Actualizing Learning and Teaching Best Practices in Online Education with Open Architecture and Standards

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Abstract: – As the integration of online education into the mainstream of higher education intensifies, maintaining quality, including learning effectiveness, remains a central issue. This paper explores how active learning strategies in the traditional classroom environment may be put into practice for online education using a wide range of open standards and technologies. First, the paper presents an overview of various research-proven learning strategies. Then it presents an array of open technologies and standards relating to learning resources, collaboration and learning experience management, and media markup languages. It discusses how the open technologies and standards may be employed in effecting active learning strategies in online learning and instruction. Furthermore, the paper calls for research into devising appropriate metrics for measuring skills such as team building, effective communication, and interpersonal behavior, so as to facilitate qualitative evaluation of the effectiveness of various learning tools.

Key-Words: - Learning strategies, open technologies, open standards, online learning, collaboration

1 Introduction
In higher education, emphasis is being placed on putting into practice effective strategies that promote desirable learning outcomes and competencies. Thus, the trend continues to shift from traditional teaching methods to student-centered strategies to achieve desirable learning outcomes. As the integration of online education into the mainstream of higher education intensifies, there is perhaps a greater onus on colleges to maintain and demonstrate learning effectiveness of their online programs. This paper shows how learning and teaching strategies that have been shown to be effective in the traditional classroom environment may be put into practice for online learning using a wide range of open standards and technologies. While there is ample choice of educational software products that may be utilized in support of instruction and learning, the task facing any institution of higher learning, or its units, is to put in place the infrastructure that is not only capable of supporting well-accepted teaching and learning strategies but is also robust enough to accommodate technological changes. Therefore, the focus of the
paper is on open standards and open technologies rather than specific products.

Section 2 of the paper presents an overview of research-supported learning strategies for active learning as well as the requirements and challenges of implementing the strategies. Section 3 presents brief overview of an array of open technologies and standards for learning resources, collaboration systems, learning experience management, and multi-media markup languages. It explores how the open technologies and standards—maintained by the Open Knowledge Initiative™ (OKI), the Advanced Distributed Learning (ADL), the IMS Global Learning Consortium (IMS), and various committees of the World Wide Web Consortium (W3C)—may be employed in effecting student-centered strategies in online learning. In Section 4, the paper shows how the open technologies and standards may be employed in effecting active learning strategies in online learning and instruction. The paper concludes in Section 5 with a discussion on the need for appropriate metrics for measuring skills such as team building, effective communication, and interpersonal behavior, so as to facilitate qualitative evaluation of the effectiveness of various learning tools.

2 Learning and Teaching Strategies
There is a large body of research on Theory of Learning as evident by the number of major theories summarized in the Theory Into Practice database [1]—a tool intended to make learning and instructional theory more accessible to educators. Three major theories of learning—learning as a mental discipline, learning as a response to a stimulus, and learning as a cognitive interaction—have dominated instructional activities in the classroom; but the cognitive-interactionist theory, the most current of the learning theories, seems to offer the most comprehensive explanation of how learning occurs [2]. The cognitive-interactionist theory deems the learner as an active participant in the teaching and learning process; the theory also allows for individual differences in cognitive styles such as learning style preferences. Rooted in the cognitive-interactionist theory, many widely accepted practices promote active learning. Thus, while there is no universally recognized current “best practices” in teaching and learning, there is general agreement that active participation of students in learning process enhances learning. Commonly referenced practices can be found in [3, 4]. This section summarizes research-supported learning strategies for active learning; it also sums up the challenges and requirements of putting the strategies into practice in the online environment.

2.1 Active Learning
Active learning calls for the student’s active, positive participation in the learning process; its effectiveness is based on the premise that learning occurs most when the learner is actively involved in the process through various activities such as engaging in discussions with the instructor or peer, answering questions, writing about the topic at hand, and working on projects in a team. Here, two classes of research-supported active learning strategies—small-group strategies and student engagement and assessment—are presented.

2.1.1 Small-group Learning Strategies
A meta-analysis in [5] shows that the effect of small-group learning on achievement, persistence, and attitudes among undergraduates in Science, Technology, Engineering and Mathematics was significant and positive. Small-group activities have also been found to enhance comprehension of course material [6]. Table 1 depicts examples of small-group learning strategies and techniques derived from many sources [7, 8, 9, 10, and 11].

<table>
<thead>
<tr>
<th>Small-group Techniques &amp; Strategies</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tutorial</strong></td>
<td>Instructor provides stimulus questions which the group should work on before members of the group share and discuss their findings</td>
</tr>
<tr>
<td><strong>Role play</strong></td>
<td>Learners enact scenarios either as role players or recipients in the roles playing</td>
</tr>
<tr>
<td><strong>Brain storming</strong></td>
<td>A technique used for creative requirements where ideas are solicited</td>
</tr>
<tr>
<td><strong>Study group</strong></td>
<td>Learners meet to review material and complete homework assignments</td>
</tr>
<tr>
<td><strong>Problem-based Learning</strong></td>
<td>Learners collaboratively solve challenging real-life problems and reflect on their experiences</td>
</tr>
<tr>
<td><strong>Support group</strong></td>
<td>Learners encourage and support each other and be a source of information for any class missed</td>
</tr>
</tbody>
</table>

Table 1: Small-group Learning Techniques
2.1.2 Student Engagement and Assessment

Studies have also shown that student engagement is linked positively to desirable learning outcomes such as critical thinking, application of skills, and high grades [12, 13, and 14]. By finding ways to get students to take an active role in the classroom, the teacher gets immediate feedback on their level of understanding and comprehension, interest, and misconceptions. The feedback may dictate that the instructor introduce new strategies, provide assistance to students experiencing difficulties or make available enrichment activities for students who have already mastered the concept being discussed. An extensive list of interactive techniques drawn from various sources is provided in [15].

Assessing student understanding is also central to active-learning and student-centered instructional design. Assessments allow the instructor to gather information to guide the adjustments both instructors and learners need to make to improve learning. An editorial in Science Scope [16] emphasizes the importance of assessment and monitoring of student engagement; it states that assessment should be used before, during, and after concept instruction, and monitoring student engagement and behavior should be the easy part of teaching—one that is done constantly during each lesson. Studies have found that frequent assessment was associated with better student performance and greater retention of course concepts [17]. The use of guided or interactive notes has also proven to be an effective strategy; a study in [18] reports improvement in note quality when guided notes are used. Other studies have shown improvement in test scores and recall of lecture material with the use of guided notes [19, 20]. Table 2 presents examples of strategies and techniques for assessing and eliciting student engagement.

### Table 2: Engagement and Assessment Techniques

<table>
<thead>
<tr>
<th>Student Engagement Techniques &amp; Strategies</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Classroom Opinion Polls</strong></td>
<td>Instructor gets a sense of learners’ opinion before a controversial subject</td>
</tr>
<tr>
<td><strong>Quote Minus One</strong></td>
<td>Instructor provides a quote relevant to current topic but leaves out a crucial word and ask students to guess what it might be</td>
</tr>
<tr>
<td><strong>Guided notes or interactive notes</strong></td>
<td>Instructor provides note sketch with spaces to be completed by students</td>
</tr>
<tr>
<td><strong>Documented Problem Solutions</strong></td>
<td>Instructor records the steps needed to solve specific types of problems. Students perform similar steps for same class of problems</td>
</tr>
<tr>
<td><strong>Make Them Guess</strong></td>
<td>To build curiosity before a new subject is introduced, instructor asks an intriguing question and accepts blind guessing for a while before giving the answer</td>
</tr>
<tr>
<td><strong>Background Knowledge Probe</strong></td>
<td>Before a new topic, determine how much learners know about the topic using questionnaire (multi-choice or short answer)</td>
</tr>
<tr>
<td><strong>Frequent Assessment</strong></td>
<td>Frequent quick quizzes and assigning short journal entries</td>
</tr>
</tbody>
</table>

2.1.3 Requirements and Challenges of Implementing Active Learning Strategies

The active learning strategies presented in the paper fall into two categories: small-group techniques most of which takes place outside the classroom and the mostly in-class techniques for engaging the learner. Implementing small-group strategies requires student training; the instructor should not make the assumption that students will know how to interact in groups. An article [21, 22] on restructuring the classroom for productive small-group activities, “...found relative effectiveness of structuring the interaction within groups by telling students what to say, providing them with explicit roles, or by teaching them strategies for discussion.” There are also other pertinent requirements that must be met in order to implement small-group strategies effectively, among them are the following derived from [8, 21, and 22]:

- Facility for group sessions where participants can see and interact with each other
- Defining and modeling the roles to be played by students
- Providing a script of the interaction where applicable
- Having enough trained staff to facilitate the groups
- Managing the interaction among the learners
• The instructor must have an efficient way of keeping a record of the feedback from students.

The requirements become even more challenging in an online learning environment.

3 Open Standards and Technologies for Learning

The Open Knowledge Initiative™ (OKI), the Advanced Distributed Learning (ADL), the IMS Global Learning Consortium (IMS), and various committees of the World Wide Web Consortium (W3C) represent the leading organizations concerned with open standards and technologies for collaboration and learning. OKI has defined an open and extensible architecture for learning technology specifically targeted to the needs of the higher education community. ADL is the custodian of the Sharable Content Object Reference Model (SCORM) [23, 24, 25]—a technical framework to foster creation of reusable learning content through a harmonized set of guidelines, specifications and standards—while IMS oversees the development of interoperability specifications for learning technologies. Together, these organizations define specifications for components that an organization may use to build a robust infrastructure, even in the face of technological advancements.

3.1 Standards for Learning Resources

A learning resource is any representation of information that is used in a learning experience, and SCORM provides Content Aggregation Model (CAM) as a way for designers and implementers of instruction to aggregate learning resources for the purpose of delivering a desired learning experience. CAM allows the instructional designer to describe a collection of basic units of learning resources and the different ways in which the basic units will be organized to provide a variety of learning experiences. The power of CAM lies in the fact that it allows the same collection of learning resources to be referenced and used in multiple learning experiences (in the model, a learning experience is referred to as an organization). By defining a common language, CAM allows learning content to be shared because any system that conforms to the standards knows how to handle SCORM-conforming content.

3.1.1 Content Aggregation Model

At its core, SCORM enables content to be shared through CAM which is made up of:

• **Content Model** (from Aviation Industry CBT Committee—AICC): nomenclature defining the content components of a learning experience
• **Content Structure & Packaging** (from IMS Global Learning Consortium, Inc.): defines how to represent the intended behavior of a learning experience (Content Structure) and how to aggregate activities of learning resources for movement between different environments (Content Packaging)
• **Meta-data** (from EEE Learning Objects Metadata 1484.12): a mechanism for describing specific instances of the components of the content model
• **Sequencing and Navigation** (from IMS Global Learning Consortium, Inc): a rule-based model for defining rules that describe the intended sequence and ordering of learning activities

The components of a learning experience—Assets, Sharable Content Objects (SCOs), and Content Organization of Activities and Resources—are defined thus:

**Assets** (basic form of a learning experience that do not communicate with the Learning Management System (LMS)): Assets are electronic representation of media that can be rendered by a Web client and presented to a learner. Examples of assets are JavaScript functions, WAV audio, JPEG image, Web page, and Flash object.

**SCOs** (the lowest level of granularity of a learning resource that is tracked by a LMS): A SCO is a collection of one or more Assets representing a single launch-able learning resource that communicates with a LMS.

**Content Organization** is a map that represents the intended use of the content through Activities (i.e. structured units of instruction); a map shows how Activities relate to one another.

Thus, central to SCORM are the concepts of sharable content, rules which describe the intended order and sequence of activities of learning resources, communication between a learning resource and the Learning Management System (LMS) mainly through exchange of values used in evaluating...
sequencing rules and tracking learner experience, and metadata for search and discovery.

3.1.2 SCORM Content Packaging and Metadata
Content organization provides the content developer with the means to specify cohesive units of instruction that reference collections of learning resources. A unit of instruction is a hierarchy of learning activities for which specific behaviors and rules may be attached in such a way that the activity structure and the associated behaviors can be reproduced in the runtime environment of any SCORM-conformant LMS. With specific rules and behaviors attached, the content organization becomes a guide that prescribes how a LMS must manage the learner’s experience and make use of the learning resources. In the absence of specific rules, the content organization is more like a table of contents which may be used to navigate at will through the learning resources in a content package.

A Content Package contains two major components at the top level—a special XML file (called manifest file) describing the content structure, together with the associated resources, and the physical files that make up the content package. The Content Aggregation metadata describes the content aggregation (i.e., the content package) as a whole at the manifest level, but metadata is also required at every other level in the hierarchy (Organization metadata for organizations, Activity metadata for activities, SCO metadata or Asset metadata for resources, and File metadata for physical files). A learning management system through the metadata gives the learner information about the content organization (i.e., courses, lessons, modules, and so on).

3.1.3 Sequencing in SCORM
Through Sequencing, SCORM enables delivery of learning activities to be tailored to individual learners based on their actions or performance at the time of delivery. Sequencing behaviors are not associated directly with the learning resources so that the resources can be used or referenced by multiple activities. The learner traverses the content in one of two modes: User Choice (learner chooses activity in any order) or Flow (learner goes to “next” or “previous” activities where next or previous activity is determined by the system). A key concept in Sequencing is the use of Objectives to model sequencing behaviors. Objectives are variables which are used in sequencing rules and the values of which are set as the learner progresses through learning activities. Every activity has a primary objective (mapped to the Progress, Completion, and Satisfaction of the activity) and zero or more secondary objectives. The learning activity in figure 1, taken from [26], shows the use of sequencing objectives to provide remediation to a learner.

![Remediation Using Objectives](image)

**Figure 1: Using Objectives in SCORM**

In the figure (Figure 1), the learner goes through Lessons 1 and 2 then takes Assessment, which sets the Satisfaction Status for Obj_1 and Obj_2, respectively, after the learner has completed the two test items. The rules are evaluated to determine the learner’s next course of action— he exits the module if both objectives Obj_1 and Obj_2 are satisfied, otherwise he goes through Lesson 1 (if Obj_1 is not satisfied) and/or Lesson 2 (if Obj_2 is not satisfied).

The power of SCORM content comes from the capability to define organizations of activities (multiple uses of same collections of resources) and being able to attach conditions to activities. With the sequencing rules, the content developer may choose to structure the content organization as an adaptive guided path / Delivery of learning content through a learning experience, invoking learning resources only if and when they are needed. The capabilities of SCORM (derived from being able to define organizations of activities and to attach rules and behaviors to activities) have strong implications for assessment of student knowledge, tailoring of content to match individual skill levels, and remediation.

3.2 Multimedia Markup Languages
Over the years, the W3C has specified a number of standards for describing various types of media in Web-based applications. This section describes
media markup standards and IMS specification for exchanging questions, tests, and result data between learning systems.

3.2.1 Synchronized Multimedia Integration Language (SMIL)
Synchronized Multimedia Integration Language (SMIL) is a standard for expressing media synchronization of objects of various media types. SMIL [27] is a HTML-like language and SMIL presentations may be specified using a simple text-editor. The capability of SMIL which allows for creation of web based presentations that integrate audio, video, images, text or any other media type makes it applicable to many learning techniques.

3.2.2 Timed Text Specification
Timed Text is textual information with associated timing information. Typical applications of timed text include real time subtitling of foreign language media and captioning. The W3C Timed Text Working Group published a candidate recommendation of Timed Text Authoring Format-Distribution Format Exchange Profile [28]. One application of Timed Text is in the replacing of audio narrations and instructions with Timed Text.

3.2.3 Pen Input and Multimodal Interaction
The Ink Markup Language [29] was proposed by the W3C Multimodal Interaction Activity [30] to serve as the format for representing ink data entered with an electronic pen or stylus. The markup allows for the input and processing of handwriting, gestures, sketches, music and other notational languages in Web-based (and non Web-based) applications. The primitives of InkML permit ink data to be organized in a variety of ways, including as Archival InkML, which allows documents to be stored for later retrieval or processing, and as Streaming InkML, where ink data may be transmitted in real time as applications exchange ink messages. Unlike today’s collaborative whiteboards, which typically use complex or closed protocols for communication and are not interoperable across multiple platforms and do not support archival of collaborative sessions for later reference, InkML represents digital ink in a form that allows both transmission and higher-level semantic analysis [31]. Direct application of Ink data and InkML in teaching and learning includes storage and processing of dynamic handwritten notes. Using dynamic handwritten notes (i.e., notes where the actual trace of the written characters is shown), rather than static notes, allows synchronization of notes with audio narration and other media.

The Extensible MultiModal Annotation markup language [32] is another specification that finds application in learning; it is a language for representing the semantics of user input which may originate from various media and devices—acoustic (microphone), tactile (keyboard, mouse, pointing device, pen, etc.), and visual (scanner, still camera, video camera).

3.2.4 IMS Question & Test Interoperability Specification
The IMS Question & Test Interoperability [33] describes a data model for representing question and test data and the corresponding results in reports. The specification facilitates the exchange of question, test, and results data between authoring tools, question banks, test constructional tools, learning systems, and assessment delivery systems. Tools based on the specification allow the instructor to create online assessments (i.e., tests, quizzes, and surveys) for delivery via a web interface to learners. The QTI specification and tools make it easier to obtain and analyze feedback from students in the classroom or online. QTI Tools may also be used to produce guided notes.

3.3 Open and Extensible Collaboration Environment
Institution of learning have always faced the challenge of building a CLE in which a wide range of learning best practices are supported and the institution concerned is insulated from technological changes. In response to the challenge, OKI has defined architecture (i.e., framework) for how software components can be assembled to meet these requirements and other needs of the higher education community.

3.3.1 The OKI Framework
The OKI architecture is based on the approach that specifies what services are needed and how software components can reference and provide or use those services—without any reference to the specific technologies used to implement a service. The approach—of organizing systems around services—is referred to as Service-Oriented Architecture (SOA). The OKI architecture is based on service descriptions (called Open Service Interface Definitions (OSIDs)), that are intended to be consistent well beyond the life-time of the specific
technology used to implement the services. Applications that acquire a service do so through the OSIDs, which should not change when a new version of the service is installed. The OKI/OSIDs [34] insulate the applications making use of the services so the service provider can easily be switched.

3.3.2 Open and Extensible CLE
A central system that implements a SOA framework provides a basis for building a flexible and robust collaboration and learning environment. Sakai is an example of an open and extensible framework which provides basic capabilities to support a wide range of tools and services; it is a realization of the O.K.I.’s Service-Oriented Architecture. The Sakai Project is a community source software development effort to design, build and deploy a collaboration and learning environment for higher education. The Sakai framework is suitable for use as a learning management system and small-group collaboration system. Institutions should select tools and modules capable of communicating with the central system through calls based on OKI/OSID specifications. The Campus Project [35] is a good example of how to build an open and extensible system for e-learning.

3.3.3 Open Tools
In addition to the basic or central learning and collaborative system, acquired tools should conform to IMS Tools Interoperability Guidelines (TI) [36]. TI provides a framework that allows tools to easily integrate into a CLE; this enables the LMS to present the external tools side-by-side with its native learning tools. For instance, Sakai CLE has a TI implementation—IMSTI.

4. Implementing Active Learning Strategies
An OKI-based CLE should be the base infrastructure for implementing active learning strategies because most of the techniques require group collaboration and management. Moreover, the OKI’s architecture protects the adopting organization from changes in technology. Sakai CLE is an example of a system that realizes OKI’s framework; it is suitable for use as a learning management and small-group collaboration system. An OKI-based CLE with basic tools and external tools offered through IMS Tools Interoperability specifications facilitates management of group activities. The infrastructure would allow instructors to setup worksites for respective groups, communicate with groups through announcements and postings, provide forums for group discussions, manage groups, and use document routing to track group work.

4.1 Implementing Small-group Learning Strategies for Online Education
A number of the open technologies may be adapted to implement small-group strategies for online education. For example, learning resources and stimulus questions may be provided with the following:

- Worked-out examples using dynamic handwritten notes and audio narration (SMIL/InkML/Timed Text)
- Tailored stimulus questions (using SCORM content with sequencing and navigation rules to direct discussion)
- Recorded class sessions for after-class review (OKI CLE / SMIL/InkML/Timed Text)
- Mini-lectures tailored to groups with captioning using Timed Text instead of audio devices

4.2 Implementing Student Engagement Strategies for Online Education
Student engagement techniques, which are mostly for the classroom, requires ingenuity if they are to be applied to synchronous and asynchronous modes of online learning. Some of the challenges to be overcome include the following:

- Getting immediate feedback on the learners’ level of understanding and comprehension or misconceptions
- Performing frequent assessment so as allow the instructor to gather information to guide the adjustments learners need to make to improve learning
- Instituting a mechanism for monitoring of student engagement in the both the synchronous and asynchronous modes of learning
- Using guided or interactive notes in the both the synchronous and asynchronous modes of learning

Let us consider one scenario where the instructor would like to perform assessments frequently and get feedbacks, so as to adjust learning activities for the learner. Tools that are based on the QTI specification allow the instructor to create online assessments (i.e., tests, quizzes, and surveys). Using SCORM-
conformant content and the sequencing feature of SCORM, the instructor is able to develop learning activities that are tailored to individual learners based on their actions or performance as the learners go through the resources. The Objective feature of SCORM captures the feedback, and the rules, taking the Objective values as input, directs the learner accordingly.

5. Conclusion
A variety of open technologies and standards have been proposed as candidates for meeting challenges of implementing established active learning strategies. While some of the technologies are already mature, others are in the early adoption stages. The W3C Multimodal Interaction Framework and the Extensible MultiModal Annotation markup language, for example, hold a lot of promise for the development of highly interactive learning resources for demonstrating conceptual, physical, natural, or mathematical systems, but commercial implementations of multimodal interfaces are only beginning to emerge.

It should also be noted that there are many commercial products (e.g. learning management systems, web conferencing software, and interactive whiteboards)—some of which are based on open standards—that are being employed in support of teaching and learning. However, for the institution that wishes to build a robust environment in support of learning and, the OKI’s open and extensible architecture, the open standards (OKI, W3C, IMS, and SCORM standards), and the related technologies offer cost-effective alternatives.

As the adoption of the open technologies begins to intensify, research studies would be required to establish their effectiveness as tools for supporting various teaching and learning strategies. Skills such as team building, effective communication, and interpersonal behavior are desirable; however, devising appropriate metrics for them still poses a challenge. Thus, more work is needed in devising effective ways of observing, assessing, and evaluating the interaction in groups.

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