Issues in Synchronous versus Asynchronous E-learning Platforms

Eric Hamilton
US Air Force Academy

John Cherniavsky
National Science Foundation

INTRODUCTION

Learning platforms and the communications they involve can be characterized along several dimensions. We present six here and a seventh (synchronicity) in the next section:

1. The control of learning activities: *Who or what is in charge of the learning activities?* (These include traditional answers of teacher or student, but also include underlying software platforms and agent systems and social structures that emerge through the systems interactivity.)

2. The communication bandwidth (electronic or otherwise). *How much information can be transmitted and/or retained and in what time frame.* (We also propose in the final section a pedagogical variant of this dimension, *interactional bandwidth*).

3. The granularity at which information can be shared. *The content level – symbols, information, knowledge - of the shared information.*

4. The representational forms used to share knowledge. *How knowledge is represented – text, graphics, animation, sound, video or other means.*
5. The persistence of knowledge representations in the learning environment.

How readily available are artifacts produced by a teacher or student to the participants in the learning environment.

6. The pedagogical frameworks that characterize the learning environment.

Is knowledge delivered, constructed individually, constructed socially? Does it scaffold and build procedural knowledge forms or higher order forms?

These dimensions apply to both WBL and F2F classroom settings, and to their blended hybrids. For example, a typical classroom-learning platform involves a blackboard and teacher. In a lecture mode, the locus of control generally resides with the teacher, though shared single user (student use), or simultaneous (multiple students at the blackboard) are possible. The representation persistency is transient (blackboards are erased; discussions are not recorded). The bandwidth is adequate for text/symbols and simple graphics. The granularity level is low since little information can be captured and shared beyond what can be written on the blackboard; the communication modalities are writing and speech; and the pedagogical framework is predominantly one of knowledge delivery rather than knowledge construction.

A more modern learning platform might consist of a large whiteboard display (the whiteboard), and individual appliances that students or teachers use to communicate with the whiteboard. The locus of control can now be the teacher, shared single user, or simultaneous users; the representations are persistent assuming a data base captures the whiteboard’s information; the bandwidth depends upon the network bandwidth and the display capabilities of the white board and the appliances; the granularity may be high
since all information sent to or from the blackboard can be captured and summarized or presented in a variety of forms; and the communication modalities are multi-media – writing, speech, video, sound, and graphics all of which are fully capable of capture and persistence.

**Synchronicity**

One other very important dimension for characterizing learning platforms is synchronicity. F2F education settings are inherently synchronous: the teacher and learners are in the same space at the same time. WBL forms, in contrast, that provide “anytime, anyplace” flexibility to learners are asynchronous, in that they do not require learners to be online or connected to a teacher at a specific time for specific purposes. Asynchronous environments can be relatively low-bandwidth, text-based and inexpensive. They can allow the learner to determine if s/he is ready to login or participate in course activities independent of whether other learners or the course teacher or facilitator are available or present in the virtual learning space. An obvious consequence is that pure asynchronous learning, by definition, does not permit real-time interaction between students, or between a teacher and students. This does not mean that there is no interaction – a threaded discussion is a simple example of interaction-intensive but asynchronous communication form.

A typical distance learning (Simonson, Smaldino et al. 2002) asynchronous learning session begins with a student logging into the system. Depending on the variables above, course material may be presented to the student in the form of text or richer multimedia (e.g., simulations and models of physical phenomenon, animations, video, etc), and the student may be asked to recite information of solve problems through
an explicit problem-solution interaction or through directed interaction in a virtual world. Typical sessions may often include threaded interactions with other learners. Asynchronous distance education does not rely on students listening to or observing live, remote lectures, nor on real-time interactions between learners and other learners or the teacher. Private online universities in the US, such as Phoenix University and Capella University, at the time of this writing, furnish a tightly formatted asynchronous environment for coursework.

In contrast to asynchronous learning platforms, synchronous platforms do not have “any time/any place” flexibility; instead, they take a “same time/any place” approach. They may permit real-time interactions, although some synchronous learning forms, such as satellite or netcast lectures or slide presentations may actually involve considerable less interactivity than asynchronous settings. Significantly different social dynamics are obviously induced when interactive rather than unidirectional.

Hybrid or blended synchronicity has been in currency for some time. In the early 1990s, for example, MIT’s Sloan School of Management provided (synchronous) live video feeds for some courses to Asia while running (asynchronous) email and internet communications for other course components (Feller 1995). More recently, the Network College of Shanghai Jiao Tong University (SJTU) gives students the choice of sitting in classrooms to listen to live lecture feeds or accessing them later. The lecture feeds are unidirectional in one sense – students cannot interact with the lecturer – but synchronously interactive in another sense, because students can interact with each other and with teaching assistants onsite at the remote locations. Further, software agents
interact with learners as they pose questions and establish ability levels by grouping learner (Yang, Han et al. 2003).

**Learning Effects**

As in the case of almost any taxonomy or categorization of educational designs, one approach (e.g., synchronicity versus asynchronicity) is not inherently better than the other in terms of impact on learning. While most distance education occurs asynchronously (Marjanovic 1999) evidence suggests learners express preferences for blended approaches, when possible, that include both forms and, where possible, include F2F sessions (Gregory 2003). As in the case of Just-In-Time-Teaching (JiTT) discussed later in this chapter, or other examples of networked and web-active classrooms, some platforms consist of dynamic composites of F2F and WBL experiences. Learning effects research, that is research that is able to determine an effect size using F2F vs WBL, (including the large body of work that has been summed up on the “no significant difference” finding comparing distance and F2F learning Cavanaugh (2001)) will not arrive at simplistic answers to “what works” types of questions. Questions about what works, under what conditions, and with what students, are more difficult to address but ultimately are more meaningful.

Research on WBL learning effects poses challenges that can be quite different from research in other education platforms. One of the most interesting is that neither the researcher nor teachers in WBL typical investigations are advantaged (or encumbered) by having spent many years in the milieu under investigation, building their own store of observations, insights and biases. For the first time in education research history, a domain in question has not produced the researchers investigating it. From the
practitioner side, at least for the foreseeable future, this also means that the authentic craft knowledge that develops in distance education settings will likely take a different character or quality than that which has been increasingly recognized as important in effectively researching classroom practice. The divergence of WBL from F2F learning forms is a matter of gradation, and thus might be considered in terms of degrees of proximity.

**Degrees of proximity to traditional F2F learning**

For example, a first degree of proximity is incremental and would involve WBL forms that are merely intended to mimic F2F instructional design but add distance as a variable. Satellite or netcast lecture feeds to distributed listeners closely mimics classroom lecture pedagogies. The goal of this synchronous education form is simply to extend the reach of the lecture; the skills the teachers develop are primarily translational (Kanuka, Collett et al. 2002) to recreate electronically the F2F experience of the classroom. Similarly, college courses offered online and asynchronously often are also designed only to reproduce the in-class experience for remote students. The virtual learning space may include a video media file of each of the professor’s lectures; synchronized presentation slides or other visuals to accompany the lecture, and syllabus and readings. These materials may be viewed at the learner’s discretion and choice of timing. The incremental advantages include any-time and any-place flexibility for the student (including lecture and slide show replay), and more immediate access to hyperlinked resources.
A second degree removed from F2F environments are WBL settings by which the medium fundamentally alters traditional F2F classroom dynamics rather than mimic or extend them over distances. Two examples are discussions and assessments.

F2F classroom discussions provide an interactional richness, by which gestures, facial expressions or other cues, voice modulation and the spoken word all “wrap around” or contribute to semantic content of oral discussions. In contrast, threaded discussion forms bottleneck messages in highly constraining ways. There are no facial gestures, no spoken language or auditory components, no classroom semiotics or other visual cues that become part of the discussion context. Discussions become serialized over multiple online sessions for each learner: numerous contributions can be seen at every login, but generally it is not until a subsequent login at the earliest that a participant can observe a response to a contribution. At first approximation, this may seem to inhibit or suppress the interactional richness of content-based discussions. But the very effort of reducing a message to a written form with no other scaffolding fundamentally alters the construction, lending it greater focus and clarity (Pilkington and Walker 2003). On a technical level, asynchronous discussion threads allow time to frame or focus interactions; they can include hyperlinks, graphics or simulations that enrich or amplify content exchanges. Disclosure of life details and personal schedules is often elicited in asynchronously linked study groups that need to plan group project activities. Additionally, as Molinari (Molinari 2004) suggests, threads often include social devices such as self-revelation that individuals exercise to create community in asynchronous settings. The medium (and asynchronicity) change the message in discussions and thus F2F and WBL discourse differ in fundamental ways.
The internet medium and asynchronicity also change the character of educational assessment. Asynchronicity requires storage of artifacts, including discussion threads. All information is collected and used to update the system’s model of the student. Asynchronous interactions with the student’s peers and/or instructor are logged and become a defined part of a continuous assessment of the learner. These threaded discussions can be a significant source of data for assessment (Tanimoto, Carlson et al. 2002). Further, the student can review progress towards learning objectives at any time.

How far away from or close to an F2F baseline that a WBL process may be is a matter of interpretation, but there is a class or processes or approaches that are spawned by mediating technologies and simply are not available without connectivity. These are especially resistant to comparative research on learning effects because they stimulate processes that do not have analogs in more traditional settings. Participatory simulations, for example, are synchronous learning events over wireless networks. In them, individual learners effectively becoming connected agents in complex systems, enacting dynamic and emergent phenomena such as the formation of traffic jams (Resnick 1996) the mathematics of variation (Kaput, Noss et al. 2001) or the behavior of gas molecules (Wilensky and Resnick 1999). Participatory simulations may easily be considered at a third degree of proximity – they do not reproduce any type of phenomena that are accessible without connectivity. The netcast lecture mimics classroom lectures but leaves them largely unchanged. WBL discussions and assessments have similar characteristics to F2F forms, but alter them significantly over the web and asynchronous translations. Participatory simulations are simply a new form altogether.
They exemplify a class of wirelessly connected web-based learning forms referred to by Pea and Roschelle as Wireless Internet Learning Devices (WILD) (Pea and Roschelle 2002).

**WILD Examples**

Current WILD devices include graphing calculators or handhelds connected by a wireless network. The critical WILD capabilities are ubiquity (all students have their own), mobility (they can be easily carried), and connectivity (the devices interconnect arbitrarily). Less important are their compute capabilities and such attributes as screen size. Newer technologies, such as wearable computers, have a different, larger, set of capabilities of which WILD devices are a subset.

Pea and Roschelle (Pea and Roschelle 2002) identified application level capabilities around which WILD-based cooperative learning occurs. These are:

1. augmenting physical space,
2. leveraging topological space – e.g. using the locations, distances, and connections of objects as essential components of learning (Lemke 1999),
3. aggregating coherently across all students,
4. conducting the class, and
5. act becomes artifact.

The WILD construct focuses on web-based collaboration over relatively small areas, but also individual learning. The cooperative learning is designed to support individual learning. The systems used as examples of WILD cooperative learning and illustrating 1) to 5) above included:
1. *Participatory Simulations*, as discussed above, that use handhelds to simulate interacting physical phenomenon such as simulations of the spread of epidemic through handheld proximity. After experiencing a simulation, participants work together to analyze data, create hypotheses, and conduct experiments to infer underlying rules for their simulation. This is an example of leveraging topological space.

2. *ClassTalk* is a networked classroom communication system in which questions can be asked and transmitted to handhelds with the answers aggregated for classroom discussion or guidance to the teacher (Dufresne, Gerace et al. 1996; Abrahamson 1998). This is an example of coherent aggregation, now emerging as what is referred to as the CATAALYST framework (Classroom Aggregation Technology for Activating and Assessing Learning and Your Students’ Thinking) (Roschelle and Penuel 2003).

3. *Probeware* is a project that has built interfaces for inexpensive probes and sensors that can then be used to display real time measurement data (Tinker and Krajcik 2001). This is an example of augmenting physical space.

4. The Exploratorium, a hands-on science museum in San Francisco, is using a wireless network and handheld computers to provide information and scaffolding for museum visitors as they explore exhibits. At the end of the visit, a web page is created for the visitor with the information they accessed when visiting the exhibit. These web pages can be accessed by the visitor and additional information or links can be added to make a science lesson compelling. This is an
example of act becoming artifact as the act of visiting the museum is captured in an artifact – the web page.

WILD systems are typically used in a simultaneous, synchronous, non-persistent, low bandwidth, low granularity, limited communication modalities. The learning research associated with WILD devices centers around measuring learning outcomes in using these devices. Such questions are, theoretically, amenable to careful experimental design. In practice such experiments can’t be performed since not only are WILD devices being used but the learning environment is being radically changed. Thus most research in using WILD devices is design research (Kelly 2003). Computer science research in WILD devices should focus on the usability of the devices – that is the amenities that the devices provide.

LEARNER ENGAGEMENT

Across any analysis of communication variables discussed at the beginning of the chapter or how proximate a WBL platform may be to F2F platforms, a question of critical interest is how to create the feedback systems in the learning experience to sustain a high level of engagement in disciplinary content. Complex factors determine how deeply engaged a student is in a learning activity. These factors include motivation, perception of personal control in a task setting, and cognitive processing constructs such as self-regulation and strategy use (Miller, Greene et al. 1996). Asynchronous settings generally enhance personal control in the learning space and opportunities to concentrate. One especially useful factor, drawing in part both on flow theory (Csikszentmihalyi and Csikszentmihalyi 1988; LeFevre 1988; Massimi and Carli 1988) and the Vygotskian (1978) proximal development zone concept, is the balance or goodness of fit between a
student’s skills and the tasks presented to the student in a learning environment. Goodness of fit is an oftentimes delicate balance or equilibrium between skills and task, though “skills” may more broadly include problem-solving abilities or evolving conceptual models, and “tasks” may refer more broadly to online or F2F exercises, labs, problem-solving activities or learning from a lecture – any situation in which a learner can take action. A good fit is achieved if a task’s difficulty is at the outer reaches but not beyond a learner’s ability level, and learning occurs as both task levels and ability levels progressively expand.

The equilibrium between task difficulty and student ability levels is often tenuous or fragile in instructional settings, as any professor knows. It is often hard for an instructor, remotely or onsite, to find that balance for even a fraction of learners. When the balance is found, it is usually fluctuates throughout an F2F or distributed session and is often at risk of being lost if the instructor cannot reliably assess whether students are “staying with” new material or conditions and then adjust accordingly. An instructor can most reliably adjust course content to help a student maintain this equilibrium if the student is able to accurately reveal cognitive processing, and do so as a part of a learning episode rather than as a separate activity. Discussion threads in asynchronous WBL environments are especially useful in providing artifacts of thought that can be subsequently analyzed and acted upon.

**Theoretical Entrée to Engagement**

Discussion threads in asynchronous environments enable one form of such continuous, embedded assessments. We argue that an important theoretical entrée to engagement involves embedded assessment and feedback systems more generally to
maintain equilibrium of skill level, scaffolding (help by the instructor or other learners or materials) and task difficulty in a learning setting. Again, this equilibrium is hard to personalize for individual students and certainly difficult to establish for all students in both F2F and distance learning environments, with each type of environment posing unique challenges. When the equilibrium between task and skill is lost, and learning tasks either exceed the student’s skill level or are too trivial for it, disengagement sets in; flow theory, discussed below, characterizes the spectrum of disengagement as anxiety (task is too difficult) to boredom and apathy (task is too easy). The assessment and feedback systems needed to preserve this equilibrium may involve dozens, hundreds or even thousands of discrete sampling and feedback events over an instructional sequence.

**Flow**

While engagement is a multivariate construct, its apex – full and unbroken immersion in demanding activities – may be characterized as the state of flow. Introduced as a psychological construct by Csikszentmihalyi (1975) it has been widely researched – it is often characterized as intrinsic enjoyment or satisfaction while engaged in work or play, fully concentrated absorption in an activity whereby an individual loses a sense of time, or optimal or heroic performance in highly challenging or desperate circumstances. Because flow refers to such a broad range of intense human experience, it is not surprising that definitions and descriptions abound; a recent review reported sixteen different operational definitions (Novak, Hoffman et al. 1998), though usually only subtle variations separate these definitions. Csikszentmihalyi and collaborators continue to refine the concept, e.g., Csikszentmihalyi (2000; Nakamura and Csikszentmihalyi 2002). Only a small fraction of the literature focuses on flow in formal educational
environments, and little or none on flow in WBL settings. Shernoff, Csikszentmihalyi and Schneider (2003) conceptualize flow in formal F2F classroom settings as involving simultaneously high levels of concentration, interest, and enjoyment in a learning task, none of which are possible without maintaining an equilibrium of challenge and ability. Both this study and that by Uekawa, Borman et al (2004, in submission) examined flow experiences of high school students.

We argue that understanding the conditions for high engagement in learning is essential for building effective WBL platforms of the future. Further, we argue that WBL research should investigate whether the experience of flow while learning is a routinely inducible phenomenon. That is, WBL platforms should seek to structure high engagement learning environments that routinely immerse learners in disciplinary content and systematically maintain a high-motivation environment with challenging tasks matching learner skills. Our conjecture is that as the frequency of those high engagement experiences climbs for a learner, so will occurrences of flow states.

We look at two relatively new platforms (a blended asynchronous, F2F form in increasingly widespread practice and a synchronous form now emerging with the advent of tablet computing). These are chosen to illustrate WBL environments in both asynchronous and synchronous modes that are organized around the rich teacher-learner feedback and embedded assessment systems to sustain the task-skill equilibrium necessary for high engagement learning.
**Just in Time Teaching (JiTT)**

Just-in-Time Teaching (Novak, Patterson et al. 1999) is a feedback-intensive teaching and learning strategy. It is especially useful in the study of synchronicity because it is a hybrid of asynchronous WBL instruction and traditional F2F instruction, and it derives its instructional value from the features that are *close* to but definitely not synchronous. Students in JiTT courses respond electronically to carefully constructed web-based assignments due shortly before an F2F class, and the instructor reviews the student submissions “just-in-time” to adjust the classroom lesson to suit the students’ needs. The heart of JiTT is this “feedback loop” formed by the students’ just-before-class work that fundamentally affects what happens during the subsequent in-class time together. Thus, the JiTT classroom session is intimately linked to the web-based preparatory assignments the students complete. Exactly how the classroom time is spent depends on a variety of issues such as class size, classroom facilities, and student and instructor personalities. Mini-lectures (ten minutes maximum) are often interspersed with demonstrations, classroom discussion, worksheet exercises, and even hands-on mini-labs.

*The common key across these variations is that the classroom component, whether interactive lecture or student activities, is informed by an analysis immediately prior to the classroom of various student responses.*

In a JiTT classroom, students may be exposed to the same content as in a passive lecture, but with two important added design features. First, having completed the web assignment very recently, the intent is that learners enter the classroom ready to actively engage in the course content. Second, they are expected to maintain a sense of ownership since the interactive lesson is based on their own wording and understanding of the
relevant issues that are the focus of the class. Although the questions over the web are short, when fully discussed, they often have complex answers. The students are expected to develop solutions as far as they can on their own as a way to “set the table” for the F2F phase, where the job is finished. The instructor uses the responses to form the framework for the classroom activities that follow. Typically, the instructor duplicates sample responses on transparencies and takes them to class. **This feedback-rich interactive classroom session, built around these responses, replaces the traditional lecture.**

JiTT practitioners are now developing a digital library of activities under NSF’s National STEM Digital Library program (Patterson and Novak 2003) and the agency has issued six other awards related to expanding JiTT practice, including a year-long effort to engage the national JiTT community in the formulation of research agendas to determine conditions of optimal use of the strategy (Hamilton, Patterson et al. 2004). The website http://www.jitt.org has more information about this web-based learning approach, which now involves several hundred faculty at over one hundred institutions around the world. The institutions include high schools, two year colleges, four year colleges, professional schools, and universities, large and small, rural and urban, private and public. The twenty-two disciplines known to use JiTT are predominantly STEM-based (e.g. astronomy, chemistry, economics, mathematics, physics, biochemistry) but also include areas such as history, philosophy and journalism.

The 1999 NSF-funded Project Kaleidoscope publication entitled “Then, Now, and in the Next Decade: A Commentary on Strengthening Undergraduate Science, Mathematics, Engineering, and Technology Education” (Rothman and Narum 1999) featured JiTT as a success story – one of the successful innovations of the decade.
**Shared Workspaces (SWs)**

The second platform is a fully synchronous web-based approach to the use of shared workspaces (SW) in both remote and F2F classes. For the purposes of this discussion, an example of a workspace is a simple writing pad and pencil. This platform uses digital writing pads (using tablet computers) that can be networked and shared by different users in a classroom. Whiteboarding over a network of classroom computers is a form of a shared electronic workspace. A user at one station in a whiteboard network can use free-hand writing, drawing, or annotation tools on a document, with markups or annotations appearing at the stations of other users. Whiteboarding is currently more common in corporate collaboration software than in educational settings (using commercial packages from firms such as Microsoft, Centra, and FirstVirtual), but the advents both of wireless networking and tablet computing have created intriguing new conditions for educational tool development and research. (Tablet computing refers in this chapter to notebook computers that use the Microsoft TabletPC XP operating system and that allow freehand writing input on a display screen.)

Early pen-based SW collaboration platforms in education were originally developed by Hamilton (1993) since then, others have developed platforms with similar features (Greenberg, Hayne et al. 1995; Hamilton 1999; Walters 2000) using hardware and operating system technologies that do not provide the human computer interaction (HCI) advantages that wirelessly connected tablets now present. One version of a shared workspace platform is currently under prototype development in partnership with the Research Assistance Program of a Canadian multinational firm extensively involved in educational and corporate collaboration tools, Smart Technologies. This platform, under
development with support from the National Science Foundation (Hamilton, Cole et al. 2004) is a hybrid of earlier systems with more recently developed web-based conferencing tools, and integrates digital libraries and pedagogical agents within it. The platform, Agent and Library Augmented Shared Knowledge Areas (ALASKA), capitalizes on the natural handwriting/typing flexibility of tablet devices and places a software design premium on giving the teacher the ability to “periscope” into and participate with unimpeded access in the workspace of students (individually and in groups), and for students to do the same with each other.

Platform Structure

Leaving aside for the purposes of this discussion, the role of pedagogical agents and digital libraries in the ALASKA platform, the affordances of synchronous (F2F and remote) interactions in shared workspaces still loom large and exemplify potentially significant pedagogical possibilities. Problems can be written on the tablet during a learning session using a pen, or teachers can prepare them in advance. The teacher may distribute a problem to any student or node of students, to an entire class, or to selected groups of students. The teacher may elect to annotate the problem (or use a blank screen) to provide notes in real-time which appear at each student's station. The teacher can also provide “blackboard” notes to students in real time. While still not in common use, these features have been available (at least with non-tablet devices) since the mid 1990s.

More recently, though, the pen and tablet interface allows learners to use both a paper and pencil problem solving mode and one conducive to physical or soft keyboard input. The notebook metaphor advanced now in the Windows TabletPC operating system is appropriate -- the student may save or discard sheets, retrieve them, have
several sheets out at a time, use an electronic eraser, etc. Additionally, the student may switch in and out of keyboard input, can use drawing tools, can use a calculator which appears in the screen by pressing the appropriate icon, or can press an icon to change the ink color, etc.  

In some synchronous SW systems, the teacher may define collaborative workgroups, based on the individuals or groups who are in the learning environment at the time. Different versions of collaborative workspace environments will allow the teacher to share a workspace, enabling simultaneous writing, erasing, or typing by the teacher, student (or workgroup members). With such a feature, the teacher can observe a student's or group's work, or actually interact or participate in the shared workspace. As embedded in the ALASKA platform, for example, the design intent is for the teacher to rapidly and repeatedly assess student conceptual frameworks and strategies and provide real-time feedback to students as they engage in substantive problem solving and knowledge construction. All the students' efforts – as represented on this tablet - are disclosed in real-time to the teacher, and all of the students know the teacher can interact with them in their problem solving.  

Additionally, within the ALASKA platform (and earlier predecessors that have contributed to its development), the teacher may view the work of many students at once, by using what are called hotboxes. When the teacher enters hotbox mode, a portion of the workspace of each student or student group becomes a shared workspace with a corresponding window appearing in the teacher’s screen. The boxes may be resized, enabling up to twenty windows to appear on the teacher’s screen at one time. The teacher is in a shared workspace with each student's or group’s window, and can see all
of the work appearing in each window at the same time. **That is, the teacher can watch all the students simultaneously as they progress through a problem or other workspace activity, and work with any one in particular by writing in their workspace, simultaneous to the student or group workspace effort.**

**Sample Scenario:** Consider a scenario familiar to almost any F2F teacher and to teachers of its online and distributed education analogs. An instructor poses a question and elicits responses through the time-honored method of hand-raising or its electronic equivalent for remote students. This is very little information on which to make judgments about whom to call on for a response, whether electronically or physically cued. In an F2F classroom, the dynamics can become very troubling, but in both distance and F2F settings over a network, determining whom to call on in response to a question is generally a matter of guesswork.

In contrast, a shared workspace system, such as the ALASKA platform, allows the instructor to concurrently see multiple (up to 20) responses – and the underlying processing, at least as the student “works” the problem – simultaneously. The design intent is for the platform to provide a dramatically bigger “pipe” to see what students are thinking, and provide a much richer information base for the rapid assessment or judgment of student understandings. The instructor can make judgments either about the aggregate online or physical classes, or individuals therein – but in either case can be sufficiently informed to give specialized feedback either on a whole class or individual basis, either orally or electronically, and in the latter case with applets or annotations. **We do not suggest at all that the teacher can process twenty times as much information in a shared workspace, we do suggest that with an electronic overview of**
what all of the students are doing, the professor can use professional discrimination and judgment to scan and select student workspaces for deeper probing and interaction, and can “move” from student to student much more freely and judiciously with a better knowledge of ongoing cognitive load and processing. **This type of wirelessly shared workspace system is intended to replace information deficits with information abundance, in order to give teachers flexibility and opportunity to interact on a deep content level with learners.** The same time frame in the dilemma above now is populated not with judgments and guesses based on visual cues of electronic or physical hand-raising-- the instructor spends the time scanning, examining and responding to “thought-revealing” representations in the workspace.

**Complementarity of the JiTT and SW platforms**

Both settings (JiTT as an asynchronous blend and Shared Workspaces as a synchronous tool) -- possesses specific strengths relative to the quest to engage learners deeply in challenging disciplinary content. Each sheds complementary light on the mechanisms for eliciting rich, actionable information from students for the purposes of providing feedback that will maintain challenge/skill equilibrium and that will sustain cognitive engagement.

For example, JiTT builds feedback loops in class on exercises completed immediately before class. The instructor generally views only the web-submitted answers to the exercises, with process-oriented interactions and discussions taking place in class. Student thinking may be complex but the artifacts – web submissions prior to class – are structured for efficiency (simple answers), with more complex representations
reserved for class discussion. JiTT is a most firmly established and readily adoptable practice.

The wirelessly connected tablets in the shared workspace (SW) distance and F2F synchronous settings provide feedback loops on instructor observation of students working problem sets synchronously, and the instructor can see and interact with the written processing in real-time. The written process-artifacts for each individual student are much richer representations of individual cognitive processing than the web-submitted answers, but not as amenable to generalizations that can be made across the class. Each provides rapidly actionable information to guide pedagogical decisions about both individuals and the whole class, but one (JiTT) provides information more efficiently about the class and the other (SW) provides richer real-time artifacts about individual processing. The SW environment is more sensitive than the JiTT environment to advances in the computing technology and human-computer-interface (HCI) developments, and the advent of wirelessly networked tablets accelerates the possibility for synchronous shared workspaces to become a viable instructional tool. The ALASKA platform’s integration of pedagogical agents (Cole, Vuuren et al. 2003) and digital libraries (Roschelle, Kaput et al. 1998) creates a new set of possibilities for synchronous instruction whereby agents become real-time teaching assistants and real-time peer-to-peer collaboration brokers (Hamilton 2004). Advances such as this expand the interactional promise of synchronous SW platforms.

**Measuring Engagement**

One looming research area is the measurement of engagement in learning settings such as the collaborative WILD devices, the Just-in-Time asynchronous setting, or
platforms where the instructor can periscope into the real-time workspace of online or F2F students. Each of these can make specific claims that the mediating technology and the nature of their synchronicity renders special advantages and opportunities to keep learners deeply engaged in disciplinary content, within their proximal development zone.

Uekawa, Borman et al. (2004, in submission) undertook a study of learner engagement patterns in science and mathematics classrooms in eight high schools, using a social organization framework to explore racial and ethnic contrasts in those patterns. Their study has policy implications for K12 education, but also marks important progress in conceptualizing and measuring engagement at postsecondary and distributed settings. They reviewed key advances and shortcomings of several methods of engagement measurement, including video analysis, interaction event counts, observer protocols, discourse analysis, and use of the Experience Sampling Method (ESM) devices – electronic paging devices Csikszentmihalyi developed in the 1970s to periodically prompt learners to self-report engagement levels during activities (such as classroom participation). They opted to use the first and last of these approaches – unobtrusive and qualitative classroom observations coupled with intrusive but more quantifiable ESM datapoints. They developed a series of quick response questions that probed interest, engagement and activity levels that students answered on each side of a survey form when paged two times in a 50 minute class. Adopting this methodology to online settings to yield important insights on whether specific learning platforms more readily and deeply engage learners, and reframe research on learning effects.
**RESEARCH ISSUES AND QUESTIONS**

This chapter identifies selected variables useful in analyzing learning platforms in general, including synchronicity as a critical variable in web-based learning (WBL). We proposed a simple, “three-degree” schema for examining the proximity of WBL forms to baseline and traditional face-to-face (F2F) educational settings, focusing interest on synchronous WBL platforms that could not readily exist in F2F settings. Synchronicity is an interesting variable in structuring WBL environments relative to the study of learner engagement and whether WBL enablements can stimulate learner flow. Two examples – an asynchronous and F2F blended platform, and a synchronous platform, are suggested to illustrate a series of research questions related to learner engagement.

These questions involve whether it is possible to use the affordances of synchronous platforms to help teachers continuously assess learners and to accurately scaffold learners in their proximal development zone. Can the learning environment be sufficiently adaptive, in other words, to “form fit” the learner continuously? The shared workspace WBL platform discussed here is organized around the metaphor of making thinking visible (Lesh, Hoover et al. 2000) in ways that are not readily possible in classroom F2F settings. Equipped with far more moment-to-moment information about learner cognition, will the professor or teacher be able to rapidly forge and act on instructional judgments? This, like other technology advances, requires more sophisticated technical and pedagogical proficiencies of teachers. Will the increased feedback that synchronous systems allow improve the motivational climate of learners? Is it possible to routinely induce high performance learning, or what might be called learning flow?
While only alluded to briefly, the role of *pedagogical agents* (animated or text-based or invisible to the user) in WBL environments is an emerging area of work that is central to questions of synchronicity and learning effectiveness. For example, software agents can perform complex community-building and pedagogical tasks in distributed learning settings, amplifying the “real-time” abilities of a teacher in a synchronous environment. The integration of effective agent systems into WBL platforms is an increasingly important research domain. It involves questions such as whether agents can stimulate effective learning communities in WBL settings (Yang, Han et al. 2003) or whether they can simplify a teacher’s workload to free him or her to concentrate on more cognitively complex challenges of the learning environment (Hamilton 2004).

Another important area relative to synchronicity goes to the heart of learning and teaching. The spectrum of from synchronous to asynchronous and the intermediate blends – all offer different content delivery functionality. Shute and Towle (2003) argue that this spectrum produces highly adaptive “anywhere, anyplace, any pace” content delivery. But content delivery may be a narrow prism for analyzing WBL platforms. At their best, as we have tried to outline, they involve interactivity between learners and learners and their teachers. “Interactional bandwidth” – a way to conceptualize the richness and speed of content-based exchanges over WBL settings, may be another analytic lens for WBL platform research, and lead to greater insights into disciplinary and social knowledge construction.

**REFERENCES (INCOMPLETE)**

International Conference of the Teaching of Mathematics, Village of Pythagorian, Samos, Greece, John Wiley and Sons.


Rothman, F. and J. Narum (1999). Then, Now, and in the Next Decade: A Commentary on Strengthening Undergraduate Science,
Mathematics, Engineering, and Technology Education. Washington, DC, Project Kaleidoscope.


Simonson, M., S. Smaldino, et al. (2002). Teaching and Learning at a Distance: Foundations of Distance Education, Prentice Hall.


