Discrepancies Between Reality and Expectation: Can Adaptive Hypermedia Meet the Expectations of Teachers?

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ABSTRACT

The effort to personalise eLearning has led to the development of sophisticated Adaptive Hypermedia (AH) systems that can adapt to many aspects of the learner's characteristics or explicit preferences. However, while many of these adaptations are grounded in sound pedagogical theories, it is unclear how effective such adaptations are in supporting everyday teaching and learning processes that take place in the classroom today. This paper presents a study that explores what teachers in the UK, who have been named by their colleagues as implementing best-practice in the classroom, expect from an eLearning platform that can adapt to the individual needs of their students. The result of the study shows that there are currently some discrepancies between the teachers' expectations and what adaptive hypermedia currently offers. The paper then concludes by describing how these discrepancies can be addressed in future AH systems.

KEYWORD: Adaptive Hypermedia, classroom practice, eLearning personalisation

1 INTRODUCTION

While the concept of adapting a system to a certain learner profile is not new in the eLearning context, it was not possible until recently to implement such a concept on a large scale in the school environment. What made this possible was not directly the development of eLearning technology, but the wider IT environment that schools operate in. With major computer manufacturers offering educational pricing of notebook and tablet PCs at prices comparable to desktop PCs, it is now a realistic possibility that a school can provide appropriate computing facilities to every student when and where necessary. This ability to provide on-demand computing facilities highlights the potential of computers to act more as a personal tutor, rather than a glorified blackboard.

However, while the real possibility of mass deployment of adaptive hypermedia (AH) in the classroom has been much anticipated by developers of AH, the prospect of mass personalisation of learning in the classroom is a relatively unknown quantity for today's teachers. The most important question of how adaptive eLearning will ultimately impact educational practices remains unanswered. While many of the adaptation and personalisation strategies are grounded in sound pedagogical theories, it is unclear how effective such adaptations are in supporting everyday teaching and learning processes that take place in the classroom. Attempts to use ICT in the classroom without successfully integrating it in a meaningful way typically fail as teachers are not supported with appropriate guidance for how the ICT can be leveraged successfully as part of their teaching.

This paper presents a study that explores what teachers in the UK, who have been named by their colleagues as implementing best-practice in the classroom, expect from an eLearning platform that can adapt to the individual needs of their students. It aims to determine whether the teachers' expectations are realistic, too futuristic or too basic with respect to the capability of AH today. The result of the study shows that there are currently some discrepancies between the teachers' expectations and what adaptive hypermedia currently offers. The paper then concludes by describing how these discrepancies can be addressed in future AH systems.

1.1 Background on AH Implementations

Brusilovsky et al. (1996) describes adaptive hypermedia (AH) as "an alternative to the traditional 'one-size-fits-all' approach in the development of hypermedia systems". In this way AH can adapt the information presented and the structure in which it is presented towards an individual's preferences. Some of the parameters that have been highlighted as suitable for adaptation to the individual learning needs of the learner include learner's goals (Melis & Andrès, 2005), preferences (Conlan & Wade, 2004) and the pre-existing knowledge (De Bra, 1998) of the learner in the topic(s) being learnt. AH systems use such information to create a profile of the learner to which the system adapts in terms of presentation (content and layout) and navigational support (Brusilovsky, 2001). The aim is to minimise the effect of information overload and irrelevance or, in terms of navigating through the resource, "being lost in hyperspace" (Conklin, 1987).

1.1.1 AH and eLearning

The effort in improving AH as a learning tool has so far been focussed on improving the experience of the learner who is interacting directly with the system. Both adaptive presentation and adaptive navigation adaptation techniques are aimed at making sure that the learner, within a particular session of interacting with the system, gets the most relevant information in the most efficient manner. However, such focus is leaving one of most important stakeholders in today's educational environment out of the picture: the teacher.

The argument here is not that AH should not provide novel methods of teaching and learning; on the contrary, such well targeted method of instruction has great potential in improving the quality of the education experience of the learner, but in order to realise this potential, such a system needs to also consider the role of the teacher and, in particular, the impact such a system will have on everyday teaching practices.

Adaptive hypermedia systems have been deployed and tested in real-world settings; for example, Trinity College Dublin's APeLS-based personalised courses (Conlan et al., 2002; Conlan & Wade, 2004) and the EU funded 3DE project (3deproject.com). However, neither of these implementations took into account the needs of the teachers or instructors when using an AH system in the real-world classroom setting, other than allowing the lecturers, in the case of APeLS, to constrain the curriculum of the personalised courses. However, this does not address how the personalised eLearning provided can be integrated with teaching and learning practices in the classroom. In other words, there is currently a lack of empirical studies on how AH will actually be used in the school setting and what potential problems will need to be overcome if implementation will spread beyond early adopters of the technology.

The study described below aims to shed some light on how AH and personalised eLearning may be perceived in the school setting in the UK, what the expectations of the teaching staff are concerning the use of AH in their classrooms and what would make AH a desirable addition to the teacher's arsenal of teaching resources. The goal is to derive a set of requirements for improving current AH systems as well as to create the next generation of AH systems.

2 TEACHERS' EXPECTATION OF AH

A study has been conducted to explore what teachers in the UK may expect from AH and also how such a resource may be used as part or in support of everyday teaching. As AH is still unfamiliar to many teachers in the UK, it was considered inappropriate to study the expectations of the general UK teachers' population. Instead, the investigation focuses on the views of a group of teachers who are currently considered to be implementing the best practice in UK classrooms today. The study consists of one-to-one interviews with some of the recipients of the UK Teaching Awards 2004 National Winners. More specifically, the following teachers were chosen for their particularly relevant experience with respect to the use of IT in schools:

- Ms. Sue Seifert: a teacher from London who won the Lifetime Achievement Award
- Mr. Philip Beadle: a teacher from London who won the Teacher of the Year in a Secondary School Award
- Dr. Baldev Singh: a teacher from Bristol who won the Innovation Unit Award for Innovation in Education Award

- Mrs. Pam Roberts: a teacher from Avergavenny who won the Teacher of the Year in a Primary School Award (interview conducted by email)

Each interview began by asking the teacher what role IT can or should play in meeting the learning needs of individual students in his/her classroom. Each teacher was then allowed to introduce topics that he/she considers to be most relevant to this issue. The interviews reveal that teachers have a wide range of expectations from computer systems that claim to adapt to the needs of individual students – excerpts from the interview transcripts (word-for-word) are provided in this paper. The interview data highlighted in the following section shows that personalising classroom teaching to the needs of individual students involves:

- more than just adapting the appearance or subject content of the resource
- providing support for the students while engaging with learning resources
- providing learning activity that requires the student to make personal decisions on the task and appropriate support for the student to carry through decisions made

2.1 Impact on classroom organisation

Teachers in this study understood the benefits of providing personalised learning experience for each of their students in the classroom via AH. However, they have some reservations as to how this will actually work out in real-world classroom setting. That is, they do not want to be in a position where each student in a large classroom (30 students) is doing something completely different from each other.

"*I think it is a mind shift when you've got 30 kids in one class… suddenly when you start dealing with them it's hard I find it personally. It needs smaller classes with that approach. With 30 kids it's not possible to add… it is a wonderful idea <personalisation> but to do it at practical level, there are some very good management in a teacher you need to do.*" **Singh**

While this suggests that there may be a limit on the number of students that a teacher can cope with when teaching through AH, the teacher's task can be made more manageable by providing support for

- personalisation according to groups of students
- the teacher to specify the criteria under which these groups are made

2.2 Factors for adaptation

One of the main questions in ensuring effective implementation of AH is what factors or parameters of the learner should AH be adapting to? There is already a substantial body of research that is addressing this issue. Therefore, the intention of this section is to provide some real-world context on why adaptation to such parameters may have instant appeals to today's practitioners.

The ability of AH to adapt to the ability of different students was considered to be a highly desirable feature. More specifically, the interviews revealed that adaptation to student's literacy level and domain specific competence would be compatible with how teaching is already conducted.

"…if you could make a piece of software which would automatically produce differentiated materials in a subject then you've got a real winner. Say I have a student who is at the early stages of literacy and I am teaching a lesson on one subject and if I put in the subject and it would produce for me differentiated materials with students who can't read and write so that they could actually be involved in the lesson then that's a real winner." **Beadle**

"*Also if you could produce something that could differentiate what could be systematised… if you could produce something that would give automatic extension work for gifted children… so again I type in the subject 'apostrophes' then I get four levels of work… I get many scalable resources. I get the resources for very very clever students, I get the resources for people who can't speak any English and resources for people with learning difficulties… you put that to me then yeah every teacher in the country will be smiling about it… as differentiation is very hard we don't do much of it.*" **Beadle**

It is worth pointing out at this stage that the issue of teaching with respect to an individual student's style was also raised. However, while these teachers work with the idea that individual styles exist, no requests were made to create learning resources that limit a particular student to a particular style. Instead, learning style theories were used as a way to systematically diversify teaching resources for all students. Some efforts were made to match learning resources with styles of particular groups of students, but this did not involve excluding students from other groups who were considered to have different styles. This view is consistent

with a previous research on the use of learning style in primary school classroom (Seyedarabi & Monthienvichienchai, 2005), but is in conflict with the strategy used by some adaptive hypermedia implementations that aim to adapt resources exclusively to a particular style of the learner (e.g., 3deproject.com).

"*I use a range of learning styles to embrace all learners', Auditory, Visual, Kinaesthetic et cetera. I also test learning outcomes and objectives met during the plenary session. I also vary the learning styles to accommodate boys/girls differentiation using differing learning methods.*" **Roberts**

"*Actually there is a systematic way in which you could devise a good lesson if one goes through whatever subject you are teaching, you go through what can I do to stimulate visually or an auditory basis… kinaesthetically and then go to Gardner seven intelligence sense. Say righ,t how am I going to appeal to musical people with musical intelligence, people with interpersonal, intrapersonal, mathematical… special linguistic so one can go through all those different things and that would be a way of generating ideas.*" **Beadle**

2.3 Adaptation of content

The issue of adaptation to learning style is part of the wider goal of adapting content to support the needs of individual students. An obvious requirement that was stressed during the interviews was that whatever the outcome of the adaptation, the content should at least satisfy the UK National Curriculum. This may seem to be an obvious requirement; however, it points to the possibility in some countries that there is a limit on what would still be considered a valid learning resource or activity following adaptation. A consequence of this is that there may be a need to provide a way to specify the adaptivity space in which adaptive engines need to work within, with respect to how concepts should be treated within a subject domain. Additionally, the interviewees would also like to maintain a degree of control over what an adaptive hypermedia system gives to their students. That is, they would like to retain the ability to fine-tune or even correct what the system had decided to give to the student. While an ideal AH system would not need correcting, the lack of the ability of the teacher to intervene in the system may affect successful adoption of the system in the long run.

2.4 Providing cross-curricular content

Another content-related area that AH is expected to contribute to is the creation of cross-curricular or "integrated" content with respect to relevant adaptation parameters (e.g. subject, topics and other student profiling parameters). Cross-curricular content integrates what the student needs to learn in one topic with one or more other topics, often from different subject domain. The goal is to help the student make meaningful links between knowledge learnt in one class with another. While it is not essential for AH to provide cross-curricula content, such ability will add value to an AH implementation in school and therefore positively affect its chance of being accepted by the teachers.

"*What I don't think any one has come up with is basically cross curricula work. Using the computer to really support cross curricula work and developing programmes which would have everything in it, so if you were doing a history project it would say here is your history project, here is your geography, that would be the literacy you can get from it, this is the numeracy you know, science and everything and the art. So that if someone said you are doing Egypt, right here is all the information on one page. If you like, these are all the things you can do with that topic, these are cross-curricula. No one has done that.*" **Seifert**

2.5 Beyond content

So far, the highlights from the interviews have focused on what AH should do to the learning resources to meet the needs of the students. However, the interviews also revealed that teachers would consider adaptive hypermedia truly useful if it goes beyond just providing content to the students. More specifically, teachers expressed the need to have a system that is adaptive while the students carry out learning tasks while interacting with adaptive learning resources.

"*…if I design a system, one of the best ways I think personalisation can happen or assessment can happen is through project-based learning, that's for teachers, now, and really for the next ten years. You will see that*

e-learning at the moment is very disjointed, but there is no integrated project which will meet in each curriculum area… that's the value added curriculum." **Singh**

An example of project-based learning is given below:

"*An example would be if I was doing a good project I would develop a project, would be for example my students and this would be 12 year-olds or 16 year-olds, to do a journey from here to South Africa. And I would ask them to develop an itinerary of how they'd actually do that travel. Could be through any country and in doing that you come to the first hurdle of finding what's the geography of the different countries, you're already starting to give students some differentiation, so you find out about the culture of South Africa, find out more about the currency and then you've got to find out the airport you might want to find out about the climate because you're going to travel there.*" **Singh**

As a result, adaptive resource and adaptive activity need to be followed by the appropriate adaptive assessment or teaching support.

"*I think the assessment has to be in two levels for me, one is the diagnostic assessment, which I think is worth having anyway, you know what do they know about that country so I would like a blended approach maybe a diagnostic assessment of do they know where South Africa is, and then actually assess them after that, after the project, so a set of multiple questions and a presentation where I would mark. So I think a blended approach is the most effective approach for a teacher.*" **Singh**

What this means for effective AH implementation in the real-world is that adaptivity needs to be reflected and supported throughout the learning activity – from content presentation, learning tasks, through to assessment (both formative and summative). This underlines the reality of school-based teaching and learning: in the end, what is taught needs to have a corresponding method of assessment. Most importantly, AH is also expected to provide this or at least go some way in doing so.

2.6 Teaching support when using AH

For AH to be accepted in the classroom environment, learning through AH needs to be supported by meaningful relevant activities in the classroom. These activities, or the plans for them, are expected from AH. A consequence of this is that it should be possible for AH-based activities to be integrated with non-AH classroom activities. In other words, AH should not only be able to operate within a blended learning environment, but also to facilitate such environment.

"*…also the resources which come with it, whether there is a printed worksheets or websites which has the resources worksheets ready to be printed out, I think the last thing which teachers are already disappointed is when you go to a website you see that there are a lot of teaching [material] but no resource to give to the kids… the most important thing we want is a button, which says print resource sheet."* **Singh**

2.7 Student tracking in AH

The last major issue that was discovered during the interviews concerns how AH has the potential to be able to provide teachers with unprecedented insight into their students' learning activities and why it is useful for teachers to have such information. This opportunity actually emerged from a perceived problem with AH in that it could allow a large group of students to pursue a multitude of different learning paths, making it very difficult, if not impossible to manage such a classroom. However, if the tracking of the students are conducted by the AH system and conveyed to the teacher in meaningful ways, then it will be giving teachers information that was not possible for them to have with conventional classroom teaching, which would facilitate more personalised learning/teaching support.

"*I think if I walk in to a classroom, depending on how deep they are going it's a good correlation with their ability. So if I went to that BBC site one student would be there whilst another student I would notice that would go to the other sites, so the depth they are going to I find… there is some link with their assessments.*" **Singh**

"*…computers that could actually say or little cameras which can actually show us how they're playing which we could have on them and when they do their play we could actually see… you know the teacher is busy at the other end of the room and these kids are playing but they've got their little badges on which are actually cameras and can record their play for us that would be heavenly because that would help us with our observations … it will help us see how children are playing and learning through play.*" **Seifert**

There are two major implications as a result of this in terms of the design of AH concerning student tracking. Firstly, the notion that the tracking of student's activity can result in some inference of the depth in which they are tackling a subject requires an AH system that can describe the content that it can provide to the students with respect to a subject domain ontology; for example, via an ontology map. That is, when a student is interacting with a learning resource, the system should know whether it is at the surface of a topic or within a deeper or more advance area of the topic. Secondly, it is not just where the student is in this ontology map that the teacher needs to know, but how the student has moved within the map. In other words, the pattern of movement in this map is also important. Consequently, one of the challenges of implementing meaningful student tracking in AH system is to determine patterns that would be meaningful for teachers, or even students, to be aware of.

2.8 Interview analysis summary

The interview data highlighted in this paper has revealed some issues that would affect the uptake of AH systems in schools in the UK in the current teaching environments, the most significant being:

- implications of personalised instruction to current classroom setup
- what parameters of the student would be useful for AH to adapt to
- how content should be adapted to add value to AH within the classroom setting
- the need for AH to support teaching and learning, not only at the content presentation stage, but also during the learning process itself and relevant assessment activities
- the potential for AH to support highly personalised teaching and learning by tracking the student's activity within the AH system.

The next section of this paper will now compare the expectations of the teachers interviewed in this study with what is actually currently available in AH system and what will be available in the short-term. The intention is to determine whether AH is heading in a direction that will satisfy the requirements of teachers and students – the real-world end-users. Inconsistencies will be pointed out and possible remedial actions proposed.

3 Discrepancies between Current AH Capabilities and Teachers' Expectations

This section will discuss the main discrepancies between current AH capabilities and the teachers' expectations of the technology as detailed in the previous section. The discrepancies in the following areas will be highlighted:

- Personalisation in the classroom
- Strategy for using learning style
- Context of using content provided by the AH system
- Tracking of student's action in the AH system

The first discrepancy between teachers' expectation and the current capability of AH systems is that current AH systems have placed heavy emphasis on providing as individualised learning experience as possible. What the study has shown is that personalisation can and should take place within the context of a wider classroom activity. For example, teachers see as a useful feature the ability to assign different learning activities to groups of students (i.e. not only to an individual) and to provide 'personalised' learning support to each of these groups. Moreover, this points to the fact that personalised teaching does not necessary mean that every student needs to have different content from another student – personalisation can also be implemented through personalised learning support.

A controversial issue of using learning style in personalising learning has also been addressed. In this case, learning style is used to balance learning resources rather than to bias the learning activities towards a particular strength or weakness of the student. This is consistent with previous research that concludes that learning style is about enriching experience rather than limiting it (Seyedarabi & Monthienvichienchai, 2005). However, this is inconsistent with the approach taken by the 3DE Project (3deproject.com), which aimed to explicitly match and mismatch content to a learner's particular learning style.

In terms of content development, AH systems have focussed on providing rich multimedia content tailored towards the learner. While this has resulted in some cases in high-quality content, such content have not been linked or contextualised within the wider context of the classroom. Teachers expect, as with most learning resources, that material provided by AH should also be accompanied with the necessary teaching support tool to use the material effectively in the classroom. In other words, for AH to be effective in the classroom, it cannot just provide content alone – not only does the content need to be adaptive, but also the teaching support. A related issue discovered in this study is that content needs to be integrated or at least highly related to each other in the form of a complete lesson plan that has the ability, if required, to cover multiple curriculum subjects and areas; for example, a complete project-based learning activity. This is something that takes the most time and effort for teachers to prepare in terms of resource creation. If this expectation can be met, then AH will be saving teachers' time, thus allowing them to concentrate on improving their everyday teaching practice.

The next shortfall is perhaps one, which if addressed can add the most value to using AH in the classroom. One of the most unrealised potentials of eLearning that has yet to be satisfactorily addressed is its ability to track with unprecedented detail what exactly students do when learning through eLearning content. The ability for the teacher to access this information has obvious benefits in terms of dealing not only with assisting students with learning difficulties but also to determine why certain students are doing better than others. Additionally, by also allowing students to access their learning history, it will enable and encourage the students to reflect on their own learning experience.

3.1 How AH Can Meet These Expectations

This penultimate section of the paper proposes how the discrepancies highlighted above can be addressed in current and future AH implementations. These high-level strategies are being implemented in the iClass project (www.iclass.info) and the evaluation of these strategies within several schools around Europe is expected to be completed by the end of 2005.

3.1.1 Two-tier personalisation strategies

The study points to the need to understand what personalisation really means in eLearning. Namely, personalisation is not just about identifying a subset of learning objects that may be relevant to the learner, but also how to help the learner explore the resulting subset in as varied a manner as possible. This approach is consistent with Brusilovsky's taxonomy of AH design (Brusilovsky, 2001), i.e. adaptive presentation and adaptive navigation. The adaptive strategy therefore needs to have the following explicit pedagogy goals:

1. Limiting what the student gets: making sure that the student does not get learning activities and events that are irrelevant to his/her goals and context.
2. Enriching what the student gets to create polyvalent learner: making sure that the student is able to access a large variety of learning activities that are relevant to his/her goals and context.

A major design consequence of this is that strategy 1 should precede strategy 2, and that both strategies need to be present in a single system. Also, the teachers' view is that learning style should not be used as selection criteria for strategy 1. Instead, it should be used as a tool to ensure that the student's learning experience is as rich as possible, i.e. in strategy 2.

3.1.2 Create personalised learning path, not just learning objects

AH system, in order to be effective in the classroom setting, needs to carry out its personalisation strategy with respect to a whole learning path, or lesson, that the student will participate in. Project-based learning indicates that the sequence of learning objects is not as important as the relevance of the learning objects to the high-level goals of the class, e.g. how to get from the UK to South Africa by land? While students need not be restricted by linear sequence of learning objects, AH systems should ensure that the learning objects they encounter help them towards the learning objectives.

3.1.3 Implementing meaningful tracking and reporting facility

Tracking the student's usage of an AH system, at first, may seem like a trivial technical exercise, given that many AH systems are web-based and as such any activities on the system can be easily logged. The real challenge here, however, is identifying what should be tracked and how that data should be analysed and

presented to the student and the teacher in order for the tracking task to be truly useful for both parties. Existing research outside the eLearning domain can give hints to what would be possible for this task. For example, the pattern of movement within an AH system can be tracked in terms of frequency of usage, revisits, time of usage for each learning object by using pre-existing know-how in techniques to analyse search and navigational behaviour analysis of search engine users (Mat-Hassan and M. Levene, 2004) and the complexity of the learning path through the AH system can also use pre-exising know-how from research in graph theory (for example, Botafogo et al., 1992) to determine the depth and variety of the learning experience of the learner. Ultimately, while the technical challenges in implementing this feature may not have already been fully met, the most important factor to identify is what information will the teacher and student benefit from having from this tracking facility.

4 CONCLUSIONS

This paper has highlighted the discrepancies between the expectations of teachers implementing best-practice in the UK and what AH currently has to offer the teachers and the students. The discrepancies vary in terms of complexity, from simple functional requirements such as the ability to personalise to groups as well as individual, to more complex requirements such as the need to provide project-based activities with accompanying personalised support to students for these activities. The paper has also presented how some of these shortfalls will be addressed in a new eLearning system called iClass. What is clear from the result of the study is that more attention needs to be paid by AH developers to the real-world context in which their systems will be used in schools. Current and future AH systems need to be able to support the current teaching and learning practice in today's classroom, in order for them to be adopted successfully on a wide-scale. Development of AH is now at a phase where human factors in teaching and learning using AH are as important as novel technological features when creating effective AH systems.

5 REFERENCES

R. A. Botafogo, E. Rivlin, and B. Shneiderman. *Structural analysis of hypertexts: Identifying hierarchies and useful metrics*. ACM Transactions on Information Systems, 10(2):142--180, 1992.

Brusilovsky, P., Schwarz, E., & Weber, G. (1996c, June 12-14, 1996). *A tool for developing hypermedia-based ITS on WWW*. Paper presented at the Proceedings of Workshop "Architectures and Methods for designing Cost-Effective and Reusable ITSs" at the Third International Conference on Intelligent Tutoring Systems, ITS-96, Montreal

Brusilovsky, P. a. S., E. (2001). Adaptive Hypermedia. *Modeling and User Adapted Interaction, Ten Year Anniversary Issue 11*(1/2), 87-110.

Conklin J. (1987). Hypertext: An Introduction and Survey. *IEEE Computer, 20*(9), 17-41

Conlan, O., Wade, V., Bruen, C., Gargan, M. *Multi-Model, Metadata Driven Approach to Adaptive Hypermedia Services for Personalized eLearning*, Second International Conference on Adaptive Hypermedia and Adaptive Web-Based Systems (AH2002), Malaga, Spain (2002)

Conlan, O., Wade, V. (2004) *Evaluation of APeLS - An Adaptive eLearning Service based on the Multi-model, Metadata-driven Approach*, Third International Conference on Adaptive Hypermedia and Adaptive Web-Based Systems (AH2004) Proceedings, Eindhoven, The Netherlands (2004)

De Bra, P. a. C., L. (1998). *AHA! An open Adaptive Hypermedia Architecture.* Paper presented at the Special Issue on Adaptivity and user modeling in hypermedia systems.

Mat-Hassan M. and Levene M. (2004) Associating Search and Navigation Behaviour Through Log Analysis. Accepted for publication by the Journal of American Society and Information Science and Technology , 2004.

Melis, E. and Andrès, E. (2005) *Global Feedback in ActiveMath*. In: International Journal of Computers in Mathematics and Science Teaching, AACE, 2005.

Seyedarabi, F. and Monthienvichienchai, R. (2005) *Discrepancies between theory and practice in using learning style in primary education: a lesson for adaptive hypermedia design*. World Conference on Educational Multimedia, Hypermedia & Telecommunications (EDMEDIA2005), 27th June 2005, Montreal