

# A Framework for Higher Education

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*Abstract:* - It is well documented that the traditional protocol for higher education doesn't suit each learner, the rhetorical method of lecturing while presupposing certain domain knowledge and experience is a very inefficient method of imparting knowledge. An ideal solution is to have a one-to-one system, where an instructor generates mathemagenic content for each learner. Obviously this is not an ideal situation considering the high increase of learners into higher education. One solution is for higher education to partially traverse into an online learning environment with an element of suitable adaptive content. Adaptive learning systems attempt to adapt learning content to suit the needs of the learners using the system. Most adaptive techniques however are constrained by the pedagogical preference of the author of the system and are always constrained to the system they were developed for and the domain content. This paper describes a personal profile that can be used to automatically generate instructional content to suit the pedagogical preference and cognitive ability of a learner in a tractable amount of time. The paper discusses the manifestation of measurable cognitive traits in an online learning environment and identifies cognitive resources that can be used to stimulate these manifestations. Additionally this paper describes a Content Analyser that is used to automatically generate Metadata to encapsulate cognitive resources within instructional content. The content is repackaged as independent Sharable Content Objects (SCOs) as described by the Sharable Content Object Reference Model. Finally the paper concludes with an example learning component that utilizes the CA for building course content to an expected predetermined minimum learning experience suited to each learner's cognitive ability and pedagogical preference delivered through Moodle.

*Key-Words:* - SCORM, Content Adaptation, Selection Model, Content Analyser, Moodle, Digital Repositories.

## 1 Introduction

The number of people entering into higher education is increasing at an incredible pace. It is estimated that currently there are approximately 70 million people in higher education and that this number will more than double before 2025 [1]. It has been suggested by Sir John Daniel that to cope with this alarming increase entry into higher education, a new university would have to be opened every week [2]. Obviously this is not a feasible option.

A number of studies have been carried out on teaching environments and the effects on the

participating students [3] and have shown that in a typical classroom environment every student, on average, asks about 0.1 questions every hour. The speed with which different students can progress through instruction varies by factors of three to seven [4]. With individual tutoring, students may ask or answer on average 120 questions per hour [4]. The achievement of individually tutored students may exceed that of classroom students by as much as two standard deviations – an improvement which is equivalent to raising the performance of 50th percentile students to that of 98th percentile students [5].

Currently, blended learning technologies such as Moodle, Blackboard and Wimba offer a wide range of functions to aid in the design of the instructional material. Other learning technologies such as Adaptive Hypermedia Systems (AHS) [6] and Intelligent Tutoring Tools (ITT) [7] are focused on developing the learning potential of a learner. In particular, AHS are designed to adapt to the needs of the learner with respect to their domain experience, while the ITT helps to develop cognitive skills. Although these learning technologies have their strengths and weaknesses, they are constrained by the pedagogical preference of the author of the learning technology and are all subject to the specific system for which they are developed.

This paper focuses on the foundation of the Advanced Distributed Learning (ADL) initiative and their production of a standardized reference model to reference instructional material as learning objects. We evaluate their goal to produce the highest quality of instructional material tailored to the individual needs of each user anytime anywhere [8]. To bridge our perceived gap between traditional adaptive learning technologies and the SCORM, an explicit consideration is taken to explore the different environmental contexts of a learning experience [9]. These include the type of learning objects, the level the knowledge is being taught at and the various methods of delivering the content to the users.

In addition to evaluating adaptation techniques and the environmental contexts of a learning experience, this paper investigates the reusability of instructional content within educational repositories, such as MERLOT, JOURAM and NDLR. The paper is mainly concerned with the introduction of a Content Analyser (CA) that enables an easy transformation to a single referencing standard that automatically generates metadata concerned with stimulating cognitive resources within an online learning environment. The paper concludes with an example learning component that uses the functionality of the CA to automatically generate instructional content for any individual learner to a predetermined minimum expected learning experience.

## 2 Learning Techniques

Adaptive content presentation is becoming an important part of educational philosophy dealing with the increased number of people entering into the higher educational market. This section briefly discusses different learning technologies that can aid

in the deployment of instructional material and investigates AHS as the foundation of instructional adaptation.

Learning Management Systems (LMS) like Moodle and Blackboard act as a framework for educational providers to organize and deliver their instructional content in a standard way. They also offer some blended learning facilities to promote a constructivist approach to learning, for example discussion forums. No content adaptation is taken into consideration consequently these platforms only act to transfer the educational sector into an online environment.

### 2.1 Adaptive Hypermedia Systems

Adaptive Hypermedia systems have been in development since the early 1990s. They extend the one-size fits all approach of hypermedia systems by building a model of the users preferences, goals and knowledge and use this model throughout the interaction with the user. In constructing any AHS there are three main components: the knowledge space, the hyperspace and the student model. The knowledge space represents a collection of knowledge elements which represent concepts. The simplest construction of the knowledge space is an unconnected scatter of knowledge elements. The most common type of link is a pre-requisite link giving the author of an AHS the ability to make sure that a concept is known before the student moves onto the next concept. Semantic links have also been applied to different AHS. The hyperspace is the actual content, which is available to be presented to the user. Using some form of mapping we create a mapping between the knowledge space and the hyperspace. The student model represents the preferences, goals and knowledge of each user. A mapping is also created between the student model and the domain knowledge elements in the knowledge space.

AHS are very useful in any application area where users of the hypermedia system have essentially different goals and knowledge and where the hyperspace is reasonably large. AHS try to overcome this problem by using information stored in the user model to adapt the information and links being presented to the given user. Knowing user goals and knowledge AHS can aid in navigation by limiting browsing. Although AHS and similar learning technologies have their strengths and weaknesses, they are constrained by the pedagogical preference of the author of the learning technology and are subject to the specific system for which they are developed.

## 2.2 Adaptive Learning Environment

To create a truly adaptive learning environment across multiple domains the cognitive ability and the pedagogical preference of a learner should be taken into consideration (see Maycock et al. [10]). Successful adaptation requires some correlation between the environmental contexts of a learning environment and the cognitive ability of a learner. These environmental contexts include the type and delivery protocol of the learning content. Brusilovsky [11] distinguished two categories of features within a hypermedia system suitable for adaptation: content adaptation and navigation adaptation. Adaptive navigation techniques such as direct guidance, adaptive hiding or re-ordering of links, link annotation, map adaptation [12], link disabling and link removal [13] can be used to control both the size and level of the instructional space available to each learner. Adaptive content presentation operates at the domain level. The information can be adapted to various types of media and difficulty to meet the needs of each user. However, with the introduction of specifications like SCORM, enhanced adaptive content presentation is possible given the fine granularity of learning objects.

### 2.2.1 Adapting to cognitive resources

Kinshuk et al. discuss the possible resources that can be adapted to suit the cognitive needs of a learner in a formalization of Exploration Space Control (ESC) [14]. They propose that the structure of the learning content should change depending on the ability of a learner. However, it is now argued by Laurillard [15] that the structure of the learning content embodies the meaning of the learning content. We believe that it should not be possible for an adaptive learning environment to change the structure of learning content thereby potentially changing the meaning of the content and subsequently changing the potential learning experience [16]. Kinshuk et al. [14] believe that the reduction of sensory resources describing an instructional object depends on the ability of a learner. In 1956, Miller [17] reviewed the current research to determine the Working Memory Capacity (WMC) of an individual and found that an individual could store between 5 and 9 items in their WMC for one-dimensional content. It was also discovered that when the number of dimensions describing the content increases, the amount of items that can be stored in the WMC of an individual increases exponentially. We believe however, that an adaptive learning environment should not reduce the number of dimensions,

potentially the WMC of a learner throughout a learning experience.

Resources \ CT	WMC	IRA	IPS	ALS
	High \ Low	High \ Low	High \ Low	High \ Low
Paths	+ --	-- +	+ --	-- +
Path Relevance	-- +	\ --	-- +	-- +
Amount of Info	+ --	-- +	+ --	\ \

Table 1: Illustrating the optimal adaptation between resources used in learning objects and suitable cognitive traits.

Table 1, adapted from [14], shows how resources in a learning environment can be adapted to suit the cognitive ability of a learner and in particular shows the relationships and correlations between WMC, Information Processing Speed (IPS) and Associative Learning Skill (ALS). In Table 1 the '+' symbol indicates an increase in the number of resources to adapt to the cognitive ability, the '-' symbol indicates a decrease in the number of resources to adapt to the cognitive ability and the '\ ' symbol indicates no change in the number of resources required to adapt to the cognitive ability of a learner. If a learner has been categorised to have high WMC then for the purposes of adapting to the number of paths, relevance of paths and the amount of information, the learner would be classified to having low Inductive Reasoning Ability (IRA) and high IPS. Similarly, if a learner has been categorized as having low WMC then for the purposes of adapting to the number of paths, relevance of paths and the amount of information, the learner would be classified as having high IRA and low IPS. Different types of media transmit certain kinds of information better than others. Audio information stimulates imagination, while spatial visualization is better interpreted visually [18]. It has also been found that diagrams are better at conveying ideas and text is better for detail [19].

Content developers are responsible for producing small granular learning objects that adequately describe a domain concept. Each learning object that is created should take into consideration the different types of media and their optimal effect on a learning experience. The following section discusses manifestations of















