T.I.M.E. – A Prototype Model for Designing *Culturally Dynamic*™ Science e-Learning Communities

Duncan A. Quarless, Jr., PhD
State University of New York College at Old Westbury
quarlessd@oldwestbury.edu

Gina Russell Stevens
Executive Performance, LLC
gstevens@executiveperformance.com

Sheila D. Gatling
Executive Performance, LLC
sgatling@executiveperformance.com

Abstract: In an era of scientific and technological innovation and progress, underrepresented minorities continue to lag in all educational science and engineering performance indicators (NCES, 2004), while demonstrating proficiency using recreational technologies. Science educators need to design and implement models that exploit the learning styles, multiple intelligences and unique cultural backgrounds of diverse students. While a scientific career path may not be suitable for the vast majority of students, the knowledge, skills and attitudes acquired in scientific endeavor yield lifelong benefits for everyone. Therefore, there exists a two-fold impetus to engage underrepresented minorities in science learning. This paper will present the prototype T.I.M.E. Model for facilitating *culturally dynamic* scientific online e-learning communities.

Introduction

Learning communities on educational campuses are social and structural constructs primarily directed at engaging and connecting learners for the purpose of retention and development. Learning communities have often engaged their members in collaborative multi-disciplined study. Learning community however is neither description nor prescription for active and progressive learning. That is, learners can be marginalized even in so-called learning communities. Online learning communities in the sciences have additional challenges in developing the learner skill sets that are required by the varied representations for presenting, interpreting and critically thinking about scientific information.

The 21st century has ushered in a time of interdisciplinary scientific study unrivaled during the past several decades. Bioinformatics, nanotechnology and proteomics are illustrations of study areas where synthesis, technology and quantitative analyses come together for real world problem-solving strategies in this new millennium.

TIME Model

Instructional and academic enrichment models within a culturally dynamic learning environment must address the unique needs of the learners in ways that not only authenticate each learning experience but also connect the learners in the collective experiences of the community. The TIME model has been developed as a prototype for culturally dynamic learning.

Theme. Interconnected learning is achieved through thematic approaches within the community. The themes have been primarily forensic science and environmental science. These themes appear to support and promote the related learner affect of the collective community, and are particularly valued by this community.

Inquiry-Based. Learners explore the relevant thematic questions through guided-discovery. Inquiry-based learning is consistent with cognitive, psychomotor and affective learning domains. Learners are usually directed to work as functional groups and independent investigators to develop learning and knowledge forming skills as well as social aspects to learning. Prior knowledge is brought into play and forced into adapting new and authentic situations in a dynamic setting for learning to take place. In essence, students assume a greater responsibility for their own learning.

Mentorship. Relationships are developed both through peer-led strategies such as cooperative learning, as well as through facilitator-learner interactions.

Enhancement. Integrating technology, informal learning experiences and community artifacts are all illustrations of enhancements. The model is culturally dynamic in that it includes student affect in a parameterization of student preparedness and potential for high academic achievement. The model has been tested with marked success in an NSF funded scholarship program for computer science, pre-engineering and mathematics students at (Computer Science, Engineering and Mathematics Scholarship - CSEMS) SUNY College at Old Westbury; in the College's learning community in the sciences; and has been continued in the New York State Education Department's pre-college and collegiate Science and Technology Entry Programs (STEP/CSTEP) to increase the numbers of underrepresented minorities who pursue careers in science, technology and licensed professions (health, engineering, architecture, law, teaching, psychology, social work, etc).

E-Learning Application

The migration of these TIME elements to an online environment is largely the focus of the current curricular enrichments for STEP and CSTEP. The programs have expanded their learning communities during this formative process to approximately four hundred learners. The course management system, Moodle, is the platform for this online community. The course offerings include the following thematic threads: college preparation, environmental science and research design, and the college survival series. The design for this migration and development is driven by two projected uses: a self-paced modular learning object format; and a supplemental instruction resource to complement classroom and laboratory instruction in the programs. The latter is the current priority which forms the basis for the development of the former. The design also includes a research component to assess learner knowledge development that includes the six knowledge forms (i.e. concept, process, tool, context, way of being and rule)(Krumsieg, 1999). Integration of e-learning technology as an enhancement complements this culturally dynamic science learning community prototype.

Many active learning strategies (Bromley, 1995) presume that each and every participant in a learning exercise will ("if properly prepared") be active – engaged (McKeachie, 1999). Unfortunately, the affective issues that are intricately interwoven in student development are not always addressed in a practical way in learning activities and learning assessments. In an online learning environment asynchronous communication provides both flexibility and challenge. Structure is especially important given the nature of the communication and engagement must be monitored and assessed effectively in order to achieve desired outcomes. Clearly if a student is uninterested, lowly esteemed or marginalized by the learning environment, there is little doubt that the pedagogy will be of none effect, and the taxonomical progression will stagnate near the base of Bloom's pyramid (Bloom, 1956). While considerable efforts have been focused on learner outcomes in distance education the quality of the online learning environment has received less attention (Walker, 2001). Similarly the metacognitive aspects of the learners (i.e. learning how to learn) (Donald, 2002) are often given little consideration in the construction the online learning environment (McLoughlin, 2001).

Student Affect and Metacognition

TIME, as a model for online learning environments is poised to address student affect, metacognition and cognition. Although affect, metacognition and cognition are treated as distinct entities, it is important to recognize the interconnectedness and subsequent dependence of all three on learning outcomes. In the freshmen chemistry course at SUNY College at Old Westbury, a student survey has been developed to assist students in determining their preparedness, predispositions and learning styles. Comparison of the pre-course and post-course administration of the survey demonstrates the significance of student affect as correlated with outcomes. Negative attitudes include biases about the nature of science (e.g. abstract and not very meaningful for life; offering only right or wrong answers) and were typically attributable to students achieving lower grades in the class. There has been also the attitude among many students that science is a solitary "sink or swim" learning endeavor. Moreover, in spite of its pivotal importance, students typically are ignorant with respect to their learning styles. Although curricular constraints preclude including a formal learning styles inventory within the chemistry course for example, the Moodle site has provided such as a supplemental resource to students in CSTEP. This resource empowers students with information that helps them leverage academic resources in a way that complements their individual learning styles in order to maximize their learning outcomes. A similar learning activity is offered in a STEP course for high school juniors and seniors.

In migrating the model to an online environment, student affect is addressed in three specific ways. First, the foundation for a culturally dynamic environment requires shared values which have largely been incorporated in the thematic elements. The Moodle course offerings include college preparation, environmental science and research design, and the college survival series. Second, the guided inquiry-based process within the thematic area of study engages and empowers the learners to ask the questions that are meaningful to them, while concurrently setting the stage for metacognitive exercises (i.e. managing and validating information; developing learning skills such as visualizing, sorting, making inferences; time and task management). Lastly, the social aspects of learner development as related to affect are facilitated by the stratified structural relationships (Weinreich, 2004). By using cooperative learning strategies, the community provides both student peer, collegiate mentor (i.e. teaching assistant) and faculty mentorship. Students are teamed, peer led and mentored primarily by collegiate students in a learning community that includes other faculty.

Metacognitive and Cognitive Facilitation

The assessment of student learning in science as a preparation for entry into the marketplace is focused on problem-solving in the sciences. Focus on inquiry-based learning at the primary and secondary levels similarly has emerged as a strategy to improve student preparations for undergraduate study and the marketplace. Particularly noted in higher education is the leap to problem-solving that usually excludes the process of "learning how to learn." That is, the processes (and requisite skill development) that lead to student cognition are often assumed rather than infused into learning environment (McLoughlin, 2001). The Moodle environment provides resource to support both the contextual process and the related content. The Research Methods course for high school students has structured activities that include: a module on team-building; a module on the environment and human activity; an environmental toxicology experiment with Daphnia; and a module on experimental design. Each module includes self-assessment and reflection exercises to capture learning discoveries. These course components fall within the four categories of metacognitive knowledge that are associated with learner achievement in distance learning environments (McLoughlin,2001). The Research Methods course design is liken to other project oriented secondary school approaches with respect to contextual learning and emphasis on process skills that have the greatest potential for transference to new contexts (Kolodner, 2003).

In addition to the metacognitive processes the Moodle designed courses include content that involves the various knowledge forms. In the environmental toxicology experiment with Daphnia the various knowledge forms are demonstrated. Concept as a form is an idea that links a series of things or identifies a series of relationships. In this case the concept is toxicological impairment. Process as a form is a sequence of steps or events associated with a change or producing a particular product (outcome). In this experiment the process involved all of the environmental conditions and sequential steps involved in the exposure of the organism to the toxicant (i.e. process of exposure leading to impairment). In order to observe the impairment a tool was employed. In this case, the tool was a sugar – food – with an attached fluorescent label and the uv lamp needed to visually observe the label; a tool being any device, instrument, implement that provides the resource for accomplishing a related task – identifying the impairment. The context here is impairment as related to the organism – the metabolism or homeostasis of the Daphnia as related to the conditions of its environment. The ways of being here include related behaviors on the part of the learner (e.g. proper use of language, and application of the scientific method). Finally rule knowledge in this illustration includes the use of concentration units in describing the concentration of the toxicant in the aqueous environment.

Learning Assessment and Knowledge Development

The Moodle environment in this formative construction is structured to provide diagnostic information on individual learners. The forms of knowledge when applied to Bloom's taxonomy provide the means for establishing a knowledge table (map) for each learner (Quarless, 2004). In designing a culturally dynamic online environment particular attention must be given to avoiding judgmental treatments that devalue the learner in any respect. Exemplars, illustrations and feedback must not contain facilitator judgments on the intrinsic factors of the learners such as family demands or living conditions, principles for living, value system or learner specific needs in the environment. The learning assessments must be learner-centered and learning process oriented. In the STEP courses in Moodle there are diverse populations in terms of ethnicities, grade level, skill development and interests.

The learning assessment is linked to a point system that appropriately affirms the learner within the learning environment. The finality of a grade is avoided as a point of emphasis as contrasted with more valuable insights on process and content discoveries. Academic milestones, as assessed by content related problem solving, account for

50% of the points; process discoveries, reflections and related skill developments account for 25% of the points; and, character related developments such as attendance, cooperative and respectful behavior, resilience, risk-taking, etc. account for 25% of the points. Finally in order to sustain motivational factors, a sustained effort factor is used to scale point totals at year's end.

Evaluation Process for Design

In this stage of development the Moodle courses are being used as a technology integration for supplemental instruction. The assessment of the formative process implementation on the Moodle course management platform has been adapted from an evaluation criteria for distance learning systems previously described in the literature (Walker 2001). A concerted effort has been made to make the online learning environment an integral component of the STEP and CSTEP programs and learner incentives for utilizing the technology within both programs have been developed. In addition to the online learning system criteria, the programs are also adapting affective criteria that have been reported recently in the computing education literature (Walker 2001).

Implications of Design

The TIME model has been a very effective strategy from the prospective of programmatic enrichment for science, technology and mathematics instruction in the undergraduate curriculum (CSEMS program). The elements of the model target learner affect, and the metacognitive and cognitive developments of the learners. The current participants in the Moodle online environment are part of a study group that will be followed through the STEP and CSTEP programs. One of the unique features of the model as well as this Moodle implementation is that it targets an evaluative process for e-learning applications at both the secondary school and undergraduate level.

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