

## A Web-Enabled Exam Preparation and Evaluation Service: Providing Real-Time Personalized Tests for Academic Enhancement

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### Abstract

We present a technology-enriched, Web-enabled, value-added Distance Exam Preparation and Evaluation Service that provides (a) offline execution of fully-featured preparatory exercises and evaluation tests in a real-life simulated examination environment; (b) content personalization to address scholastic weakness and (c) the use of data mining techniques to ensure content effectiveness and the pro-active identification of the academic needs of various student segments. The solution is designed as a client-server architecture featuring Java technology and XML-mediated information exchange over the Internet.

### 1. Introduction

In Malaysia, secondary-level academic evaluation is government mandated and centrally administered. The evaluation exams comprise multiple-choice questions. Traditionally, students whilst preparing for such exams tend to refer to a vast pool of past examination questions and in-house tests. However, for more thorough exam preparation students like to seek multiple perspectives of a topic/subject vis-à-vis evaluation material prepared by educators different than their own teachers. The motivation being that exposure to a wide range of evaluation material can assist in comprehending the idiosyncrasies of the topic, and in turn better prepare them to undertake the centrally designed scholastic exams comprising questions culled from diverse educators.

In Malaysia, as throughout the world, there is a profound trend advocating web-mediated distance learning [1], computer aided instruction and computer supported collaborative learning systems [2]—the so-called *E-Learning portals*. Notwithstanding the success of such web-mediated distance learning systems, however certain limitations are noted: (1) The imperative on on-

line service delivery, i.e. the user need to maintain Internet connectivity throughout the training/evaluation regime, and hence bear with network connection bandwidth fluctuations; (2) The education/evaluation content is derived from a singular or a limited number of educators; (3) Training/Evaluation is conducted on a cohort basis as opposed being individual-specific. The content is designed to cater for a large generic audience, hence is ineffective towards person-specific educational needs; and (4) Lack of analysis of student responses to evaluation tests; this to determine the efficacy of the evaluation content and the general trends in the student population.

To address the above limitations, in this paper we present a technology-enriched, web-enabled, value-added Distance Exam Preparation and Evaluation (DEPE) Service in support of secondary school education and exam preparation in Malaysia [3, 4]. The DEPE system—a web-based client-server application incorporating XML and Java technological components—exhibits the following technical and functional features:

- 1) Offline execution of fully-featured preparatory exercises and evaluation tests in a real-life simulated examination environment. This is followed by automatic evaluation and corrective explanations.
- 2) Personalization of tuition and test material based on an individual's longitudinal evaluation record, so as to address scholastic weakness and strength.
- 3) Student profiling—based on cohort student evaluation responses—leveraging data mining techniques to provide system-guided tuition and test.
- 4) A substantial corpus of tuition and school-specific evaluation material (exercises, questions and solutions) of relatively high quality, collated from a nation-wide ensemble of educators.
- 5) The use of state-of-the-art Information Appliances (IA) as the next generation DEPE service medium.

The featured DEPE service exhibits four functional components: (a) *Content Compilation* vis-à-vis the population of a test bank comprising past exams together

with school-specific tests prepared by an ensemble of teachers; (b) *Real-time Test Administrator* allowing for WWW-mediated generation of ‘personalized’ tests, yet offline real-time execution of the tests, followed by automatic test evaluation and reporting. Built-in regulation mechanisms ensure ‘non-alterable’ timekeeping, policy-enforcement and on-request hints; (c) *Solution Constructor and Performance Monitor* to track the student’s overall performance on a longitudinal basis and provide the necessary guidance; and (d) *Student Response Analyzer* leveraging cohort student responses for *content review*—i.e. to gauge the relevance, quality and impact of the test questions—and *student profiling*.

The featured DEPE service is developed through a collaboration with high school teachers affiliated with premier secondary institutions in Malaysia.

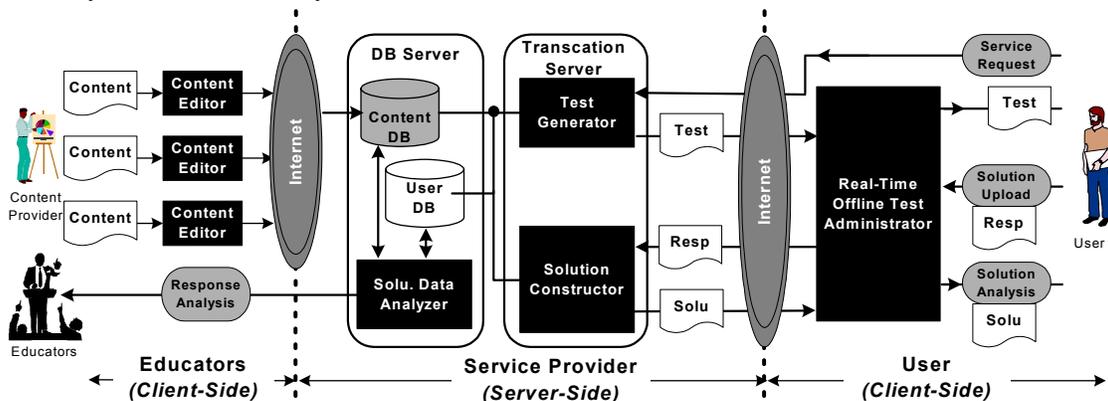


Figure 1. The functional architecture of the DEPE service. Information exchange is realized via XML document objects, whereas the functional modules are implemented using Java technology.

### 2.1. Content compilation

Collaborative content compilation involves the authoring and collation of tuition/evaluation material—i.e. preparatory exercises, tests, solutions and explanations—from nation-wide secondary-level educators [5].

The content representation scheme distinguishes each singular test/exercise in terms of its origin (i.e. school at which the test was administered); date of administration; subject; class level; type (exercise, test or final exam), coverage (i.e. single/multiple chapters); topic(s) covered; duration and number of questions.

We have developed a generic Windows-based client-side content compilation application, downloadable from the DEPE server (subject to DEPE service provider approval). The content compilation application features: (a) electronic forms for providing the above-mentioned test-identification information; (b) a question specification GUI—enabled with multimedia and mathematical formulae inclusion facilities—to provide the question text, multiple solutions, the correct answer, hints, difficulty level and some relatively difficult answers for enhanced testing options; (c) a specialized

## 2. Functional Description

The functionality of the DEPE service focuses to support secondary-level students in the undertaking of real-time tests, with particular emphasis on long-term scholastic support and corrective measures. The DEPE solution is derived via the fusion of educational content compilation, test administration mechanisms and student profiling methods—each aspect has been addressed at a modular level. We explain below the functional workflow of the DEPE solution as illustrated in Figure 1.

XML based content representation format; and (d) an Internet-based content upload mechanism to directly send the compiled content to the DEPE service provider, for eventual down-load to the content DB maintained by the service provider.

Prior to storing the content into the content DB we (i) perform terminological standardization—necessary since the content is pooled from diverse sources—based on a subject-specific thesaurus; (ii) maintain a glossary of keywords to facilitate future glossary based search; and (iii) establish both inter-topic and intra-topic relationships with existing content to facilitate both personalized and group based test construction.

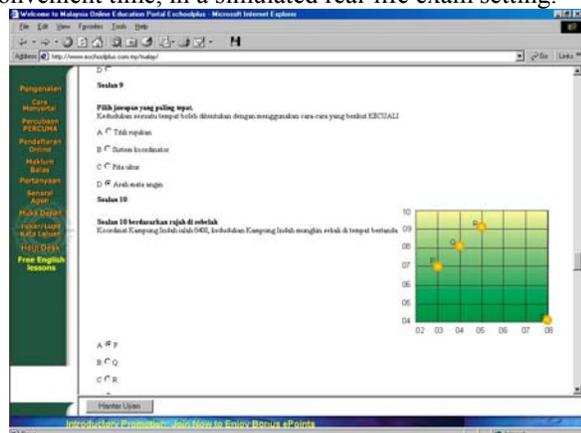
### 2.2. Real-time test administration

An operational session is initiated by a service request by a registered user, i.e. access to the DEPE service website, which triggers the following server-side functionalities: (a) *Personalized Test Construction* (PTC) and (b) *Remote Test Management* (RTM). The DEPE service offers three options for PTC:

- 1) *Pre-designed Tests* that the user can undertake.

- 2) *Customized Test* that the user can dynamically design based on the following parameters: topic(s) to be included, single or multiple origin, test currency (a date range), difficulty level and test duration.
- 3) *Guided Test* whereby the DEPE system advises the user, based on observed test performances, to focus on specific topics and in turn designs tests aiming to rectify the noted academic shortcomings.

The dynamically designed 'test document'—a HTML document (see Figure 2)—is transmitted to the requesting user who can subsequently undertake the test, at any convenient time, in a simulated real-life exam setting.



**Figure 2. A sample screenshot illustrating a test question with graphics and multiple choice answers.**

Note that for operational efficiency reasons we do not necessitate continuous dial-up Internet connectivity with the DEPE service provider—live Internet connection was deemed impractical as a test can last from 30-180 minutes and a dial-up Internet connection for such a long duration is not only costly but also the connection's QoS cannot be guaranteed. Rather, as soon as the test document is downloaded the dial-up Internet connection is automatically terminated and subsequent test administration is carried out in an offline mode at the client-side. The downloaded test document is initially 'sealed' and is activated—i.e. the test content becomes visible and the test timer starts—when the user agrees to start the test.

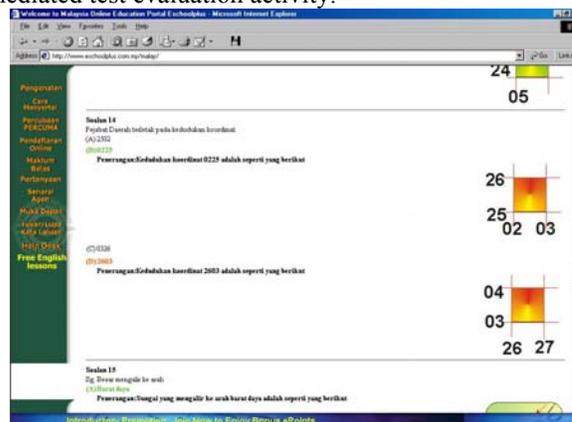
Initiation of the test activity by the user, prompts the client-side RTM process that involves:

- a) Test time regulation via a timer embedded in the test document—the timer is non-alterable even if the system clock is modified. The timer regulates the stipulated test duration and disables the test GUI at the expiry of the test duration, akin to a real-life exam environment.
- b) User assistance in terms of hints, partial elimination of the solution options and provision to continue the test even after expiry of allocated time, all at the expense of reduced credit.

- c) Capture of the user's responses, as an encoded response string, at the expiry of the allocated test duration. Initially the response string is internally stored, but is automatically up-loaded to the DEPE service server once a dial-up Internet connection is established by the user.

### 2.3. Solution construction and response analysis

The solution construction process is primed via the establishment of a dial-up Internet connection, following which the response string is automatically re-directed to the DEPE service provider to commence the system-mediated test evaluation activity.



**Figure 3. A test solution (correct answers in green & incorrect ones in red color) with explanations.**

Upon receipt of the response string the DEPE system:

- a) autonomously evaluates the user's test response as recorded in the response string.
- b) generates a solution document comprising test evaluation, explanations, performance indicators and future preparatory suggestions, as shown in Figure 3.
- c) pro-actively 'pushes' the solution document to the user over an active Web channel.

Review of the solution document can again be executed offline, whereby the user can (i) select detailed explanations of his/her responses; (ii) view his/her longitudinal performance record; (iii) compare his/her performance with cohort student responses; and (iv) follow-up the system-generated study recommendations.

### 2.4. Student response analysis

The efficacy of the DEPE service largely depends on both the effectiveness of the compiled tests/exercises and the pro-active identification of the academic needs of various student segments. To meet this end, a data-mining agent—featuring OLAP, rule-association and clustering algorithms—is implemented to 'mine' population-wide student responses to effectuate detailed analysis of:

- a) Population-wide student profiles as the basis for formulation of an individually focused programs

- emphasizing areas in which the user has either already tested or is anticipated to test poorly.
- b) Difficulty level of each question and inductive grouping of questions into different difficulty levels.
  - c) Effectiveness of a set of questions if presented together, i.e. whether a certain set of questions if presented together lead to better understanding.
  - d) User response patterns i.e. whenever a user correctly responds to question  $x$  then he/she also correctly responds to question  $y$ .
  - e) Inductive derivation of topic-specific association across different questions.
  - f) Students performance across different schools, regions or states.
  - g) Performance over different types of questions, for e.g. fundamental, problem-solving, analytical, etc.
  - h) Inductive grouping of students, based on a variety of criteria, whereby each grouping depicts a particular perspective of the student population.

### 3. DEPE Service Solution Architecture

Our technology-enriched DEPE service solution emphasizes document-centric client-server computing, featuring extensive use of XML as the underlying information exchange construct and Java technology for system functionality. Server-side modules are responsible for populating the content repository, test construction and evaluation, student performance analysis and student response analysis. The client-side modules provide remote test administration, delivery of the completed test to the server and viewing of the solution document.

To support content compilation we have developed a client-side Java based content editing application. The content compilation and submission solution is based on nested definition of problem/solution XML objects that can be conveniently transferred over the Internet. The compiled content sent by the educators is subsequently inserted into an Open DB Connectivity compliant data repository, in our case a MS SQL server.

Server-side activities are programmed as Java-based transaction-specific *servlets*. Client-side test-administration, necessitated by the offline functionality, has been realized via the rich Javascript programmability of the browser-client (embedded in the test/solution document). Our DEPE service solution has been designed to be flexible with anticipated development of solution variants featuring: (1) email-based delivery, and (2) Personal Digital Assistant (PDA) based test administration/review. Both variants are made possible by the basic offline functionality of the original Web-based solution. A PDA based solution would be especially attractive given the greatly reduced unit price and physical bulkiness; and the increasing acceptance of

these prototypical IA for limited-interactivity document processing such as would be the case for undertaking multiple-choice evaluation tests.

### 4. Concluding Remarks

We believe that the DEPE service augurs well with the competitive nature of Malaysian formal education, with good performance in the centralized examinations being a key determinant for professional advancement. The significantly large registered user-base suggests that the ubiquitously available service is well received by both students and educators, as it provides:

- a) Access to exam preparatory material of relatively high quality and in relatively substantive quantities to students disadvantaged by their physical location.
- b) Offline test execution and solution review facilities, thereby dispensing the necessity for continuous Internet connectivity which most students usually find expensive and infeasible.
- c) Back-end content and student response analysis to assist educators to moderate content and to enable identification areas of scholastic weakness.

The featured solution has been developed on behalf of and deployed by a distance learning service provider, accessible at [www.eschoolplus.com.my](http://www.eschoolplus.com.my). Anticipated future developments include development of glossary-based searching of the content DB, PDA based functionality and use of peer-to-peer technology.

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