The AOLA Framework for e-Learning in Mathematics Education

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Extended Abstract

1. Background

The concept of AOLA (Author-Once-Learn-Anywhere) is not new. A published mathematics textbook basically ensures anyone can learn from the same materials that are written (authored) once[1]. E-Learning is enabled by technology that brings the learning experience in an electronic environment. The Web plays a pivotal role in facilitating a standardized way of representation and presentation, and promoting the ease of use with a common browser interface. A website that teaches how to cook can be an example of AOLA e-Learning, completed with multimedia enhancement. The learning experience could be enhanced if online interactive cooking exploration is facilitated.

When this AOLA e-Learning idea is extended for Mathematics Education (ME), the mere creation of a website is not sufficient. The exploration element is missing in general. Exploration in ME should be supported by "dynamic mathematics." Such content should be *accessible* independent of the electronic environment of the learner, preferably via the Web, and *viewable* and *explorable*. Furthermore, teachers should be operating in the same electronic environment in their preparation of instructional materials such as lessons (e.g. as e-Activities), exercises, and tests, etc. That is, the learning, exploring and assessing environment is common to all the participants.

Of course, exploration can be assisted by currnet mathematics software systems – the AOLA concept is intact within the software system environment. Similarly, individual self-contained mathematics applications can be accessed via the Web. For example, applications developed in Flash/Shockwave[2] have been successfully used by educators in bringing interactivity to the learning environment of students[3]. The word 'mathlet', in here, taken in meaning as a small mathematics computational engine that provides usually one single function capability, has been also used to label mathematics applications written in Flash or in Java[4]. Inherently, as the word 'applet' implies, these mathlets can take a presence within a Web browser, deliverable via the Web. The 'LA (Learn-Anywhere)' element will be completed as these 'mathlets' can be *discovered* – how to find them and seamlessly incorporate them individually into lessons. Taking the open-source idea, development with reference to 'osslets' (Open Source, Sharable Mathlets) – a NSF (National Science Foundation) supported project, may be helpful in the integration of these mathlets into lesson plans.

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[1] E-books provide an easy avenue to reference materials of the book in an electronic environment.
[2] Shockwave has a root in 'Director' software, while Flash is a programmable alternative to enable animation for the Web
[3] 'Mathlet' offered in http://www.joma.org – the Journal of Online Mathematics and its Applications (JOMA); number of articles from past ATCM conferences
[4] For example, "Java Applets for Math Explorations" in http://cs.jsu.edu/mcis (Jacksonville State University, Alabama)

Thus, AOLA is very much now in practice by educators – as also evident by scholarly presentations of ATCM conferences over the years. The individual approaches are novel in enhancing the learning experience. Yet it is a challenging task that requires contributions from many professional areas to bring these experiences into a common environment, enabling sharing and learning for ME. Here are a few areas that we need to face when we begin our work:

- The computation specialty is embedded within the defined environment – limits collaboration
- AO does not imply LA as the dynamicity only is guaranteed if the computation engine exists in the same user environment – limits exploration
- AO not reusable, thus e-Activity can not be shared indiscriminately – limits scholarly exchange
- A community platform to facilitate the AOLA experience is missing – limits sharing capabilities and ease of use
- Enjoy by all without special training other than Web-aware – enable openness

Each of the topics above (and others) requires more investigation with respect to the AOLA framework. We will provide some observations next to help establish the important AOLA framework for e-Learning in ME. One of the key elements of this framework is the need for 'dynamic delivery of mathematics content' – leading to the special session II in ATCM conferences – global opinions are sought.

One notable effort that we could learn from is the Web-based Mathematics Education (WME) framework[5] proposed and is in development. Authors (e.g., teachers) will be able to author 'mathematics education pages' using *Madmath* (under development). These pages are represented as MeML, processed by a backend engine, delivered to the users via a transformation process to view in a browser as HTML pages.

2. *Limiting the Scope for the Framework*

We narrow our investigative scope to activity-based learning (as discussed in 2003). That is, learning is defined with respect to an (mathematics) activity, and the exploration within and the assessment required. We are not ready to deal with the more general issues of learning in general, and how to assess students of a subject. It may be similar, but we are not at ease to consider the possibility. We will leave this and others to the experts, and will wait until we establish our proposed framework with sufficient grounding. So, the proposed framework is based on the premise that:

- It is an activity based learning – an activity is defined with respect to the e-Activity example that we discussed in last year corresponding special session.
- The learning and exploring environment is Web-based and Web browser enabled.
- Assessment is also activity-based

We believe that each subject will be introduced in stages, and each stage may take a number of lessons to complete. Part of this belief is inherent from the structure of common education systems, and part of this could be a constructivism approach to learning. Thus, we consider a lecture is an activity, and an activity implicitly brings out the default learning mechanism where interaction is

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[5] P.S. Wang, Y. Zhou, and X. Zou "Web-based Mathematics Education: MeML Design and Implementation," Proceedings IEEE/ITCC, Volume 1, April 2004, 169-175.

assumed most commonly. The e-Learning environment that ties to Web-based could be argued from how the Web can enhance information sharing in one common interface, eliminating any unnecessary switch of context that may interfere with the learning process. Lastly, we are not well understood how best to carry e-Assessment in a controlled and successful manner. This will be investigated later with advise from scholars in this area.

The framework is developed based on the premise that learning in an electronic environment (e-Learning) is enabled and sustained by the intellectual exchange between the students, teachers and technology. Yes, technology can be smartly reacted to the interchange of the parties – the semantics web envisioned by Dr. T. Berners-Lee. The technology plays three different roles:

- Provide the infrastructure for students and teachers to coexist in the same electronic environment independent it is in the teachers' office, students' lab, or at home doing their homework, and to interact online with any other classmates or tutors or teachers
- Provide the students tools to learn and experiment
- Provide the teachers to author and assess work performed

To generalize the requirements that are necessary to support mathematics education in this electronic environment, we identify the following key functional purposes:

- Learn – to gain an understanding or knowledge of
- Explore – to examine further (to enhance the gain)
- Evaluate – to ascertain measurable gain (to provide feedback)

The intersections of these three distinct functions cover other areas that are necessary to facilitate the continuous interaction among students, teachers, and student-and-teacher. For example, the intersection of *evaluate-and-learn* is the assessment exercises that are needed to fairly evaluate the students based on what should have learned. The intersection of *evaluate-and-explore* provides the students and teachers individually to understand how well one understands the topical example, and if the direction is right for students. Similarly, the teacher will gain the exploration and devise help to guide the learner in the right direction and termination point. The intersection of learn-and-explore provides the incentive for students to continue their interests in the concepts. The overall intersection of all three elements completes the examination that is required, their existential relationship is defined for the system.

The AOLA framework supports these functions and provides interactions among the three participants – Teachers, Students and Technology (See Figure 1).

3. *AOLA Framework for e-Learning*

This framework can be characterized by its *adaptive, interoperative* and *collaborative* nature. To realize such e-Learning environment, we propose the following framework to achieve the AOLA push. The e-Learning triangle projects what each corner must be able to do:

- Technology – interoperable and any-to-any
- Students – review and practice
- Teachers – author, evaluate and challenge

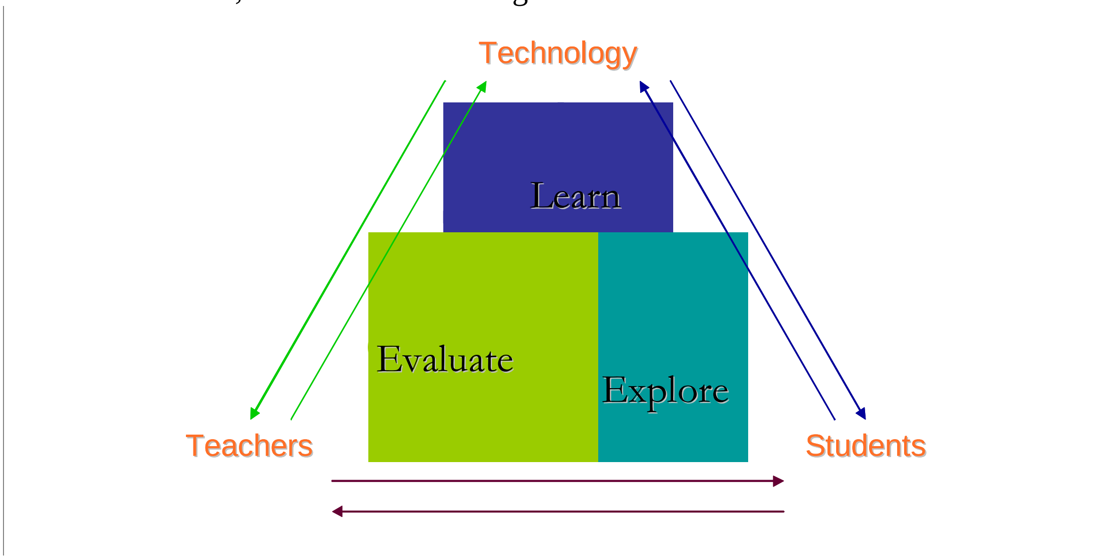

Figure 1. Participants of AOLA Framework for e-Learning in Mathematics Education

The core technology to make this happen rests in three main categories of developments:

- Mathematics portability, e.g., MathML and OpenMath (including semantics)
- Lessons portability, e.g., ActivityML[6] to Flash, Java Applets, etc.
- Knowledge portability, e.g., XML or any knowledge-encapsulated XML-based language
- Computation portability, e.g., computation engine that can be activated

Technology components could be viewed as that shown in Figure 2. Commercial community environments such as Blackboard, and WebCT are provided within a licensed domain (e.g., an university) – interoperability among these domains is not necessary and commercial not viable. Nonetheless, it is the core computational engines (CCE) that provide the computational aspects of the activities. These engines should be distributed and available on demand. This is the role of the commercial mathematics software engines – using applets, servlets and mathematical services.

[6] This 'standards' will help the consolidation of activity description and formats.

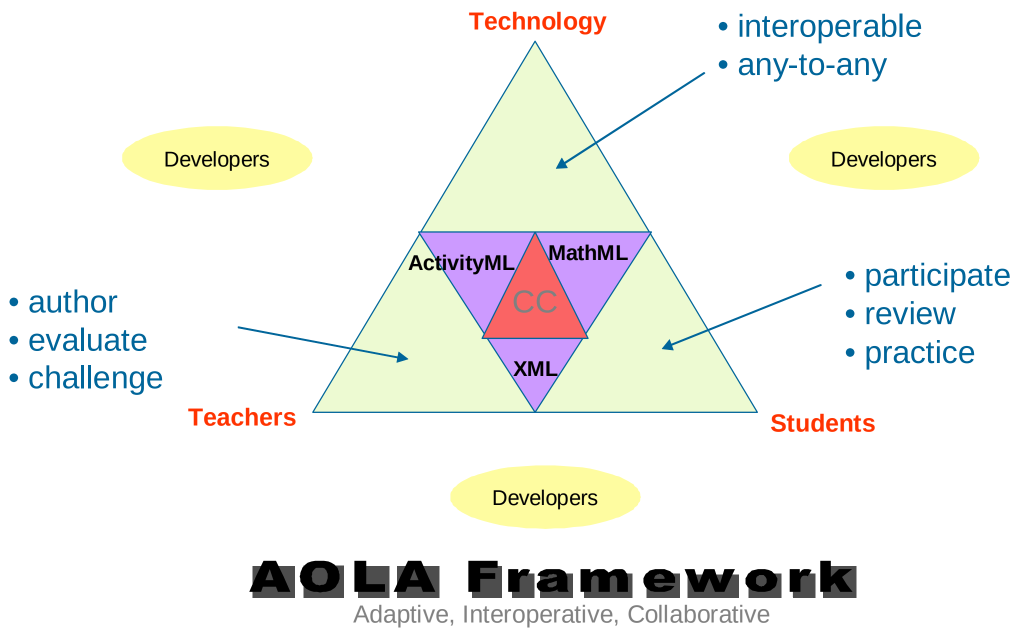

Figure 2. Technology Components of AOLA Framework

4. A Proposed System Design

We like to propose a system design to realize the AOLA framework based on two key designs – a platform environment and discoverable mathematical services. We will discuss the design of an e-Activity and e-Platform that are important to our discussion in special session II of a system as shown in Figure 3. We propose the following design for the deployment and management of AOLA materials.

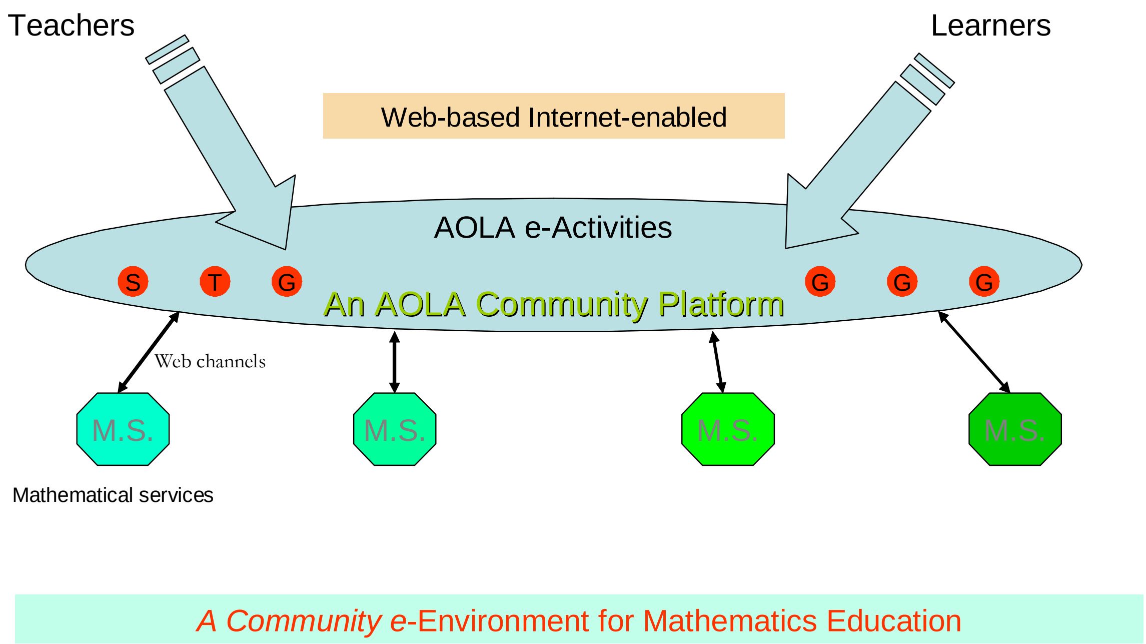

Figure 3. A Proposed Community Platform for AOLA Framework.

4.1 *The Design of an e-Activity*

We divide an e-Activity into two different "what" components: dynamic (mathematics) object and static object.

Static Textual Object (STO)

This object contains textual information that could include mathematics symbols that are non-actionable. The textual information is organized according to the subject matter (e.g., geometry or trigonometry), and textual matters – instructional, problem statement, Q&A and clarification. The design of these submatters can be swappable, re-usable, and context-sensitive help.

Dynamic Mathematics Object (DMO)

The DMO can be stand-alone or embedded within a STO (that is, it must be context-sensitive). In both cases, these objects serve the main purpose of real-time exploitable learning enabler. These objects have these characteristics:

- Discoverable – it is quite often that a DMO already exists in a Web environment that is reusable, without knowing exactly where it is resided at the time of definition, and how it is being implemented. The existential nature of a discoverable DMO is at the time of usage, and at which time, the service will be defined (billing, associated mathematics engine, etc.)
- Accessible – the accessibility is defined within the Web environment and it is quite often identified as the binding between two communicating parties. The binding is necessary to enable machines to exchange information 'correctly.'
- Manipulatable – the content must support manipulation.
- Viewable – text and graphics carry different interpretation and meanings to the participants.

4.2 A Platform Design to Support the AOLA Framework

To provide these functionalities, a community platform (See Figure 4) will be designed as follow:

At the systems level, we need to provide these functions to bring life to these e-Activities:
- Exchanging – facilitating information exchange,
- Processing – facilitating the computational processing of any activity's DMO, and,
- Rendering – facilitating the presentation according to the static environment of the user.

For the user level, we will be able to provide functionalities for them to operate these e-Activities:
- Creating – authoring of an e-Activity,
- Manipulating – how to incorporating e-Activities into lesson plans, and,
- Managing – of e-Activities, of lesson plans, of topics, of individuals and of educational entities.

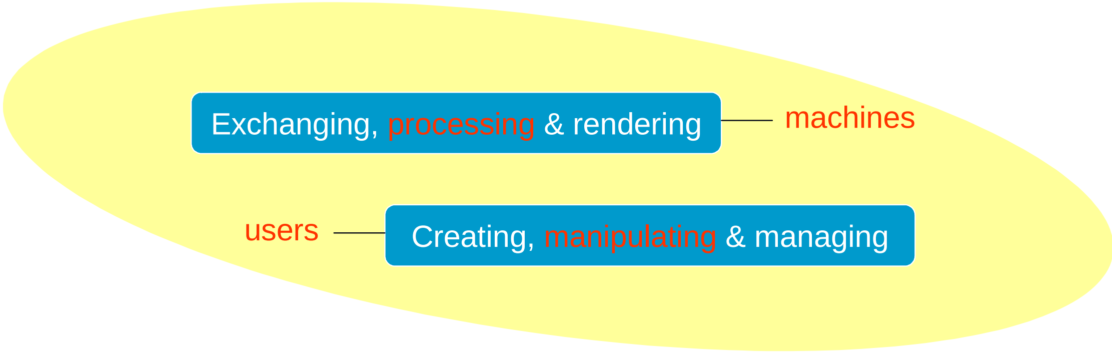

Figure 4. Community Platform Core Functions.

A community platform is needed to support the framework to rip benefits for teachers and students. Community platforms have been proposed, e.g., clubs, discussion forum, etc. The Web Service developments remain in academic research to create collaboration among web services. Privacy and security will be an issue when information sharing is transparent.

5. Concluding Remarks

This ME community environment can begin to take shape – supported by the emerging Web technologies such as Web Services development to provide collaborative linkage, and open discussions in ATCM conferences and other communications. For now, the design of the community platform will continue. The design of ActivityML must be considered, and participation of developers and mathematical software companies is a must – to ensure the vault of valuable lessons currently in use by teachers over the world can be ported quickly to the AOLA Framework. In here, we propose the formation of a steering committee to begin the work of AOLA framework, or if not the design, but at least the spirit behind the AOLA framework. That is, the development of an e-Learning environment for Mathematics Education (ME) where teachers, researchers and students gather online to share, learn, and explore.

There are many issues and concerns – not because of the discussion of the AOLA framework, yet the framework amplifies the need for a coordinated approach to face the issues. We can only state a few here. Distance Learning offers the opportunity to learners that are otherwise not possible due to geographical reasons or temporal restriction[7]. With Web technologies, an effective client-side learning environment can be enhanced with the AOLA framework. Teachers' education should be considered along with students' education – in parallel and with appropriate opportunities[8]. In the AOLA framework, the linkage is even apparent and can be facilitated by the framework. Proper assessment[9] of different types of skills effectively and reliably is practiced with paper and pencil.

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[7] P. Barmby, and R. Coe "Evaluating the MEI 'Enabling Access to Further Mathematics' Project," Teaching Mathematics and its Application 23 (3), 119-132, The Institute of Mathematics and its Applications 2004.
[8] "The International Commission on Mathematical Instruction (ICMI) – The Fifteenth ICMI Study: The Professional Education and Development of Teachers of Mathematics," Journal of Mathematics Teacher Education, Volume 7, Issue 3, September 2004, Pages 279 - 293
[9] Pedersen, S., & Williams, D. (2004). A Comparison of Assessment Practices and Their Effects on Learning and Motivation in a Student-Centered Learning Environment. *Journal of Educational Multimedia and Hypermedia 13*(3), 283-306. [Online]. Available: http://dl.aace.org/16317