METIS: A Multi-faceted Hybrid Book Learning Platform

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ABSTRACT

Today, students are offered a wide variety of alternatives to printed material for the consumption of educational content. Previous research suggests that, while digital content has its advantages, printed content still offers benefits that cannot be matched by digital media. This paper introduces the Meaningful Education and Training Information System (METIS), a multi-faceted hybrid book learning platform. The goal of the system is to provide an easy digital-to-print-to-digital content creation and reading service. METIS incorporates technology for layout, personalization, co-creation and assessment. These facilitate and, in many cases, significantly simplify common teacher/student tasks. Our system has been demonstrated at several international education events, partner engagements, and pilots with local universities and high schools. We present the system and discuss how it enables hybrid learning.

Keywords

Hybrid Learning; Printing; Automated Publishing; Education

1. INTRODUCTION

With the advent of portable devices such as tablets and e-readers, reading online content for educational, learning, training or recreational purposes has become a very popular activity. Compared to printed material, readers of digital content are offered several levels of interactivity. For example, digital content allows more interactive and collaborative learning, users may read additional or supplementary online content related to a specific part of the e-text that they have difficulty understanding or wish to explore more; they can add annotations; zoom-in on a picture, or play a video embedded in the content. Despite these advantages, printed media still provides other benefits that cannot be matched by digital [3]. Some of the advantages of printed material include: 10-30% faster reading rate [9], lack of distractions, no device compatibility or Internet connection issues, cost effectiveness and, most importantly, the fact that print is still the medium preferred by the majority of students [8]. Instead of eliminating these benefits, we believe that learning should be based on print and enhanced by the use of technology, rather than replaced by it.

To leverage the benefits of reading of both printed and digital content and provide further enhancements to the reading experience, we present METIS, a multi-faceted hybrid book learning platform with the following advantages:

- As an integrated system, METIS provides an easy digital-to-print-to-digital book creation and reading service, which leverages the benefits of learning with both media types
- Using its inbuilt layout engine, METIS automatically lays out and paginates the content, ensuring a publication-quality appearance
- Everyone learns differently. To provide the most appropriate reading content for each student, the system offers a personalized book generation service that adapts to each individual’s learning profile
- Interactive book enhancement is another benefit of METIS, which offers readers multiple content interaction, exploration and annotation capabilities
- METIS has the capability to automatically extract key concepts from each book chapter. Readers are able to define the relations among these concepts and receive reviews and comments from other peer readers. Such comments and reviews may further help the reader and enhance the book reading experience

2. HYBRID BOOK GENERATION

We provide several functions to help users to generate their own books in METIS, where they have the ability to define the book title, select the cover image, automatically generate the book index and table of contents, etc. In this paper, we will focus on a few advanced book generation features that enhance the book reading experience in multiple facets: layout, personalization, co-creation, and assessments. We also refer the reader to the live demonstration of METIS.

2.1 Automated Book Layout

The layout framework is one of the core components of the METIS system. The input to the layout framework is a stream of content, which is composed of text, images, and other multimedia elements that need to be laid out. Given this input, the layout
framework produces a static, paginated layout of the content, which is output both as PDF for print and HTML for on-screen print preview. The HTML preview additionally includes UI elements that permit interaction, such as the TOC, images, page flipping, page scrolling, drag-and-drop content, overlay content and external side-bars.

In the current version of the METIS system, we have integrated two automated layout engines. The Aero engine [13] leverages native web browser rendering to rapidly render content and apply scoring functions. The JPDM engine [4] uses a probabilistic document model for matching content on templates.

A book is generated by the teacher or instructor as follows: (1) The user searches, filters, and selects content, (2) The user selects a layout engine and customizes its execution, (3) The layout framework merges the selected content and provides it to the layout engine, (4) The layout engine generates the online (HTML) and print (PDF) versions, which are stored in the user’s account.

### 2.2 Personalized Book Generation

Everyone learns differently. Providing the learning content that best fits each individual learner’s learning profile is a challenging and important task. Traditionally published content fails to consider this aspect of learning, and provides every learner the same core content (e.g. workbook) and resources. This results in reduced learning efficiency and can result in the learner losing interest.

METIS makes use of a new concept to generate personalized books for an augmented learning experience. This also keeps the core content identical from student to student, but provides different supplementary learning resources based on each reader’s learning profile. In the current system implementation, we consider three attributes defined in Table 1 to describe each reader’s learning profile, which could be further expanded in the future. In the table, “Affinity” denotes various media formats, “Attention span” denotes the length of concentration while reading and “Complexity” indicates the reading skill of each learner. Also, although our system has the ability to create a personalized book for each individual, we currently generate 6 book types (1-6) and assign each reader to the most appropriate book type based on her profile. The purpose is to optimize the usage of computing and storage resources. This trade-off is especially helpful in cases with a high volume of readers.

In the current system, each newly enrolled reader is first assigned a default profile and a corresponding book type. While they continue reading in our system, their learning profiles are dynamically updated. Using the new profile attributes, the system will automatically recalculate and assign the most appropriate book type periodically.

### 2.3 Enabling Co-Creation

In general, readers make annotations to record information that they will need to learn/review at a later time. However, the result of doing so is much more than the production of a passive “external” information store, as the action of creating annotations itself is part of the memorization process and results in the creation of a form of “internal” storage. Furthermore, the creation of annotations eases the load on the working memory and thereby helps people resolve complex problems.

In the METIS reading platform, we provide a novel interactive book enhancement experience in a hybrid learning environment. Our system allows different users who read the same page to create, manage and share their annotations in real-time. These annotations cover different types of learning resources, such as web links, videos, images, comments, articles, etc.

Our system allows users to create annotations at different stages when playing different roles. For example, a user can create the annotations when creating her own reading materials during the content creation phrase; such annotations correspond to the content she wants readers to focus on. On the other hand, a user can also create annotations when she reads the created content as a learner to note any portion that she may wish to emphasize at a later time or share with others for discussion or peer-teaching purposes. We also support editing, deleting, moving, resizing any of the annotations.

### 2.4 Enabling Assessments

Assessing educational achievement and providing feedback to learners is crucial to academic success. METIS enables classrooms and school systems to incorporate concept mapping in formative and summative assessments. Our technology provides two types of automation and support for the wide-scale adoption of concept mapping for assessing student understanding. First, teachers have the capability to embed Q/A to any page. Secondly, METIS has the capability to auto-generate a set of key concepts for each chapter; learners then connect these terms and build a diagram that shows their understanding of how pairs of concepts are related. Furthermore, reviews and comments from other peer learners may help the learner and enhance the reading experience.

### 3. HYBRID BOOK CONSUMPTION

METIS provides a digital and print learning environment for content consumers. It allows them to easily update reading material, make annotations, and obtain additional learning resources that best align with the individual. In this section, we discuss and demonstrate some of the features for content consumption.

#### 3.1 Interactive Book Consumption

As discussed in Section 2.1, a layout framework is used to generate books that can be consumed interactively in the web browser. When a book is read by the student, the cached version of the previously laid out book is retrieved together with the additional UI elements required for content interaction. When the interactive elements are updated, these are stored and associated with the book.

Figure 1 shows two screenshots of the interactive book consumption UI displayed in the web browser. The two screenshots show the

<table>
<thead>
<tr>
<th>Book Type</th>
<th>Affinity</th>
<th>Attention span</th>
<th>Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Video</td>
<td>10 min</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>Video</td>
<td>20 min</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Wiki</td>
<td>10 min</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>Wiki</td>
<td>20 min</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>Video &amp; Wiki</td>
<td>10 min</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>Video &amp; Wiki</td>
<td>20 min</td>
<td>25</td>
</tr>
</tbody>
</table>

Table 1: Personal Profile Attributes
same content rendered using two different layout engines. Additionally, the screenshots also display various UI elements to enable interactive consumption. These elements are: (1) Automatically generated table of contents (left side), (2) Scroll bars (next to book pages), (3) Automatically generated table of images (center), and (4) Notes sidebar (right side, discussed below). Also available, but not shown in the figure, are the mouse and keyboard interactions used to navigate the book.

The user can interact with the notes sidebar by dragging and dropping. Content can be selected from the page and dragged on to the notes sidebar to create a note. The selected content can contain text or other multi-media elements. Once on the notes sidebar, the copied content is fully editable. Colored markers are used to match the note to the location where the text was originally selected on the page. Additionally, sections can be used to organize the notes, and notes can be ordered using different criteria. Finally, note collections can span across books, and a note-only view (with printing options) is also available.

3.2 Personalized Book Consumption

The personalized book can be made available in both print and/or digital formats. The core content is identical for every reader; the HP LinkReader app enables readers to access additional supplementary learning material digitally by scanning the printed page. The reader is then led to customized learning resources that best fit each individual profile (see Fig. 2). When using the digital version of the core content, the “extra content” feature of the METIS reader interface can be used to access this supplementary material.

![Figure 2: Personalized learning with HP LinkReader](image)

The METIS reader interface is shown in Figure 3. Book type 1 is assigned to the reader in this example based on her reading profile. Supplementary learning resources allocated to this type of reader will appear in a pop up window after clicking the icon in green rectangle as illustrated in Figure 3.

For a more immersive experience, we have also developed a METIS client for the HP Sprout computer, which uses the inbuilt projector to project the supplemental content on top of the physical printed book. Due to space limitations, we refer the interested reader to our video demonstration.

3.3 Co-Creation Experience

The embedded annotation resources that are created in section 2.3 by the book creator are available to all readers. In addition, different users who read the same page can create and share their annotations with others. This allows for a real-time co-creation experience.

3.4 Interacting with Assessments

METIS provides two types of assessment modules: assessments created by the content author and concept map based peer-review assessments. Assessments created by the content author appear in the right sidebar (see Figure 3, orange-dashed rectangle). Readers can answer these embedded questions and submit their answers by pressing the “Submit” button. A notification is automatically sent to the teacher.

For concept map based peer-review assessment, we first automatically extract key concepts for each book chapter; readers can then access such concepts at the end of each chapter to perform the
4. EVALUATION

To evaluate the system, we conducted group studies with students and teachers from high schools and universities involving four types of subjects: college students, college teachers, high school students and high school teachers. All these groups of subjects come from diverse institutions. The book content and teachers were chosen to cover multiple subjects as well. Students varied in age, grade, gender, and GPA, in order to make our survey more objective. Each study involved 8 persons in a two hour session, with a detailed demonstration of METIS features, followed by an in-depth discussion to identify both successful features and areas for improvement.

This study showed that the platform was well received from both teachers and students. Teachers preferred METIS for the ability to easily customize course materials, the interactivity with paper, the personalization via supplementary content and the recommendation engine for content creation. Students liked the interactivity with other electronic learning resources, the ease in making annotations and the system’s support of students learning together. Furthermore, as the printed books were lighter, their carrying load was significantly reduced. These focus group studies confirmed the effectiveness and value of our hybrid book learning system.

5. RELATED WORK

Automatic document layout has been a topic of much research in the document engineering community [5, 7] and METIS uses a layout framework which can integrate different layout engines. As discussed in Section 2.1, we integrated two different layout engines discussed in [13] and [4], respectively.

Other systems for personalized books [2, 10] generate visually different books for different readers, where the same content is not necessarily presented in the same location for each reader. This affects (1) the teachers, who, when teaching the book in class, need a consistent view of the book and (2) the publishers, who are looking to reduce costs when producing the book. To address these problems, the personalized book technology in METIS uses two categories of content: core and supplemental. The core content is laid out identically in all versions of the book, while the supplemental content is present at predefined locations.

Previous work on book annotation creation [2] has mainly focused on solving individual exercises alone, empowering the student with additional tools to help understand the topic. In the METIS reading platform, we provide a novel co-creation book enhancement experience by allowing different users who read the same page to create, manage and share their annotations in real-time.

To date, most automatically scored assessments use closed-ended questions that are easy to grade, such as multiple choice and fill-in-the-blank types [1, 11]. Open-ended assessments are very revealing and useful to teachers and students, but are generally scored manually. Automating the assessment and feedback mechanisms for open-ended assessment tasks has been especially challenging, and as a result has limited the widespread use of such assessments. In METIS, we provide a novel approach to open-ended assessment, which enables classrooms and school systems to more easily incorporate concept mapping in formative and summative assessments. This active engagement motivates readers/students to think deeper about the topic, brings additional energy to the learning process and has been justified as an effective strategy to learn efficiently and maintain high retention rates [12].

6. CONCLUSION

In this paper, we have presented a multi-faceted hybrid book reading platform to provide an efficient digital-to-print-to-digital book generation and reading service. Our system has features that enhance the book reading experience in multiple facets, including automated book layout, personalized book generation, co-creation and assessments. The system has been demonstrated in international educational events, partner engagement, and pilots with local universities and schools. The reception has been consistently positive.

7. REFERENCES

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3https://www.youtube.com/watch?v=fnEebreN1HI