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Intermediate Math through an Online Learning Environment

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Abstract

Technology is omnipresent in today's society. With the advent of communications technology and the proliferation of Web 2.0 tools, online learning is becoming more and more popular. It enables people from remote areas to have access to education, which was almost impossible some years ago. Online learning is gaining ground in Ontario schools and is rapidly expanding throughout Canada and the world. It allows the breaking of barriers of distance and all that is needed is an internet-accessible device connected to the Internet. This paper gives an overview of the important factors that have to be considered when designing an online learning environment, with a focus on the teaching of Mathematics to students in the intermediate grades.

Keywords: *Communications technology, social media, online learning, 21st century, Web 2.0, Mathematics*

Introduction

Technology is omnipresent and we are more than ever interconnected. Students at schools and universities are using technology heavily in their learning. The Ontario elementary and secondary school curricula that were revised some years ago now include a section on technology. While it may be true that students are sometimes more knowledgeable than their teachers when it comes to the use of technological devices, teachers nonetheless have a good opportunity to capitalize on that strong interest to promote students' learning. Students are using Facebook, Twitter, Instagram, Wikis, and Blogs to share information and stay connected. The craze towards social media sites is increasing rapidly year after year and users are getting connected at a younger age than it used to be some years ago.

This paper highlights the different factors that have to be taken into consideration when designing an online learning environment, with a particular emphasis on the teaching of Mathematics. Learners interact with other learners, the content and the teacher via a medium. The content may be of any type and can range from Mathematics to Educational Law. While some content are better taught in a physical classroom where physical presence is required or achieved, some can be effectively delivered via a virtual classroom, thus enabling students to study irrespective of where they are located. Several studies relating to the design of online learning environments conducive to students' learning have been realised by various researchers and the most salient findings are presented. The last section of the paper gives some recommendations regarding the main factors to be considered when designing an online learning environment to teach Intermediate Mathematics.

In this 21st century, teachers may find it quite challenging to keep students on task and engaged with what they are learning. As technology is permeating the teenagers' world rapidly and considering the amount of time they spend online chatting and sharing things, it may be an easy task for teachers to use social websites as a platform for teaching and as a means to keep them engaged. These social websites are increasing exponentially in user numbers and unique visits everyday (Keenan & Shiri, 2009) and so, why not use them as a catalyst for teaching. Furthermore, the rapid acceptance of the Internet, the irrepressible revolution in information distribution, and the rapid expansion of information and communication technologies (ICT), have led to new human communications and expressions that challenge long-held cultural beliefs about education, particularly at the school level. The convergence between computers and communications has created 'virtual' communities and organisations in all fields and that have resulted in the reduction of the barriers of time and distance. These barriers were

preventing collaboration on a wide range of tasks and activities. Because of these new developments, “it is now technologically feasible for students and teachers from all over the world to ‘meet’, collaborate, and exchange views” (Quinton, 2010, p. 331). Furthermore, “available evidence suggests that over the course of the coming decade, technology will exert a major role in breaking down the entrenched barriers instilled by industrial-centric thinking that are not only unsustainable, but will prove inadequate for resolving the educational demands of the twenty-first century” (Quinton, 2010, pp. 331-2). Thus, online learning is well positioned to fill in the educational demands of the future. What follow are some of the important aspects to consider when designing an online learning environment.

Constructivism and Online Learning Environment

Many authors have written about the importance of students interacting with each other to construct meaning. Neo-Vygotskians believe that individual learners construct conceptual knowledge through guided instruction rather than independent exploration alone (Merrill, 1992; Kozulin, 2003; Xin and Feenberg, 2006). Vygotsky (1978), with his theory of 'More Knowledgeable Other' (MKO), argued that students learn with the help of more capable peers or the teacher. Irrespective of whether the classroom is a face-to-face or virtual one, the goal of constructivist educators is to guide students to think and act like experts (Bednar et al. 1992; Vrasidas, 2000). Thus, in any kind of learning environment, it is important for students to have the appropriate space to interact and learn from each other.

Environmental conditions conducive to learning and to the sharing of information are to be created and provided if students are expected to successfully transfer skills to other contexts. The teacher mainly acts as the facilitator and provides opportunities and space for learners to have discussions. This space for interaction can be achieved through an online learning environment that incorporates computer-mediated communication and/or through forums or social websites that can be used as spaces for exchanging ideas and providing feedback. Synchronous or asynchronous networks are also used as they allow students to engage in argumentative practices thus promoting knowledge building (Cohen & Scardamalia, 1998; Hiltz & Goldman, 2005; Larreamendy-Joerns, J. & Leinhardt, G., 2006). Within the same breath, Papert (1980) argues that “in instruction-centered learning, one directly teaches a learner something, one robs that learner of the opportunity to discover it for him or herself" (cited in Pea, 1993, p. 64).

Interaction and Significance in an Online Learning Environment

The following quote from Thackara (2005, cited in Quinton, 2010, pp. 332-333) highlights the importance of interaction and of synchronous communication in a learning environment:

> *Technology fixes for education are an old and discredited story. The delivery of precooked content, by whatever means, is not teaching. Radio, film, television, the videocassette recorder, fax machines, the personal computer, the Internet, each of these, in turn, that here was a wonder cure that would transform education for the better. And yet here we are, hundreds of years after the first books were printed, and teachers are still giving lectures, and students still line up to hear them. Why? They do this because the best learning involves embodiment – live experiences and conversation between people: Most people prefer talking to one another to talking to themselves.*

In any kind of learning environment, students interact with the teacher, with the content and with other learners (Anderson, 2003). During their interaction, learners always receive some kind of support and guidance from someone who is more knowledgeable, usually the teacher. The teacher will plan the course delivery and will decide on the best strategies to successfully deliver the content and create a space for learners to develop targeted skills. Some course content requires more synchronous interactions like tutorial classes while other course content, a more self-guided and exploratory approach would be enough. In a distance education setting, which includes online learning, Hillman, Willis, and Gunawardena (1994) argue that all interaction is mediated via a medium. It is through this medium that all interactions will occur and they therefore, in addition to the three types on interaction cited above, have come up with what they call, the ‘learner-interface interaction’. It is through the interface that interactions occur in an online learning environment.

However, interaction itself does not guarantee engagement (Garrison & Cleveland-Innes, 2005; Lulee, 2011). As Anderson (2003) and Lulee (2011) posit, there is no single 'best way' to use interaction and the best interaction for a particular context is the interaction that has the right mix of interaction. “Deep and meaningful formal learning is supported as long as one of the three forms of interaction (student-teacher, student-content, student-students) is at a high level. The other two may be offered at minimal levels, or even eliminated, without degrading the educational experience” (Anderson, 2003; cited in Lulee 2011, p.16). In an online learning environment, learners interact with other learners and with the

teacher. However, not all learners will always be willing to share and open up during discourses, unless they feel part of a safe learning environment. To this end, this safe environment may be created by including within the environment, collaborative activities that allow learners to get to know each other better so that they may feel more connected to the online community, which usually leads to better socio-emotional climate in the online course (Rovai, 2002; Richardson & Swan, 2003; Garrison & Arbaugh, 2007). As a result of this connectedness, it is likely that most if not all of the online learners will be more willing to take risks and share their thoughts openly during discussions.

Learners in an online learning environment interact a lot through writing. While some researchers may argue that writing does not help the auditory learners a lot, the results of a study by Kanuka (2005) claim that text-based internet communication technologies can facilitate effective learning environments through the use of certain instructional strategies, resulting in the ability to facilitate higher levels of learning. Online discussion can reach beyond the temporal and spatial constraints of the campus class, and as a result can often add a richer and deeper perspective [than is possible in traditional classes] as students respond when they are informed and inspired (Dare, 2011). Moreover, "online threaded discussions can help in the development of higher level thinking skills" (Rizopoulos and McCarthy, 2009, p. 376) and peer feedback has been shown to be an effective pedagogical strategy in online (and on-ground) courses (Lin & Chien, 2009; Dare, 2011).

Some people are concerned with regards to the validity and quality of distance and online learning. Nakamura (2002) writes that "certain forms [of online learning] allow or disallow the articulation of certain ideas" (cited in Vander Valk, 2008, p. 205). This may partly explain why some course providers and learners are sceptical about accepting the validity of online learning. Furthermore, most of the concerns about distance education have focused on the limitations inherent in different delivery technologies (e.g., correspondence, radio, television, Internet) as they seek to replicate critical features of physical classroom instruction: social interaction, prompt feedback, engaging activities, instructional flexibility, the dynamism of a knowledgeable scholar, and adaptation to individual needs (Larreamendy-Joerns & Leinhardt, 2006). Conversely, online education has been celebrated by many because of its potential to provide educational opportunities to populations who are unable to attend traditional face-to-face classes for financial, geographical, physical, or family reasons (Dare, 2011). In addition, Agre (1998) claims that the Internet is capable of producing laboratories, classrooms, tutors, lectures,

textbooks, and libraries that exhibit many of the properties of their real counterparts needs, thus showing the validity of online education. Therefore, a virtual learning environment is well-positioned to bridge the gap between a distance and a face-to-face learning environment. Dare (2011, p.1) highlights that "as online educators attempt to develop courses and curricula that are as (or more) effective as traditional classrooms, the biggest stumbling block is often assumed to be the fact that students and instructors are never (or rarely) engaging the course material at the same time". This is not an issue anymore as synchronous communication software like Skype, Facetime, AdobeConnect, etc..can be integrated in the online learning environment, thus enabling the teacher and learners to interact in real time.

Teaching Mathematics and Online Environment

There are subjects or concepts that are easier taught through online learning and those that would require a lot of interaction with the teacher and/or with peers. An example of a subject that may require strong teacher support is Mathematics. In Mathematics, there are some basic formulas that researchers have invented since decades and centuries ago, and that are still very widely used nowadays. It does not seem appropriate to ask students/learners, especially those at the intermediate level, to reinvent the wheel by trying to invent new formulas. By giving them the opportunity to apply formulas that have been invented to real life context-based problematic life situations, learners will derive more positive learning experiences. However, they will surely require support and some direct instructions from a MKO from time to time. Even though technology can help with simulating and visualizing some mathematical concepts through the use of dynamic 2-D that contributes to learning and reasoning in Mathematics and Science Education (Pea, 1993), technology does not exist independent of its use. Substitute activities, artefacts and environment for technology and the message remains the same (Stahl *et al*., 2006).

Assuming that the teaching of Intermediate Ontario Mathematics using the Comprehensive Math Program Framework requires a rather structured learning environment for mini-lessons, it may be a real challenge to teach explicit mathematical concepts through the use of a virtual classroom that does not have the constant availability of a blackboard to write mathematical signs and symbols. The key to sustain learning in such kind of virtual environment may require learners to have a high level of motivation. Moreover, research suggests that authentic activities can impact motivation and learning outcomes (Harel & Papert, 1991; Forte & Bruckman, 2006) and cognitive scientists have discovered that learners retain material better and are able to generalise it to a broader range of contexts when they learn

deep knowledge rather than surface knowledge, and when they learn how to use that knowledge in real-world social and practical settings (Sawyer, 2008). Thus, to sustain learners' interest and motivation in an online learning environment, it is useful to include some synchronous interactions within the learning environment. This is achieved through online face to face communication via a webcam, through chat, or through telephone conversations. As Walther (1996) and Lulee (2011) suggest, rich media such as video conference are better for highly equivocal tasks, whereas lean media such as email are more efficient for less equivocal tasks. So, assuming that math is a subject that requires strong teacher support, then it is suggested to include short videos to which learners can refer to during their time online. Furthermore, given that most learner's contribution is written, online posting is sequential, and there are traceable records of the conversation flow, these (online learning) environments provide learners with wait time and, consequently, encourage reflective learning in both on-task and post-task interactions (Tolmie & Boyle, 2000; Larreamendy-Joerns & Leinhardt, 2006). Burbules and Callister (1996) provide a more precise account of what these notions infer by explaining that 'learning' and 'understanding' operate by making connections with other learners' posts, and "learning becomes a process of enculturation as learners are immersed in real life situation and act as experts" (Lave & Wenger, 1991, cited in Vrasidas, 2000, p. 9) when they are asked to comment on the posts of others. The possibility to engage in reflective thinking during interactions is achieved through a synchronous online learning environment and less in a face-to-face environment, as very often in a brick and mortar classroom, conversations can get side-tracked and think time for thoughtful contributions is missing due to impulsive and unsupported claims.

Design of Online Learning Environment

In an online learning environment, the learning experience depends on many factors interacting with each other. However, the question that is still open to debate is how to design that perfect online learning environment that can mimic, surpass or complement a face-to-face learning environment. What follows is a list of the most salient findings emanating from various authors in the field of online learning design:

Quinton (2010) puts forward three key components of the educational environment design. He posits that the learning environment should provide:

- a means of organising learner input and experience,

- a mechanism for applying that experience into context, and
- a means of empowering learners to create knowledge and to share the experiences of other individuals or groups.

Sawyer (2008), from the Learning Sciences group, suggests some design principles:

- Customised learning for each child - e.g. video to those who need help, and just skip the videos if someone is already familiar with what is to be done in the activity,
- Availability of diverse knowledge sources - e.g. students can access the Internet and/or consult peers and others,
- Collaborative group learning - e.g. students collaborate and give each other feedback on their work, thus sharing understanding and building knowledge,
- Assessment for deeper learning - e.g. teacher gives feedback to students at different times.

Hung and Chen (2001) claim that a web-based learning environment should take into account these factors:

- Situatedness - learning is in rich context of practice,
- Commonality - participants work together with shared interests and problems that require joint effort,
- Interdependency - participants make use of each other's abilities to learn: student work with a partner who act as the MKO,
- Infrastructure - learning is facilitated through the use of a meaningful problem.

Boettcher (2007) proposes ten core principles for designing effective learning environments based on findings from Brain Research:

- Core Learning Principle #1: Every structured learning experience has four elements with the learner at the center
- Core Learning Principle #2: Every learning experience includes the environment in which the learner interacts
- Core Learning Principle #3: We shape our tools and our tools shape us

- Core Learning Principle #4: Faculty are the directors of the learning experience
- Core Learning Principle #5: Learners bring their own personalized knowledge, skills, and attitudes to the learning experience
- Core Learning Principle #6: Every learner has a zone of proximal development that defines the space that a learner is ready to develop into useful knowledge
- Core Learning Principle #7: Concepts are not words; concepts are organized and intricate knowledge clusters
- Core Learning Principle #8: All learners do not need to learn all course content; all learners do need to learn the core concepts
- Core Learning Principle #9: Different instruction is required for different learning outcomes
- Core Learning Principle #10: Everything else being equal, more time-on-task equals more learning

Garrison &Arbaugh (2007) argue that the three types of presence, namely the social presence, the cognitive presence, and the teaching presence should be present in a Community of Inquiry (CoI) that is formed during online discussions in an online learning environment.

- Social presence: Social presence is very important in a CoI. Activities that cultivate social presence also enhance the learner's satisfaction with the internet as an educational delivery medium. Social presence is necessary for the development of cognitive presence. The three stages that an individual go through before he/she feels part of a community are: online acquaintances through open communication; thoughtful and purposeful academic exchange of ideas; and after long-term and intense association a feeling of camaraderie is achieved.
- Cognitive presence: Cognitive presence is achieved through the four phases of the practical inquiry model: triggering event for the need to find further; exploration through critical reflection and discourse; integration and constructing meaning; resolution and the application of newly gained knowledge.
- Teaching presence: Three components are required to achieve teaching presence:
    - Instructional design and organization of the course - dynamic discussions

- Facilitating discourse - sharing meaning, review and comment on students responses, move discussion to a desired direction
- Providing direct instruction - teacher is the subject matter expert, inject sources of information, instructor guides and orchestrates the discourse

What other authors conclude:

Quinton (2010, p.347) supports the view that there is a need to develop new learning environments that "… facilitate support for the divergent needs of current and past generations, from pre-school through to senior citizens…" and effective learning environments will "… support the lifelong learning needs and personal development of all individuals through the provision of dynamically facilitated and /or self-directed environments, characterized by flexible, ubiquitous, and/or mobile delivery at any time and to any place".

Scardamalia (2002, p.6) cautions that "discussions over the Internet show low levels of participation and a lack of continuity and moreover typically require a good deal of teacher direction".

Bender (2003) asserts that the online learning instructor should act in ways that are "supportive and encouraging, giving ample feedback, being a good role model, being appropriately informal, and eliciting discussion" (cited in Dare, 2011, p. 11).

Recommendations

In light of the above discussions and taking into account the findings of the various authors, we have come up with some recommendations relevant to the design of an online learning environment conducive to teaching mathematical concepts to intermediate students

The online learning environment has to:

- Contain some videos that explain difficult concepts and how-tos. There have to be some links to external resources for those who need additional support.

- Include the use of authentic math activities that emanate from real life situations so as to sustain the learner's engagement. Students are more likely to stay engaged if they are involved in activities that are meaningful and to which they can relate to.
- Include at least an activity that requires every learner to collaborate with at least another learner. The pair or small group is formed by the teacher or by the students.
- Provide a space where the teacher can interact with the learners in a synchronous way and provides support to individuals or to group of learners. Communication software like Skype, Go-To-Meeting, Adobe Connect, etc. enable users to see each other via a webcam and to share their screen for deeper discussions. This increases the social presence aspect as users will be able to use their body language while communicating.
- Provide a space for learners to communicate their ideas and engage in discussions in writing in small and large group. This space can be through the use of a platform like Moodle, Blackboard, Facebook (if they are at least thirteen years old), Google Hangouts, etc... Social websites may also be appropriate to that effect.
- Enable the teacher to intervene to clarify any misunderstandings and redirect discussions if need be.
- Specify the minimum number of interactions that are expected so that learners know how much is enough.
- Specify the time lines by which learners have to post their work and comments for others to respond, and by when they are expected to respond. This enables more timely and focussed interactions.
- Provide learners the possibility to choose to which discussion thread they want to participate.
- Enable the three types of interaction
    - Learner to Learner(s) (sharing and working collaboratively on a product and sharing to large group discussion)
    - Learner to Teacher (support from the teacher)
    - Learner to Content (through web pages, short videos, external links etc...)

Closing Remarks

In this article, we have reviewed some of the most important factors that have to be considered when designing an online learning environment. The design and components to be included in a particular online learning environment will depend on the content, the learner, the types and level of interactions desired. Many questions inevitably come to mind. Is the online environment for primary students? Then this would require more videos and a more cartoon-like approach. Is the online environment for teaching Educational Law? Then this would require a space where learners will have much interaction with each other and the teacher stepping in to clarify misunderstandings or to share past experiences. Is the online environment for teaching Mathematics to high school students? Then the environment will most likely have several synchronous sessions scheduled, some short videos that explain complex concepts, a platform for exchanging ideas, and a space for learners to ask questions and give feedback. The learner, the content, the teacher and the medium of interaction all play an important role when designing an online learning environment. The key is to find that right mix.

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