Abstract: Searching through the Web or Internet for any mathematics concept will return hundreds of hits. But browsing through these sites will generally reveal a similar pattern of knowledge organization that is characterized by lack of utilization of the true power of the Information and Communication Technologies to deliver web objects that support authentic mathematics learning in eLearning mode. What needs to be realized is that the Internet technologies inherently contain power to go beyond the “link and show” and to add authenticity to the learning situation through visualization, interactivity and connectivity. Authenticity promotes realistic problem–solving settings and engagements in activities that result in development and exposure of learners’ thinking and metacognitive patterns. This paper presents a set of guideline for mathematics educators who plan to design authentic learning activities for implementation in the eLearning environments.

Introduction
A search through the Web or Internet for any school mathematics concept, such as for example, on triangles or quadratics, will return hundreds of hits. But by browsing through these sites, a similar pattern of knowledge organization is seen. A lot of cases are characterized by lack of utilization of the true power of the Web to support authentic learning. Most of mathematics resources that we found on the Internet were characterized with: a page–turner approach, text and graphics hypermedia content, not meaningful learning structures and non-existence of learning activities. As such these resources were reduced to mere information containers that are in no way different from printout material or textbooks readily available in students' school bags.

Many “enthusiasts” have discovered the Web to be an alternative mechanism of delivering content material. But what needs to be realized is that Web contains a power to go beyond the “link and show” and to add authenticity to learning through visualization, interactivity and connectivity. The authenticity must promote realistic problem–solving context and engagement in activities that will result in development and exposure of learners’ thinking and metacognitive patterns.

Authentic activities are possible through combination with web objects that provide learners with real-life contexts where domain knowledge is embedded, not simply presented. In this paper we are examining ways in which technology can be utilized to design and deliver authentic mathematics eLearning activities. Based on the theoretical model of Cognitive Apprenticeship (Collins, Brown and Newman, 1989) we are proposing C-A-S-E approach to the integration of content, activities, support and evaluation, to develop eLearning environments.

From Classroom Learning to e-Learning
Classroom Learning

When planning for eLearning, “teachers as designers” must look at what processes take place in successful mathematics classroom teaching and learning, and then attempt to bring forward their knowledge of pedagogy, pedagogical content knowledge (Langral, 1997) and understanding of educational technology to re-create learning but not simply to re-create information. During a teaching segment that takes place in a mathematics classroom, there are books, notes, charts, teachers, other learners, and other sources of “domain knowledge” (Collins, Brown and Newman, 1989) as “information containers” available to learners. Further, learners are engaged in an activity in order to gain appropriate level of understanding and construct their own mental representations. The challenge for teachers is not simply what domain knowledge to present but also how learners gain access to that information, interpret and use that it - beyond domain knowledge towards what Brown, Collins, Duguid (1996) call “strategic knowledge”. When some learners experience problems during learning activities, they usually turn to each other, resources or teachers for querying, clarification and further explanations. Support occurs as learners are engaged in processes of “knowledge construction” (Yager, 1984; Boyle, 1997). A teacher is to ensure that each individual learner successfully completes the activity and constructs knowledge. This is sometimes neglected in classrooms due to the constraints such as time, class size, curriculum expectations, and so on.

Following upon successful completion of the activity, learners are engaged in evaluation where their ability to de-contextualize and use knowledge is to be exposed. Focus of evaluation must move away from traditional assessment of “judging” and “culture of correct answers” where recall and comprehension are in focus. Dryen and Vos (1994) underlined that what schools need to do is to prepare students for open-minded inquiries instead of reproductions of right answers. McLellan (1996) also perceived traditional assessment as inadequate and wrote that “…knowledge is a product of the activity, context, and culture in which it is developed and used, and must be evaluated as such” (p.101). Similarly, Young (1993) argued that traditional assessment is inadequate for “collaborative, situated and distributive learning” and as such should be replaced with methods that focus on processes of learning, perception and problem solving. Such methods must be an integral part of learning environment and must provide feedback to both, teachers and learners. Evaluation must be “…seamlessly integrated into meaningful learning experience and not tracked at the end” (Wilson, Teslow & Osman–Jouchoux, 1995; p.11). As such, evaluation “…works FOR learning, not as punishment for NOT learning. It is a tool of learning, not a weapon of control; assessment can be a learning experience in itself” (Springboard, 1999).

The C-A-S-E

Four separate elements are distinguished in successful classroom teaching and learning: content, activities, support and evaluation. During the recent Global Chinese Conference for Computers in Education held in May, 2000 in Singapore we (Churchill & Wong, 2000), argued that when moving to eLearning, these four elements should be accounted for. As such we introduced the C-A-S-E approach for planning of eLearning. This approach argues for integration of content (C), activity (A), support (S) and evaluation (E) in an eLearning environment. The C-A-S-E is based on the strong theoretical underpinning with focus on Cognitive Apprenticeship, authentic learning activities, learner support, and evaluation of learning.

Authentic Activities
Mathematics is a subject where many learners experience difficulties. Our teachers’ ethics and customer focus attitude must drive us to search for possible solutions rather than for possible guilty “parties”. One of possible cause of such manifestation is that traditionally mathematics is perceived as being about mathematics but not being about life all around us. To bring mathematics closer to our learners' lives, we need to plan for authentic learning activities where application of mathematical constructs in real-life situations is to be explicit. Such learning is best described by "Cognitive Apprenticeship" of Collins, Brown and Newman (1989). Learning, according to Cognitive Apprenticeship, happens through facilitation of acquisition and integration of strategic knowledge (cognitive and metacognitive strategies) employed to use, manage and discover domain knowledge (facts, concepts and procedures). Collins, Brown, and Newman (1989) underlined that we must realize that “...cognitive and metacognitive strategies and processes are more central than either low-level sub-skills or abstract conceptual and factual knowledge” (p.455).

Cognitive Apprenticeship argues for engagement of learners in authentic learning activity that contains domain and strategic knowledge. These authentic activities are seen as ordinary practices of "communities of practitioners" who share similarities by being connected through socially constructed web of beliefs - the culture (Brown, Collins, Duguid 1996). A learner needs to be engaged in social construction of these webs to understand that particular community of practice. In addition there are tools that these practitioners use to perform tasks. Brown, Collins, Duguid (1996) underlined that culture and use of these tools characterize practitioners and determine the way in which they see the world. To learn how to use tools as practitioners use them, a student must become a member of that community of practice. This process is a process of “enculturation”. Learners “…need to be exposed to the use of a domain’s conceptual tools in authentic activity — to teachers acting as practitioners and using these tools in wrestling with problems of the world” (Brown, Collins and Duguid, 1996; p.25). As such, learning in authentic activity must focus on expert performance in using cognitive tools in realistic problem solving.

Authentic mathematics activities must emphasize application of mathematics in real-life and should result in acquisition of domain and strategic knowledge. Such authentic activities are to involve learners to:

(i) Relate key concepts to prior knowledge;
(ii) Look for information;
(iii) Explore and evaluate alternatives when constructing their own views;
(iv) Collect evidence, analyze it to construct interpretations and recreate information and collect artifact of knowledge construction;
(v) Develop understanding of application and generalize by understanding problems and where it can be applied;
(vi) Reflect on experience and develop an approach to learn similar concepts or solve similar problems;
(vii) Learn from others by sharing answers and strategies, and appreciate multiple perspectives;
(viii) Provide and obtain support;
(ix) Pose new problems.

Design of Authentic e-Learning Activities
Role of technology is to provide tools and environments where learners provide the intelligence and use the technology "...as tools for analyzing the world, accessing information, interpreting and organizing their personal knowledge, and represent what they know to others" (Jonassen & Reeves, 1996, p. 694). It (technology) is not simply to be a medium for delivery of content, but an environment that involve learners in critical and creative thinking (Swartz & Parks, 1994), and constructive learning when completing an activity. Through learners’ engagement in the authentic activity and evaluation and subsequent delivery of outcomes of such activity, a facilitator can identify learners’ constructs and thinking patterns. Based on the need, a particular learner or group of learners might be approached through on-line communication tools and directed towards expert performance through provision of additional scaffolding, content resources, learning and thinking strategies. However, the facilitator must be careful to resist temptation to provide “ready–made” solutions to learners who need support. Rather, learners should be provided with hints, pointers, analogies and metaphors, or guided towards expertise through social negotiation using on-line communication tools such as discussion forums and chats.

A key in planning of authentic eLearning is not in beginning with content but with planning an activity that involves learners in knowledge construction. Main strength of technology, as perceived in this paper, is in its ability to deliver web objects and present realistic contexts that involve learners in knowledge constructions. Domain knowledge, in such context, is not presented simply as a set of linked pages or documents, but it is embedded in the context. The activity defines context, web objects, and content to be embedded in the context. Planning of authentic eLearning will, in a lot of cases, spread across curriculum, especially to science, and even social studies and arts. For example, collecting water quality indicators from an "interactive scenario", and then analyzing and representing data, or browsing through "web gallery" of art pieces and drawing a scaled "history line".

A web object can be anything ranging from simple HTML or text, and JPG or GIF graphical scenarios, through tabular, graphical and pictorial representations, towards more complex cognitive tools that simulate some aspects of mathematics as it happens in reality and provide a source of "fuel" for cognition. But most importantly, web objects must facilitate authentic mathematics eLearning activities and support the content, but minimize material and maximize learning. Web provides environment and tools for design and delivery of web objects that provide:

(i) Visualization of mathematical tools and concepts such as geometric objects, functions, equations, statistical relationships and representations;
(ii) Interactivity with and manipulation of mathematically defined values and properties, and immediate exposure to outcomes of such manipulations; and
(iii) Connectivity that facilitates articulation of mathematical concepts and/or mathematical concepts to other subjects’ concepts and real-life.

Some technologies that we found useful for designing web objects are web-enabled tools from Macromedia®, QuickTime™ technologies from Apple™ Computers and digital media development tools from Adobe®. Figure 1 shows a screen from an eLearning context as seen within the C-A-S-E on-line environment. This resource is developed with the combination of these tools. In this activity, learners are instructed to work out the problem by accessing tools and information that are embedded in the resource, and then to write-up, in a form of reflective entry, about how they completed the solution.
Figure 1: Learning about volume

The 3D object of prunes container can be turned around and measurements can be collected using the rulers. Content information can be accessed within the textbook in order to complete the task. Similar activities can be set for learners to collect measurements from QTVR™ movie and use proportions to work out sizes of objects, or move through a set of samples, for example, height and weight of a group of people and represent information statistically. Similarly, learners can be engaged in constructing understanding of factorization by manipulating a set of interactive algebra blocks, or solving equations graphically using an online graphics calculator.

Technology plays an important role as it makes possible to integrate content, activities, support and evaluation in one eLearning environment.

**e-Learning: What Must Change**

**From Development of Resources to Design of eLearning**

Design of eLearning must include integration of content, activities, support and evaluation but not solely focus on re-creation and delivery of content in any positivist formats. Content is commonly misinterpreted, and assumptions are made that a learner learns by just reading a screen, viewing graphics, listening to audio, watching video, interacting with simulations. Digital content is in no way different from all other “exogenic” forms of knowledge (Gergan, 1992) found in the world — except that it might be more interesting (in short term) due to the ability of technology to merge sounds, colors, effects and so on. Content might always stay somewhere on the “digital bookshelf” unless embedded in context and used by learners through a knowledge construction activity. Many of eLearning modules that we have pre-
viewed stop just there - delivering content as compartmentalized knowledge units without any learning activities that would involve learners in interactions and use of that content. As such, Internet is utilized as sole information delivery vehicle. The role of learners as “information consumers” is leveled to readers and passive recipients of whatever digital media information presented. We must understand that resources are to be coupled together with activities that engage learners in knowledge construction. Hence, a key role of an eLearning facilitator is to be designer of learning and subsequent facilitator of this process, but not simply be a designer of information resources.

**Shift in Thinking**

Our latest interpretative inquiry into teachers as designers of eLearning shows us that all of our study participants were trying to implement classroom teaching planning when designing eLearning modules. Such planning was largely characterized by linear thinking where focus is on “What I do as a teacher?” As traditional mathematics teachers we plan a sequence of events that occur in linear fashion. Activity is existent not as something that facilitates learning, but as something to follows learning and it usually involves multiple practices and comes in forms or exercises. Use of technology in such teaching approach is characterized by the use of the presentation tool such as PowerPoint® from Microsoft®. A series of slides is presented and information elaborated by a teacher through the reference to learning material such as notes and textbooks. Technology, in this context, plays very little difference except that it enables easy modification of information, and allows for color, sounds, and dynamic media to be added. However, value of such presentation over traditional overhead transparencies is not always justifiable. Transparencies, in many of cases, represent most practical and most economical approach to facilitation of delivery of lectures.

When we consider information and communication technologies for eLearning, there must be a radical shift away from “thinking about teaching” towards “thinking about learning”. This is achieved by asking ourselves a question “What will learner do to learn?” rather than “What will teacher do to teach?”. Design of eLearning is a design of learning, not the one of teaching. As such, eLearning is characterized with learning activities, rather than the delivery of information in linear formats. One must think about what will happen in learners’ minds once they are engaged in learning, and how an activity facilitates so that desired cognitive processes do take place. In the simplest terms, learners are engaged in interaction with content in order to complete given knowledge construction tasks. Interaction with content is not linear but learners approach content as reference, source or data, or as a tool for learning.

Designers of eLearning must move away from linear thinking about information presentation towards lateral thinking about learning as interaction within environment where domain knowledge is derived, not simply absorbed. Teachers as designers need tools that facilitate lateral thinking, such as MindManager® from MindJET and to engage in rapid prototyping. Giving a right tool to teachers as designers of eLearning to facilitate thinking and planning is more important than standardizing and setting up expectation.

We must also keep in mind that during planning teachers-as-designers are driven by their objectives rather than with what technology can do, or what they can do with the technology. Thinking about what technology can do and what they can create using technology will significantly limit their ability to think laterally towards the establishment of sound eLearning contexts.
Conclusion
The design of eLearning should begin with planning of authentic activities that involve learners in knowledge construction. Authentic activities are possible in combination with web objects that provide learners with real-life contexts. A web object can be a simple HTML page, tabular, graphic and pictorial representation, or more complex cognitive tools that simulate some aspects of mathematics as it happens in reality. A web object is to provide a source of "fuel" for the cognition through visualization, interactivity and connectivity. Domain knowledge, in such context, is not presented as an "ordered" set of linked pages or documents, but it is embedded in the context and built around the web object. The eLearning activity defines context, web objects, and content to be embedded in the context. As such, domain knowledge is positioned as a set of relevant reference material, information or cognitive tools that learners interact with during the task completion. Domain knowledge is derived, not simply found. Towards the task completion, learners are engaged in the interaction with the domain knowledge and its application, and through this process, in acquisition of cognitive and metacognitive skills.

Teachers as designers of eLearning must focus on what will learners do to learn rather than what will the system do to "tutor" the learners. Teachers as designers must be engaged in lateral thinking about knowledge construction rather than thinking linearly about content presentation.

References


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