Authoring Personalised Interactive Content

Maria Grigoriadou and Kyparisia Papanikolaou
Department of Informatics & Telecommunications, University of Athens,
Panepistimiopolis, GR-15784 Athens, Greece
{gregor, spap}@di.uoa.gr

Abstract

Authoring e-content for personalised learning is a challenging task for both educators and learners, stimulating them to develop a variety of skills for developing and using digital resources. In this paper we investigate the authoring process of educationally meaningful content for personalised learning. To this end, the skills that authors of an Adaptive Educational Hypermedia system need to develop are also investigated. Moreover, a paradigm of interactive content developed for INSPIRE, is described. Lastly, the authoring system developed to support different types of users, such as educators and learners, in authoring personalised content for INSPIRE, is presented.

1. Introduction

The hypermedia form of the educational content in a Web-based educational system makes learning a task-driven process, where learners are motivated to control their access to information and explore alternative navigational paths through the content. Hypermedia implicitly stimulate the user to digress to other information, facilitating cognitive flexibility or stimulating versatility in mental perspective [9]. Especially, the flexibility in browsing [9] (a) allows learners to adapt reading sequences to their cognitive needs for specific information letting them find their own way, and (b) stimulates learners to make sequencing decisions that support a higher level of metacognition (consciousness about what and how one knows, progress, goals, etc). Adaptive Educational Hypermedia (AEH) [4] [8] aim at providing educational hypermedia with the ability to dynamically adapt the hypermedia form of the content to the changing learner's state and needs. Especially, AEH systems accommodate individual differences such as goals, knowledge, learning/cognitive style, needs, preferences, by using knowledge represented in the learner model to adapt the information and links being presented to the given learner. Adaptation can assist the learner providing individualised navigation support, which is particularly relevant for a large hyperspace, and/or delivering personalised educational material by adapting the presentation or the layout of the content.

However, the task of developing courseware to be used for personalized learning is not at all a trivial task. As Brusilovsky [7] states "the secret of adaptivity in all adaptive hypermedia systems is 'knowledge behind pages'. All AEH systems explicitly model the knowledge of the domain to be taught in the form of elementary knowledge elements or concepts that form a knowledge space". Thus, educators need to possess or develop specific skills for designing, organising and setting up lessons to be delivered through an AEH system. But what about placing learners in the role of adaptive hypermedia content authors? Which range of skills could learners develop in project management, research, organisation and representation, knowledge building? Based on Jonassen and Reeves' findings [1] through engaging learners more systematically in authoring their own works they (1) develop critical-thinking skills as authors, designers and constructors of knowledge and (2) learn more in the process than they do as the recipients of knowledge. For example, in the SimQuest project [12] students work on activities that involve authoring domain models, whilst Arroyo et al. [2] created an authoring tool for the AnimalWatch tutor for students in order to enable them authoring arithmetic word problems for their peers. Moreover, several researches have focused on student authoring of hypermedia content [10] [11], although this is an innovative idea for the AEH area. Since the field of AEH authoring [7] is relatively new, there is a need for a development in understanding of the necessary skills for authoring AEH and the appropriate factors for creating productive learning situations.

In this paper we investigate the AEH authoring process and the skills that authors need to develop for authoring content for personalised learning. In this context, a paradigm of interactive content for the AEH system INSPIRE is presented. Moreover, the authoring system that supports different types of users such as educators and learners, in authoring content for INSPIRE is described.

2. The authoring process and skills for authoring AEH

Authoring tools aim at decreasing the cognitive load involved in various design steps of an AEH system. The final product of the authoring process is the internal representation of knowledge and information in a special form that is understandable and manageable by the system. Generally, the structural domain model of an AEH is represented as a network of domain *concepts* [8]. The concepts are related with each other forming a kind of semantic network which represents the structure of the subject domain. Thus, developing the domain model of an AEH system demands the identification of the domain concepts and their interrelations, i.e. the knowledge space needs to be structured. Moreover, content pages need to be designed for the domain concepts and linked to form a network of hypermedia pages with educational material, i.e. the hyperspace needs to be structured and linked with the knowledge space. The above processes are usually guided by the instructional design of the AEH system. One of the main aims of an authoring tool is to explicitly represent the design of the AEH system and guide authors in developing content based on the underlying pedagogical rules. Additionally, it could also support authors in controlling the main functionalities of an AEH system such as learner modeling, adaptive behaviour, reflecting on them their own perspective.

As far as the content authoring process is concerned, first of all, authors need to modularise the content into reusable educationally meaningful elements (allowing the system to re-use them under different contexts and learners' profiles) and design its hypermedia representation. To this end, the author needs to determine the learning outcomes, analyse the content and modularise it into primitive components (concepts) which reflect the main topics of the domain and are physically and conceptually connected and interrelated. Then, the author needs to develop educational material for the domain concepts. In this process the author should take into account that the content will be used by a variety of learners. Thus, the author should develop educational material for the domain concepts in multiple formats and present information from multiple perspectives allowing those with different, for example, knowledge level or style, accomplish learning tasks in different ways. Critical characteristics of the educational material are its degree of interactivity and the learner control opportunities offered. To this end, skills on using or developing content for the Web are helpful, including information retrieval and designing activities using multimedia representations or computer simulations.

Summarising, the authoring process demands that authors possess the necessary competence at both technological and educational level. In this context, an authoring system may support authors in designing e-content for personalised learning based on a specific instructional framework adopted by the AEH system.

3. Developing content for INSPIRE

In an attempt to elaborate on the design of AEH systems based on alternative learning theories, the Education and Language Technology group at the Department of Informatics & Telecommunications, University of Athens, developed INSPIRE (INtelligent System for Personalized Instruction in a Remote Environment). INSPIRE [3] is a platform that may deliver many different personalised courses. In INSPIRE, learners have always the option to select and study the learning goal they prefer, independently of their previous selections; all the material necessary for their study is provided when a learning goal is selected. In particular, INSPIRE plans the content of instruction for the particular learning goal and learner, i.e. the system selects the contents of a sequence of lessons that gradually support the learner to achieve his/her goal. INSPIRE aims at facilitating learners during their study, by (a) proposing a navigation route through the lesson contents based on learner's knowledge level and progress, and (b) adapting the presentation of the educational material to the learners' learning style.

We have used INSPIRE in order to deliver personalised content for the undergraduate course of "Computer Architecture" for the session on Computer Memory Hierarchy, and we currently develop content for the course "Introduction to programming" (visit http://hermes.di.uoa.gr/inspire2). The aim in both courses is for students to use INSPIRE as an additional learning resource. The main aims at developing content for INSPIRE are to support multiple levels of performance and enhance the interaction with the learner providing opportunities for self-assessment,

experimentation, and reflection on the learning process.

INSPIRE provides learners with structured *content* which is comprised of units, such as concepts and educational material modules that can be reused by learners of different profiles. The notion of *learning goals* is used in order to build a hypermedia structure that provides learners with an overview of how all the relevant information fits together. In particular, each goal is associated with a conceptual structure that includes all the necessary domain concepts and their relationships – outcomes, prerequisites, related concepts. Each outcome concept is accompanied by educational material pages which include a variety of knowledge modules of different interactivity level – theoretical presentations, examples, hints on the theory, exercises, experimentation activities, self-assessment questions/tasks -. Three types of pages are developed for each outcome concept aiming to support learners in achieving the three levels of performance (Merrill, 1983): Remember, Use and Find. The educational material pages have specific learning outcomes and/or focus on learners' misunderstandings/false beliefs. For example, a page of the Use level for the concept "Loop construct 'while'" (Learning goal: 'How to use the loop constructs;') may have as a learning outcome the infinite loop or the number of iterations in a loop construct. The type of the knowledge modules included in a page depends on the level of performance to which the page corresponds, i.e. a page of the Use level includes theory tips, an example, an exercise, an activity, whilst a page of the Remember level includes a question, an example, theory (see in Figure 1 a page of the Use level of performance).

The design of the educational material focuses on stimulating learners to use tools, make assumptions, test their ideas in a real context, experiment with alternative conditions. To this end, several examples (see Figure 1), exercises, activities include microworlds developed with MicroWorldsPro [4] focusing on general programming constructs, or stimulate learners to use free C compilers and tools available on the Internet such as the ones developed in the "Teaching and Learning Research Lab" (http://www.sis.pitt.edu/~taler/): KnowledgeSea (provides reach content about C organized on an innovative way based on social navigation), NavEx (adaptive examples of C programs), QuizGuide (adaptive assessment tests).
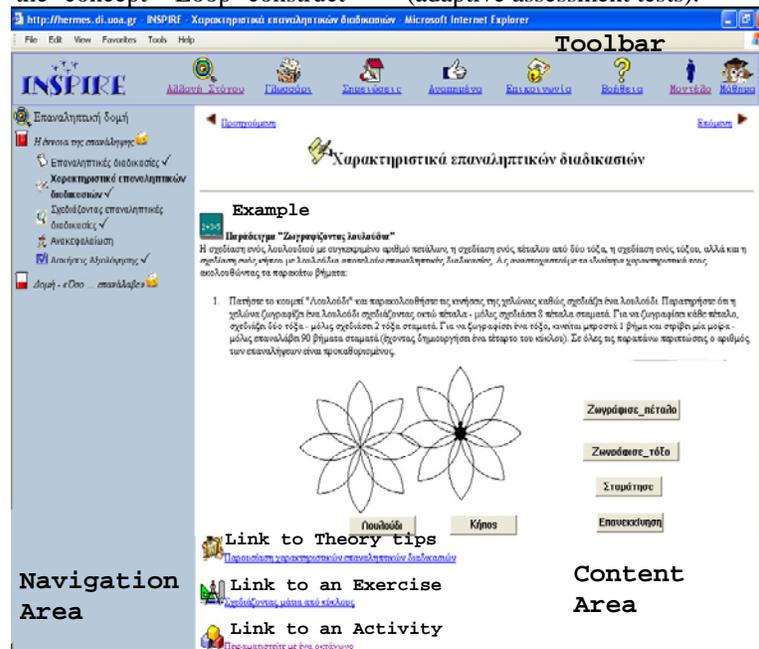

Figure 1. The main screen of INSPIRE consists of three areas: Navigation Area where the hypermedia content structure appears, Content Area where the educational material pages appear, Toolbar. In the Content Area a page of the Use level appears which starts with an interactive example that includes a microworld developed with MicroWorldsPro. In this example the learner is encouraged to experiment with the number of iterations in a loop construct

4. INSPIRE authoring system

A form-based authoring system has been developed to facilitate the authoring process of INSPIRE. The aim is to support *educators* in authoring personalised content for their classes, and *learners* in knowledge

construction (stimulating self-assessment, reflection, knowledge structure and representation). Moreover, both groups of users are encouraged to critical analyse digital media necessary for the changes in e-learning currently occurring. Thus, the authoring system offers different functionalities to educators and learners. Both educators and learners are allowed to develop their own content. However, educators have full access to the content of INSPIRE, whilst learners are able to update and delete only their own content. Moreover, both are allowed to preview and evaluate content developed by others. To this end, a peer review functionality is provided through which authors are allowed to (i) act as reviewers of educational content, submitting a special review-form, (ii) receive reviews of their content and revise it accordingly. In this paper we concentrate on the content authoring process.

The INSPIRE authoring system supports authors in the different stages of creating an AEH system [7] (a) structuring the knowledge, i.e. the domain model, (b) structuring the hyperspace, i.e. a network of hypertext pages with educational material, (c) connecting knowledge with educational material. Currently,

several tools and forms are provided to support authors in designing content based on the instructional framework of INSPIRE [3] and define specific parameters of system adaptation.

Structuring the knowledge. The domain model of INSPIRE consists of learning goals and concepts. The domain model is a natural framework for goal modelling which is simply a target subset of domain concepts to be learned; learning goals are composed of a sequence of elementary sub-goals called layers each one composed as a set of concepts to be learned. Thus, the knowledge space is formed by a set of learning goals and concepts. Concepts are related to each other through prerequisite links and grouped in layers from the more general ones to the more specific. The INSPIRE authoring system offers a variety of tools and forms for authoring and structuring the components of the knowledge space (goals, concepts) such as the tools for goal and concept management (see Figure 2), the forms for goal and concept authoring (see in Table 1: Goal form, Concept management tools, Outcome concept form).
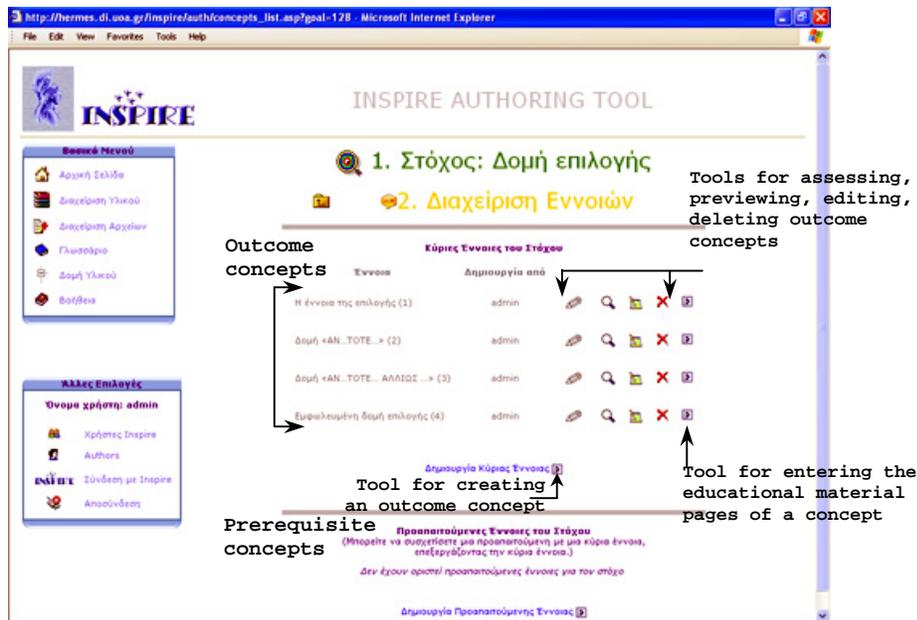

Figure 2. Concept management tools of the INSPIRE authoring system

Structuring the hyperspace. The hyperspace is formed by content pages connected by navigation links and the topology of connection between the pages is called hyperspace structure. The content pages of INSPIRE include the introductory goal pages, the introductory concept pages (or 'hub' concept pages) and the educational material pages. The hierarchical approach has been adopted to structuring the hyperspace – goal,

concepts, educational material pages. This hierarchy sets natural navigational paths from every node down to all descendants nodes and up to ancestor node. Concept and educational material pages sequencing are authored through the appropriate forms such as the Outcome concept form (concept presentation information) and Educational material page form (page presentation information) described in Table I.

Connecting knowledge with educational material. The enhanced concept-based hyperspace approach [7] is used for connecting the knowledge space with the hyperspace forming the information space. Following this approach, multiple pages describing the same concept are connected to this concept in the information space and hyperspace. Each concept has a 'hub' page in the hyperspace which is connected by links to all educational material pages related to this concept (the same stands for the goals; the goal introductory page is connected by links to all concept 'hub' pages related to this goal). In the case of INSPIRE, three types of educational material pages which correspond to the Remember, Use and Find levels of performance, an assessment page and a summary page, are associated with each outcome concept. This way, a role is assigned to each page link distinguishing several kinds of connections between concepts and pages and supporting system adaptation. For example, INSPIRE distinguishes the level of performance that a page supports and graphically annotates the educational material pages to reflect the progress of a learner. The authoring system offers forms for authoring the three types of pages which consist of a variety of knowledge modules (such as activities, examples, exercises, assessment questions). Depending on the type of a page a specific form is provided that prompts the author what should be entered in textboxes that correspond to the appropriate knowledge modules (see in Table 1 the Educational material page form of the Remember level of performance). The INSPIRE authoring system supports the use of externally authored content elements (applets, objects) with modern content authoring tools such as MicroWorldsPro, Dreamweaver, etc.

Authors are guided in linking the knowledge with the hyperspace: they are stimulated to define for each goal a conceptual structure and for each concept the corresponding educational material pages (see in Figure 2 the link for entering the educational material pages of a concept). Finally the functionality of Information space structure preview illustrated in Figure 3 aims to support learners in linking the knowledge with the hyperspace providing a graphical representation of the information space structure.
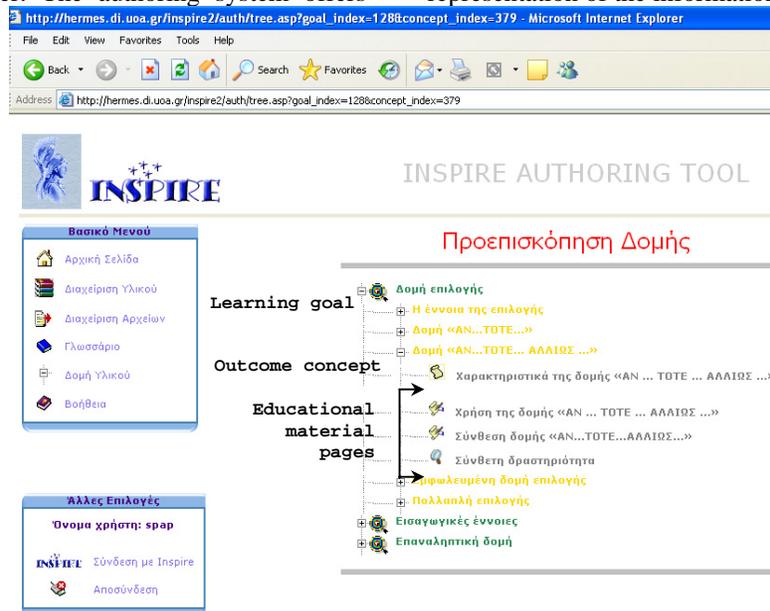

Figure 3. Graphical representation of the information space structure linking goal, concepts and educational material pages

Table 1. A sample of the forms/tools provided for authoring the knowledge and hyperspace of INSPIRE

Forms / Tools	Role	Contents
Goal form	Allows authoring the goal introductory page, the goal presentation at the Navigation Area, the internal representation of the goal (metadata)	*Information included in the goal introductory page*: goal name, a brief description, an abstract *Goal information*: goal title at the navigation area, a hint appearing on the goal title at the navigation area, number of layers of the goal *Metadata about the goal*: authors, publisher, subject area, sources, reviewers, guidelines for

		using the content, language, interactivity level, semantic density, education level
Concept management tools	Allows the management of the conceptual structure of a goal	*Tools provided* for assessing, editing, previewing, deleting, creating the conceptual structure of a goal, and entering the educational material management tools of a concept
Outcome concept form	Allows authoring the concept introductory page, the concept presentation at the Navigation Area, the internal representation of the concept (metadata)	*Information included in the 'hub' page*: concept name, brief description, learning outcomes, scope, prerequisite and related concepts *Concept information*: concept sequence, the layer to which it belongs *Metadata about the concept*: similar to those used for the goal
Educational material page form of the Remember level of performance	Allows authoring pages that correspond to the Remember level of performance	*Page information*: page title, page sequence, a hint appearing on the page title (navigation area) *Textboxes for knowledge modules:* html form of a question, an example, theory *Metadata about the page*: author, publisher, interactivity level, semantic density, advisable study time

5. Conclusions

The content of INSPIRE proved popular amongst the students during the formative evaluation of the system (Papanikolaou et al., 2003). Educators that developed content for INSPIRE characterised the process as quite demanding but also helpful in making them speculate on learners' individual differences and elaborate on the subject matter and learners' misconceptions. The design of the authoring system of INSPIRE was based on several researches in which learners studying AEH and educators were asked to develop content for INSPIRE following specific guidelines. Currently, the evaluation of the authoring tool of INSPIRE is on progress. In the near future we also intend to elaborate on involving learners in the content authoring and evaluation process. Moreover, we plan to extend the authoring tool functionalities to the adaptive dimension of INSPIRE.

6. References

[1] D.H. Jonassen and T.C. Reeves. Learning With Technology: Using Computers as Cognitive Tools. In: D. H. Jonassen (Ed.) *Handbook of Research for Educational Communications and Technology*, NY: Macmillan, 1996.

[2] I. Arroyo, A. Schapira, and B. Woolf. Authoring and sharing worked problems with AWE. In: Moore et al (Eds.): *Proceedings of AI in Education*, 2001, pp.527-529.

[3] K.A. Papanikolaou, M. Grigoriadou, H. Kornilakis, and G.D. Magoulas. Personalising the Interaction in a Web-based Educational Hypermedia System: the case of INSPIRE. *User-Modeling and User-Adapted Interaction*, Kluwer Academic Publishers, Netherlands, 13, 3, 2003, pp. 213-267.

[4] LCSI - MicroWorlds Pro http://www.microworlds.com/ Last visit 9/9/2006.

[5] Grigoriadou, M., Papanikolaou, K.A., Tsaganou, G., Gouli, E., Gogoulou, A. E-Competence Skills for Adaptive Learning Environments in Higher Education. In: I. Mac Labhrainn, C. McDonald Legg, D. Schneckenberg, J. Wildt (Eds.): *The Challenge of eCompetence in Academic Staff Development*. CELT, NUI Galway, 155-166, 2006. Available at http://www.ecompetence.info/index.php?id=93

[6] P. Brusilovsky, and C. Peylo, Adaptive and Intelligent Web-based Educational Systems. *International Journal of Artificial Intelligence in Education,* 13, 2003, pp.156–169.

[7] P. Brusilovsky. Developing Adaptive Educational Hypermedia Systems: From Design Models to Authoring Tools. In: T. Murray, S. Ainsworth, and S. Blessing (Eds.): *Authoring Tools for Advanced Technology Learning Environments*, 2003, pp. 377-409.

[8] P. Brusilovsky. Methods and Techniques of Adaptive Hypermedia. *User Modeling and User-Adapted Interaction,* 6, Kluwer Academic Publishers, Netherlands, 1996, 87-129.

[9] P. Kommers. Multimedia Environments. In: Kommers, P.A.M., Grabinger, S., Dunlap, J.C. (Eds.): *Hypermedia Learning Environments. Instructional Design and Integration*. Mahwah, NJ: Lawrence Erlbaum Assoc., 1996.

[10] S. M. Carver, R. Lehrer, T. Connell, and J. Eriksen. Learning by hypermedia design: issues of assessment and implementation. *Educational Psychologist*, 27 (3), 1992, pp. 385-404.

[11] S.V. Turner, and V.M. Dipinto. Students as Hypermedia authors: themes emerging from a qualitative

study. *Journal of Research in Computer Education*, 25, 1992, pp. 187-199.

[12] W.R. van Joolingen, and T. de Jong. SIMQUEST: Authoring Educational Simulations. In: T. Murray, S. Ainsworth, and S. Blessing (Eds.): *Authoring Tools for Advanced Technology Learning Environments*, 2003, 1-31.