Hyper-authoring for education: a qualitative evaluation

Maria Emilia Xavier Mendes *, Wendy Hall

University of Southampton, Southampton, UK

Abstract

The complexity involved in hypermedia authoring has lead to many different proposals of models, methodologies and systems. And this complexity can become even greater when the purpose is to develop applications for education.

In this paper we describe a qualitative evaluation that analysed the processes involved in the authoring of hypermedia applications for education by interviewing both researchers and lecturers from the University of Southampton involved in the development of hypermedia. This study is part of a research project called SHAPE, the aim of which is to aid authors in the development of good quality large-scale applications for education. In the project, the quality characteristics considered are reusability of information, maintainability of applications and authoring effort.

The results show that there is little point in trying to improve the authoring of hypermedia applications for education by proposing an authoring methodology. So, rather than trying to improve hypermedia authoring by proposing an authoring methodology, we decided to define hypermedia metrics to measure the quality characteristics of hypermedia applications and systems and to give the necessary feedback for the improvement of authoring. © 1999 Elsevier Science Ltd. All rights reserved.

1. Introduction

This paper describes a qualitative evaluation which analyses the processes involved in the development of hypermedia applications for education. We wanted to understand the authoring process in order to identify the need for proposing a hypermedia authoring methodology. In Section 2 we offer some background information about hypermedia authoring so the reader can understand the difficulties involved in authoring for education and what has already been proposed by the hypertext community. In Section 3 we present the SHAPE
project, describe the qualitative evaluation which is part of SHAPE, and comment the results of the study. Finally, in Section 4 we present our conclusions and future work.

2. Background

Hypermedia authoring has been a major area of research and interest in the last few years. It is a vast area because there are many ways of understanding the meaning of authoring and the level of understanding is directly related to what system is being offered to hypermedia authors. In the literature we can find many different proposals of hypermedia authoring models, methodologies and systems. HDM (Garzotto, Paolini & Schwabe, 1991), OOHDM (Schwabe & Rossi, 1995) and EORM (Lange, 1994) propose models for the conceptual design of hypermedia applications. RMM (Isakowitz, Stohr & Balasubramanian, 1995), PHD (Schuler & Thüring, 1994), and Thüring’s framework (Thüring, 1994) are methodologies that cover all the development phases. SEPIA (Haake, Hannemann, Lamke, Schuler, Schutt et al., 1992) and MacWeb (Nanard & Nanard, 1995) are hypermedia systems based on cognitive theories. IDE (Jordan, Russell, Jensen & Rogers, 1989) is an instructional design system, built on top of NoteCards (Halaz, Moran & Trigg, 1987).

We define a hypertext authoring system as an environment that facilitates the creation of a hypermedia application (Isakowitz et al., 1995). Hypermedia Templates (Catlin & Garrett, 1991), Aquanet (Marshall, Halasz, Rogers & Janssen, 1991), VIKI (Marshall & Shipman, 1995), RMCase (Diaz & Isakowitz, 1995) and ODMTool (Lange, 1996) are examples of hypermedia authoring systems based on conceptual models. But general hypermedia systems can also facilitate authoring. Some good examples are Microcosm (Davis, Hall, Heath, Hill & Wilkins, 1992), Intermedia (Meyrowitz, 1986), StorySpace (Bernstein, Bolter, Joyce & Mylonas, 1991), The Web (Berners-Lee, Cailliau, Luotonen, Nielsen, Frystyk et al., 1994), HyDesign (Marmann & Schlageter, 1992), and HyperWave (Flohr, 1995).

Authoring can also be considered a writing process (Nanard & Nanard, 1995) and in this sense it involves the same processes used in writing: that is, planning, translating and reviewing (Hayes & Flower, 1980). When developing large-scale hypermedia applications there are additional concerns which arise and that must be taken into careful consideration. They are reuse, maintainability and planning (Ginige, Lowe & Robertson, 1995). As mentioned by Schwabe and Rossi (1994) (p. 39) “building large hypermedia applications is difficult, and is further complicated by the fact that, once an application has been built, its maintenance is

![Fig. 1. A dimension of text types (Whalley, 1993).](image-url)
correspondingly more complicated. Moreover, as in other software domains (such as information systems, databases etc.) hypermedia applications are usually built from scratch: reuse is still a dream”.

When hypermedia authoring is applied to education there is an increase in the number of variables to analyse and take into account. Education is concerned with transmitting the information in such a way that allows the learner to construct a mental model of it (Jih, Hueyching & Reeves, 1992; Carr, 1995). Both the learner and the author can have different levels of control over the information (Whalley, 1993), as shown in Fig. 1, but as far as education is concerned it’s important to present the information inside a context, so the learner can interact with the application keeping local as well as global coherence (Thüring, Hannemann & Hakke, 1995). Hypermedia authors, when developing applications for education, should always be concerned with novice learners. They need to be guided to a certain extent. It does not mean that experienced learners have to go through the same steps as the novice ones. The application can be developed in a way that allows learners to choose different points of entry in the hyperdocument, or even use a search engine that brings back documents with the information required.

Hypermedia allows information to be structured in many different topologies: linear, hierarchy and in a web style (Ginige et al., 1995) and in this sense is considered to be very flexible. It’s non-linearity has been widely emphasised and described as the biggest advantage over conventional text. But, as Peter Whalley points out (Whalley, 1993) (p. 9), conventional texts also allow non-linearity “hypertext is often described as being ‘unstructured’ and ‘non-linear’, presumably in contrast to conventional ‘structured’, ‘linear’ text. However it is a mistake to think of conventional texts, and particularly expository teaching texts, as being purely linear. The skilful author may use the linear text form to weave and entirely non-linear pattern of associations in the reader’s mind…. The most significant pedagogic feature of hypertext is its malleability: it may change over time and it is capable of offering multiple perspectives on a particular domain. It is possible to use hypertext to present, and then represent, ideas in ways that are difficult to achieve in print”.

For Thüring, Haake and Hannemann (1991) (p. 165) “If a reader wants to navigate effectively, she has to understand the relations between the nodes of the hyperdocument. Therefore, it is not enough to provide structure but it becomes necessary to notify explicitly or even explain the structure to the reader. In order to improve both, navigation and comprehension, an author has to construct hyperdocuments which enhance the perception of local and global coherence relations”.

Hypermedia nodes are often described as self-contained units of information and in this sense a text could be translated into a web of related paragraphs. But to do so is to forget all the principles of composition and the importance in the order and in the relationship among paragraphs. Landow has emphasised that it is important to have a rhetoric of hypertext, especially when developing materials for education (Landow, 1987). For Peter Whalley (1993) (p. 9), “to dispense with paragraph structure is to lose one of the most important techniques of composition available to the writer, and means that hypertext is only likely to be suited to encyclopaedic or fragmented forms of knowledge”.

3. The SHAPE project

SHAPE is an acronym that stands for Southampton Hypermedia Authoring Paradigm for Education. The aim of SHAPE is to aid authors in the development of high quality large-scale applications for education. In this sense, high quality means easy reuse and maintenance of information and also means that the authoring tool used positively influences the authoring process. The qualitative evaluation described in this paper represents the first third of the project. The results are being used to inform the design of SHAPE.

3.1. Design of the qualitative evaluation

3.1.1. Subjects and method

The qualitative evaluation (Mendes and Hall, 1997) aimed at analysing the processes involved in the development of hypermedia applications for education. We wanted to understand the authoring process in order to identify the need for proposing a hypermedia authoring methodology. In order to collect the necessary data interviews were conducted at the University of Southampton in 1996. The thirteen participants that volunteered consisted of researchers and lecturers involved in the authoring of hypermedia applications for education using as development tools either Microcosm or the Web. Nine authors were involved in all the development phases, from the design of the structural knowledge (Diekho/C128, 1983) for the domain and the authoring of the contents of nodes, to the interface design and application implementation. Three authors were only involved in the management of the development and one author was involved in the definition of the structural knowledge and in the authoring of the contents of nodes. Some authors had been involved in the development of more than one application, which makes the number of applications used in our sample data (twenty) greater than the number of volunteers.

![Number of Applications](image)

Fig. 2. Number of applications and corresponding subjects.
3.1.2. Characteristics of the applications

Nine applications were developed by authors who already had experience in the development of at least one hypermedia application for education. Six applications were developed by authors who had already read about hypermedia but had no direct experience in the development of hypermedia applications, and five applications were developed by authors who had no previous experience or knowledge about hypermedia.

The number of applications and the corresponding subjects are presented in Fig. 2.

The number of small, medium and large applications, where we consider that a medium size application has a number of nodes between 100 and 500, was five, ten and five respectively.

3.1.3. The issues considered in the qualitative evaluation

The issues considered in the interviews were arranged into general and specialised. Each type will be described in the next sections.

3.1.3.1. The general issues. The general issues addressed were:

a) Was there a general method/methodology for the authoring of hypermedia applications for education?
b) What are the differences and similarities between the cognitive writing processes used in the development of hypermedia and non-hypermedia applications for education?
c) Were links essential when structuring the knowledge domain?
d) Is it important to represent the author’s cognitive map (Diekho & Diekho, 1982) in the structure of the application and do learners need to know it in advance?
e) Could the development be divided into different phases and groups of authors?
f) Were there commonalities among the resources used?
g) What was the most commonly used instructional approach?
h) How were the applications introduced in the courses?
i) Did the authoring tool used influence the interface design and the implementation of the application?

3.1.3.2. The specialised issues. The specialised issues addressed were:

j) Were there differences between experienced and non-experienced authors concerning the approach used for authoring?
k) Did the application’s size influence on the approaches used by the authors?
l) Was there a relationship between the authors’ role and the authoring approach used?
m) Did authors structure the information using different levels of granularity?
n) Did authors consider context-dependent links as well as typed links important for conveying information to the learners?

3.2. Results of the qualitative evaluation

3.2.1. Results for the general issues
a) Was there a general method/methodology for the authoring of hypermedia applications for education?

We cannot affirm that there was a general method/methodology if we consider the strict definitions of both words. But we can affirm that we found general guidelines. Among the applications we found that: (i) twelve were developed by authors who designed the structural knowledge for the domain in the first place and then looked for resources (references, images, videos, sound, etc.); (ii) seven were developed by authors who alternated between the design of the structural knowledge and the search for resources; and (iii) one was developed by an author who looked for resources before designing the structural knowledge.

The design of the structural knowledge can be considered as a planning process since it is “the knowledge of how concepts within a domain are interrelated” (Diekhoff, 1983). This result shows that planning is a very important process, as already pointed out by Hayes and Flower (1980). Despite the many different definitions and interpretations of hypertext structure (Carr, 1995), we define structure to be comprised of both: (a) the rhetoric involved in the composition of nodes and in the maintenance of global as well as local coherence (Thu¨ring et al., 1995); and (b) the semantics of the relationships between nodes, given by the links.

Considering the issue about a common way of structuring any domain, the answers were: (i) eight authors answered that there was not a common way that could be used to structure any domain; (ii) three answered that it could be the same when considering the same domain; and (iii) two answered that it could be the same for any domain.

Twelve authors answered that there was no best way of structuring the domain, from the readers’ point of view. These results were expected since the structure is influenced by many different variables including for example the educational goals, the author’s understanding of learning and teaching, and the social and cultural environment of the author.

b) What are the differences and similarities between the cognitive writing processes used in the development of hypermedia and non-hypermedia applications for education?

The top-down approach was used by seven authors. Among these four authors had already developed more than one application.

The top-down approach was used in three different ways: (i) subdividing the domain into different areas—two authors; (ii) using a Table of Contents—one author; and (iii) defining a hierarchy of concepts—four authors.

The mixed approach was used by six authors. This approach is also described as one of the possible mental processes commonly used in the composition activity (Nanard & Nanard, 1995; Hayes & Flower, 1980).

The bottom-up approach was used by one author on when she developed her first application. The bottom-up approach was small and at that time the author had only read about hypermedia. We can understand this result since for the development of hand-crafted applications little planning is required since all of the information can be kept in short-term memory.

An interesting point to mention is that all the large applications (four) were developed
using a top-down approach. Among these, three were developed by non-experienced hypermedia authors—two with the role of manager and one with the role of developing everything. One large application was developed by an experienced author whose role was to develop everything.

Hayes and Flower (1980), when describing the processes involved in writing, mention that the plan used to organise thoughts and information could be structured either temporally or hierarchically. Our results also confirm that.

c) Were the links essential when structuring the knowledge domain?
Ten authors answered that the link information was not essential when structuring the knowledge domain. Among these, half had already developed at least one hypermedia application for education before and four were the authors of the four large applications considered in our sample data.

Two authors answered that the links were essential and one answered that it was dependent on the educational goals.

This result reflects the idea that the development of a hypermedia application should neither be constrained by the links available nor by the “hypermedia style”.

d) Is it important to represent the author’s cognitive map in the structure of the application and do learners need to know it in advance?

The results about the importance of representing the author’s cognitive map were: (i) eight authors answered that it is important to represent the author’s cognitive map for the knowledge domain in the structure of the hypermedia application; (ii) three answered that it was not important; and (iii) two answered that it was dependent on the educational goals.

A cognitive map (Diekhoff & Diekhoff, 1982) is the representation of the author’s structural knowledge. Cognitive maps can be used as an instructional strategy that allows the effective learning of a domain. They can also facilitate the construction of a mental model (Jih et al., 1992) since the author can use it as a way to offer both local and global coherence to the learner (Thüring et al., 1995).

In relation to the need for learners to know in advance the author’s cognitive map the answers were: (i) nine authors answered that learners needed to know in advance the author’s cognitive map for the knowledge domain; (ii) three answered that it was not necessary; and (iii) one answered that it was dependent on the educational goals.

The literature also corroborates the answers given. It is important both to structure the application showing the author’s cognitive map as well as allowing the learner to know it in advance (Landauer, Egan, Remde, Lesk, Lochbaum et al., 1993).

e) Could the development be divided into different phases and groups of authors?

Eight, out of the thirteen authors answered that the interface design, the structural knowledge design and the authoring of the contents of the nodes can be done separately. Among these six answered that it is possible if there was constant interaction among the groups of authors and two answered that it was possible even if the interaction occurred only at the end of the development.

Four authors answered that the structural knowledge design and the authoring of the contents of the nodes should be done by the same group.

Two of the three authors involved in the development of large applications answered that
the development could be split into different phases and groups of authors. Interaction between groups of authors was a word mentioned by eight authors. It could happen at the end or be a continuing process, but it should happen. The results were very important since large-scale hypermedia applications can very rarely be developed entirely by the same group. It may involve the sharing of tasks among different groups, departments, universities and even countries.

f) Were there commonalities among the resources used?
The resources used and the number of authors that used each one (Table 1) reflect the kind of applications being developed at the University.

g) What was the most commonly used instructional approach?
Eleven applications were developed using problem-solving as the instructional approach. Seven used an exploratory/research approach and two used drill and practice. It is important to mention that among the four authors involved in the development of applications using an exploratory approach, three answered that the author’s cognitive map should be present in the structure of the application and that learners should know this cognitive map in advance. So, exploratory here means neither being completely guided nor learning through searching.

The results show that hypermedia applications for education are more than just encyclopaedias where the students have to explore freely the contents in order to learn. To develop a hypermedia application as an encyclopaedia is to forget the existence of the context in which learning takes place. And the context is one of the fundamental tools for education (Whalley, 1993; Thüring et al., 1991). The importance of context for educational purposes is very well explained by Simon (1995) (part 2) “the evocation of certain symbols may evoke others by the chain reaction that we call mental association. The burst of evocation that a bit of text may induce is limited only by the richness and complexity of the memory structures that it activates. The more elaborate the structures that are evoked, the more the meaning to the reader is defined by the reader’s memory, the less by the author’s words. The meaning of text is determined by a relation between the text itself and the current state of the memory of the reader, its contents, and its state of activation”. This means that if the reader’s mind does not have the appropriate structures, the author can help the reader to construct those structures. If the reader has to do everything on his own and if he does not have elaborated structures, so it will be difficult to construct appropriately those structures.

h) How were the applications introduced in the courses?
Sixteen applications were used to complement classes, two were used as a substitute for traditional teaching and two were used either to complement classes or as a substitute for classes.

This analysis shows that authors are generally not developing hypermedia applications to substitute their classes. The applications are mostly being used to complement classes, so they can enhance learning. The authors who developed applications to be used as a complement to classes had either of two objectives in mind: the application be used in a way to reinforce the knowledge acquired during formal classes or to allow learners to revise the concepts presented in the classes.
i) Did the authoring tool used influence the interface design and the implementation of the application?
Our objective was not to evaluate or even compare the authoring tools used but to find out generally the influence of the authoring tool on the design of the interface and implementation. All the authors of our sample either used the Web or Microcosm as an authoring tool. Some authors used a front-end authoring tool (Assymetrix ToolBook or Microsoft Visual Basic) on top of Microcosm to design the interface. The only issues considered (Fig. 3) were the ones mentioned by the authors, since there were no suggestions provided.

3.2.2. Results for the specialised issues

j) Were there differences between experienced and non-experienced authors concerning the approach used for authoring?
All the four authors who did not have any previous experience in the development of hypermedia applications used a top-down approach.
Among the authors that had only read about hypermedia before developing their first application: (i) two used a top-down approach; (ii) one used a bottom-up approach; (iii) three used a mixed approach.
Among the seven authors that had developed at least one hypermedia application for education three used a top-down approach and four used a mixed approach.
The top-down approach was chosen by the majority of authors, independently of their role.

k) Did the application’s size influence on the approaches used by authors?
All the four large applications were developed with a top-down approach to authoring.
Among the ten medium size applications developed, five were developed with a top-down approach and the other five with a mixed approach.
Among the six small applications, three were developed with a top-down approach, two with a mixed approach and only one with a bottom-up approach.
The bottom-up approach on its own was used only once, considering the twenty

Table 1

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applications of our data sample. Almost all the applications were developed using either a top-down or a mixed approach. This result shows that planning is fundamental for the development of applications, either in the beginning of the development or as an iterative process.

l) Was there a relationship between the author’s role and the authoring approach used?
   We did not find a significant relationship since in all situations the majority chose either a top-down approach or a mixed one.

m) Did authors structure the information using different levels of granularity?
   All the thirteen authors used different levels of granularity for the information they structured.
   This result reinforces the idea that it is fundamental to impose some levels of abstraction in order to help the learner. To quote from Thüring et al. (1995) (p. 58): “If authors want readers to construct relationships exceeding the level of local coherence, they have to incorporate cues at a net level that increase global coherence. Such cues should help the reader to identify the major components of the hyperdocument and the way in which these constitute its overall structure”.

n) Did authors consider context-dependent links as well as typed links important for conveying information to the learners?
   In relation to the use of contextual links the answers were:
   (i) nine authors considered important to use context-dependent links;
   (ii) four did not consider contextual links important.
   In relation to the use of typed links the answers were:
   (i) nine authors considered typed links important for conveying information to the learner;
   (ii) one author answered that it was dependent on the kind of application;
   (iii) three authors did not consider typed links important.
   Typed links have already been described as very useful in conveying information to the learners (Carr, 1995; Baron, 1994).

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Fig. 3. The general influence of the authoring tool.
Links are one subset of what we consider to be the structure. So, through links the author can also organise the information in a way to help learning to take place. In this sense, it is important to apply explicit meaning to links. The more explicit the meaning is the better it is for the learner. So the learner does not have to guess the relationships in order to construct a mental model.

3.3. What the study tells us about hypermedia authoring for education

In this section, the letters in brackets at the end of a statement refer to the list of issues in the previous section from which we have drawn these overall results.

3.3.1. In relation to a general methodology

We could not identify any general methodology, but the top-down approach was widely used as a way of planning, organising thoughts and structuring the knowledge (a). Links were not considered essential when structuring the knowledge domain. Authors planned the knowledge structure beforehand rather than considering links in order to know how to structure the information (c).

The authors in our study do not think that there was a common way of structuring all the domains. This reinforces our conclusion that one single hypermedia authoring methodology is not what hypermedia authors need (a).

Our study leads us to deduce that authors’ cognitive writing processes remain the same when considering hypermedia authorship. They do not seem to need to know what they are going to link before structuring their knowledge: they prepare the overall structure first and only as a second stage plan the links. So, what is necessary to complement this process is a rhetoric of links, rather than a general rhetoric, as discussed by Landow when he proposes a rhetoric of links (Landow, 1987) (b).

The authors answered that the development of a hypermedia application can be divided into different phases and amongst groups of authors, as long as they interact among themselves. The phases considered were interface design, structural knowledge design and authoring of the contents of the nodes. This gives some insights into co-operative authoring and what kind of activities different groups could be involved in to develop an application co-operatively (e).

3.3.2. In relation to the type of use

The authors used hypermedia applications as a complement to their classes, which means that they see technology as an aid to the lecturer rather than as a substitute (h). The instructional approach mostly used was problem-solving which reflects the teaching methodology of the volunteer authors in our study (g).

3.3.3. In relation to hypermedia design

Cognitive maps, contextual links and typed links are important for knowledge structuring and for conveying local as well as global coherence to learners. This implies that authors should seek to make the knowledge as explicit as possible in order to give both coherence and context to the learners (d, n). Text was the resource mostly used for conveying information to
learners, followed by images. If text is still widely and heavily used all the research that already exists about good writing can be immediately applied (f).

4. Conclusions and future work

So how can hypermedia authoring for education be improved?

The original aim of SHAPE was to create a hypermedia authoring methodology to be used with Microcosm. But the interviews have shown that there is little point in trying to improve the authoring of hypermedia applications for education by proposing an authoring methodology. Authors do not seem to change their cognitive writing processes because they are using hypermedia and they often have their own usually pre-determined way of organising the application’s structure.

As we are concerned with large-scale applications, three important issues arise—authoring effort, reusability of information and maintainability of applications.

With these issues in mind we can say that another way of improving authoring is also to offer authors an environment where they can: (i) author applications without a lot of effort; (ii) reuse the information authored; and (iii) easily maintain the application.

To support this idea, we are developing metrics in order to identify how adequate an authoring tool is in respect of these issues.

The principles of the metrics we are developing are based on the work of Fenton and Pfleeger (1996), and on the guidelines from the DESMET project (Kitchenham, 1996). We are carrying out a quantitative evaluation (Kitchenham, 1996) in order to identify if applications developed using an open hypermedia system such as Microcosm are more easily maintainable and their information more easily reusable than the ones developed in a standard World Wide Web environment. We will also carry out a qualitative evaluation (Kitchenham, 1996) to measure the effort required in authoring the same hypermedia application using either Microcosm or the Web.

Microcosm is an open environment, characterised by the separation of link structures from the information being linked (Davis et al., 1992). The WWW, on the other hand, provides a closed hypertext system, offering a simple point-to-point linking model based upon embedded links (Hill, Hall, de Roure & Carr, 1995). We have therefore chosen the Web to be compared against Microcosm because it proposes a different way of representing and managing links which could have a significant influence not only on the maintainability and reusability but also on the authoring effort required.

Our intention is that through the metrics defined we can identify: (i) useful improvements to be made to Microcosm and other advanced hypermedia systems; (ii) how to measure maintainability and reusability in hypermedia applications; (iii) how to measure the authoring effort required in the development of a hypermedia application for education.
References


