A Framework of Collaborative Adaptation Authoring

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***Abstract*—Adaptive Educational Hypermedia systems (AEH) enhance learning by adaptation and personalisation. As a consequence, wide ranging knowledge and learning content are needed. Problems then emerge in the provision of suitable authoring tools to carry out the authoring process which is complex and time consuming. Based on the fact that former research studies on authoring have identified drawbacks in collaboration, usabilility, efficiency, or interoperability, this paper proposes an approach for collaborative adaptation authoring for adaptive learning. The intended approach aims at improving authoring for AEH systems by allowing many people to participate and enhancing authors' interaction. The novelty of the approach lies in how the domain knowledge which has been semantically defined is enriched, and in the application of Computer Support Collaborative Work (CSCW). This approach adopts the advantages of existing semantic web technology and wiki-based authoring tools used to develop domain knowledge; its output is then enriched with pedagogy-related knowledge including adaptation. The output of the system is intended to be delivered in an existing AEH system.**

***Index Terms*—Adaptive Educational Hypermedia, Adaptation, Computer-supported Collaborative Work, Semantic Web Technology, Wiki, the Collaborative Adaptation Authoring Approach.**

I. State of The Art and Motivation

One problem in adaptive learning systems like Adaptive Educational Hypermedia (AEH) systems is authoring learning resources. To support adaptation and personalisation, such systems need to maintain knowledge spaces that consist of domain-related knowledge, content, pedagogy-related knowledge, and adaptation rules [1, 2]. To establish knowledge spaces, three types of authoring activity are needed; these are authoring knowledge, developing content, and then structuring knowledge and linking it to content [1, 3].

With such activities, authoring for AEH systems is not simple and it is time consuming. We identified four problems which are *collaboration, usability*, *efficiency*, and *interoperability* in our former paper [4].

- *Collaboration*. A challenge from the view of usability relates to the provision of collaborative authoring tools which deal with the fact that instructional designers or course designers work collaboratively [5, 6]. Until recently there has been no authoring tool which implements collaborative work to enable interaction among authors. Translating authoring functions into computer-supported authoring tools should translate the collaborative authoring environment in which authors discuss, brainstorm, coordinate, or make notes about their work.
- *Usability*. One challenge in authoring is the provision of user-friendly authoring tools. There is evidence from past research that collaborative authoring tools are difficult to understand or use; as a result people continue to use word processors for face to face meeting, emails, or chatting tools to communicate and coordinate their work [7, 8].
- *Efficiency*. There is a clear need for the availability of authoring tools that can prevent authors from developing the wide ranging courseware including domain knowledge, pedagogy-related knowledge, and content by themselves. Repurposing output produced in other existing authoring systems will make the authoring process more efficient in time and effort. The authoring process then can then focus on the enrichment of such defined output.
- *Interoperability*. Authoring tools are required to have an ability to produce courseware that is not specific to a particular AEH system. A big problem found in authoring for adaptive learning systems is that the tools produce courseware in specific formats that prohibit reuse or repurposing by other systems.

There is a large body of research on how to improve the authoring process. We claim that methods and techniques for collaborative work and existing widely used collaborative authoring systems can improve learning resource authoring and enhance the quality of the authored objects. Former research studies found that most of the work in academia, business, and industry was completed by groups of people collaboratively [7]. In addition, authoring is not merely a series of technical tasks carried out by administrators. Based on an insight into how learning takes place, being aware that courseware development is a complex endeavour and to enhance the quality of the authored objects, the participation of people with various specialisms is important. There is a need for domain experts to engage in online Communities of Practice to participate in authoring activities, thus shifting authorism to the development of collective intelligence.

A challenge then emerges in dealing with the availability of suitable authoring tools. Research studies in the area of Computer Support Collaborative Work (CSCW) have risen to the challenge. It concerns how best to enhance collaborative work [7, 9]. There has been some proof that the implementation of CSCW has improved collaborative authoring in efficiency, collaboration, and suitability; for example, in authoring tools to develop hypermedia documents [10] and courseware [11]. Another research study developed a tool for authoring adaptive learning system resources with various authors involved [12]. In such a system, the development team and teachers were involved as authors.

Apart from research on AEH systems, there are many research studies on authoring documents. Research studies [13, 14], for instance, investigated the feasibility of the social and semantic annotations in authoring AEH systems. Other studies have been carried out on wikis and Web 2.0 systems

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which are enormously popular, and which have successfully provided asynchronous distributed collaborative authoring for online communities to participate. The enhanced wikis, semantic wikis [15-17], apply semantic web technology enabling people to semantically annotate wiki pages using special markups and they have the capability to represent knowledge and to manage content [18].

With recent developments in the social web with Web 2.0, the way that experts are building documents and knowledge has changed. Documents are now produced by a large number of people through collaborative work. Hence, authoring tends to be a continuous process and authored documents are dynamic and constantly updated; we call them 'evolving objects'. From the view of learning resource development, the social web is considered capable of supporting the maintenance of learning resources through continuous updating, thus keeping it relevant to students' needs [19, 20].

This paper describes an approach of collaborative authoring for learning resources of adaptive learning systems; it applies CSCW and social semantic technology and aims at answering the main research question:

How can adaptations be collaboratively authored by a group of teachers or instructional designers?

The paper is structured as follows. First, we present related work in Section 2, such as past research studies on authoring for Adaptive Educational Hypermedia systems. Then, in Section 3 we discuss factors that need to be considered in developing a collaborative authoring approach for AEH systems. Section 4 describes requirements for collaboration, the authors' roles, and the authoring flow, whereas Section 5 discusses the knowledge representation and the enhancement of the domain knowledge which has been semantically organised. Finally, some conclusions are drawn, and areas for future work in the field are suggested.

II. Related Work

The main characteristics of Adaptive Educational Hypermedia (AEH) are adaptation and personalisation in learning. AEH systems combine an Intelligent Tutoring System (ITS) for adaptive learning and Intelligent Learning Environment (ILE) for personalised learning [21]. As they support personalisation and adaptation, AEH systems maintain a large learning resource with various elements. Such a system maintains a knowledge space and a hyperspace consisting of domain knowledge, content, and pedagogy-related knowledge including adaptation rules [1, 2]. Authoring aims at developing the knowledge space, structuring the hyperspace, then linking both spaces [1, 3]. In our former paper [22] we summarised authoring tasks for AEH systems as presented in Figure 1.

The last step of authoring AEH is to link hyperspace to knowledge space. Adaptation is performed by inferencing domain and pedagogic knowledge, adaptation rules, and user/learner models. The links, however, are not sufficient to provide adaptation; adaptive rules which take into account the user model must be added over the links. There are various adaptation types that can be provided by AEH systems. Originally adaptation was distinguished in two forms: adaptation of presentation which represents what is shown to the user, and adaptation of navigation which refers to future learning materials for students [2, 23]. Paul De Bra and Peter Brusilovsky revised the adaptation by adding a new type called the adaptation of content [24] which is useful to adapt additional or pre-requisite information. A research project, GRAPPLE [24, 25], extends adaptation to service provision, assessment, problem solving support and learning selection.

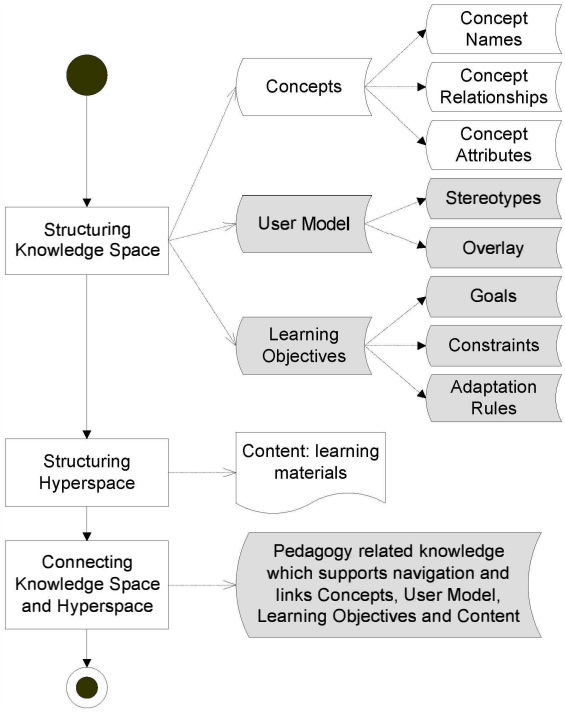

Figure 1. The authoring process of AEH systems [1, 3, 22]

Until recently there have been many authoring tools for AEH systems; for example, AHA! [26, 27], MOT [28-32] that is still being enhanced, and GRAPPLE [24, 25] that is being developed. From the analysis of such authoring tools, we conclude that the implementation of collaborative authoring for adaptation support still remains an issue. A question is how adaptation support can be authored collaboratively by a group of teachers or instructional designers. Such authoring tools described above support collaboration in the form of object reuse without any support for communication and coordination among authors. Regarding the *efficiency* problem described in Section 1, adding adaptation rules into domain and pedagogic knowledge authored in other existing authoring tools is another issue. It is considered that the use of existing tools can reduce the authoring phases that must be done by teachers or instructional designers

III. Considerations in Developing Authoring System for Adaptive Educational Hypermedia

Based on the related work in the previous section, we propose a number of aspects that need to be considered in developing an approach for authoring adaptation. First, authoring should not be focused only on developing learning content. One problem in former research studies was that

authors spent a great deal of time in developing learning content [33]. This would be reasonable if the authoring was intended to provide learning resources for a general learning system with a static single learning scenario, because such a system does not require many pedagogic strategies to conduct learning. However, when authoring is aimed at supporting an adaptive learning system, much effort is needed to establish adaptive learning strategies. Indeed, such a learning system must be supported by learning content too, but it can reuse learning content provided by open corpus systems likes digital libraries and wikis.

Second, authoring learning resources should not be a static one-stop process in which authors work within a period of time and then finish [34]. Authoring learning resources must be a dynamic, continuous process, thus keeping the authored objects continuously updated and relevant to students' needs. As a consequence, authors are required to realise their responsibilities in the authoring process. Without authors' awareness, there is the potential for this process to lose its objectives, thus resulting in learning objects that are not suitable for requirements.

Third, reusing objects without working collaboratively is not appropriate for developing learning resources. There is a fundamental difference between object reuse and collaborative work. We consider the former as a series of individual work activities without any concensus, coordination, or communication for combining authors' work. This is contrary to the reality that commonly one course is collaboratively developed by a group of teachers [5, 6]. In collaborative work, it is essential that teachers commit to perform a collective learning resources which combines authors' knowledge, insights, and considerations.

Fourth, in conducting collaborative work, it has to identify whether it needs many people to contribute or just a small group of people. Based on the authoring workflow presented in Figure 1, we conclude that learning resources for AEH systems are twofold: domain knowledge and pedagogy-related knowledge. As the former is context-independent, many people can contribute, and reaching consensus in this case is not essential. In this case, the more people participate, the better the authored objects will be. That is contrary to the authoring for the pedagogy-related knowledge, in which authors establish learning strategies, that communication and coordination among authors are fundamental [35-37].

Fifth, mechanisms that make authors aware about what has been done in the authoring are needed. A list of recent updates or notification emails are two examples. On the other hand, such mechanisms can be implemented in the forms of comunication features that enable authors to exchange information [38, 39]. Such features, however, must be implemented efficiently, so that the authoring process is not burdened.

IV. THE COLLABORATIVE ADAPTATION AUTHORING MODEL

We develop a new authoring model called the *Collaborative Adaptation Authoring Model* for AEH systems. The model provides feature that applies CSCW to address *usability* and *collaboration* issues. Such a feature is one of the novelties of our research, as to the best of the authors' knowledge, there are no existing studies on the implantation of authoring AEH systems implementing them. We argue that the participation of a large number of people and the application of CSCW in the authoring process will result in a high quality of learning resources for adaptive learning.

The main idea of the intended approach is to employ domain experts and the general public to develop learning resources; and where, at the end, a small group of teachers shapes the course by selecting the most relevant topics and appropriate learning contents, establishing learning paths, and adding adaptation rules. The implementation will establish learning resources to be delivered by an existing AEH system.

A. Collaboration Requirements

We have analysed the requirements for the Collaborative Adaptation Authoring model from the perspective of CSCW [4]. It includes:

1. *Asynchronous distributed.* The model supports groups of people to work collaboratively towards a common goal from different locations at different times as well sometimes working concurrently. On the other hand, although the model aims at supporting collaborative work by a number of people, it is also suitable for individual work.
2. *The integration of authored objects with discussions*. As the face-to-face meeting is considered as the most common way of communication that authors use, it is important to implement communication features in CSCW systems that can replace the face-to-face meeting.
3. *Implicit planning with explicit coordination.* The Collaborative Adaptation Authoring model combines implicit planning and explicit coordination. As a simple planning, implicit planning can prevent the system from the complexity of planning tasks that potentially distract authors from the main tasks. By this feature, one author will play a role as coordinator and create a learning path in the form of a list of topics/concepts that will be developed. However, there is no explicit task allocation to a particular member. Authors can change the learning path, create alternative paths, and create/update objects listed in the path. To communicate among authors, a facility for explicit coordination is provided in the form of shared notes though which authors can share anything.
4. *Progressional awareness support.* To make authors aware about the authoring progress, a mechanism to show authors what has been done, by who, to which objects, is needed. We designed a colored sign attached to each authored object that will display a different color if an author updates the object.
5. *Provenance information.* Such information is important for progress tracking. Moreover, it can help novice users to know what has been done and to what objects, and also to understand how the authoring process is progressing.
6. *Members control membership*. It is common that courses and learning are carried out by a small group of instructional or course designers whose members know each other. In the Collaborative Adaptation Authoring membership is fluid; it means that communities can evolve as they open up to everyone to subscribe to. Somebody can become a contributor if there is a member who gave

approval for her/his membership subscription. In this way, every author has the same responsibility in authoring and in giving approval for new subscriptions.

B. *Authors*

The proposed model enables people from different concerns to participate in different roles. We claim that the participation of people with different concerns can improve the authoring output. We defined three-level hierarchiecal roles of authors including *General Public*, *Community of Practice*, and *Teacher*. *General Public* is the lowest level community that has a responsibility to develop learning materials in an existing semantic web technology-wiki based authoring tool. General Public is open for everybody to participate.

In addition to the General Public, Community of Practice also works in the wiki-based environment. Like the General Public, Community of Practice has responsibility for developing learning materials of a course. Moreover, they also have responsibility for establishing concepts/topics covered by the course. Community of Practice consists of domain experts who may not have any teaching experience (practitioners for example), and also people who have teaching and learning experiences like teachers, instructional designers, or students. As it is open for anybody to subscribe to, Community of Practice can be a large community.

The highest-level community, Teacher, has authority to contribute to the authoring domain knowledge like Commounity of Practice. In addition, Teacher is responsible for developing pedagogy-related knowledge and adaptation support. The community comprises a group of teachers, instructional designers, course developers, and people who have experience of or knowledge in teaching the authored subject. Whereas a Community of Practice can be a large community of people, Teacher is a group with only a small number of participants who carry out authoring tasks through the Collaborative Adaptation Authoring; that is the main sub-system that receives the domain and general pedagogy-related knowledge as input and produces learning paths and rules supporting adaptation.

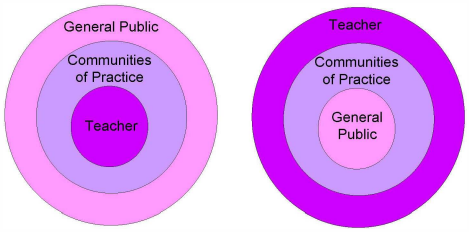

Figure 2. The members of General Public cover Community of Practice's and Teacher's members (a). On the contrary, the responsibilities of Teacher covers Community of Practice's and the General Public's responsibilities (b)

C. *A Layered Authoring Model*

We designed a new authoring model, *the Collaborative Adaptation Authoring Model*. The proposed model enhances earlier models in that it is a two dimensional model covering *Adaptation Support* and *Collaboration Support* dimensions. There are four layers within the former dimension which are Content, Domain Knowledge, Pedagogy-related knowledge, and Constraints and Rules layers. The design fits adaptive hypermedia concepts [1, 2] and the authoring flow presented in Figure 1, and extends former AEH models like AHA!, MOT, and GRAPPLE.

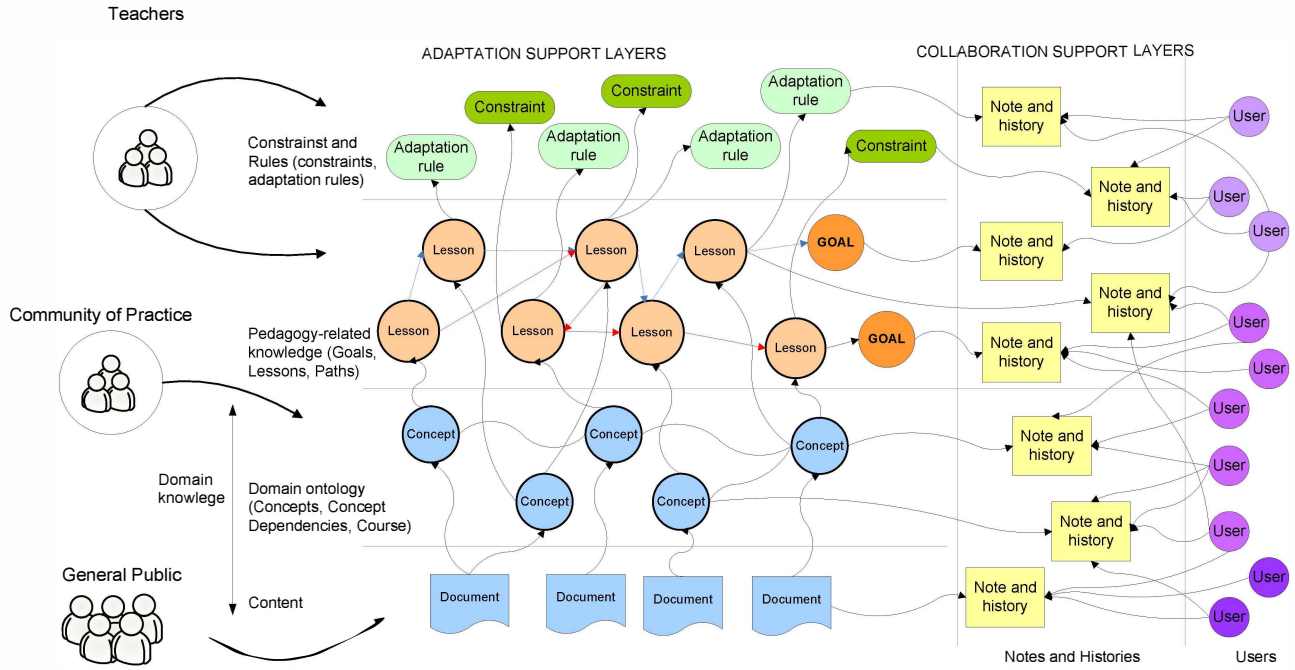

Figure 3. The proposed authoring model.

The *Collaboration Support* dimension makes the proposed model different from other authoring models as such layer applies CSCW principles. There are two layers within the Collaboration Support dimension: *Note and History* layer and *User* layer. Each node in the *Note and Hist*ory layer links to one element in the Adaptation Support layers and some nodes in *User* layer; for example, one element in Content layer or Pedagogy-related layer. In addition, it has one or more links to authors who made contributions in authoring the element. *Note* in this layer is useful for coordination and communication among authors. On the other hand, *History* maintains a record of what a contributor has done and to what objects. As a result, each author always knows how the authoring is progressing and what future work is required.

The proposed authoring model supports two kinds of adaptations including *content adaptation* and *navigation adaptation*. Content adaptation is implemented in the form of additional lessons. Such lessons are those considered more suitable than the lessons currently being learned for a particular topic. Differing with content adaptation which supports students through more suitable lessons without moving to other concepts, navigation adaptation offers additional concepts to help students to reach a better understanding of the concept they are currently learning

V. The Framework

The framework of the authoring process is presented in Figure 4. We consider Learning Managements System (LMS) standards for representing the authored learning resources. One requirement that must be fulfilled by authoring tools for adaptive learning resources is that the authoring outcomes must be able to work properly in adaptive learning systems. However, delivering learning resources in adaptive learning systems is not simple because the adaptation is influenced not only by learning resources consisting of domain model and adaptation model, but also by user model. Furthermore, differences in structuring and representing knowledge and specific inference mechanisms implemented in learning systems have the potential to cause problems for delivering the authored objects in such adaptive learning systems.

The problems can be solved by designing the authored objects in particular formats which conform to LMS standards; for example, standards for vocabulary, learning design, and content packaging maintained by the IMS Global Learning Consortium. The outcome is a set of learning resources which mainly consists of *concepts, learning units, learning path, learning materials,* and *rules for adaptation*. Community of Practice which consists of people who have working, learning, or teaching experiences in the fields related to the authored course have an authority to develop all the resources except adaptation rules. However, teachers' considerations and decisions through adaptation authoring as the final phase are those which will mainly determine what adaptive learning will be supported by the authored learning resources.

In all designing processes, there are three aspects considered, such as expressivity, efficiency, and collaboration. To evaluate the intended authoring model from the perspective of expressivity, a kind of Black Box software testing method called the *Comparison* method will be conducted. This testing is aimed at proving the suitability of knowledge representation used in the adaptation authoring. The second aspect, efficiency, will be considered in a workflow analysis to get an objective evaluation of the intended authoring flow and this will be compared with those of former authoring tools which did not utilise learning resources from wikis. Finally, empirical studies will be carried out to evaluate the usability of the implemented CSCW features.

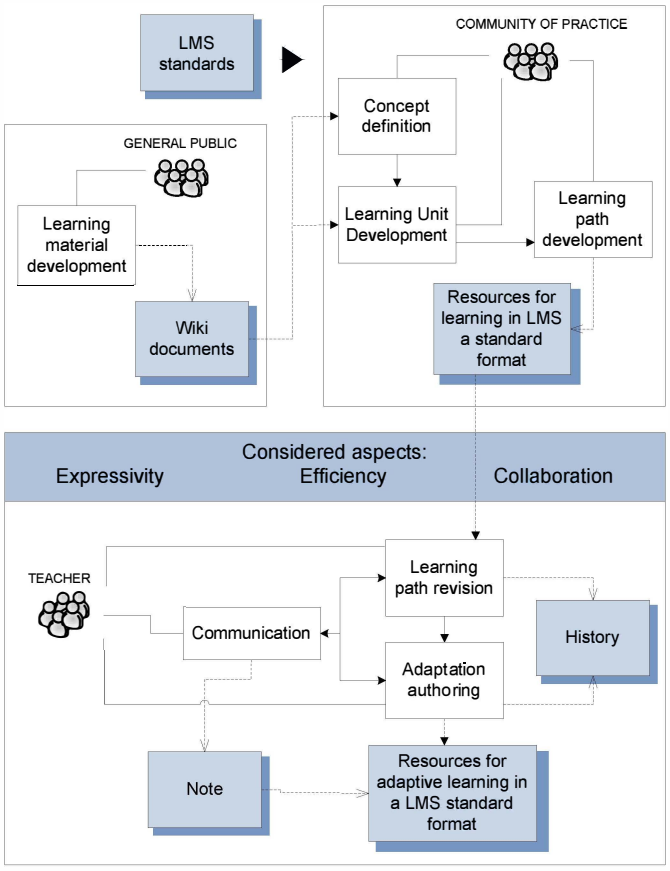

Figure 4. The Framework

VI. Conclusions

Novelty. Unlike former research studies that focused only on adaptation, the proposed model considers two aspects: adaptation and collaboration. The collaboration aspect is represented in the forms of *Note* for communication among authors and *History* that records all changes made by authors.

Vision. The model will demonstrate that the application of CSCW and the enrichment of learning resources defined in existing wikis produced by a large number of people has advantages for authoring adaptation by a small group of teachers.

Testing. In designing testing, three aspects are considered including expressivity, efficiency, and collaboration. Testing will include specific software testing method to evaluate the expressivity of the authoring outcomes. Furthermore, it includes a workflow analysis to get an objective evaluation of

the intended authoring flow efficiency. Finally, interviews and questionnaire will be used to gain human evaluation about the importance and the usability of the intended collaborative authoring approach.

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