'AUTHORING ONCE, DELIVERING MANY': CREATING REUSABLE ADAPTIVE COURSEWARE

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ABSTRACT
This paper addresses the issue of creating *reusable* adaptive courseware from the point of view of the author (teacher or instructor). We illustrate the idea of reusability under the motto "Authoring Once, Delivering Many" by showing the conversion process from a generic authoring system, MOT (My Online Teacher), to a different delivery system, WHURLE. This exercise is but one in a series of interfacing exercises, through which we try, step by step, to come closer to the goal of being able to reuse adaptive educational material, once created, on any adaptive delivery platform desired. The focus here is less on the technical aspects of the interfacing, as on the reduction of authoring burden, on one side, and on the maintenance of a certain level of pedagogical flexibility during the conversion, on the other.

KEY WORDS
Adaptive Hypermedia, Authoring, Interoperability, MOT and WHURLE

1. Introduction

There is a vast diversity of learners in the world; each person has their own learning preference, aims and objectives. Every learner has the right to demand a high quality, personal learning experience. However as current web-based learning environments offer a 'one size fits all' approach to the delivery of learning materials (every learner is given the same set of resources), the personalised approach to education is sadly lacking from most online systems. Adaptive Educational Hypermedia (AEH) seeks to address this lack. It aims to create new opportunities for learners, whilst also enhancing existing approaches – delivering lessons and courses adapted to the requirements of each learner.

There are now-a-days a few such AEH systems, many of which are as yet experimental (e.g., Interbook [1], AHA! [2], TANGOW [3], WHURLE [4]). Their focus is on the learner's requirements: they adapt their educational content to different *dimensions* of each learner, such as: knowledge levels, user goals, tasks, educational context (e.g., are they in school, university, or learning from home?), and more recently learning styles (e.g., LSAS [5]). Until very recently (ref) little attention has been given to the complex and often confusing task of authoring materials for AEH systems. An author faces a multitude of problems when they decide to use one of these systems, such as:

- Which one of the many AEH systems available should they use?
- These systems are invariably very complex to use from an authoring perspective
- They often require a great degree of technical expertise to setup and use the AEH system itself.
- As each system is unique (there are as yet no AEH standards) materials created for a single system are non-transferable or re-usable.
- The time and effort an author spends on learning a system is also non-transferable to other AEHs. If an author wishes to use an improved but different system, they will have to learn how to author for it once again.
- There is often very little support for authors in AEH systems, in the form of tutorials or help files.

A methodology to combat these problems is that of "write once, use many". That is, an author should only ever have to write or create a piece of material once. This material should be easily re-usable in many other AEH systems. This means that an author only has to learn how to use one AEH authoring system; if they subsequently wish to deliver their lessons in another AEH then a simple and transparent conversion process will enable this. This allows for the cost-effective re-use of both materials and skills.
This paper presents an example implementation of this methodology. We use one AEH (MOT) to create adaptive lessons for another (WHURLE). This represents only one of the ongoing implementations; the other two are "MOT to AHA!" and "MOT to Blackboard". These will not be discussed further here, but are indicative of the shift towards an "Authoring Once, Delivering Many" paradigm. The focus here is on the authoring perspective,

from a content creation and pedagogic construct point of view. We illustrate how not only the authored content can be reused on a different system, but also how it can be reused in an identical way as the one intended originally, by exporting also some elements of the pedagogy (pedagogical personalization strategy) as well.

2. Authoring Content and Pedagogy in MOT

2.1. MOT Basics

MOT (http://adaptmot.sourceforge.net/) is an online environment for the authoring of adaptive educational hypermedia. It is based on the theoretical framework LAOS [6], and aims to provide maximum flexibility whilst concomitantly reducing the author load. As a result MOT can describe any pedagogical strategy required by an author. MOT has been tested previously with students and these results were reported [6]. This paper will demonstrate MOT's flexibility and how it can be used to deliver content in an entirely independent system (WHURLE). To this end we will demonstrate how MOT can be used to create a Lesson which will adapt content to a learner depending upon their position along the *Visual:Verbal* dimension of the Felder & Soloman Index of Learning Styles (ILS) [7], and how this lesson will be delivered in WHURLE.

2.2. Authoring Content

Authoring educational content in the lightweight version of MOT can be reduced to a two stage process:

1. authoring static *domain concept maps*, with pure domain-related content and domain-related hierarchies and relations, and
2. authoring so-called *goal and constraints maps,* with extra pedagogic information.

This two-stage process means that each stage can have a different author. Figure 1 shows a short list of Concept Maps (instances of the domain concept model) and Lessons (instances of the goal and constraints model).

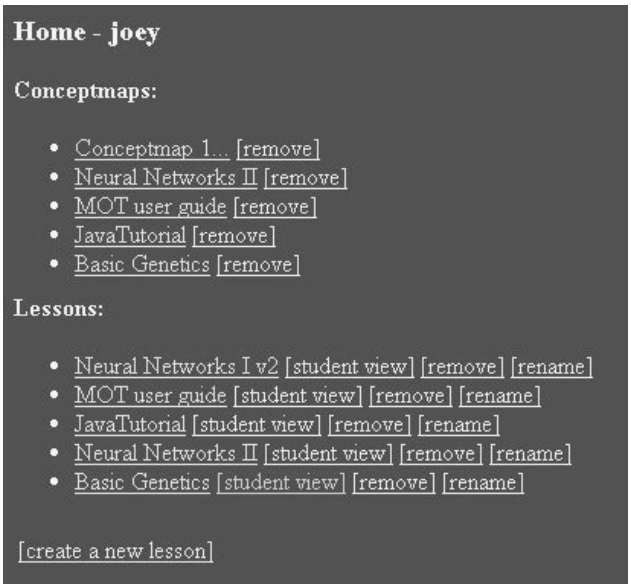


Figure 1: Example lists of Concept maps and Lessons in MOT

The domain concept model, contains the learning resources, organized hierarchically (Figure 2), and their descriptions (i.e., domain attributes – see Figure 3). Other types of relations between these learning resources are allowed, as long as they are relations inherent to the nature of the domain, but are not further elaborated on here. MOT provides a default domain attribute set of the following types: *title*; *keywords*; *introduction*; *pattern*; *text*; *explanation*; *conclusion* and *exercise* (only the title must be filled in).

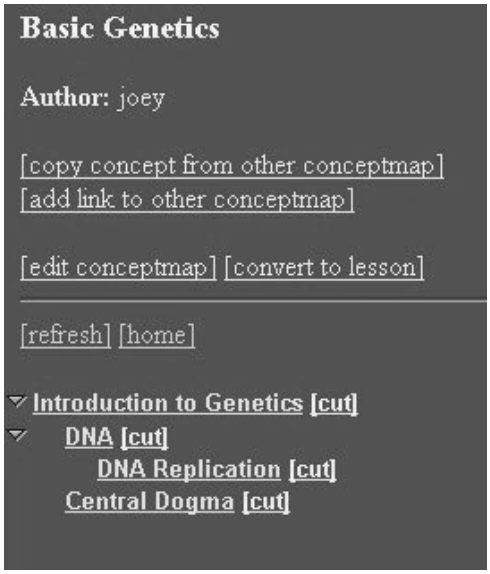


Figure 2: MOT Domain Concept map instance

In Figure 2, an author ('joey') has created a lesson called 'Basic Genetics'. This lesson already has part of its hierarchy defined with four *concepts* 'Introduction to Genetics' etc. Figure 3 shows the basic attributes of the 'Introduction to Genetics' concept.

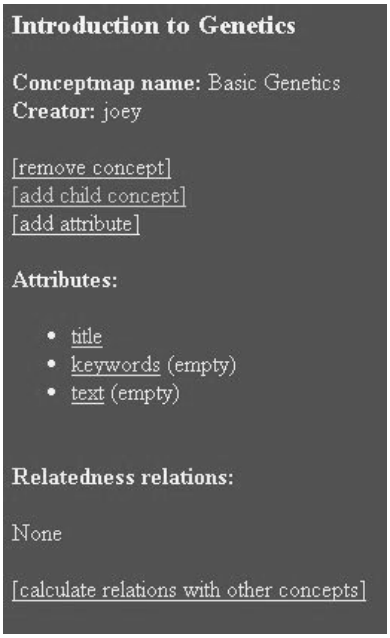


Figure 3: MOT domain concept attributes

For the purposes of describing content to be used with the Visual:Verbal dimension of the ILS, additional attributes of different types to the standard ones need to be described. Two attributes need to be added in addition to the MOT standard set: *image* and *mixed*. This will allow for three different aspects of the concept to be stored:

1. Text – textual data only
2. Mixed – both textual and visual representation
3. Image – visual representation of data

An example of an 'image' attribute and its contents is displayed in Figure 4. Adding to the simplicity of authoring in MOT is the fact that HTML can be used to describe the contents.

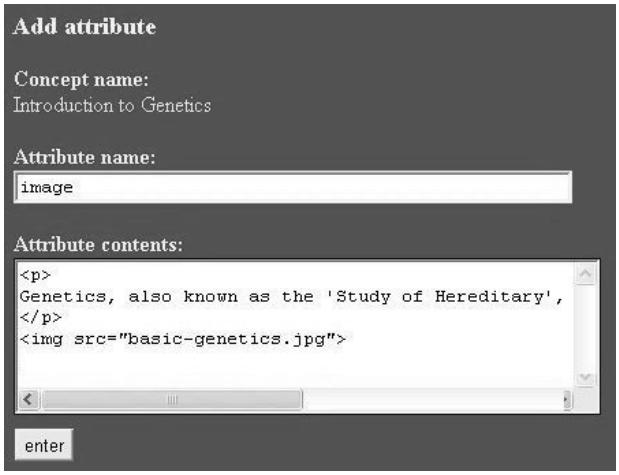


Figure 4: Editing a domain concept attribute in MOT

2.3. Authoring Pedagogy

All the pedagogical content and linking elements are contained in the Goal and Constraints Model.

Once one or more domain concept maps have been created, populated with all the learning material extracted from the domain specialists, the second phase of the MOT authoring process can occur. Out of one or more such domain maps, a lesson in the goal and constraints (G&C) layer can be created. This lesson contains selections filtered from the domain model based upon instructional views and goals [8] (such as expected timeframe, level, background knowledge, learning styles, etc.). For instance, Figure 5 filters all attributes from the domain into the G&C lesson.

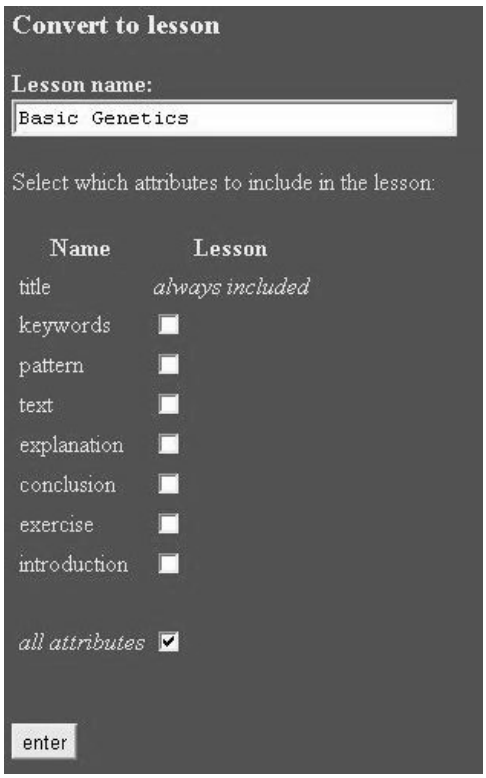


Figure 5: transforming a domain concept map into a lesson in MOT via a filter

The objective is, as said, to separate purely domain-dependent information (such as learning resources) from additional pedagogic information added by the teacher. A typical example of such pedagogic information is the creation of prerequisite relations. These types of relations should not be used in the domain model, because the presentation order of the resources to the learner should depend on the learner model. Adding such relations at domain level would hardwire the presentation, having as an effect the delivery of the same presentation regardless of the user preferences and needs.

In addition to these prerequisites however, MOT also allows an overlay model of pedagogic information, on top of the domain model. For instance, in our illustrative example, information about the relevance of the resource to the different types of learner (textual, mixed or visual) is stored in the Lesson. This is done in the form of labels, showing the type of learner the resource is aimed at, and weights, which can be used for a more refined tuning of the classification (see Figure 6).

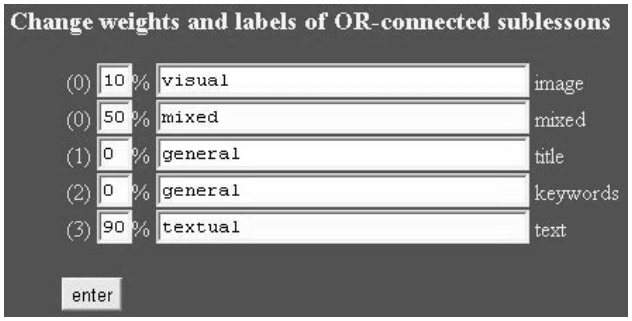


Figure 6: Adding pedagogic overlay information to resources in a MOT Lesson

Figure 6 shows the weights and labels for each of the attributes of the 'Introduction to Genetics' concept. For example the 'image' attribute is given a weight of '10' and a label of 'visual'. These labels identify which attributes are to be delivered to which type of learner. Table 1 describes the Visual:Verbal dimension of the ILS and the G&C lesson labels associated with it.

ILS Dimension [7]											
Visual											Verbal
11b	9b	7b	5b	3b	1b	1a	3a	5a	7a	9a	11a
Visual				Mixed				Textual			
MOT label											

Table 1: The Visual:Verbal dimension of the ILS; the number of choices (either an 'a)' or a 'b)' for each of eleven questions – see Figure 7) as extracted from the ILS questionnaire

Once the attributes have had these labels and weights added to them, the MOT G&C lesson is ready to be converted for use in WHURLE.

Interoperability between educational systems requires the semantics of one system to be mapped onto the semantics of another. The MOT to WHURLE conversion takes the contents and their metadata, from the G&C layer of MOT, and interprets it according to the semantics described in WHURLE. Details of this contextual mapping can be found in [9].

3. Delivering Lessons with WHURLE

3.1. WHURLE Basics

WHURLE is a flexible, discipline-independent integrated learning environment, designed to deliver adaptive content over the web. The learner is presented with a lesson, which is constructed from a collection of underlying educational resources, according to a default narrative that is defined in a *Lesson Plan,* and filtered according to rules specified in the user model [10].

The basic WHURLE content resources are called *chunks*. Each chunk is a conceptually discrete piece of information (i.e. there are no interdependencies between chunks, and no links to other resources). Owing to the flexibility provided by WHURLE's use of chunks, adaptation may be implemented at the content level (using conditional transclusion [10]) to determine which chunks are made available to each class (or 'stereotype') of learner.

3.2. MOT Lessons in WHURLE

The conversion of educational materials from MOT to WHURLE is a simple process (described in more detail in [11]), and results in the automatic creation of the WHURLE chunks and Lesson Plan. Here we highlight the conversion features that help describe the pedagogical aims during the conversion process.

The conversion of static domain maps and concepts from MOT is skipped, as this type of reuse is similar to the learning object reuse approach. Instead, we look at the transfer of pedagogic information. The conversion engine can determine the WHURLE chunk stereotype from a table of MOT weight & label values, as follows. Table 2 shows an example of such a table, corresponding to the ILS Visual:Verbal dimension. .

MOT Weight	MOT Label	WHURLE Stereotype
0	general	general
1-49	visual	vis
50-89	mixed	mix
90-99	textual	tex

Table 2. A simple table of MOT weight & label values mapped to WHURLE stereotype values

Therefore, labels and weights from MOT can be directly understood in WHURLE, with the help of this conversion table. This allows flexibility and ease-of-use for the author since they can create/modify/delete attributes in an authoring system and subsequently convert it, when needed, into another delivery system. Although this is an 'authoring once, delivering once elsewhere' approach, it is but one of the similar exercises we are researching towards the ideal of "author once, deliver in many". For instance, similar experiments are done with a conversion from MOT to AHA!, a generic adaptive hypermedia system.

After the resources and pedagogic information are converted into a WHURLE readable form, WHURLE can deal with it and present it accordingly. The stereotype classification is done in WHURLE via a questionnaire. When a learner first accesses the converted lesson in WHURLE their preferred learning style – whether 'visual', 'mixed' or 'verbal' – has to be determined. This is done using the eleven questions appropriate to the

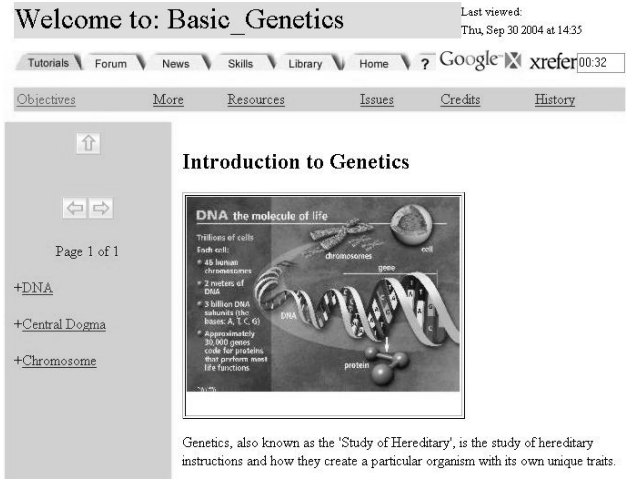
Visual:Verbal dimension of the ILS; six of these questions (as given to the learner) are shown in Figure 7.

1. When I think about what I did yesterday, I am most likely to get:
   - ○ a) a picture
   - ○ b) words
2. I prefer to get new information in:
   - ○ a) pictures, diagrams, graphs, or maps
   - ○ b) written directions or verbal information
3. In a book with lots of pictures and charts, I am likely to:
   - ○ a) look over the pictures and charts carefully
   - ○ b) focus on the written text
4. I like teachers:
   - ○ a) who put diagrams on the board
   - ○ b) who spend a lot of time explaining
5. I remember best:
   - ○ a) what I see
   - ○ b) what I hear
6. When I get directions to a new place, I prefer:
   - ○ a) a map
   - ○ b) written instructions

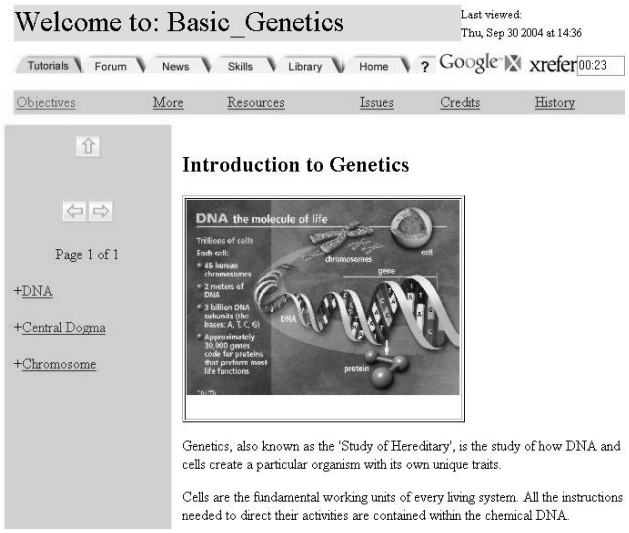
Figure 7: six of the eleven ILS questions presented to each learner of the converted MOT lesson. These are used to determine their learning style preference.

This questionnaire is interpreted as was previously shown in Table 1, by counting the number of 'a)' or 'b)' answers.

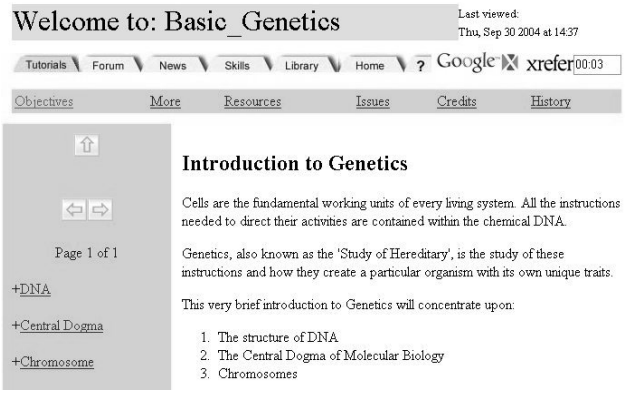
Once a learner's individual ILS preference has been determined the appropriate educational material can be presented. Figure 8 shows examples of the different presentations of the lesson created in MOT (as shown in Figure 2-6), filtered according to the learner's preference as obtained from the above questionnaire.



a) Visual



b) Mixed



c) Textual (Verbal)

Figure 8: Three different representations of the single MOT concept 'Introduction to Genetics (as shown in Figure 2)

Figure 8a displays the content that learners who prefer less text and more images will receive, whilst Figure8b displays the content that learners will get if they have no strong preference for either images or text. Finally Figure 8c shows what learners who prefer more text and fewer (or no) images will see.

4. Conclusion

It is recognised that learners differ in their ability to learn [12], and research continues to find new and improved ways in which to adapt to the needs of the learner. These discoveries are being incorporated into existing learning environments, resulting in a) constantly changing authoring tools, and b) increasing complexity in these authoring tools. However this complexity means that non-technical content authors can find it difficult and time consuming to create and maintain educational materials.

A paradigm shift is required, away from an "author once, use once" methodology – in which an author has to learn a new authoring system for each delivery system - to-

wards an "author once, use many" paradigm - where an author only has to learn the complexities of a single authoring system but can have the content delivered in any system they chose.

In this paper we have briefly presented MOT, focussing on its functionality as an authoring system, and WHURLE, focussing on its functionality as a delivery system. We then demonstrate the authoring process with an example lesson *Basic Genetics,* concentrating on how a lesson in MOT is created using its web-form authoring system. The material is then converted for use in WHURLE. This easy-to-use process means that an author does not require any knowledge of XML, HTML (although this can be used if desired) or any of the technical details for authoring in WHURLE. This leaves an author free to concentrate on the pedagogical delivery of the lesson, as shown in this paper with the implementation of the Visual:Verbal dimension of the Felder & Soloman ILS. An author may take advantage of the WHURLE environment with little or no knowledge of the actual system.

There is still much work to be done. MOT is an ideal authoring system, and we have just begun to explore its flexibility and adaptability. Ideally any authoring system should allow an author to create (and re-use) more complex pedagogical strategies, such as, for instance, written with the LAG grammar, a language for creating adaptive strategies [13]. Any generic conversion system should also interpret these pedagogic rules as appropriate to the delivery system.

It is constructive to strive towards being able to create material in one system, e.g., MOT, and being able to deliver it on various platforms. In this way we tackle several important problems arising from authoring for adaptive educational hypermedia. By examining the challenges and problems of translation between AEH systems, first *pair-wise* then *one-to-many*, we can, in principle, determine the elements needed for a generic interface and move towards interface standards for adaptive educational systems.

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References:

1. P. Brusilovsky, J. Eklund & E. Schwarz, Web-based education for all: A tool for developing adaptive courseware. Computer Networks and ISDN Systems, In *Proc. of 7th Intl World Wide Web Conference*, 30 (1-7), 291-300, 14-18 April 1998.
2. P. De Bra, A. Aerts, B. Berden, B. De Lange, B. Rousseau T. Santic D., Smits & N. Stash, AHA! The Adaptive Hypermedia Architecture. *Proc. of the fourteenth ACM conference on Hypertext and Hypermedia*, Nottingham, UK, 81-84, 2003.
3. R. M. Carro, E. Pulido, P. Rodríguez, Designing Adaptive Web-based Courses with TANGOW. *Proc. of the 7th Intl Conference on Computers in Education, ICCE'99*, Chiba, Japan, V. 2, 697-704, November 4 - 7, 1999.
4. A. Moore, T. J. Brailsford and C. D. Stewart, Personally tailored teaching in WHURLE using conditional transclusion. *Proceedings of the twelfth ACM conference on Hypertext and Hypermedia*, Denmark., 2001
5. LSAS, Learning Style Adaptive System, described at: http://www.archives.ecs.soton.ac.uk/users/nb99r/intro_short/frame.htm
6. A. Cristea and P. Cristea, Evaluation of Adaptive Hypermedia Authoring Patterns during a Socrates Programme Class, *Advanced Technology for Learning Journal*, 1(2), ACTA Press, 115-124, 2004.
7. M. R. Zakaria and T. J. Brailsford, User modeling and adaptive educational hypermedia frameworks for education, *New Review of Hypermedia and Multimedia* (NRHM 2002), 8 (2002), 83-97.
8. F. Garzotto and A. Cristea, ADAPT Major Design Dimensions for Educational Adaptive Hypermedia, *Proceedings of ED-MEDIA'04*, AACE.
9. Felder, R. M., Soloman, B. A.: Index of Learning Styles [online]. Available at <http://www.ncsu.edu/felder-public/ILSpage.html> .(2004)
10. A. Moore, C. Stewart, D. Martin, T. Brailsford, H. Ashman, Links for Learning: Linking for an Adaptive Learning Environment. *IASTED Intl Conference on Web-Based Education*, Innsbruck, Austria, Feb 2004.
11. C.D. Stewart, A.I. Cristea, A. Moore, T.J. Brailsford and H.L. Ashman, Authoring and Delivering Adaptive Courseware. Authoring Adaptive and Adaptable Educational Hypermedia Workshop; *AH2004, Workshop proceedings (part II)*, Eindhoven, Netherlands, Aug 2004.
12. P. Adey, R. Fairbrother, D. Wiliam, B. Johnson, and C. Jones, *Learning styles & strategies: a review of research* London, King's College, Centre for the Advancement of Thinking, 1999.
13. A.I. Cristea, & L. Calvi, The three Layers of Adaptation Granularity. *Proc UM'03*, Springer.