tools consists of the Stack Documenter, Field Content Documenter, Script Documenter, and Selected Property Documenter. The Stack Documenter records every object and its properties in a stack into a text file (Table 2.9). It even copies the pictures in the foreground and background of each card into graphic files. It creates a detailed and lengthy documentation. This documentation can be modified and then used to generate a stack. The Stack Documenter is also useful in creating the maintenance documentation after a courseware is completed.

The Script Documenter records scripts in each object of a stack. The Field Content Documenter records the text information in each field. The Script Documenter is designed for programmers, while the Field Content Documenter is designed for content experts. The Selected Property Documenter records only the selected properties of objects in a stack.
Table 2.9
A text file of stack properties (part)

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(Figure 2.26). It is useful for the process of modifying part properties of objects in an original stack. It records only the properties in which a producer is interested. Thus, the Selected Property Documenter reduces the size of the text file.
These documentation tools help users record the properties of stack objects into text files. The users then can examine and make necessary changes on text files without going to a tedious computer interaction.

**Generation tools**

The generation tools are used to create or modify a stack based on the specification on a text file. There is a Stack Generator and a Stack Modifier in the generation tools. The Stack Modifier, based on the specifications in a text file, modifies the original stack. The Stack Generator creates a new stack instead of modifying an old one. For the convenience of typing and editing, the Stack Modifier has two forms: full text and simple text. Full text tools use the full names (such as background and field) in the text file while simple text tools use abbreviations (such as bg and fld). However, both work the same.
These tools allow users to modify or create stacks without sitting in front of a computer and using an authoring system to do the tedious development jobs. All the modification and creation of courseware is done in a text file. Instead of doing the development tasks step-by-step, the generation tools do the tasks in one shot with great speed.

**Functional buttons**

The functional buttons perform various functions to facilitate the creation and modification of courseware. These tools include the Object Identifier, Picture Copier, Background/Card Objects Copier, Lock/Unlock Fields Tool, Gray Out Buttons Tool, Object Namer, Page Numberer, Put Script Codes Tool, Add Colors Tool, and many others.

The Object Identifier is used to identify the name of an object (see Figure 2.27).

![Object Identifier in Action](image)

*Figure 2.27 Object identifier in action*
When a content expert or a computer programmer wants to modify the data in objects, the Object Identifier will help them list the names of the target objects. The Picture Copier goes to each card in a stack. If there is a picture in the background or card layer, the Picture Copier will copy the picture into a graphic file and automatically name it as the sequential number of the background or card. The graphic file can then be used in other applications.

Except these two tools, all the other functional buttons must be copied into the prototype stack. Typically, a producer would go to the menu of the functional buttons in order to copy the desired button to his/her prototype stack. Then, clicking this pasted functional button will prompt the producer for extra information. When the button gets the needed information, it does the job.

For example, if producers want to add colors to the courseware, they simply specify the colors' code numbers for the groups of objects. The Add Colors Tool will go to each background or each card to add colors into the specified objects. Consider how much time will be wasted without the Add Colors Tool if a producer has to color a stack with averaged 14 buttons in 75 backgrounds.

Courseware developers' guide

The above tools can be used to meet various demands. However, for producing hypermedia courseware, a suggested approach is described in Table 2.10. A courseware developers' guide (see Appendix B) will illustrate these activities in detail.

1. Select template

The prototype design of an instructional hypermedia system begins with a discussion of what the courseware should look like based on the learners' characteristics, learning goals, and the available resources. Then, the instructional designer and/or content expert go to the Template Library to select an appropriate course template.
Table 2.10  
Tools usage

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* 3.1, 3.2, and 3.3 are conducted concurrently.

2. Modify template

Using this course template as a basis, instructional designers will modify the template by selecting the appropriate cards, buttons, fields and graphics from the object libraries to develop a course structure and screen layouts. The designers can also use functional buttons, such as the Background Objects Copier or Card Objects Copier, to duplicate backgrounds and cards.

For further use, this courseware template is transformed into a text file by using the Stack Documenter. The instructional designer can then examine and make the necessary modifications on the text file. With the modified text file, they select the Stack Modifier to modify the original stack, or select the Stack Generator to create a new one.

However, at this point, this prototype courseware has the basic structure and screen layouts only. It does not have the real subject content. Nor have it the artistic design and articulated control. A detailed description of these activities is presented in “Flow of production activities for instructional designers” in the Courseware Developers’ Guide (Appendix B).
3. a Construct content

After team members agreed on the courseware template, content experts begin to transform their knowledge into the instructional content. The instructional content should comply to the types and formats needed in the displaying fields of the courseware template. For example, the content experts may need to provide examples or practices to a concept. These examples and practice also should come in certain formats.

The content experts, with or without the help of typists, can type the content into a text file. They put control codes, which indicate where the content goes, into the text file. With the Stack Modifier, the instructional content in the text file will be integrated into the courseware template. The content experts can also use the Field Content Documenter to extract content from courseware template into a text file.

The integration and extraction processes are repeated until the content satisfies the production team. For minor modification, content experts can also use functional buttons such as the Lock/Unlock Fields Tool, Page Numberer, and the Show All Hidden Objects Tool to add, delete, or modify instructional content in display fields. For a detailed description of these activities, see “Flow of production activities for content experts” in the Courseware Developers’ Guide.

3. b Programming

Programmers work on the courseware control functions. The programmers can choose program routines from the Script Library or use functional buttons. Non-professional programmers can use the Gray Out Buttons Tool, Page Numberer, Put Script Codes Tool, and Objects Namer to complete most of the control requirement. More sophisticated programmers may want to create their own scripts and work on the customized functions. But they also get benefits from use the Script Documenter and the Stack Modifier. For a detailed description of these activities, see “Flow of production activities for programmers” in the Courseware Developers’ Guide.
3.3c Graphic design

Artists produce audio, graphical, or video fragments based on the requirements of that courseware design and instructional content. They can create new graphics, video, or audio. They can also copy audio and graphic files from the object libraries. The artists integrate the pictures into courseware template by the Stack Modifier. They can use the Picture Copier to export pictures into graphic files.

After the prototype courseware is completed, artists use the Add Colors Tool to transform the black-and-white HyperCard version into a color version. For a detailed description of these activities, see "Flow of production activities for artists" in the Courseware Developers' Guide.

4. Integration

The content experts, programmers, and artists repeat their create-integrate-modify process as many times as needed. The librarian will provide information about the available resources, and register new products into libraries. The typist produces and modifies the text files. Eventually, all the information from instructional designers, content experts, programmers, and artists will be integrated into a file. Using the Stack Modifier or Stack Generator, the production team creates a completed courseware unit.

5. Documentation

After completing the courseware, the production team can use the Stack Documenter to generate detailed documentation for maintenance purposes. To record only the instructional contents or the programs, the production team can use the Field Content Documenter or the Script Documenter to generate the desired documentation.
Chapter 3

Implementation: Producing a Sample Courseware Product

This chapter describes the implementation of the proposed courseware template, project template, and courseware tools in an example of a hypermedia production project. The beginning of this chapter describes the contexts of this project. Then, the processes and results of the activities in each production stage are reported. The last part of this chapter describes the end products of this project: the courseware, users' manual, and the progress log of this implementation.

I. Project Contexts

To validate the usefulness of the proposed templates and tools, one hypermedia production project was developed. A lesson in a course entitled "Plant Science Laboratory" was selected. This study uses the instructional materials in this lesson to create a unit of courseware by means of the templates and tools.

Instructional needs

This selected courseware unit addresses the needs of students who take the course of "Plant Science Laboratory." Biology majors are required to take the course "Plant Biology," usually in the second year of their college studying. This course requires
courses "Principles of Biology" and "Principles of Biology Laboratory" as its prerequisites. It provides basic knowledge about plants on the earth from a prospective of adaptation to the environment. It is also a fundamental basis for courses "Plant Taxonomy", "Developmental Biology", "Genetics", "Ecology", and many other advanced courses in Department of Biology and School of Forestry and Wildlife Resources.

At Virginia Tech, the course of "Plant Biology" is delivered through a series of lectures. About 200 students registered for this course in spring 1994. The instructor of this course had devoted a great effort to make the lectures interesting as well as informational. Yet the lectures are restricted to theoretical and verbal knowledge. Just as it is difficult to teach swimming without going into a pool or to teach driving without getting into a car, "Plant Biology" students need hands-on experience to appreciate the subject knowledge. The lectures, even with various audio-visual aids, still are one-way communication and the students become easily bored.

The instructor was frequently frustrated in handling teaching devices, too. There was not enough time to set up these audio-visual devices before the class begins. It was also difficult to talk and at the same time to change slides, overheads, and video. The lecture attendance was not great.

In Spring 1994, the instructor offered an experimental course, "Plant Science Laboratory", to supplement the lecture course "Plant Biology." This new course included fifteen units of laboratory activities which aimed to help students to get hands-on experience and better understanding of the course content of "Plant Biology."

This new course was a one-credit, three-hour optional course and fourteen students had registered in Spring 1994. This course is creative not only in that it adopts a different approach to teach plant biology, but also in that it uses computer and video technologies to facilitate the instruction. In addition to regular lab activities, students observed high quality photographs, animations, graphics, and video clips through computer-interactive-video
workstations. Students also used computers as communication tools for group discussions. In-house and commercial courseware were available for some lab lessons. However, many lab lessons had only paper-based manuals for controlling the viewing of videodisc images. Only two of these fifteen lab sessions had fully developed, computer-based courseware.

There was a strong feeling that this course was useful to complement the studying of "Plant Biology." Administrators and faculty had proposed having this course as a requirement for Biology majors; and this course might be taught together with "Plant Biology." If this proposal is approved, multiple course sections will be required to satisfy the demand of increased student registration. A series of self-sufficient computer tutorial programs would be helpful to ease the burden of teaching and guiding large numbers of students. If the courseware can link the laboratory exercises with the theoretical information (normally covered in lecture), then the students may attain deeper understanding through the integration of concepts and observations. This courseware can also be used as part of a lecture presentation; and the instructors can use it to deliver their instruction by integrating various devices, such as slide projectors, overhead projectors, videodisc players, and computers.

The courseware is not substitute for the direct exercise of lab activities. Nor will it be used to replace direct communication between students and instructor. The courseware will be used to enhance learning and decrease the repetitive burdens of teaching. Students who need acceleration as well as remediation of learning will also be benefited from using the courseware.

We expected that the adoption of computer courseware in this course would:

1. individualize the instruction based on students abilities and interests,
2. facilitate learning through multi-channel, multi-media experience,
3. integrate the observation with the explanation.
4. free instructors from repetitive instruction,
5. decrease the burden of controlling various audio-visual devices, and
6. make repeating a course unit a possibility at any time.

Production resources

For the purpose of verifying the usefulness of the templates and tools in this study, this project focused on the production process of a courseware unit, “Plant Growth”, which was one of the fifteen lab lessons in the course of “Plant Science Laboratory.” The available resources for this courseware production project are described below.

1. Task force

In this project, six roles of the production team were identified. The sponsors were from the department of Biology and the Educational Technologies division at Virginal Tech. The instructors of the course “Plant Science Laboratory” acted as content experts. The author of this study played the other roles of the production team: instructional designer, media specialist, artist, and project manager. Several professors and colleagues from the Department of Curriculum and Instruction served as external evaluators for this courseware unit.

2. Equipment and facility

The equipment available for this project included Macintosh Quadra 800, HyperCard 2.2, Pioneer LD-V2200 videodisc players, image scanners, and laser printers. The available facility included copy machines, telephones, meeting rooms, etc. The above equipment and facility were provided by the Educational Technology Lab at Virginia Tech.

3. Production time

This courseware production project was part of a dissertation study. In order to complete the dissertation before September 1994, approximately three-months (from May to July) of production time was scheduled for this project.
4. Reference materials

Reference materials for producing the courseware unit “Plant Growth” included textbooks, syllabus, classroom handouts, videodisc “Plant Science Lab”, and teacher-made test questions. Other supporting materials were videodisc player manuals, HyperCard manuals, Macintosh system manuals, some reference courseware units, and HyperCard software tools.

5. Resource persons

Major resource persons for this project were Dr. Mike Moore, Dr. John Burton, Dr. Glen Holmes, Dr. Susan Magliaro, Dr. David Taylor, Dr. Stephen Scheckler, Mr. Stewart Hili and Ms. Laurie Ruberg. Dr. Alice Walker and Mr. Edward Schwartz also helped in the production of this project.

II. Actions

Project planning

This project followed the prescribed procedures of this dissertation study carefully. It used the project template to manage the production activities; it also used the courseware template to design the courseware. The courseware tools were used to their maximum opportunities during the production process.

It must be remembered that these templates and tools may not necessarily be used in the way they were used in this project; and the time and efforts in each production activity may not fully reflect the actual demands in another project. Although the author has recorded the demands of time and effort as accurately as possible, the data shown on the Gantt chart (Table 3.1) and Progress Log (Appendix E) are context-dependent. It has only reference value.
Since no monetary support was available for this project, the estimation and allocation of expenses were omitted. The Gantt chart, which scheduled the man power and production time for this project, is shown as Table 3.1. The production activities in this project closely followed the prescription of the project template.

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The project was formally kicked off on April 29. The development time was planned to be twelve weeks. However, most of the development time was overlapped with summer break. Production team members and external evaluators had been unavailable in some days or weeks. Schedules for some activities were delayed. Therefore, the duration of an activity is not as important as the sequence of the activities.

As described in the previous chapter, a summative evaluation is conducted only after the courseware unit has been installed and used in the real instructional settings. For the purpose of the dissertation study, the summative evaluation is not included in this project.

Analysis stage

The analysis stage consists of three activities: goals analysis, learners analysis, and resources and constraints analysis. The main purpose of this stage is to understand the background and contexts of the development environment. Based on the results, the activities of designing and developing courseware can be better directed.

In this project, the production team had reviewed related documents and interviewed the instructors. They even came to the actual class to participate the learning process. At the end of this stage, the analysis result was sent to sponsors for confirmation.

A. Goals analysis

Goals are broad and general statements of the instructional intention. For the course of “Plant Science Laboratory”, the instructor defined the general instructional goals as:

1. Learners will know the basic concepts of the ecology and biomes,
2. Learners will understand the growth and development of plants,
3. Learners will understand the reproduction of plants,
4. Learners will understand the evolution of plants,

5. Learners will be interested in learning plant biology, and

6. Learners will learn and apply required lab skills in studying plants.

For the course instruction, emphasis was placed on high level thinking processes. Basic facts, such as names or features of plants, were important. But understanding the adaptation of plants to their environment was more important. This course also addressed the importance of students' attitude toward the subject knowledge. It used various hands-on activities, on-line discussion, and a great deal of visual information to arouse students' interests in studying plant biology.

B. Learners analysis

The target audience of this selected courseware unit were students who were taking course “Plant Science Laboratory”. They came from different grades as well as different departments. The profile of these students was described below.

1. Age: Although students' ages varied from 17 to 45, the majority (85%) were 19 to 22.

2. Educational level: The largest portion of students were sophomores from department of Biology. However, about one fifth to fourth of the students were from other grades or departments.

3. Prerequisite knowledge: This course required “Principles of Biology” and “Principles of Biology Laboratory” as its prerequisites. Therefore, all the students already had the background knowledge and lab skills in biology.

4. Learning time: All the students were full-time learners. They had plenty of time to study the course.

5. Computer literacy: Not all the students had experience in using computers and courseware. However, no special computer skill was required to use this
courseware unit. Even novice learners had no difficulty in controlling the computer and video devices.

6. Cultural backgrounds: Most students were Americans. Very few students were from other countries.

7. Attitudes toward the course: At the time of developing this project, this course was elective. The registered students volunteered to take it. Therefore, their attitude toward this course was quite positive. They expected this course would help them better understand plant biology. In the future, if this course becomes mandatory for all biology students, the attitude may not be as good as now. It is up to the course design to improve the students' attitude toward this course and plant science.

8. Laboratory experience: All students had taken “Principles of Biology Laboratory” as a prerequisite for this course. They already had general lab skills and experience.

9. Academic achievement: The entry academic achievement was about average. No particular learning difficulty had been reported.

10. Learning style: Instructors had the impression that about half of the students were a little passive. They only participated in those learning activities that were required. They did not ask for extra information or even go through all listed activities on handouts. They might follow the lab instruction without knowing exactly what was going on.

C. Resources and constraints analysis

The followings are the possible contexts in which most of the target students will use this courseware unit.

1. Course context: The biology students already have learned “Principles of Biology”, “Principles of Biology Laboratory”, “General Chemistry”, “General Chemistry Laboratory”, and other basic courses. When taking this course, they may also
taking "Organic Chemistry", "Organic Chemistry Laboratory", and "General Zoology" or "Microbiology". After this course, the biology students may take "Introduction to Genetics", "Cell Biology", "Principles of Ecology", or other core or elective courses.

2. Computer equipment: In the Biology Laboratory, there are 7 Mac-IIIsi computers with 13" RGB monitors, 7 Pioneer LD-V2200 videodisc players, 7 Panasonic video monitors, and 1 Mac-Workgroup 80 LAN server. All seven Mac-IIIsi computers are networked to the Mac-Workgroup 80 LAN server through AppleTalk.

3. Classroom setting: There is a dedicated laboratory for this course. In addition to the computer equipment, this Laboratory has an overhead projector, a portable screen, a LCD board, microscopes, closets around the walls, and many other lab equipment. Tables and chairs in this Laboratory are sufficient for 20 students at a time.

4. Learning resources: In addition to the Biology laboratory, learning resources also include Geology Museum, Virginia Museum of Natural History, Newman Library, herbariums, green houses, and neighboring forests. All these resources are on or around the campus.

5. Learning hours: At the time of developing this project, the Biology Laboratory opens only when there is a class. Other time to use this Laboratory must be scheduled by appointment. In the future, it may be open for students for extended periods.

Development stage

Throughout the development stage, five instructional elements were considered. They were: subject content, instructional strategies, media, instructional settings, and achievement test. Although the production team might focus on one instructional element at a time, all these five components were considered in every developmental activity. The
developmental activities were grouped into two sub-stages: prototype design and formal production. The production team constructed a courseware prototype first. After a confirmation of the prototype from the sponsors, the project then proceeded to formal production.

In this stage, the production team members used the courseware tools to construct a new courseware template. They combined graphics, content texts, and scripts into the template to form a courseware prototype. Then, the project manager discussed the prototype with external evaluators and sponsors. Some technical problems, such as showing colors in standalone application and displaying video controller palette, had delayed the progress of this project. But the most difficult decision came when the design principles conflicted with the sponsors’ or practitioners’ demands.

This project had to satisfy the sponsors’ needs according to the project template. Therefore, the instructional design had to compromise between the theoretic design and the sponsors’ preferred design. Part of the content organization did not follow the prescription of Merrill’s theory. The task schedule was also not kept accurately due to the unavailability of some team members and external evaluators in the summer break.

A. Subject Content
1. Core topics

The course "Plant Science Laboratory" has several broadly defined goals. This specific unit, which encompassed one lab session, is dedicated to accomplishing the goal of understanding the growth of plants. To help students understand the concepts and various processes of plant growth, this courseware unit contains four major content topics: Cell division, Cell expansion, Cell wall synthesis, and Meristems. An extra overview topic gives an general introduction to the unit content. All these topics are further divided into small fragments.
Based on these core topics, we constructed our learning objectives and detailed instructional contents. For each objective, there is tutorial information; and for those tutorial information, there are associated lab activities.

2. Content organizations

In this courseware unit, there are two types of content organizations. The tutorial screens are organized into a hierarchical structure (Figure 3.1). The general description of the theme, "plant growth", and a topic menu forms the first hierarchical level of the tutorial screens. From the topic menu, learners go into a topic to explore.

![Diagram of Hierarchical Content Organization](image)

**Figure 3.1 Hierarchical Content Organization**

If a topic is not being further divided, it is a basic concept. The basic concept is explained in the definition. From the definition, the concept has examples, practices, and other linked referential information (lab screens). If the selected topic has multiple
concepts, it will contain a general topic description and a sub-topic menu. Learners can go further into a basic concept from the sub-topic menu.

The general description of a complex topic or the definition of a concept topic is at the second hierarchical level. The concept definition from a sub-topic menu is at the third level of knowledge hierarchy. Examples, practices, and linked screens are at the next hierarchical level from the concept definitions.

Usually, students can go down or up in the knowledge hierarchy by selecting menu items or clicking heading bars on a tutorial screens. While selecting a lower level hierarchy leads to the more specific subject content, selecting a higher level hierarchy will provide a broader and more general view of the content knowledge. This hierarchical organization corresponds to the presentation sequence of elaboration theory (Reigeluth, 1987).

In addition to the hierarchical organization, this courseware unit also has a flat linear content organization. This linear organization (Figure 3.2) provides an index to the lab activities in this unit. All the lab activities are listed at the same level in the index table. Students select a lab activity from the index and go to the lab screens. They can review the lab requirements and procedures in activities in any sequence.

![Figure 3.2 Linear Content Organization](image)

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The purpose of a laboratory activity is to offer hands-on experience to augment the tutorial information. Therefore, doing a correct laboratory activity relies on the understanding and is subject to the verification of tutorial knowledge. There is a need to link the tutorial screens and the lab screens. From a lab screen, students can click the "LINK" button (see Figure 3.3) and link to the related tutorial screens. They can compare their lab results with the descriptions and examples of tutorial screens. Students can also go from a tutorial screen to the lab screens by clicking the list of related lab activities (see Figure 3.4).

![Diagram of Plant Science Laboratory: Unit 3. Plant Growth](image)

**Figure 3.3** "LINK" button in a Lab screen
3. Content formats

Once the learning objectives had been identified, the presentation forms of subject contents were prescribed by checking Merrill’s tables of Primary and Secondary Presentation Forms. In this courseware unit, we had prescribed primary presentation forms such as: overview, definition, explanation, examples, demonstration, and practices. We also prescribed secondary presentation forms such as: highlights, acknowledge feedback, informational feedback, and related links. All the information within different presentation forms was integrated under the common objective. Presentation forms of an example objective are described below:
Objective: Students will be able to describe cell division in plants.

Expected learning outcome: Use the Performance-Content matrix to classify the expected learning outcome:

Remember generality (Performance dimension)
Concept (Content dimension)

Primary presentation forms: Check the Performance-PPF Consistency table to determine the primary presentation forms. Then, check the Content-PPF Consistency table to see the prescription for each primary presentation form.

For presentation: $E_g \rightarrow E_{egs}$
For practice: $I_g P$
For performance: $I_g P$

This courseware unit gives a definition to the concept ($E_g$) (see Figure 3.5). The definition includes name, attributes, and relationships. Then, it provides multiple examples ($E_{egs}$) (see Figure 3.6) of the concept. For practice or performance, this courseware unit asks students to state the definition or identify the attributes or relationships of the concept (see Figure 3.7 & 3.8).

Secondary presentation forms: Check the Performance Adequacy table to see the prescription for secondary presentation forms:

For $E_g$: enhancement, prerequisite information, and alternate representations.
For $E_{egs}$: enhancement and alternate representations.
For $I_g$: correct answer feedback and informational feedback.
Enhancement: In presentation, highlighting devices are used to emphasize the name and critical attributes of the concept (see Figure 3.5).
Prerequisite information: The presentation also addresses the broader knowledge of the concept (see Figure 3.9).
Alternate representations: The presentation describes the definition or presents examples in different formats (see Figure 3.6).
Correct answer and informational feedback: They are provided in each practice and test question (see Figure 3.7 & 3.8).
Plant Science Laboratory: Unit 3. Plant Growth

Cell division of plants is a distinctive process. A **PHAGOMPLAST** guides the formation of a **CELL PLATE** perforated by **PLASMODESMATA** that completes **CYTOKINESIS**. Cells are thus fixed in their relative positions by **INTRACELLULAR CEMENT** (the middle lamella) as well as by the cytoplasmic strands of plasmodesmata.

Figure 3.5 Screen of the definition for Cell Division with enhancement

**Videodisc Examples:**

1. Mitosis
2. Cytokinesis
3. Primary Cell Wall Structure
4. "Pre-Prophase Band" of Microtubules
5. Animation of Cell Wall Deposition

(Please click the item lines to review video.)

Figure 3.6 Screen shows a list of examples for part of Cell Division (Multiple examples show alternate representations)
Figure 3.7 Screen of a practice question for Cell Division with incorrect answer and feedback

Figure 3.8 Screen of a test question for Cell Division with correct answer and informational feedback
B. Objectives and assessment

1. Learning objectives

Theoretically, instructional content should be constructed after the objectives have been identified (Myers, 1990). However, in most schools and training institutes, instructional content is already assigned or limited by authorities. For instance, a public school teacher has to use textbooks selected by school boards. Even in this college course, the content is limited to the available knowledge in this subject domain. And most of the times, there are some “outstanding” textbooks which direct the contents of instruction.

In this courseware unit, we compromised the theoretical and practical viewpoints. From existing subject contents, we defined our learning objectives. However, we also used our objectives to reorganize the subject contents. The production team had defined the learning objectives of this lesson unit and presented them in the "Objectives" screens (see Figure 3.10 & 3.11).
Plant Science Laboratory: Unit 3. Plant Growth

Objectives
(Card 1 of 2)

After having finished this course unit, you should be able to:

1. distinguish the process of growth in plants from that in animals.
2. recognize the key components of the growth process in plants: cell division, cell expansion, and cell wall synthesis.
3. define the role of meristems in plant growth.
4. recognize, based on cell shape and position, growth patterns in plants.
5. identify causative forces that create cell patterns in plants.

Figure 3.10 Screens of Learning Objectives for Plant Growth (1)

Plant Science Laboratory: Unit 3. Plant Growth

Objectives
(Card 2 of 2)

Additional course objectives include:

1. conduct a series of laboratory activities exploring plant growth and find the prescribed results.
2. pass the achievement test at a 80% correct-rate level.

Figure 3.11 Screens of Learning Objectives for Plant Growth (2)
2. Assessment

In this courseware unit, an achievement test was adopted. For the convenience of scoring and programming, only multiple-choice questions were used. The content expert and the instructional designer constructed test questions for each objective. Various types of learning effects were considered in this test. Graphic as well as textual questions were used to measure the learning achievement. These questions composed a test bank. Each time a student takes a test, the computer will randomly select questions from the test bank.

Students answer questions from a test sheet at any order. They can go back and forth to change their answers. Until the "SCORING" button is clicked, students can use as much time as they need to answer questions. After students have clicked the "SCORING" button, the computer will check their answers. It provides a total score and correct answers. Students then, can pick up any question, no matter its answer is correct or wrong, to review its informational feedback (see figure 3.8).

This delayed feedback strategy was adopted to allow students more time to ponder the difficult questions. The computer will keep a record of the students' learning achievement. The pass level was set to the 80% correct rate by the content expert and the sponsors.

C. Instructional strategies

The adoption of instructional strategies into a courseware design was based on the characteristics of media, goals, subject contents, and learners. Before this production began, many factors had been considered to decide which medium should be adopted in this project. When the decision came to use hypermedia to deliver the instruction, this production project was defined by the characteristics of hypermedia.

From the goals' analysis, the instructors stressed the importance of arousing learners' interests in studying plant science. The subject contents also by nature composed
a huge amount of visual information. Therefore, the production team adopted the strategy of using multiple information formats to represent the instructional contents.

In the analysis of learners' characteristics, the instructors reported that some learners were relatively passive and they easily lose the whole picture of the course contents. In the courseware design, the designer, therefore, intended to adopt strategies to encourage students' active participation and provide structured contents.

In general, these following strategies were specifically emphasized in the design of this courseware:

1. Individualizing instruction.
2. Encouraging students' active participation.
4. Providing non-linear learning path.
5. Providing links to quickly retrieve related information.
6. Adopting "learner-centered control" strategy.
7. Providing maps to help users control their navigation.
8. Providing reinforcement and informational feedback.
9. Presenting instructional events based on learning needs.

D. Media formats

Adopting multiple information formats was the proposition of this hypermedia project. However, the production team still needed to decide the formats of fonts, sizes, and colors of texts. Decisions also were needed on the types (graphic or text) of information and the amount of interaction. This project had considered three factors in deciding what formats should be adopted to present information.

The first factor was the characteristics of the content. Plant biology is a field which incurs a lot of visual information. As Dale has asserted (1946, cited in Heinich et al.,
1989) that concrete knowledge is the foundation of abstract concepts. In order to help students understand the abstract concepts of plant science, the concrete, graphical information is critical. Therefore, this courseware unit used many video images and animation to illustrate the concepts and processes in plant biology. The graphic information was greatly emphasized.

The second factor for deciding media formats was learners' characteristics. From research, we had established guidelines for selecting media attributes, such as the text fonts, text sizes, colors, highlightings, etc. Miller (cited in Ashcraft, 1989) has asserted that the capacity of human short-term memory is rather limited. Therefore, it is inappropriate to present a great amount of information on a single screen. To decrease the amount of information presented on a screen will also increase the frequency of learners' interaction with the computer. However, an unstructured, database type of courseware may cause learners to become lost in hyperspace (Park, 1991). A structured content with limited interaction was adopted in this format selection.

The last factor to decide media formats was the practicability. Resources of money, time, and effort were considered in the selection of media formats. The formats were also restricted by the availability of information formats. For instance, in designing the title page of this courseware unit, the author liked to create an attractive colorful animation. However, the time, artistic talent, or even the available computer function did not support his fantasy. The title page eventually ended up with a still picture and some textual animation.

E. Instructional setting

It is essential for the success of a courseware unit to think about what the real instructional context will be. The production team had investigated the real classroom environment. There were sufficient computers and videodisc players. The computer
monitors supported color functions. The network server was also powerful enough to handle the download and upload of system information.

However, there was no HyperCard 2.2 in those computers. To decrease the purchasing expenses, the production team decided to use a run-time version system. The run-time version courseware was executed without the software package (HyperCard) which created this courseware product.

Another consideration was the convenience of moving back and forth from computers to lab tables. This courseware unit was not intended to replace the manual lab activities. It would provide tutorial information and lab examples to students. When doing laboratory activities, students still need to leave computers and go to lab tables. Frequently, they need to refer to the lab procedures or check the video images to verify their findings. The courseware unit thus organized the lab activities into an index table. Students can select the description of a lab activity from the index. They can also click the "LINK" button to refer to related tutorial information or visual examples. This may not resolve the problem of moving back and forth between computers and lab tables, but it does make checking related information easier for students.

F. Prototype design

Constructing a courseware prototype was the main task of the first half of this development stage. The prototype design began with the selection of a courseware template from the Template Library in Courseware Tools. Using this selected template as a basis, the production team modified and designed the screen layouts, instructional strategies, and content organizations by means of the object libraries, generation tools, documentation tools, and functional buttons.

The production team had considered all the five instructional components in the constructional process. Nevertheless, to assure the appropriateness of this prototype,
developmental reviews and a prototype evaluation were conducted during and after the prototype construction process respectively.

The developmental reviews occurred during the process of constructing a prototype. The participants in a review included sponsors, content experts, instructional designers, artists, programmers, or target users. They could be internal or external to the production team. They participated in the review process at any moment that a team member felt it was necessary to have some experienced and knowledgeable people to provide advice and confirm his/her actions. The sooner a problem is spotted, the less costly will the modification be. If team members are not confident with what they have done or are doing, it is better to have others to review the design immediately.

A prototype evaluation was conducted at the end of prototype construction. Its participants were external experts in the fields of subject content and instructional design. They reviewed the prototype from a professional viewpoint. The related team members were with the evaluators during the evaluation process. The team members explained their design to clear the possible misunderstandings or asked evaluators to explain their comments in depth. In this project, this prototype had been sent to Dr. Burton, Mr. Hou, Dr. Holmes, Dr. Magliaro, and Dr. Moore for evaluation. Their suggestions are listed in the Progress Log (Appendix F).

The comments of developmental review and prototype evaluation were carefully examined before any actual modification began. Reasons for the examination were: (1) any modification will probably have some effects on the other "OKed" parts, (2) sometimes, the limited resources may restrict the implementation of suggested modification, and (3) some suggestions are mutually conflicting and there is no way to satisfy every viewpoint of experts. However, once decided, the modification was done as accurately and quickly as possible. The documentation tools, generation tools, and functional buttons were
convenient for non-professional software producers to construct and modify the courseware prototype.

The final prototype was sent to the sponsors for confirmation. The sponsors had the right to demand how this courseware unit should be designed. When a major revision occurred, confirmation was repeated.

G. Formal production

A courseware prototype does not have the full content or completed art works. It may even be just a dry-run computer template. The activities in the formal production sub-stage are to integrate the real, completed text, graphics, and programs into the prototype. In the hypermedia project, the content experts, instructional designers, artists, and programmers simultaneously worked on their own tasks based on the specifications of the prototype. Various courseware tools were used to facilitate the creation and integration of their tasks. Among these tools, the Field Content Documenter, Stack Modifier, and Script Library were most useful for content experts, artists, and programmers, respectively.

After the prototype was fully developed into a courseware product, an operational manual was prepared for the pilot test in the next step.

Evaluation stage

Evaluation of an instructional system should include formative and summative parts. In this project, the formative evaluation was conducted through the developmental reviews, prototype evaluation, and pilot test. The summative evaluation is critical for the purpose of disseminating the product. However, it cannot be done before the instructional system is formally installed and used. Therefore, the summative evaluation will only be briefly described in this project.
A. Pilot Test

A pilot test was conducted after the courseware unit had been completed but before it was formally accepted. In the pilot test, the courseware unit was installed into the real classroom. A class of eight students participated this pilot test. The instructional process with this courseware unit was realistic. The purposes of the pilot test were to find out problems in administration, classroom settings, users' attitudes, and learning effects.

At the beginning of the pilot test, the instructor briefly explained and demonstrated the courseware's operation. After this introduction, students began to use this courseware unit. The instructor and four helpers helped them to solve technical problems. These students used this courseware unit to explore the content knowledge for forty-five minutes. Then, they filled out a courseware evaluation form (Appendix C) and proceeded to hands-on experiments.

The courseware evaluation form composed two parts. The first page contained several rating scales on subject content, instructional strategies, and media design. The second page had five open questions about the whole system. The result of the courseware ratings is shown on Table 3.2. All the criterion on the rating list got positive to very positive feedback. In open questions, seven out of eight students described visual information as one of the best features of this courseware unit. Two described user-friendliness as a best feature.

The negative responses toward this courseware unit focused on the fast learning pace and the technical language. Two students were not comfortable with the technical terms used in this courseware unit. Modifications were needed. Three students complained that too much information had to be learned in such a short period. The fast pacing was due to that the instructor had requested students to complete the courseware unit in forty-five minutes in order to have time for experiments. If this courseware unit was
<table>
<thead>
<tr>
<th>Subject Content</th>
<th>Excellent</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Learning objectives are appropriate for the course.</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>2. Tutorial information matches the objectives.</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>3. Tutorial is appropriate for your knowledge level.</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>4. Information is well organized.</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>5. Information is accurate and up-to-date.</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>6. Language is clear and easy to understand.</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>7. Video information is related and meaningful.</td>
<td>6</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructional Strategies</th>
<th>Excellent</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Objectives are clearly stated.</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>2. Strategies are flexible to meet the needs of various learners.</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>3. Learning activities are appropriately organized.</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>4. Practice questions are helpful in understanding the content.</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>5. Test questions are closely related to objectives.</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>6. This program provides appropriate informational feedback.</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>7. Lab activities help understand tutorial information.</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Media Design</th>
<th>Excellent</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Media are appropriate for the instruction.</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>2. Screen layout is attractive.</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>3. Interface is easy to use.</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>4. System is stable and reliable.</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>5. Help section is detailed and helpful.</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>6. Important information is well highlighted.</td>
<td>6</td>
<td>2</td>
</tr>
</tbody>
</table>

1. Totally, eight students attended this pilot test.
2. The numbers in the right column represent the frequency responses to the rating scales and the criteria statements.
3. *: Two students did not respond to this statement.
4. ^: One student did not respond to this statement.
### Table 3.2
Evaluation results of Hypermedia Courseware (continued)

<table>
<thead>
<tr>
<th>Evaluation Form for Unit 3: Plant Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IV. General Impression</strong></td>
</tr>
<tr>
<td>1. <em>How do you feel about this courseware unit?</em></td>
</tr>
<tr>
<td>Helpful, educational, or wonderful: (8)</td>
</tr>
<tr>
<td>2. <em>What are the best features of this courseware unit?</em></td>
</tr>
<tr>
<td>Visual information: (7)</td>
</tr>
<tr>
<td>User-friendly: (2)</td>
</tr>
<tr>
<td>Test with feedback: (1)</td>
</tr>
<tr>
<td>Clear language: (1)</td>
</tr>
<tr>
<td>3. <em>What are the poorest features of this courseware unit?</em></td>
</tr>
<tr>
<td>Limited learning time: (2)</td>
</tr>
<tr>
<td>Technical language: (1)</td>
</tr>
<tr>
<td>Missing animation: (1)</td>
</tr>
<tr>
<td>Separated computer and video images: (1)</td>
</tr>
<tr>
<td>Lost in navigation: (1)</td>
</tr>
<tr>
<td>4. <em>How can this courseware unit be improved?</em></td>
</tr>
<tr>
<td>Slow down the learning pace: (1)</td>
</tr>
<tr>
<td>Simplify language: (1)</td>
</tr>
<tr>
<td>Add colors: (1)</td>
</tr>
<tr>
<td>Provide feedback to answers: (1)</td>
</tr>
<tr>
<td>5. <em>Other comments?</em></td>
</tr>
<tr>
<td>Spelling errors: (1)</td>
</tr>
<tr>
<td>Add colors: (1)</td>
</tr>
<tr>
<td>Have more learning time: (1)</td>
</tr>
<tr>
<td>Simplify language: (1)</td>
</tr>
</tbody>
</table>

*The number inside parentheses is the number of responding students.*
distributed before class or was allowed to be used after class, this problem would be resolved. The instructors had considered to install the courseware unit into a public accessible computer laboratory. Students will have more time to learn from it.

Two students had suggested to add colors into courseware. Since the lab computers were slow, the pilot test did not use the color version unit. Before more powerful computers are installed, the color version courseware unit probably will not be used.

In addition to these responses, the author also found two other problems. During the pilot test, some students constantly referred to handouts while exploring the tutorial screens. One of them even took notes from the screen. It seemed that these students had not adjusted their "old" learning strategies to the new setting.

The other problem related to the sharing of computers. When a student suddenly added this course, this lab had no extra computer for his use. This new student had to share a computer with another student. The new student read the screen more slowly, and his partner had nothing to do and was bored. This showed that the effect of individualization in hypermedia courseware could be damaged if multiple students had to share one computer. It is especially true when these multiple students have different learning strategies or abilities.

B. Summative Evaluation

After this courseware unit had been examined in a pilot test, it was refined. The final product was sent to the sponsors for acceptance confirmation. It was then formally packaged and installed in the instructional setting. System documents were prepared by using the Stack Documenter for future maintenance. The production project was finished. However, an evaluation cycle is just at the beginning.
At the end of each semester, a survey will be conducted to collect students' feedback and suggestions. Based on the information, this courseware unit will be modified accordingly. If major changes occur in course content, learner characteristics, or instructional settings, this courseware unit will be reconstructed.

III. End Products

After implementing the templates and tools into a hypermedia project, this study successfully created a courseware unit for "Plant Science Laboratory." The courseware printouts are listed in Appendix D. The actual courseware unit is available upon request to the author through Educational Technology Lab, College of Education, at Virginia Tech.

With this courseware unit is a Courseware Manual (see Appendix E). This manual explains the system requirements, installation, operation, maintenance, and copyrights to the courseware users.

In the process of implementing courseware tools, the design of those tools has been refined or expanded. Screen printouts of the "Courseware Tools" are listed in Appendix A. Also, a diskette of the "Courseware Tools" is available for research purposes by requesting to the author.

Again, accompanied with the changes of the Courseware Tools, the Courseware Developers' Guide is updated. This guide describes how these tools are used by different team members. A task flow is suggested in this guide. This flow is the actual activities the production team has experienced in this sample project. The Courseware Developers' Guide is listed in Appendix B.

The author has recorded the activities of the courseware production project. This Progress Log is listed in Appendix F. This progress log shows the task numbers, the
work hours, and the team roles involved. It describes the task activities in detail; the tools which have been used in these production activities are also recorded. This progress log sheds light on how this sample courseware unit is constructed and how the tools are used. However, production contexts vary case by case. The recorded work hours for these activities in the sample project may not be directly usable in other projects. The task sequence is more important.
Chapter 4

Discussion

This study was triggered by the fascination and promise of hypermedia for instruction. Hypermedia with the capabilities of providing non-linear information access and the presentation of multiple information formats has great potential for creating effective instruction. However, research consistently reports that learners are lost in hyperspace and local teachers have difficulties in producing hypermedia courseware. The study takes the position that if hypermedia is going to have a significant role in education, these problems have to be resolved.

This study has reviewed the historical development of hypermedia. It has also examined the theories and research findings related to the application of hypermedia to education. Encouraged by the potentials of hypermedia to realize individualized instruction, this study is dedicated to adapting hypermedia for education. To resolve the disorientation of using hypermedia, this study proposes a courseware template which is based on instructional theories and research findings. Hopefully, this template will fulfill the potentials of hypermedia and avoid the pitfalls of existing hypermedia courseware.

In order to help teachers produce hypermedia courseware, this study has developed a project template and a set of courseware tools. The project template reminds producers of the important instructional factors and coordinates the efforts of a production team. It helps producers to better estimate and manage their hypermedia projects. In addition to the project template, this study has created a set of courseware tools to reduce the barriers of
technology. These tools minimize the demands of computer programming in producing courseware. All of these templates and tools have been successfully implemented in a sample production project.

This chapter looks back at how this study has contributed to the fulfillment of adapting hypermedia for instruction. Then, it reports the author's reflections during and after the implementation of these templates and tools. Finally, this chapter looks forward to how future studies in instructional technology can be built upon this study.

I. Contributions of This Study

The first contribution of this study is to urge the inclusion of instructional elements in the production of hypermedia courseware. As has been made clear in the first chapter, there is not much "instruction" in existing hypermedia courseware. Even though educators are enthusiastic about using hypermedia, most of them are fascinated by the technology only. They import commercial software into educational settings. Not much thought has been put into the design of "instructional" hypermedia systems.

This study adopts an approach of designing hypermedia courseware from the viewpoint of a "complete" instruction package. It has considered as many instructional elements as possible while exploring the usage of hypermedia technology. The proposed courseware template is based on instructional theories and research findings. Here, hypermedia is the tool to embody instructional strategies. Instruction is not distorted to fit into the fantasy of technology.

The second contribution this study makes is to bring the principles of software engineering into the production of hypermedia courseware. The computer industry has experienced the pains of mismanaging software projects for the past several decades. From
its errors, the computer industry has built up software engineering principles to handle the software production. Educational institutions have less financial support than the computer industry. School teachers also know less about software production than professional programmers. To use these limited resources to produce courseware, educators have to control the courseware project more effectively and efficiently.

This study adopts software engineering principles from the computer industry. They are integrated with an instructional design model to form a practical project template. The workflow is planned. Tasks, as well as member roles, are defined. More importantly, customers' or sponsors' demands are frequently checked by formal confirmations at the end of each major stage. Its step-by-step confirmation ensures that the end products will meet the needs of the customer.

The third contribution of this study is the creation of a set of courseware tools. These tools are devised to meet the technical demands in a courseware production project. Ideally, they will partially automate the courseware production. Therefore, they not only accelerate the production speed, but also ease the demands for technical skills. With these tools, school teachers, who do not have the professional programming skills, are more likely to participate in courseware production.

Besides these three contributions to instructional technology, this study also promotes the concept of "libraries". Instructional designers can select a courseware model from the Courseware Template Library. Programmers can reuse the script codes from the Script Library. Cards, buttons, functional fields, and graphics are stored in various object libraries. These objects are the building blocks of a complete courseware package. The use of various libraries will not only make production faster and easier, but also more maintainable. Certain standards are established when these products are built from common components.
The sample courseware unit is directly usable for a lesson unit in "Plant Science Laboratory." The progress log is also a useful reference to estimate the effort and time span required to produce a similar hypermedia courseware. The summative evaluation of this courseware is not available at this moment. But the project template and the courseware tools were actually used and tested in the production process of this sample courseware unit. The feedback about the courseware design from a series of formative evaluations and a pilot test has also been positive. These facts reinforce the belief that the objectives of this study have been mostly fulfilled.

II. Reflections

During and after the development and implementation of the templates and tools, the author continues thinking about how to make hypermedia an applicable medium in instruction. The following have been prominent in the reflections.

Emphasize instructional needs and theories

Multimedia, as Hood (1994) has pointed out, is about communication, not technology. The same is true for instructional hypermedia. However, too often educators have placed their emphasis on the technologies instead of the instructional process. Technologies do make hypermedia powerful and attractive. Nevertheless, it does not mean that technologies will increase learning effects automatically. For instructional use, technology should be adopted only when it improves learning. Instructional needs should be the decisive factor to adopt a technology.

In designing hypermedia courseware, we should also go beyond intuition. We should use theories to guide our designing activities. Without theories, we will not know
what to do in courseware design. Even if by chance, we created a “good” piece of courseware, without theories, this design cannot be generalized to other cases.

**Accommodate practitioners' views**

The application of hypermedia courseware is in the hands of educational practitioners. Courseware can be used as supplemental learning tools or self-sufficient learning tools. The key point of successfully adopting hypermedia to instruction is focused on how teachers will incorporate hypermedia into their instruction and how students will be directed to use it. In both situations, only teachers fully understand their instructional needs. The participation of the local teachers in the courseware production is critical. They provide the feasible and practical views to complement the logical and ideal viewpoints from theorists.

Ideally, the practitioners' views will be in accord with those of the theorists. However, conflicts do exist. During the hypermedia production process, this study had involved the contributions of multiple experts in several aspects. Each expert had his/her rationale; however this study could choose only one design. The theoretical design also conflicted with the user's preferred design. Eventually, a temporary compromise was reached to keep the project going on. The evaluation results in the future will be the basis for the refinement of these temporary compromises. If a practitioners' viewpoint is proved to be valuable, it will become a new theory.

**Do the changes as early as possible**

In producing courseware, anything overlooked in early stages will come back again and again (Gleason, 1991). Moreover, the cost of fixing the overlooked task gets higher and higher as time passes. Therefore, the author had set a check point at the end of each production stage. The result of each production stage was sent to the sponsors for
confirmation. Ideally, the subsequent activities were based on the confirmed results of previous stages. The producers would not have to re-do the tasks in previous stages. However, the sponsors had changed their minds and requested modifications on the confirmed results. They had their reasons on either theories or practice. But, from the viewpoint of managing a project, making these changes decreased the efficiency of this project.

The experience of producing the sample courseware unit proves that it is painful to make changes on a full fledged project. When this sample unit had expanded to a 241-card stack, any “minor” change was not as easy as it was in a 13-card prototype. For example, the author had decided to change the sizes of all background buttons to make the screens look more pleasant. In that moment, there were 73 backgrounds in this courseware prototype; in average, there were about 14 buttons in each background. Without the assistance of courseware tools, this change meant that the author had to click on 14 by 73 buttons and drag their corners to the exact location. For fully developed courseware, there is no “minor” change. Therefore, it is important to do the design carefully before programming the courseware. It is also important to assure the confirmation of sponsors before going on to the next stage. The later a change happens, the more it costs.

**Coordinate the team members**

Producing hypermedia courseware demands various types of expertise. The more complex a hypermedia project is, the more man-power is needed. However, when the number of people in a production team is increased, the complexity of communication is also increased exponentially. Team members need to clearly understand their task specifications. They may have to work with others on the same task. If a production team is well coordinated, each member will use his/her best talent and the time and effort of this
project will be at the minimum. Without good communication, the team’s efficacy and efficiency are drastically decreased.

This study acknowledged many different roles in a hypermedia project. It also developed a series of procedures and tools to coordinate the efforts of team members. These procedures and tools will help hypermedia producers to accomplish their project more effectively and efficiently. Nevertheless, in our example project only a few persons played those roles. The burden of internal communication was trivial. In the real world, more people will be involved, and the load of communication among them will become significant. If their jobs are not clearly defined, the working sequence is disorganized, or ideas are not fully communicated, then time, money, and effort are wasted. Team cooperation is vitally important in hypermedia production.

Prepare technical backgrounds for local producers

Hypermedia is relatively new in education. Most teachers have not used hypermedia courseware before. They may even have not learned about it yet. The long-term goal of this study is to promote hypermedia in education; not only for teachers to use hypermedia courseware in their instruction, but also to produce their own courseware. Therefore, templates and tools to actualize these intentions have been developed.

In creating courseware tools, this author had tried to make these tools as user-friendly as possible to reduce the technical barriers. However, each time the author reviewed these tools, he felt that there still was room to make these tools more friendly. It seemed there was no way to be too user-friendly. The author modified these tools again and again. Finally, the modification had to stop somewhere; the author had to admit that even user-friendliness had its limitation. The users must have a certain technical background in order to use the courseware tools.
If teachers want to produce hypermedia courseware, they must understand the general concept of hypermedia and have some basic technical skills. These tools can only help them in certain degrees. Without a technical background, teachers will have difficulty using and making a sophisticated hypermedia courseware.

Complement courseware design for missing factors

When designing the sample courseware unit, the author had thought a great deal about how this courseware unit should be used in real contexts. The author has tried to integrate as many instructional factors as possible into the courseware design. The objective was to make this courseware unit a self-sufficient instructional medium. However, this does not mean that this courseware unit has to be used in a stand-alone fashion. Using it under the guidance of instructors or designers is recommended.

Even with the significant advancement of technologies in recent years, only the human teachers have the intelligence to monitor learners' progress, interact with them, and dynamically prescribe individualized content. Although powerful, hypermedia is not the ultimate instructional medium (Not to mention existing courseware which has not fully fulfilled the potentials of hypermedia).

Human teachers, with their intelligence and professional experience, can supplement the missing factors of a courseware package to complete an effective instruction unit. Any courseware is only a tool to ease the load of teachers and to help them more efficiently reach their goals (Yang, 1987). In the foreseeable future, computers can never replace human teachers.
III. Future Work

This study has the goal of improving the learning effects of instructional hypermedia systems. It also has the intent to help teachers produce their own courseware. Therefore, the author has proposed a courseware template, a project template, and a set of courseware tools. The courseware template, project template, and courseware tools have been used in the implementation of producing a sample courseware unit. The successful completion of the courseware unit shows the usefulness of the templates and tools. The courseware product has also been evaluated in a pilot test; the feedback has been positive. However, further work is needed in several directions.

Examine the effects of the courseware design in real classrooms

The design of the example courseware unit is based on theories and research findings. It has been tested in a pilot test. However, the courseware design still needs a close examination to verify the effects of each design strategy. It should also be investigated using larger subject groups. This investigation will allow the examination of its learning effects and its practicality. The results will verify the theoretical assumptions of the courseware design and shed light on the improvement of these theories.

Test the production process in other contexts

In addition to studying the courseware design, the project template and courseware tools should also be put into examination in other contexts. A school teacher may use the project template to estimate and control a hypermedia project. This experiment should also use the courseware tools to produce its courseware products. It will verify the usefulness of the project template and courseware tools in other production situations.
Create more templates and tools

This author has neither an intention nor the ability to create the ultimate templates and tools for courseware design and project management. All the templates and tools proposed in this study should be adjusted or expanded as frequently as needed. The author would like to see other instructional theories transformed into hypermedia courseware templates. It is also important to see the local producers modifying the project template to fit their practical contexts. The courseware tools should be expanded to broader libraries to meet the various challenges in producing hypermedia courseware.

Feasibility and cost-effectiveness studies

Studies are needed to examine the cost-effectiveness of producing hypermedia courseware. In the sample project, the author used about 200 work hours to complete the tasks of project manager, instructional designer, programmer, and artist. After this sample unit was completed, the sponsors wanted to produce another courseware unit for the same subject course. It took the author about 14 hours to complete the construction of a new unit. The amounts of work hours in these two projects are not directly transferable to other projects. How many persons are involved, how fast the production machine is, or how complex the courseware will be are some of those factors which have effects on the implementation of the templates and tools.

It is important to see whether teachers without various technical skills are able to participate in the production of hypermedia courseware and how effective or efficient their engagement in these activities is. Improvements can then be made to promote the grassroots participation in hypermedia projects.
Establish a channel to share products and experience

When more and more templates, tools, and courseware have been produced, a channel to share the products and experience is essential (Chen, 1990). The courseware products should be publicized and disseminated. A sufficient amount of courseware is vital to the adoption of hypermedia in education (Gayeski, 1989; Gleason, 1991). Widespread usage of templates and tools not only makes courseware production easier, but also establishes certain standards for hypermedia products.

IV. A Final Note

In history, we have seen many man-made as well as natural disasters. Our ancestors have suffered hunger, diseases, floods, wars, and even holocausts. Modern society has promoted “science” and “democracy” to resolve the sufferings.

This is especially significant in modern China (Taiwan), my home country. Our people had suffered several thousand years of dogmatic monarchical ruling. Our living standard was relatively low. More importantly, our country was besieged in a hostile international environment. A group of elites, therefore, advocated “science” and “democracy” to save our endangered country seventy years ago. They believe that science will help us improve living and empower our country while democracy will release us from dogmatic rule and ceaseless political struggle.

Time has passed. Our living standards has been improved. Our people also has more freedom than ever. We can not say that we have already achieved an ideal society. But, with science and democracy we hold a hope to create a better society.
However, how can we promote science and democracy in our society? Education is the ultimate means. We have witnessed the success of many countries in North America and western Europe (D'Aeth, 1975; Feibleman, 1987). Their advancements in economy, politics, or daily lives are attributed to the implementation of better education.

Ironically, while our educators disseminate the ideal of science and democracy, our educational practice is neither democratic nor scientific. Nowadays, most school teachers still use poor-quality, old-fashioned instructional aids to teach huge groups of students. Teachers are excluded from the use and production of sophisticated technologies. Most students are treated uniformly. They are not allowed to explore their own interests and abilities due to the limitation of group instruction.

Hypermedia comes as a new hope to vitalize the dream of individualized instruction. It is a scientific tool. Hypermedia uses state-of-the-art multimedia technology to enhance the learning effects. It is also a democratic medium. The learner can explore the subject knowledge non-linearly. The hypermedia instruction is based on learners' individual needs, interests, and abilities.

It is the sincere hope of the author that this study will contribute to a democratic and scientific education through the introduction of hypermedia courseware. A much more comprehensive effort from all the educational theorists and practitioners is called upon to make our society more desirable.
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Thank You!
Appendix B: Courseware Developers' Guide

This booklet is an operational manual to the "Courseware Tools." Courseware Tools is a construction tool for producing HyperCard stacks. If a HyperCard stack is used as an instructional medium, multiple expertises are needed in producing this courseware stack. Courseware Tools is developed to ease the demand of computer programming and to facilitate the cooperation of a production team.

This Courseware Developers' Guide addresses the activities of instructional designers, content experts, programmers, and artists in a HyperCard production project. It suggests a task flow (Diagram 1) of producing courseware. However, we should not limit the use of the Courseware Tools to this flow. Users are encouraged to model new flows of producing courseware.

The suggested task flow illustrates a series of task activities and the use of various courseware tools. It begins with a selection of courseware template from "Template Library" (ID-1). Then, instructional designers modify the template to suit the project demands (ID-2 to ID-6). A courseware prototype is thus created.

After the prototype is agreed to by the production team, content experts, programmers, and artists work concurrently on their own tasks based on the specifications of the prototype. Content experts write instructional contents (CE-1 to CE-3). Artists create graphics (ART-1 to ART-3). Programmers either select programs from "Script Library" or create their own programs (PG-1 to PG-8). Their products are continuously integrated into the prototype by courseware tools.

The integrated prototype may reveal new problems. Adjustments are needed to fix these problems (ART-4, CE-4, ID-7, & PG-9). The process of creation, integration, and adjustment is repeated until the prototype satisfies all team members. If color is preferred, artists will add colors into the courseware (ART-5). A courseware is then completed.
Diagram 1. Task flow of hypermedia production activities
Task Activities

For Instructional Designers

ID-1. Select a courseware template
ID-2. Modify or create backgrounds
ID-3. Duplicate and modify cards
ID-4. Name and number objects
ID-5. Adjust attributes of text fields
ID-6. Other adjustments
ID-7. Put suggested operation into each screen

For Content experts

CE-1. Write instructional contents into a text file
CE-2. Add control codes into the text file
CE-3. Integrate instructional contents into the courseware prototype
CE-4. Modify the instructional content as needed

For Programmers

PG-1. Gray out buttons
PG-2. Modify card “MAP”
PG-3. Put page numbers
PG-4. Trace navigational path
PG-5. Put command codes into heading bars
PG-6. Put codes into menu fields or menu buttons
PG-7. Link contents
PG-8. Create and integrate scripts into the courseware prototype
PG-9. Modify scripts as needed

For Artists

ART-1. Create graphics according to the prototype specification
ART-2. Integrate internal graphics into prototype
ART-3. Integrate external graphics into prototype
ART-4. Modify graphics as needed
ART-5. Put colors

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I. For Instructional Designers

ID-1. Select a courseware template

**Tools:** [Template Library]; HyperCard functions

**Steps:**

1. A courseware template is a "dry-run" model. It shows the logic structures and screen layouts of a courseware; but it has no real contents. Before production team members can work on their own tasks, they must agree on a template. It is the responsibility of instructional designers to develop an appropriate template. They can create a new template, but it is much easier to select an existing one and make the necessary modifications.

2. Open stack "Courseware Tools". Choose "Library of Courseware Templates" from main menu. The system will take you to stack "Course Templates".

3. Select a template from main menu of stack "Course Templates". The system will take you to the desired template stack.

4. When in the desired template stack, choose command "Save a Copy..." from menubar item "File". Type a name for the template, then, click "Save". A copy of the selected template is created.

5. You can open the copied template by choosing command "Open Stack..." from menubar item "File". Select the stack name and then click "Open" in the dialog window.

6. You can go through this template by clicking buttons or pressing arrow keys. To have a printout of this template, choose command "Print Stack" from menubar item "File".

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ID-2. Modify or create backgrounds

Tools: [Copy Background Objects]; [Object Libraries]; HyperCard functions

Steps:
1. A background contains common objects for a series of similar cards. You don’t have to create all the common objects for each of the similar cards. You simply design a background and let all the similar cards share it.
2. Open the new courseware template. Go to the card where you want to insert a new background. Choose command “New Background” from menu bar item “Objects”. The system will create a blank new background and automatically change to background layer. You then can copy or create objects in this background.
3. If you want to modify a background, go to any card which is owned by this background. Then, choose command “Background” from menu bar item “Edit”. The system will change to background layer. You then can modify this background.
4. To create objects, such as buttons, fields, graphics, you can use HyperCard functions. You can also copy objects from “Card Library”, “Button Library”, or “Field Library” by selecting related menu items from stack “Courseware Tools”.
5. To create a similar background with different identification, you can use tool [Copy Background Objects]. Copy card button “Copy bg objects to a new bg” from stack “Courseware Tools”. Then paste this button to a card where you want to insert a similar but independent background. Change the cursor to browse tool. Clicking this button will create a background immediately following the original card. This new background will have all the identical buttons, fields, and graphics of the original background. Any change on the new background will not affect the original background.
6. When done, delete unnecessary functional buttons. Choosing command “Background” again will take you back to card layer.
ID-3. Duplicate and modify cards

Tools: [Copy Card Objects]; [Object Libraries]; HyperCard functions

Steps:
1. In HyperCard, a card is an information screen. It shows objects in both background and card layers. Once you have the backgrounds needed for courseware, it is time to create cards.
2. Go to a card. Choose command “New Card” from menu bar item “Edit”. The system will create a blank card which shares all the background objects with the original card but has no card objects. Duplicate as many cards as you need in each background.
3. To create objects in card layer, such as buttons, fields, and graphics, you can use HyperCard functions. You can also copy objects from “Button Library” and “Field Library” by selecting related menu items from stack “Courseware Tools”.
4. To copy card objects from another card, you can use tool [Copy Card Objects]. In stack “Courseware Tools”, copy button “Copy cd objects without bg” from main menu. You then paste this button to a card where you want to copy objects from another card. Change the cursor to browse tool. Click this button and specify a card number. The system will copy all the card objects from the specified card to this card.
5. When done, delete unnecessary functional buttons.
ID-4. Name and number objects

Tools: [Naming Objects]; [Numbering Objects]; HyperCard functions

Steps:
1. To enable a non-linear navigation, each object inside the courseware template should have a name. We can name the objects by using HyperCard functions. However, a more efficient way to do so is using tool [Naming Objects].
2. In stack “Courseware Tools”, copy card button “Name objects in cd layer” or “Name objects in bg layer” from main menu. You then paste this button to any card or any background where you want to name the objects. Change the cursor to browse tool.
3. Moving the cursor inside this button will cause all the objects’ IDs and names in the card /background layer be displayed on a temporary field. You can change these objects' names on the temporary field. By clicking the [Naming Objects] button again, the system will rename all the objects based on your specification on the temporary field.
4. You may also want to change the sequence of objects. Functional buttons “Change object sequence in bg layer” and “Change object sequence in cd layer” in stack “Courseware Tools” will help you to change the object sequence numbers.
5. When done, delete unnecessary functional buttons.
6. You are advised to use certain conventions to name the objects.
* An example of naming convention *

A. For TUTORIAL screens:
   1. Name cards as tutorial, section1, section1_2, section1.1, section1.1_2,...
   2. Name cards field MENU as menu_fld
   3. Name background field HEADING as "level 1 heading", "level 2 heading", ...
   4. Name background field TEXT as text_fld
   5. Name background field QUESTION as question_fld
   6. Name background field ANSWER as answer_fld
   7. Name background field FEEDBACK as feedback_fld

B. For LABORATORY screens:
   1. Name cards as "lab activity", "lab activity 1", "lab activity 2",...
   2. Name card field MENU as menu_fld
   3. Name background field HEADING as "level 1 heading", "level 2 heading", ...
   4. Name background field TEXT as text_fld

C. For TEST screens:
   1. Name card TEST INSTRUCTION as testinstr, testinstr_2,...
   2. Name background field TEXT as text_fld
   3. Name card TEST QUESTIONS as test1, test2,...
   4. Name background field QUESTION as question_fld
   5. Name background field ANSWER as answer_fld
   6. Name background field FEEDBACK as feedback_fld
ID-5. Adjust attributes of text fields

**Tools:** [Selected Property Documenter]; [Stack Modifier]; Word Processing Programs

**Steps:**

1. In HyperCard, a field is used to display instructional contents. It has many attributes, such as: style, spacing, size, font, etc. A well design of these attributes will well communicate the information.

2. If you want to adjusted the attributes of text fields, you may do so by using HyperCard functions. But, a more efficient way is using tools [Selected Property Documenter] and [Stack Modifier].

3. In stack “Courseware Tools”, choose “Selected Property Documenter” from main menu. Select the property or properties you want to change to fields, and click the action button. The system will generate a text file contained the selected attributes of all the fields.

4. Use any word processing program to change the field attributes (properties) in the text file. Issuing a change-all command is a powerful way to change object properties. After you have modified the attributes, save the text file as an ASCII file again.

5. In stack “Courseware Tools”, choose “Stack Modifier (Full-text)” from main menu. The system will based on the specified text file automatically modify the object properties of your courseware template.
ID-6. Other adjustments

**Tools:** HyperCard functions; [Selected Property Documenter]; [Stack Modifier]; [Lock/Unlock All Fields].

**Steps:**
1. Other adjustments may be needed in creating a courseware template.
2. For minor changes in field content, [Lock all fields] and [Unlock all fields] in stack "Courseware Tools" are useful.
3. However, [Selected Property Documenter] and [Stack Modifier] in stack "Courseware Tools" are more useful for major modification. They can be used for various adjustments of object properties. For detailed description of using these tools, please refer to ID-5.
4. When done, delete unnecessary functional buttons.
ID-7. Put suggested operation into each screen

Tools: [Show All Hidden Objects]; [Lock/Unlock Fields]; HyperCard functions

Steps:
1. Being lost in hyperspace is one of the most serious problems of using hypermedia courseware. This problem can be partially resolved if we provide on-line advisement to lost learners. We propose that if a learner has not respond to a screen for a certain amount of time, the system should provide a suggested operation. This time-triggered suggested operation will be more helpful if it is individualized in each page.
2. In stack “Courseware Tools”, copy button “Show all hidden objects” and paste it to any card in your courseware stack. Clicking the button will make all the hidden fields and buttons inside the stack become visible.
3. If the field you want to make changes is locked, you can copy button “Unlock all fields” from stack “Courseware Tools” and paste it to any card in your courseware stack. Clicking the button will unlock all the fields in your courseware stack. You now can change the texts in fields.
4. After changing texts, copy another button “Lock all fields” from stack “Courseware Tools” to lock all the fields. Then users won’t be able to mess up the texts.
5. When done, delete unnecessary functional buttons.
II. For Content Experts

CE-1. Write instructional contents into a text file

Tools: Word Processing Programs (save content data as a text file)

Steps:
1. Content experts have the subject knowledge. Their knowledge is transformed into instructional contents. However, in order to deliver the knowledge through computer screens, the instructional contents must accord with the types and formats of the courseware template. For instance, the instructional contents displaying on a screen may not exceed 8 lines. For another example, if there is a "TEST" section in the courseware, a minimum number of questions may be needed for the test.
2. The instructional contents must be typed into an ASCII file for further processing.
CE-2. Add control codes into the text file

Tools: Word Processing Programs; [Object Identifier]

Steps:
1. In courseware, instructional contents are displayed in the fields on various cards. In order to put instructional contents into the right fields and right cards, you should recognize the identification numbers or names of these fields and cards.
2. You can choose “Object Identifier” from stack “Courseware Tools”. The system will ask you to which stack you want to go. Give the name of your courseware template. The system automatically open your template stack.
3. Each time you move the cursor inside an object, the system will display the names and identification numbers of this object, card, and background. Jot down the information as you will need it later. After closing the courseware template, the function of “Object Identifier” is automatically eliminated.
4. Once you have recognized the names and identification numbers of the text fields, you can put the information into your text file. The information should comply to the control code formats.
5. Save the text file as an ASCII file.
Control Codes:
A. To place instructional contents into background fields:
   @[bg]@N[@*-*]@
   @[bf]@N[@[text]@XXXXXXXXXXXXXXXXXXXXX@[*-*]@]
B. To place instructional contents into card fields:
   @[card]@N[@*-*]@
   @[cf]@N[@[text]@XXXXXXXXXXXXXXXXXXXXX@[*-*]@]

Remark:
In control codes, “bg” stands for background layers; “card” stands for card layers; “bf” stands for background field; and “cf” stands for card field. N represents the identification number of a background, card or field. “[*-*]” indicates the end of an object’s definition. “XXX...” is the content text. And @ is the delimiter to separate an object and its property.

Usages:
Put content menu into card field "menu_fld" or card buttons
Put the content headings into background field "level 1 heading", "level 2 heading"...
Put instructional texts into background field "text_fld"
Put practice/test questions into background field "question_fld"
Put practice/test answers into background field "answer_fld"
Put practice/test feedback into background field "feedback_fld"
CE-3. Integrate instructional contents into the courseware prototype

Tools: [Stack Modifier (Simple-Text)]

Steps:
1. In the text file, insert "@[stack]@your file name@[*.*]@" at the very beginning and "@[end]@" at the end. This information will tell the system which courseware template is going to be merged with the instructional contents.
2. Choose "Stack Modifier (Simple-Text)" from main menu of stack "Courseware Tools". Give the name of your text file. The system will, based on the stack name specified in the text file, go to your courseware template and put the instructional contents into the fields.
CE-4. Modify the instructional content as needed

Tools: [Field Content Documenter]; [Numbering Objects]; [Stack Modifier]; [Lock/Unlock fields]; HyperCard functions; Word Processing Programs

Steps:
1. You can modify the instructional content by HyperCard functions or courseware tools. If lots of modification is needed, "Courseware Tools" is more efficient.
2. Choose "Field Content Documenter" from stack "Courseware Tools". Specify the name of your courseware prototype and give a name to the content text file. The system will go to your prototype and record all the contents into the text file.
3. You can open the text file by any word processing program to read and modify the content.
4. Use [Stack Modifier (simple text)] to modify the instructional contents in the courseware prototype again. For detailed description of using [Stack Modifier], please refer to CE-3, step 2.
III. For Programmers

There are many control functions in a courseware unit. This section addresses several mostly used control functions and how they can be done by the Courseware Tools.

PG-1. Gray out buttons

Tools: [Gray Buttons]; [Script Documenter]; [Stack Modifier]

Steps:
1. In courseware design, we usually gray out (disable) "PREVIOUS" or "NEXT" buttons in the first or last screen of a series of similar instructional screens. You can do so by HyperCard functions. However, using Courseware Tools is more efficient.
2. Choose button "Put gray button script" from stack "Courseware Tools" and paste it into any card in your courseware prototype.
3. Click the [Gray Button]. The system will ask you to provide the button name which you want to gray out and the card numbers where that button resides. You can click this functional button repeatedly to gray out other buttons or the same button in different cards. The command codes (see example) are placed into the appropriate card script.
4. When done, delete unnecessary functional buttons.
5. You can also use tools [Script Documenter] and [Stack Modifier (Simple-Text)] in stack "Courseware Tools" to place these command codes.

Example Scripts:

```
on openCard
  set enabled of background button "previous" to false
end openCard

on closeCard
  set enabled of background button "previous" to true
end closeCard```
PG-2. Modify card "MAP"

Tools: [Naming Objects]; [Selected Property Documenter]; [Stack Modifier]; HyperCard functions

Steps:
1. It is recommended that building a structure map for hypermedia courseware. This MAP screen shows the organization of the course contents and the learners' accessing paths. Therefore, in your courseware prototype, you must modify the button names in the MAP screen.
2. Generally, you can use HyperCard functions to do so. However, tools, such as [Name Objects], "Selected Property Documenter", or "Stack modifier" can be useful.
3. You have to create as many buttons as needed to reflect nodes of the content structure.
4. Use "Selected Property Documenter" in stack "Courseware Tools" to read your courseware prototype and generate a text file.
5. Use any word processing program to open the text file. Then, you give names to the buttons in card "MAP". You can also assign locations to these buttons. After you have done the modification, save the text file.
6. Use "Stack modifier" to read the text file and modify the courseware stack. One advantage of using courseware tools is that you can do all the changes in one time. You can also calculate the location precisely.
7. When done, delete unnecessary functional buttons.
PG-3. Put page numbers

Tools: [Page Numbering]; HyperCard functions

Steps:
1. In order to give learners an estimated completion time, it is recommended that the number of total screens and the current screen number in a section be indicated. Therefore, an instructional designer should put this information into a field on the content screen.
2. Choose button “Put page number into page_no fld” from main menu of stack “Courseware Tools” and paste it into your courseware prototype.
3. Click button “Put page number into page_no fld”. The system will start from the first card of the courseware prototype to count the page numbers. It treats any card with a disabled button “PREVIOUS” as the first page in a series of content screens. It also treats any card with a disabled button “NEXT” as the last page of that series of screens. Then, the system count the total cards between these two cards. It then give the sequential number to each card in these series screens. The message looks like “Card 3 of 10”.
4. When done, delete unnecessary functional buttons.
PG-4. Trace navigational path

Tools: [Put Tracing Codes]; [Script Documenter]; [Stack Modifier]; HyperCard functions

Steps:
1. In order to monitor users' learning strategies, courseware usually has a tracing function to record their navigational paths. In HyperCard, you need to record the visited cards' names into a variable to get this information.
2. You can open each card and put the command codes (see example below) into the card script. However, it is easier to use button [Put Tracing Codes] in "Courseware Tools".
3. Choose button "Put field content into card script" from stack "Courseware Tools" and paste it into any card of your courseware prototype.
4. Create a temporary card field "Temp_script" and put the command codes into this temporary field.
5. Click button "Put field content into card script". The system will place the command codes into card script of every card in your courseware prototype.
6. To save disk space, you can put this script into stack script instead of every card script. However, to do so, you need to put a "Pass opencard" statement into every card script.
7. When done, delete unnecessary functional buttons.
8. You can also use tools [Script Documenter] and [Stack Modifier (Simple-Text)] in stack "Courseware Tools" to place these command codes.

Example Scripts:
```plaintext
on openCard
  global visitedlist
  put (short name of this card) & " " after visitedlist
end openCard
```
PG-5. Put command codes into heading bars

Tools: [Put Script into Heading bars]; [Script Documenter]; [Stack Modifier]; HyperCard functions

Steps:
1. In courseware, heading bars not only indicate the relative position of this current screen in the content structure, but also serve as link buttons. Clicking a heading bar will take learners to a related screen. An example command codes behind the heading bars are show below.
2. You can use HyperCard functions to open each heading bar and put command codes into the field script. However, it is easier to use button [Put Script into Heading bars].
3. Choose button “Put script into heading bars” from stack “Courseware Tools” and paste it into your courseware prototype.
4. Click this functional button, and the system will ask you the common name of heading bars, the destination card to where the clicking headingbar should go, and the beginning and ending card numbers where the headingbar resides. Then, the system will place command codes into the field script of the specified heading bars from the beginning card to the ending card.
5. When done, delete unnecessary functional buttons.
6. You can also use tools [Script Documenter] and [Stack Modifier (Simple-Text)] in stack “Courseware Tools” to place these command codes.

Example Scripts:

```
on mouseup
  go to card "section1"
end mouseup
```
Put codes into menu fields or menu buttons

Tools: [Script Library]; [Script Documenter]; [Stack Modifier]; HyperCard functions

Steps:
1. A topic menu of the courseware contents can be represented in either button or field formats. Both themes need command codes to activate the control function. An example of field script is shown below.
2. You can write your HyperTalk command codes by yourself and use HyperCard functions to place the codes into menu fields or buttons.
3. It is easier to copy codes from "Script Library". Go to stack "Courseware Tools" and copy the needed command codes from "Script Library".
4. Go back to your courseware stack. Open the menu buttons or menu fields. Then, paste the command codes into button or field scripts.
5. You can also use tools [Script Documenter] and [Stack Modifier (Simple-Text)] to place these command codes.

Example Scripts:
```plaintext
on mouseup
    if "line 1 " is in clickedline() then
        go to card "section1"
    end if
end mouseup
```
Tools: [Script Library]; [Script Documenter]; [Stack Modifier]; [Lock/Unlock Field Tool]; HyperCard functions

Steps:
1. In HyperCard, subject knowledge are broken into many small fragments. The courseware needs various links to connect these fragments into a meaningful concept. Some of the suggested links are links between objectives and tutorials, tutorials and index, and test feedback and tutorials.
2. You can write your HyperTalk command codes by yourself and use HyperCard functions to place the codes into the link buttons.
3. It is easier to copy codes from "Script Library". Go to stack "Courseware Tools" and copy the needed command codes from "Script Library".
4. Go back to your courseware stack. Open the link buttons or fields. Then, paste the command codes into button or field scripts.
5. You can also use tools [Script Documenter] and [Stack Modifier (Simple-Text)] to place these command codes.

Example Scripts:
```
on mouseup
go to card "section2.1_3"
end mouseup```
Create scripts according to the template specifications and then integrate scripts into the courseware prototype.

Tools: [Script Documenter]; [Stack Modifier]; HyperCard functions

Steps:
1. To create programs you can use HyperTalk commands.
2. You can also copy programs from "Script Library" and modify them to fit your needs.
3. To integrate command codes into objects, you can use HyperCard functions.
4. You can also use tools [Script Documenter] and [Stack Modifier (Simple-Text)] in stack "Courseware Tools" to integrate command codes into objects.
PG-9. Modify scripts as needed

Tools: [Script Documenter]; [Stack Modifier]; HyperCard functions

Steps:
1. To modify programs you can use HyperCard functions.
2. You can refer programs from "Script Library" to make the modifications.
3. You can also use tools such as [Script Documenter] and [Stack Modifier (Simple-Text)] to change or integrate command codes.
IV. For Artists

ART-1. Create graphics according to the prototype specification

Tools: Graphic Packages; [Graphic Library]; [Picture Copier]

Steps:
1. In general, you will use any appropriate graphic tool such as MacPaint, MacDraw, and Photoshop to create graphics based on the needs of the courseware prototype.
2. If a picture is used as an internal graphic, then save it as a bit-map (Mac Paint) file. If it is used as an external graphic, then save it as a PICT file.
3. You can choose pictures from graphic libraries, such as stack “Background Arts”. You can also put your creations into graphic libraries for future use.
4. If you want to copy all the pictures from a HyperCard stack, choose “Picture Copier” in stack “Courseware Tools”. The system will ask you which stack you want to make the picture copying. Then, the system will copy pictures in all the card and background layers of that stack.
ART-2. Integrate internal graphics into prototype

**Tools:** Word Processing Programs; [Stack Modifier]; [Picture Copier]

**Steps:**

1. It is recommended that you name those picture files appropriately. For example, you name a background graphic as “bkgndN.png”, in which N represents the background ID. It then will not easily be confused when the picture files grow to a huge amount.

2. You can integrate bit-map pictures into stack one by one by using HyperCard functions.

3. You can use courseware tools to integrate all bit-map pictures at one shot. First, you use a word processing program to create a new text file.

4. Then you put control codes into the text file to indicate where the pictures go to. In the text file, insert "@stack@N@importpic@XXXX@[*.*]@" at the very beginning and "@end@" at the end. This information will tell the system which courseware template is going to be merged with the instructional contents. Save the text file as an ASCII file.

5. Choose “Stack Modifier (Simple-Text)” from stack “Courseware Tools”. Give the name of your text file. The system will, based on the stack name specified in the text file, go to your courseware prototype and add the pictures into it.

**Control Codes:**

```
@[bg]@N@importpic@XXXX@[*.*]@
```

or

```
@[card]@N@importpic@XXXX@[*.*]@
```

**Remark:**

In control codes, “bg” stands for background layers; “card” stands for card layers; N represents the identification number of background or card; “[*.*]” indicates the end of an object’s definition; “XXXX” is the picture file’s name; and @ is the delimiter to separate an object and its property.
ART-3. Integrate external graphics into prototype

Tools: [Script Library]

Steps:
1. You have to use programs to control the display of an external picture.
2. You can write HyperTalk command codes by yourself.
3. You can also copy script from “Script Library” in stack “Courseware Tools” and paste it into the card script.

Example Scripts:

```plaintext
on openCard
  picture "PICTFILE", file, rect, false
  set loc of window "PICTFILE" to X,Y
  show window "PICTFILE"
end openCard

on closeCard
  close window "PICTFILE"
end closeCard
```

Remark:

In script codes, "PICTFILE" stands for the name of a graphic file. This graphic file must be “PICT” format. X and Y are the location of Horizontal and vertical positions.
TOOLS: Graphic Packages; [Graphic Library]; [Picture Copier]; [Stack Modifier]; HyperCard functions

STEPS:
1. Use any graphic tool to modify your pictures and save them as bit-map or PICT files.
2. You can use courseware tools to integrate the internal or external pictures into your courseware prototype. However, if the change is minor, you may want to use HyperCard functions. In this situation, you may consult with programmers.
Tools: [Color tool]

Steps:
1. Color attracts learners’ attention. It also motivates learners. However, color in some low-end machines may drastically slow down the computer performance. You have to have a good rationale for adopting colors in courseware.
2. You can add colors onto the HyperCard stack manually. But it really is time consuming.
3. You can also choose button “Add colors to a stack” from stack “Courseware Tools” and paste it into any card of your courseware prototype.
4. Before click this [Color tool], you have to specify the color identification codes and object names inside the button script. Indeed, you may need programmers’ help. Then, clicking this functional button will add colors into the courseware stack.
5. When done, delete unnecessary functional buttons.
Appendix C: Courseware Evaluation Form

<table>
<thead>
<tr>
<th>Evaluation Form for Unit 3: Plant Growth</th>
</tr>
</thead>
</table>

**Instruction:**
Please mark your response or answer questions based on your immediate feelings after using this program. Thanks for your participation.

### I. Subject Content

<table>
<thead>
<tr>
<th>Quality</th>
<th>Excellent</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Learning objectives are appropriate for the course.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>2. Tutorial information matches the objectives.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>3. Tutorial is appropriate for your knowledge level.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>4. Information is well organized.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>5. Information is accurate and up-to-date.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>6. Language is clear and easy to understand.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>7. Video information is related and meaningful.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
</tbody>
</table>

### II. Instructional Strategies

<table>
<thead>
<tr>
<th>Quality</th>
<th>Excellent</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Objectives are clearly stated.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>2. Strategies are flexible to meet the needs of various learners.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>3. Learning activities are appropriately organized.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>4. Practice questions are helpful in understanding the content.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>5. Test questions are closely related to objectives.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>6. This program provides appropriate informational feedback.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>7. Lab activities help understand tutorial information.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
</tbody>
</table>

### III. Media Design

<table>
<thead>
<tr>
<th>Quality</th>
<th>Excellent</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Media are appropriate for the instruction.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>2. Screen layout is attractive.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>3. Interface is easy to use.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>4. System is stable and reliable.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>5. Help section is detailed and helpful.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>6. Important information is well highlighted.</td>
<td>1 2 3 4</td>
<td></td>
</tr>
</tbody>
</table>
**Evaluation Form for Unit 3: Plant Growth**

### IV. General Impression

1. How do you feel about this courseware unit?

2. What are the best features of this courseware unit?

3. What are the poorest features of this courseware unit?

4. How can this courseware unit be improved?

5. Other comments?
Unit 3: Plant Growth

Additional course objectives include:
1. Conduct a series of laboratory activities explaining plant growth and find the prescribed growth.
2. Pass the achievement test at a 100% satisfactory level.

Getting around the program...

This program is designed to teach you how to use the program. You should work through this entire section before proceeding with the lesson.

Getting around the program...

Navigation buttons are located on the left and on the bottom of the screen. Clicking on these buttons will take you to the selected screen. If the buttons are pressed out, then the buttons cannot be used on the current screen.

Getting around the program...

The program allows you to use the mouse to navigate. You can click on each screen to open it, and the program will tell you the selected topic or area.

More on getting around: program structure...

The program is organized into a hierarchical structure. Each screen has a title, which can be used to return to the main menu, and the program will tell you where you are in the hierarchy.
### Plant Science Laboratory: Unit 3. Plant Growth

#### What the buttons mean...

This section contains the instructions and practice questions, so you will spend most of your time here.

- **What the buttons mean**: This is a "video test". A single number represents a still picture on the video; if you number appears at a fast rate, they represent an animation which is a sequence of still pictures. Clicking on a still in the list causes the video player to show the picture or animation.

#### What the buttons mean...

These screens provide a description of the purpose, requirements and procedures of each laboratory activity. While you are on a Lab Activity screen, you can click on a "Link" button to browse through related tutorial information.

#### What the buttons mean...

The first part of this section explains how to take the test. When you click the "Start Test" button, a unique test will be randomly generated from the test bank for you.

This button will stop the user from having to finish the test. The computer will then check your answers to give you a score, and you will proceed to the correct section with all questions.

#### What the buttons mean...

This button takes you to the next screen in a series of related screens. If it is grayed out, then the screen you are on is the last in a series. If you click on it however, it will go to a header or menu or another level.

This button takes you to the previous screen in a series. If it is grayed out, then the screen you are on is the first in a series.

---

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This menu was designed by Chin-Shing Yang under the direction of Drs. D.M. Meier, J. Portnoy, G. Holmen, S.马格里里, and J. Taylor. He is a graduate student in the Instructional Technology Program, College of Education, Virginia Tech.

The subject matter and video pictures are prepared by Dr. G. Scholz and Dr. R. A. Hill, Department of Botany, Virginia Tech. The whole project is guided by Dr. Taylor.

The following menu will guide you to photographs and animations that illustrate growth in plants.

If this is your first time to use this lesson, we suggest that you start with "Overview of Growth" and then proceed through the other lessons in numerical order.

GROWTH is the irreversible process by which organisms, or parts of organisms, get larger by increasing in cell number by CELL DIVISION or by increases in size by EXPANSION.
Section 2. Cell Division in Plants

5. Prophase Band of Microtubules

The microtubule band (prophase) divides the cell into two parts: a new cell plate (blue) and the "nuclear" area marked out by the "prophase band" of microtubules.

Section 3. Cell Division in Plants

6. Description of Cell Wall Formation

The microtubule network is perpendicular to the cell's axis (determined by growth, regulation, and cell movements) and guides the deposition of new cell wall material.

Section 2. Cell Division in Plants

6. Description of Cell Wall Formation

The microtubule network is perpendicular to the cell's axis (determined by growth, regulation, and cell movements) and guides the deposition of new cell wall material (green) parallel to them.

Section 2. Cell Division in Plants

6. Description of Cell Wall Formation

The microtubule network is perpendicular to the cell's axis (determined by growth, regulation, and cell movements) and guides the deposition of new cell wall material (green) parallel to them.

Section 3. Cell Expansion

1. Growth of Cell Area

Growth examples:
1. Gradual Cell Age
2. Gradual Cell Types
3. Differential Cell Expansion
4. Practice

(Plase click the images to watch videos)
**Section 1. Meristems**

**MERISTEMS** are localized regions of cell division and expansion. They are named for their location within the plant body: **MILLER MERISTEMS** are in the root, **APICAL MERISTEMS** are found at the tips of roots, stems, and leaves, and **LATERAL MERISTEMS** are located circumferentially on the stem of roots.

<table>
<thead>
<tr>
<th>Plant Science Laboratory</th>
<th>Unit 3. Plant Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 1. Meristems</td>
<td>(Cont'd 1/4)</td>
</tr>
<tr>
<td>MERISTEMS divide rapidly and form new cells. These cells then expand and differentiate into various types of cells. The process continues until the plant reaches maturity.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>Unit 3. Plant Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 1. Meristems</td>
<td>(Cont'd 2/4)</td>
</tr>
<tr>
<td>Collectively, meristems, xylem derivatives, and phloem derivatives establish the miotic and elongation patterns that lead to mature organs. This process results from the plane. In which new cell division takes place. The rates of these divisions and differentiation control the growth of cell division.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Section 1. Meristems</td>
<td>(Cont'd 3/4)</td>
</tr>
<tr>
<td>Experiments show that directional divisions of cell divisions are the most important factor in determining cell lineage, size, shape, interactions with growth regulators, and chloroplast position. In the primary wall, a cell-lying major role here.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plant Science Laboratory</th>
<th>Unit 3. Plant Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 1. Meristems</td>
<td>(Cont'd 4/4)</td>
</tr>
<tr>
<td>Plants of cell division, in meristems, as a small cell ( \text{PREPARED ORIENTATION} ) of a:</td>
<td></td>
</tr>
<tr>
<td>(a) minimizes the potential for mechanical shear ( \text{123456789} ) in the new cell wall due to a change in the wall's structural integrity, or</td>
<td></td>
</tr>
<tr>
<td>(b) is parallel to the low direction, enabling gradient of growth regulating molecules.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plant Science Laboratory</th>
<th>Unit 3. Plant Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 1. Meristems</td>
<td>(Cont'd 5/4)</td>
</tr>
<tr>
<td>This visible difference may be the result of different traits of the cell dynamics, including: the ( \text{YOUNG} ) derivatives divide rapidly, and the ( \text{YOUNG} ) derivatives divide at a slower pace as the same expansion by vacuolation occurs.</td>
<td></td>
</tr>
</tbody>
</table>
Plant Science Laboratory: Unit 3. Plant Growth

Section 5. Marisette
1. Root Apical Meristem
   - Root tip
   - Root meristem and root elongation

2. Root Primordia
   - Internal view of root apex
   - Lowest x (mm) Highest x (mm)

3. Root Primary Meristem
   - Primary meristem of the root apex: x5 view

4. Lateral Meristem
   - Lateral meristems arise within intercalary meristems and are separated by both intercalary and lateral meristems. The plane of LEAST SHEAR is therefore PARALLEL to the root surface so that most of the cell division takes place in the lateral meristem should be in that plane.
Plant Science Laboratory: Unit 3. Plant Growth

Section 5. Meristems

We will use the VASCULAR CAMBRIUM OF SHOOTS as a model for our all lateral meristems.

In shoots, the VASCULAR CAMBRIUM arises first in the middle of the individual vascular bundles (the FASCICLES) and is called PRIMARY VASCULAR CAMBRIUM (VPC).

Section 5. Meristems

We further distinguish the two types only because they often produce different tissues of derivative cell layers that can have different functions in the middle region.

The cells form a layer of INITIALS that are derived from which DERIVATIVES are divided from the same and outward. These derivatives divide further, but eventually revert into the SECONDARY TISSUES of the plant axis.

SECONDARY TISSUE is in the same meristems as the VASCULAR CAMBRIUM as that we can observe much about it by studying the other.

Section 5. Meristems

The LOCATION and GEOMETRY of the VASCULAR CAMBRIUM allow us to examine it either remotely. We therefore, commonly refer to the plant in a cross-section of our sections by the prominent arrangement within the whole plant.

Section 5. Meristems

TANGENTIAL LONGITUDINAL SECTIONS (TLS) are longitudinal to the axis and show the SURFACE of the VASCULAR CAMBRIUM.

RADIAL LONGITUDINAL SECTIONS are aligned through the center of the axis and are parallel to each other; they show the STEM EDGE of the VASCULAR CAMBRIUM.

Section 5. Meristems

TRANSVERSE or CROSS SECTIONS refer to the whole axis and show the STEM EDGE of the vascular cambium.

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VASCULAR CAMBium consists of two types of initials:
- **PLATFORM INITIALS** which are elongated parallel to the apex's side, and
- **RAY INITIALS**, which occur in an array of alternate rows.

The **RAY INITIALS** produce derivatives that mature into cell types (e.g., xylem, phloem, etc.) that function when oriented parallel to the apex's side.

VASCULAR CAMBium **INITIALS** are recognized from their round (or oblong) shape, wall thickening, presence of primary pit fields, and bordered pitted ends in T.S. and a dense cytoplasm in which the organelles and cytoplasmic matrix have a polar distribution.

**ANATOMY**

**EXTERNAL VIEW OF LARGE TREE**
- A. External View of Large Trunk
- B. Internal View of Small Trunk
- C. Internal View of Small Trunk
- D. Internal View of Large Trunk
- E. Radial LS of Older Trunk
- F. Tangential LS of Older Trunk
- G. Amination of Secondary Growth

Please click the icon to view.

**EXTERNAL VIEW OF SMALL TREE**
- A. External View of Small Trunk
- B. Internal View of Small Trunk
- C. Internal View of Small Trunk
- D. Internal View of Large Trunk
- E. Radial LS of Older Trunk
- F. Tangential LS of Older Trunk
- G. Amination of Secondary Growth

Please click the icon to view.

**XS views of delphinium (Delphinium) and oaks**

**Conductive tracts in show beginnings of sapwood zones of vascular bundles in young primary vascular bundles.**

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Plant Science Laboratory: Unit 3. Plant Growth

Section 5. Meristems

4. Lateral Meristems

G. Transectional LS of Outer Trunk

There show FUSIFORM and RAY INITIALLS of the VASCULAR CAMBIIUM of a maple tree (Elm). Note how abut the fusiform initials are.

LOW X

HIGH X

Plant Science Laboratory: Unit 3. Plant Growth

Section 5. Meristems

4. Lateral Meristems

H. Lateral Meristems

Plan Face

1. Cells produced by a LATERAL meristem are derivatives of cells produced by an apical meristem.

2. The statement is correct.

3. The statement is incorrect.

Plant Science Laboratory: Unit 3. Plant Growth

Section 5. Meristems

4. Lateral Meristems

I. Lateral Meristems

J. Stellate LS of Inner Trunk

Tissue sample from an aden (tracheid) that shows secondary xylem. Glycated cells and synergid cambium (bottom).

LOW X

HIGH X

Note the dense cytoplasm of bottom row of cells.

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Plant Science Laboratory: Unit 3. Plant Growth

Lab Activity 1
Shoot Apical Meristems

Use the following prepared sections to search for confirming evidence of your interpretations of lateral meristems. Xs of young Helianthus shows where soybean shows early stage of inception of vascular cambium.

Lab Activity 2
Lateral Meristems (FVC and IVC)

Can you see the fascicular vascular cambium? Where doesn't appear? Is there any interfascicular vascular cambium? Where do they form? Can you see before xylem and phloem arise?

Lab Activity 3
Lateral Meristems (FVC and IVC)

Xs of Populus shows tangential growth in a grassy environment. Which is it different?
### Plant Science Laboratory: Unit 3. Plant Growth

#### Question 1
1. The primary portion of a cell expansion is precursor to:
   - a) primary wall only
   - b) secondary wall only
   - c) primary and secondary walls
   - d) no wall

   **Correct answer:** c

#### Question 2
2. Which cells illustrate:
   - a) primary wall only
   - b) secondary wall only
   - c) primary and secondary walls
   - d) no wall

   **Correct answer:** c

#### Question 3
3. Zymase of vacuolar juice splits vacuolar membranes:
   - a) are produced by secondary growth
   - b) are only found in non-woody stems
   - c) are produced by primary growth
   - d) become disconnected during secondary growth by lacunae vesicle認為

   **Correct answer:** d

#### Question 4
4. The plane of division in the plane of cell division:
   - a) plane is perpendicular to the plane of cell division
   - b) plane is the diameter of the cell division
   - c) plane is the diameter of cell division
   - d) plane is not connected by plasmodeum

   **Correct answer:** a

#### Question 5
5. The pyrophosphate part of macromolecules:
   - a) occurs perpendicular to the plane of cell division
   - b) occurs along the new circumference
   - c) occurs parallel to the plane of cell division
   - d) occurs along the circumference

   **Correct answer:** a

#### Question 6
6. The vacuole is surrounded by:
   - a) inside the cell membrane
   - b) outside the cell membrane
   - c) inside the cell wall
   - d) B, C

   **Correct answer:** a

#### Question 7
7. These cells illustrate:
   - a) primary wall only
   - b) secondary wall only
   - c) primary and secondary walls
   - d) no wall

   **Correct answer:** c

#### Question 8
8. The plant wall is composed of:
   - a) inside the cell membrane
   - b) outside the cell membrane
   - c) inside the cell wall
   - d) B, C

   **Correct answer:** a

#### Question 9
9. The primary portion of a cell expansion is precursor to:
   - a) primary wall only
   - b) secondary wall only
   - c) primary and secondary walls
   - d) no wall

   **Correct answer:** c

#### Question 10
10. The primary portion of a cell expansion is precursor to:
    - a) primary wall only
    - b) secondary wall only
    - c) primary and secondary walls
    - d) no wall

    **Correct answer:** c

---

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Plant Science Laboratory  Cat 2: Plant Growth

You can click the following button to quit now.

Thanks for being with us.
Appendix E: Courseware Manual
(1994 Fall)

I. Welcome

Welcome to the “Plant Science Laboratory” series. These series courseware units provide tutorial information and computer-administered tests to help you, as a learner, to better understand the concepts of plant science. They also provide many lab activities related to the plant knowledge to guide your hands-on experiments. These units are designed to accomplish the course “Plant Science Laboratory” provided by department of Biology at Virginia Tech. However, they can also be used as remedialional or independent study materials.

This particular courseware unit is “Unit 3: Plant Growth.” In this unit package, you have two diskettes and a booklet of “Users’ Manual.” Diskette One contains a standalone application which is executable by itself. Diskette Two contains a stack (program) which can only be opened under HyperCard 2.2 or later versions. Both diskettes contain the same information. However, if you do not have appropriate HyperCard version, you have to use the standalone application in diskette One. The application will take 1.2 MB memory plus space for picture files. On the other hand, if you have HyperCard, you can use the courseware stack in diskette Two. The courseware stack takes about 500 K memory only. In HyperCard environment, you can also have the power to modify the content and questions in the stack if you wish.

II. System Requirements

In order to execute this courseware unit, you should have the following equipment:

A. Hardware

1. Macintosh computer: To get a better performance, Mac IIci or above is recommended.
2. Color Monitors: Two monitors are needed; one for computer and one for videodisc player. Color monitors are preferable to see the color instructional screens.

3. 4 MB RAM: At least 2 MB of them is allocated to HyperCard or the application.

4. Hard drive or other compatible devices.

5. Videodisc player: You can choose one from Pioneer LD-V2200, LD-V4200, LD-V6000, Hitachi, Philips VP406, or Sony players.

6. Videodisc “Plant Science Lab”: This videodisc is produced by department of Biology, Virginia Tech. in 1993. It contains the still images and animation used by this courseware unit.

B. Software

1. Macintosh System 7.0 or above.

2. HyperCard 2.2 or later version, if HyperCard stack is used.

3. This courseware unit: “Plant Growth” is the main program. The others, such as Note1, Note2 and Tree.pic, are the picture files used by the main program.

III. Installation

A. Make a backup copy

In case there should have a damage on your disk, make a backup copy and save the original copy in a safe place. The backup procedure is simply copying the whole programs in your original diskette into another diskette.

B. Install courseware into hard drive

To get a better performance, courseware should be executed from a hard drive. To install courseware into your hard drive, please follow the procedures:

1. Create a folder, and name it as “Unit 3: Plant Growth”

2. Copy all programs in original diskettes into that folder.
IV. Operation

To operate the courseware, follow the procedures:

A. Turn on the computer
B. Open application from your courseware folder
C. Navigate in the courseware.

Once the courseware is opened, the title page will appear first. Simply click the mouse at anywhere to continue. This courseware will present the learning objectives. And since then, you are free to explore this course based on your needs and interests.

If you are beginners of this courseware series, please click the “HELP” button at the left side of the screen to learn about the navigational control. It is also recommended to review the “MAP” screen to have an overview of this course structure in order to guide your later navigation.

V. Maintenance

This courseware can generate a record file which contains users’ information such as the learning date, learning time, test scores, and comments. You can review this information by double-clicking the file “USERRECORD.” However, if you do not need this information, you can delete that file by dragging it to the trash can and empty it. This will save the space which is used by the file “USERRECORD.”

VI. Copyrights

This courseware template was designed by Chia-Shing Yang under the supervision of his dissertation committee: Drs. Moore, Burton, Holmes, Magliaro, and Taylor. Dr. Taylor also coordinated the whole production project. Course content and video pictures were prepared by Dr. Sheckler and Mr. Hill. All rights are reserved.
## Appendix F. Progress Log

**Remark:** For the convenience of reference, two tables duplicated from Table 2.7 and 3.1 are presented here as Table F.1 and F.2. Please refer task numbers and member roles in Progress Log from these two tables.

### Table F.1
Procedure flow of developing hypermedia courseware

(P: primary responsibility; s: secondary responsibility)

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**Abbreviations of key words:**

S/C: sponsors, customers, instructors, or students
PM: project manager
ID: instructional designers
CE: content experts
MS: media specialists (programmers & video specialists)
AR: artists or musicians
EV: external evaluators
TP: typists and other logistic persons
LB: librarians

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Table F.2
Gantt chart for "Plant Growth" project
(^: check point; *: work day; -: preparation day )

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<td>6. Final report</td>
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</tbody>
</table>
# Progress Log (Unit 3: Plant Growth)

<table>
<thead>
<tr>
<th>Date</th>
<th>Task No.</th>
<th>Tools Used</th>
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<th>S</th>
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<th>I</th>
<th>D</th>
<th>P</th>
<th>A</th>
<th>R</th>
<th>V</th>
<th>Activity Description</th>
</tr>
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<tbody>
<tr>
<td>4/29</td>
<td>1</td>
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<td></td>
<td></td>
<td>Discuss the courseware production project with Dr. Taylor (the sponsor).</td>
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<td></td>
<td>- Discuss the rationale and resources of producing a courseware unit.</td>
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<td></td>
<td></td>
<td>- Decide the course subject and lesson unit of the courseware.</td>
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</tr>
<tr>
<td>5/3</td>
<td>2.1</td>
<td></td>
<td>1.5</td>
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<td>X</td>
<td>X</td>
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<td></td>
<td>Discuss the general background of this project with Dr. Taylor. Topics include:</td>
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<td>2.2</td>
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<td>- contexts of this course subject,</td>
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<td>2.3</td>
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<td>- prerequisites of this course subject,</td>
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<td>- perspectives of this course subject,</td>
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<td>- students and instructors,</td>
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<td>- instructional settings,</td>
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<td>- related courses, and</td>
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<td>- available learning resources.</td>
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<td>5/3</td>
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<td>X</td>
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<td></td>
<td>1. Read &quot;Undergraduate Catalogue&quot; to learn about this course and its related contexts.</td>
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<td>2. Study course syllabus and classroom handouts.</td>
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<td>5/4</td>
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<td>2.5</td>
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<td>1. Go to the classroom to observe the actual setting and instructional process.</td>
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<td>2. Interview the instructor, teaching assistants, and students.</td>
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<td></td>
<td>1. Copy and reorganize the instructional content into a text file.</td>
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<td>2. Study the instructional content. The purpose of studying content is mainly to learn the course goals and learners prerequisite abilities.</td>
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<td>5/9</td>
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<td></td>
<td>Prepare interview questions for ID Analysis.</td>
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<th>V</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/10</td>
<td>2.1</td>
<td></td>
<td>2</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td></td>
<td>Interview the instructor (Mr. Hill). Discuss: - learners characteristics, - course contexts, - subject structure, - learning environments, and - other topics.</td>
</tr>
<tr>
<td>5/10</td>
<td>2.2</td>
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<td></td>
<td>Prepare Analysis report.</td>
</tr>
<tr>
<td>5/10</td>
<td>2.3</td>
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<td>Continually prepare Analysis report.</td>
</tr>
<tr>
<td>5/11</td>
<td>2.1</td>
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<td>3</td>
<td>X</td>
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<td>Send the Analysis report for confirmation.</td>
</tr>
<tr>
<td>5/12</td>
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<td>1</td>
<td>X</td>
<td>X</td>
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<td>1. Select a courseware template from &quot;Template Library&quot;. 2. Modify the courseware template to fit into this course unit. The modification includes: - changing screen layouts, - creating new backgrounds, - changing navigational descriptions, etc. (It is logical to use a new background for each subsection of the content. But, I find out later that sharing a background for similar subsections is more efficient.)</td>
</tr>
<tr>
<td>5/13</td>
<td>3.3</td>
<td>Template Library</td>
<td>5</td>
<td>X</td>
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<td>1. Reorganize the pseudo instructional content in a text file. 2. Create some pseudo practices and test questions. 3. Add control codes into the content file. (The instructional content is classroom handouts. In general, these handouts are directly usable for this software. Some modification and expansion are needed in later stages.)</td>
</tr>
<tr>
<td>5/14</td>
<td>3.1</td>
<td></td>
<td>4</td>
<td>X</td>
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<tr>
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</thead>
<tbody>
<tr>
<td>5/14</td>
<td>3.3</td>
<td>Copy BG Objects</td>
<td>3</td>
<td>Since creating new backgrounds is difficult and time-consuming, I create a &quot;copy background objects&quot; tool.</td>
</tr>
<tr>
<td>5/14</td>
<td>3.4 Extra</td>
<td>Page Numbering, Unlock Fields</td>
<td>5</td>
<td>1. Create a tool to put the page numbers in each section on screens.</td>
</tr>
<tr>
<td>5/16</td>
<td>Extra</td>
<td>Selected Property Docu., Stack Modifier</td>
<td>3</td>
<td>2. Create a tool to lock/unlock all fields.</td>
</tr>
<tr>
<td>5/17</td>
<td>3.1</td>
<td>Selected Property Docu., Stack Modifier</td>
<td>3</td>
<td>Use &quot;Selected Property Docu.&quot; and &quot;Stack Modifier&quot; to put contents into the courseware template.</td>
</tr>
<tr>
<td>5/17</td>
<td>3.4</td>
<td>Stack Modifier</td>
<td>2</td>
<td>Put structural information (headings) onto screens.</td>
</tr>
<tr>
<td>5/17</td>
<td>Extra</td>
<td>Simple-text: Stack Modifier, Script Docu., Field Content Docu.</td>
<td>3</td>
<td>I found that the &quot;Stack Modifier&quot; required too much information. The lengthy text file made it difficult to read. Therefore, I modify it and other related tools to create some new simple-text tools.</td>
</tr>
<tr>
<td>5/18</td>
<td>3.3</td>
<td>Script Docu., Stack Modifier</td>
<td>5.5</td>
<td>1. Go through each card and modify the scripts to control the system flow.</td>
</tr>
<tr>
<td></td>
<td>3.4</td>
<td></td>
<td></td>
<td>2. Based on a convention to name all the objects in this prototype courseware.</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td>3. Modify &quot;Map&quot; to correspond to the structure of this prototype courseware.</td>
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<td></td>
<td>4. Get the first printout of this prototype.</td>
</tr>
<tr>
<td>5/18</td>
<td>Extra</td>
<td>Name Objects</td>
<td>1.5</td>
<td>Create a tool to display all object names in a temporary field. I can make changes in this field and then the computer will modify the object names accordingly.</td>
</tr>
<tr>
<td>5/19</td>
<td>3.3</td>
<td>Selected Property Docu., Stack Modifier</td>
<td>2</td>
<td>1. Put scripts into Heading Bars.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. Put scripts into Menu Fields.</td>
</tr>
</tbody>
</table>

* This task is not directly relate to this project. However, it creates some useful tools for future courseware productions.
## Progress Log (Unit 3: Plant Growth)

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<th>V</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/20</td>
<td>3.1 3.4</td>
<td></td>
<td>5</td>
<td>X</td>
<td>X</td>
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<td></td>
<td></td>
<td>Check tutorial content and modify its formats. (Such as spacing, capitals, etc.)</td>
<td></td>
</tr>
<tr>
<td>5/20</td>
<td>Extra</td>
<td>Number objects</td>
<td>2</td>
<td></td>
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<td></td>
<td>Create a tool to change object sequence numbers in a card or background to get a good content printout.</td>
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</tr>
<tr>
<td>5/20</td>
<td>3.4</td>
<td>Selected Property Docu.,</td>
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<td></td>
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<td></td>
<td></td>
<td>X</td>
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<td></td>
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<td></td>
<td>Change fonts and sizes of all the fields.</td>
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<tr>
<td></td>
<td></td>
<td>Stack Modifier</td>
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<td>5/23</td>
<td>Extra</td>
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<td></td>
<td>Reorganize the &quot;Courseware Tools&quot; to include some useful buttons.</td>
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<tr>
<td>5/24</td>
<td>Extra</td>
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<td>3</td>
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<td></td>
<td>Reorganize the &quot;Courseware Tools&quot; and get the Script printout.</td>
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</tr>
<tr>
<td>5/24</td>
<td>3.3</td>
<td>Script Library, Name Objects</td>
<td>2</td>
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<td>X</td>
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<td></td>
<td></td>
<td></td>
<td>Study the Videodisc functions.</td>
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</tr>
<tr>
<td>5/25</td>
<td>3.3</td>
<td>Script Library, Name Objects</td>
<td>2</td>
<td>X</td>
<td></td>
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<td>X</td>
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<td></td>
<td></td>
<td>1. Put Videodisc function codes into video buttons (codes are from Voyager Stack).</td>
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<td></td>
<td>2. Rename the backgrounds in the stack to fit into my naming conventions.</td>
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<tr>
<td>5/25</td>
<td>3.6</td>
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<td>2.5</td>
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<td>X</td>
<td></td>
<td></td>
<td>External evaluators (Dr. Burton &amp; Mr. Hou) go through this prototype and give their feedback:</td>
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<td>- navigational (grayed out) buttons must be consistent.</td>
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<td>- link content from tutorial to laboratory.</td>
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<td>- provide feedback to erroneous clickings.</td>
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<td>- suggest operation on each screen.</td>
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<td>- use color to indicate the course hierarchy.</td>
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<td></td>
<td>2. Modify Videodisc function codes. Originally, this courseware prototype requires a copyrighted external drive to control videodisc players. Now this prototype becomes self-sufficient.</td>
<td></td>
</tr>
</tbody>
</table>
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<th>G</th>
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<th>R</th>
<th>V</th>
<th>Activity Description</th>
</tr>
</thead>
</table>
| 5/26 | 3.7      |            | 2          | X | X | X | X | X |   |   |   |   |   | Refine the courseware prototype according to suggestions of the evaluation.  
- make navigational buttons be consistent.  
- link content from tutorial to laboratory.  
- provide feedback to erroneous clickings. |
| 5/26 | 3.1      | 3.4        | 1          |   |   |   | X | X |   |   |   |   |   | Discuss the formats of course content and instructional strategies with the instructor (Mr. Hill). |
| 5/27 | * 3      |            | 1          | X | X | X | X | X |   |   |   |   | X | Dr. Taylor joins in the developmental review. We go through the prototype and find some program problems, such as a mis-typed button and incorrectly recorded user information. |
| 5/27 | 3.6      |            | 1.5        | X | X | X |   |   |   |   |   |   |   | Dr. Holmes serves as an external evaluator. He goes through this prototype and suggests:  
- hide titlebar and menubar.  
- relate course content to objectives.  
- link objectives to tutorial content.  
- rewrite some sentences in the direction statement.  
- practice questions immediately follow concept explanation.  
- put suggested operation on each screen. |
| 5/31 | 3.7      | Lock/unlock Fields, Show All Hidden Objects | 1          | X | X |   |   |   |   |   |   |   |   | Refine the courseware prototype according to suggestions of the evaluation.  
- hide titlebar and menubar.  
- rewrite some sentences in the direction statement.  
- practice questions immediately follow concept explanation.  
- suggested operation on each screen. |

* This activity is part of the developmental review.
## Progress Log (Unit 3: Plant Growth)

<table>
<thead>
<tr>
<th>Date</th>
<th>Task No.</th>
<th>Tools Used</th>
<th>Work Hours</th>
<th>S</th>
<th>C</th>
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<th>C</th>
<th>E</th>
<th>P</th>
<th>A</th>
<th>R</th>
<th>V</th>
<th>Activity Description</th>
</tr>
</thead>
</table>
| 6/1  | 3.7      | Lock/unlock Fields, Script Library | 2.5 | X | X | X | X | X | X | X | X | X | X | X | Refine the courseware prototype:  
  - link objects and content screens.  
  - indicate whether an objective has been visited.  
  - use “idle” function to control the display of suggested operations.  
  - rewrite the messages of suggested operations. |
| 6/2  | Extra    | Page Numbering, Put Field Content into Script | 2 | X | X | X | X | X | X | X | X | X | X | X | Devise or rewrite tools:  
  - place page numbers on screens.  
  - enable/disable buttons based on a list of card numbers. |
| 6/3  | 3.8      | Page Numbering | 1 | X | X | X | X | X | X | X | X | X | X | X | Confirm prototype with Dr. Taylor. Suggestions for modification are:  
  - change some statements, such as direction --> instruction.  
  - change the presentation style and waiting period of suggested operations. |
<p>| 6/8  | 4.4      | Copy BG Objects, Copy Card Objects, Selected Property Docu., Stack Docu., Stack Modi. | 2 | | | | | | | | | | | | Study and try HyperCard 2.2 color functions. |
| 6/9  | 3.7      | Copy BG Objects, Copy Card Objects, Selected Property Docu., Stack Docu., Stack Modi. | 5 | X | X | X | X | X | X | X | X | X | X | X | Modify courseware prototype to minimize the number of backgrounds. The program size is reduced from 780K to 470K. |
| 6/10 | 4.4      | | 3 | | | | | | | | | | | | Try to color the stack. |</p>
<table>
<thead>
<tr>
<th>Date</th>
<th>Task No.</th>
<th>Tools Used</th>
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<th>G</th>
<th>R</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/10</td>
<td>3.8</td>
<td></td>
<td>3.5</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Activity Description:
- Re-confirm prototype with Dr. Taylor and Mr. Hill.
  Suggestions are:
  - build in a videodisc controller.
  - auto play videodisc when enter a new screen.
  - add visual questions.
  - change button name from "Laboratory" to "Lab Activity" and from "Direction" to "Instruction".
  - change the style of buttons in "Map" screen.
  - change backgrounds design.
  - take away the linkages between objectives and instructional screens. Use a check mark to indicate these menu items which have been selected.
  - use buttons to represent the menu items.
  - change the size of answer sheet in "Test" section.

<table>
<thead>
<tr>
<th>Date</th>
<th>Task No.</th>
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<th>G</th>
<th>R</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/13</td>
<td>3.7</td>
<td></td>
<td>7</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<td>X</td>
</tr>
</tbody>
</table>

1. Modify the size of answer sheet.
2. Dynamically create the answer sheet based on the selection of total question number.
3. Change menu fields to menu buttons.

<table>
<thead>
<tr>
<th>Date</th>
<th>Task No.</th>
<th>Tools Used</th>
<th>Work Hours</th>
<th>S</th>
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<th>G</th>
<th>R</th>
<th>V</th>
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</thead>
<tbody>
<tr>
<td>6/13</td>
<td>4.1</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
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</tbody>
</table>

Create new backgrounds.

<table>
<thead>
<tr>
<th>Date</th>
<th>Task No.</th>
<th>Tools Used</th>
<th>Work Hours</th>
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<th>M</th>
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<th>E</th>
<th>G</th>
<th>R</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/14</td>
<td>4.3</td>
<td>Macpaint; Photoshop</td>
<td>4</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

1. Put new backgrounds into prototype.
2. Change "Direction" to "Instruction" in all backgrounds.

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<thead>
<tr>
<th>Date</th>
<th>Task No.</th>
<th>Tools Used</th>
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<th>E</th>
<th>G</th>
<th>R</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/14</td>
<td>4.5</td>
<td>Selected property Docu., Stack Mod.</td>
<td>2</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
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</tbody>
</table>

Create a videodisc controller (using another stack)

<table>
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<tr>
<th>Date</th>
<th>Task No.</th>
<th>Tools Used</th>
<th>Work Hours</th>
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<th>R</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/15</td>
<td>4.4</td>
<td>Script Library</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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</tbody>
</table>

1. Create another Videodisc controller using palette.
2. Draw a picture for the videodisc controller.
3. Restructure the scripts, but the whole program falls due to continuously issuing external commands to control videodisc players. System fails, and scripts have been incidentally changed. Today is a disaster.

<table>
<thead>
<tr>
<th>Date</th>
<th>Task No.</th>
<th>Tools Used</th>
<th>Work Hours</th>
<th>S</th>
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<th>M</th>
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<th>E</th>
<th>G</th>
<th>R</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/16</td>
<td>4.4</td>
<td>Script Docu., Stack Mod.</td>
<td>10</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
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</tbody>
</table>

1. Create another Videodisc controller using palette.
### Progress Log (Unit 3: Plant Growth)

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<thead>
<tr>
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<th>D</th>
<th>E</th>
<th>C</th>
<th>P</th>
<th>G</th>
<th>A</th>
<th>R</th>
<th>V</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/17</td>
<td>* 4</td>
<td></td>
<td>1.5</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1. Install courseware in customer's site for evaluation. 2. Discuss the courseware with Dr. Taylor.</td>
<td></td>
</tr>
<tr>
<td>6/17</td>
<td>4,4</td>
<td>Script Library, Script Dcu., Stack Mod.</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1. Modify the video functions. 2. Refine the scripts. 3. Use &quot;autoselect&quot; function to indicate the selection of a frame number from the video listing.</td>
<td></td>
</tr>
<tr>
<td>6/22</td>
<td>** 3.6</td>
<td></td>
<td>1</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>Dr. Magliaro serves as an external evaluator. She goes through this prototype courseware and suggests: - match the order of screen buttons with the order of &quot;Map&quot; buttons. - give description to each video number. - give description to each lab activity. - do not use negative statements in practice or test questions. - rewrite some of the instruction statements. - some bugs in control buttons.</td>
<td></td>
</tr>
<tr>
<td>6/22</td>
<td>4.2</td>
<td></td>
<td>1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
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<td></td>
<td>Refine the courseware. - match the order of screen buttons with the order of &quot;Map&quot; buttons. - rewrite some of the instruction statements. - some bugs in control buttons. However, a bug in video functions can not be found again.</td>
<td></td>
</tr>
<tr>
<td>6/23</td>
<td>4.2</td>
<td>Gray Buttons</td>
<td>3</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
<td>Refine the courseware. - rewrite the &quot;Instruction&quot; statements. - check grayed buttons.</td>
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<tr>
<td></td>
<td>4.5</td>
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</tr>
<tr>
<td>Extra</td>
<td>Color Tool</td>
<td></td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1. Work on color functions. 2. Create a tool to put colors into stack objects.</td>
<td></td>
</tr>
<tr>
<td>6/24</td>
<td>Extra</td>
<td>Color Tool</td>
<td>4</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Continue to create a tool to put colors into stack objects.</td>
<td></td>
</tr>
</tbody>
</table>

* This activity is part of the developmental review.  
** Due to the availability of the External Evaluator, this activity has been postponed until now.
## Progress Log (Unit 3: Plant Growth)

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<th>E</th>
<th>P</th>
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<th>R</th>
<th>E</th>
<th>V</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/5</td>
<td>4.1</td>
<td>Lock/unlock Fields</td>
<td>4</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Modify instructional contents.</td>
<td></td>
</tr>
<tr>
<td>7/6</td>
<td>4.2</td>
<td>Lock/unlock Fields</td>
<td>4</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Reorganize the screen layouts.</td>
<td></td>
</tr>
</tbody>
</table>
| 7/6   | **3.6**  |                          | 1.5        |   | X |   |   |   |   |   |   | X |   | Dr. Moore serves as an external evaluator. He goes through this prototype courseware and suggests:  
  - possible link from practice feedback to tutorial information.  
  - rewrite some statements in assistance screens.  
  - group instructional descriptions into several sub-topics.  
  - some bugs in control buttons. |
| 7/14  | *4       |                          | 1          | X |   |   | X |   |   |   |   |   |   | Discuss the progress of this project with Dr. Taylor.                              |
| 7/14  | 4.1      | Lock/unlock Fields       | 5          |   | X | X |   |   |   |   |   |   |   | 1. Modify content and test bank.  
  2. Get a full printout of courseware.                                               |
| 7/14  | 4.5      |                          | 5          |   | X |   |   |   |   |   |   |   |   | 1. Due to the changes of content and test questions, many names of cards and buttons have to be modified accordingly.  
  2. Change the links between cards.                                                 |
| 7/15  | 4.4      | Name objects             | 4          |   |   |   | X |   |   |   |   |   |   | 1. Change "Instruction" to "Help".  
  2. Change statements in "Help" section.                                             |
| 7/15  | 4.5      |                          | 4          |   |   |   | X |   |   |   |   |   |   | 1. Change buttons to icons.  
  2. Modify buttons in "Map" screen.                                                 |
| 7/16  | 4.3      |                          | 3          |   |   | X |   |   |   |   |   |   |   | 1. Create new backgrounds for the Test and Lab Activity screens.                  |
| 7/16  | 4.4      |                          | 3          |   |   |   | X | X |   |   |   |   |   | 2. Build icon graphics into System screens.                                         |
| 7/19  | Extra    |                          | 4          |   |   |   | X |   |   |   |   |   |   | 3. Create pictures and animation for the title page.                               |
| 7/20  | 4.6      |                          | 3          |   | X | X |   | X |   |   |   |   |   | Prepare courseware manual.                                                        |
| 7/25  | 4.5      |                          |            |   |   |   |   |   |   |   |   |   |   | 2. Build icon graphics into System screens.                                         |

* This activity is part of the developmental review.  
** Due to the availability of the External Evaluator, this activity has been postponed until now.
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</tr>
</thead>
<tbody>
<tr>
<td>7/26</td>
<td>*</td>
<td></td>
<td>1.5</td>
<td>Discuss with Dr. Taylor about this project. His suggestions: 1. Modify statements in Test Instruction screens. 2. Modify the linkage between Tutorial and Lab Activity screens. 3. Modify the format of linked fields in Tutorial screens.</td>
</tr>
<tr>
<td>7/26</td>
<td>4.3</td>
<td>Lock/Unlock Fields, Script Docu., Stack Modifier</td>
<td>6</td>
<td>1. Modify statements in Test Instruction screens. 2. Modify the linkage between Tutorial and Lab Activity screens. 3. Modify the format of linked fields in Tutorial screens. 4. Reorganize the script to minimize the stack size.</td>
</tr>
<tr>
<td>9/1</td>
<td>5.1</td>
<td></td>
<td>1</td>
<td>Discuss the preparation of pilot test.</td>
</tr>
<tr>
<td>9/2</td>
<td>5.1</td>
<td></td>
<td>0.5</td>
<td>Install and test the courseware unit in the pilot test setting.</td>
</tr>
<tr>
<td>9/6</td>
<td>5.1</td>
<td>Lock/Unlock Fields, Script Library</td>
<td>1.0</td>
<td>Last-minute modification: 1. Hide &quot;Video Palette&quot; from screens if there is no animation. 2. Hide &quot;Video List&quot; from screens if it contains only one frame number. 3. Change some contents and test questions. 4. Delete some cards, rename the cards, and modify &quot;MAP&quot; screen. 5. Change the locations of &quot;PREVIOUS&quot; and &quot;LINK_RETURN&quot; buttons. 6. Hide &quot;Related Lab Activity&quot; function from tutorials. 7. Test video functions. 8. Make a stand-alone application package.</td>
</tr>
</tbody>
</table>
## Progress Log (Unit 3: Plant Growth)

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<tr>
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<th>M</th>
<th>D</th>
<th>E</th>
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<th>P</th>
<th>A</th>
<th>R</th>
<th>V</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/7</td>
<td>5.1</td>
<td></td>
<td>3</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pilot test this courseware unit.</td>
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<td></td>
<td>1. Explain and demonstrate the operation.</td>
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<td></td>
<td>2. Subjects use this courseware unit.</td>
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<td></td>
<td>3. Subjects fill out the evaluation forms.</td>
<td></td>
</tr>
<tr>
<td>9/7</td>
<td>5.1</td>
<td></td>
<td>1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Analyze the results of the pilot test.</td>
<td></td>
</tr>
<tr>
<td>9/9</td>
<td>5.2</td>
<td></td>
<td>1.5</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Modify this courseware unit based on the result of pilot test:</td>
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<td></td>
<td></td>
<td></td>
<td>1. Correct spelling errors.</td>
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<td></td>
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<td></td>
<td>2. Change practice format to be accord with test format.</td>
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<td>3. Add video initiation function at the beginning.</td>
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<td>9/11</td>
<td>5.3</td>
<td>Field Content Doc., Script Docu. Object Libraries</td>
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<td>X</td>
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<td>Prepare system documentations:</td>
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<td>1. Courseware printouts.</td>
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<td>2. Content printouts.</td>
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<td>4. Expand object libraries.</td>
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<td>9/14</td>
<td>5.4</td>
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<td>Confirm the final products with the sponsors.</td>
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<td>0.5</td>
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<td>Package diskette with Users’ manual. Turn them to the sponsors.</td>
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<td>9/15</td>
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<td>Discuss the project and its future application with the sponsors:</td>
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<td>1. Summative evaluation at the end of the semester.</td>
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<td>2. Allow courseware units be used before or after class.</td>
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<td>3. More units will be produced based on this template.</td>
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</tbody>
</table>
Chia-Shing Yang

Permanent Address:
National Open University
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Lu-Chow, Taipei County 24702
Taiwan, R.O.C.
Phone: (011-886-2) 2829355

Current Address:
1217 University City Blvd. #188
Blacksburg, VA 24060
U.S.A.
Phone: (703) 951-4783

Education

Ph.D. Instructional Technology
Virginia Polytechnic Institute and State University

Graduate Study Educational Psychology and Technology
University of Southern California

M.S. Instructional Media
Illinois State University

Graduate Study Guidance and Counseling
National Taiwan Normal University

B. Ed. Education
National Taiwan Normal University

Professional Experience

03/89 - 07/92 Instructor and Leader of CAI Team
National Open University, Taiwan
* Teach courses: Basic Concepts of Computers with BASIC, COBOL, and
  Computer-Assisted Instruction.
* Lead a team to design and develop computer-based courseware.

07/88 - 03/89 Information System Project Manager
Golden International Information Company, Taiwan
* Analyze and design customized informational systems.
* Manage informational system production projects.

09/86 - 06/88 Information System Analyst
Computing center, Cooperative Bank of Taiwan
* Analyze and design on-line or batch bank systems.
* Manage on-job training programs for the Computer center.
10/82 - 07/84  Application Programmer
Computing center, Cooperative Bank of Taiwan
Develop on-line and batch transaction programs.

08/75 - 09/82  Teacher, Division Leader, and Counselor
Taipei Municipal Ker-Chi Junior High School, Taiwan
Teaching, school administration, and student counseling.

Publications

*In English

Resources In Education:
02/93  Perspectives on Electronic Performance Support System
(with Glenda R. Scales)

Educational Technology:
03/87  Individualizing Instruction Through Intelligent Computer-
Based Instruction: A Prospective

*In Chinese

Journal of Business, National Open University: (yearbook)
1993  Electronic Performance Support System

Resources in Chinese Education: (yearbook)
1992  Audio-Visual Education & the Development of Distance
      Education in China

Audio-Visual Education Bimonthly:
11/91  A Case Study: The Design of a Hypermedia Courseware
01/91  The Transition of Instructional Design
08/87  Screen design of a CAI Courseware
06/87  Gaming Courseware
05/87  Introduction to Intelligent CAI
03/87  Variables in Research of Instructional Design
11/86  How to Design a CAI Courseware
08/86  A Review of Adaptive Strategies in CAI
08/86  A Review of CAI Research in U.S.A.
03/86  The Development of CAI in America

Collection of Papers on Distance Education: (yearbook)
1990  Guidelines for Designing a Tutorial CAI Courseware
1989  The Design Strategies of a CAI Courseware

Today's Cooperative Bank:
01/88  Introduction to Chinese Microcomputers
08/86  Introduction to Chinese Operating System

Scientific Education:
10 - 11/86  The Perspectives of Intelligent CAI (I)--(II)
Instructional Software Production

09/94  Plant Science Laboratory Series: Unit 3 - 4
       Virginia Polytechnic Institute and State University

07/92  Chinese LOGO Project: PST
       Department of Education, Taiwan Province, Taiwan

06/92  Selected English Readings Series: Unit 1 - 54
       National Open University

02/92  English for High School Students Series: Unit 1 - 12
       Informational Science Exhibition Center, Taiwan

06/91  Basic English Readings Series: Unit 1 - 36
       National Open University

03/91  Basic Concepts of Computers Series: Operating System
       National Open University

09/90  Basic Concepts of Computers Series: Flow Chart
       National Open University

05/90  Basic Concepts of Computers Series: Random Files
       National Open University

05/85  Microcomputers in Schools
       Illinois State University

Awards and Special Recognitions

1992 - 94  Fellowship for Studying Abroad
           National Science Council, Republic of China

1991  Award of Outstanding Research
       National Science Council, Republic of China

1991  Yearly Award of Outstanding Research Paper
       Association of Distance Education, Taiwan

1990  Award of Outstanding Research
       National Science Council, Republic of China

1989  Yearly Award of Outstanding Research Paper
       Association of Distance Education, Taiwan

1984 - 86  Fellowship for Studying Abroad
            Ministry of Education, Republic of China