

# Journal of Research in Innovative Teaching

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## Editor's Column

This is the second issue of the **Journal of Research in Innovative Teaching (JRIT)**, published by National University. It is another milestone in our quest for research culture. The first issue, a great success, published 16 articles. This second issue includes 20 articles, accepted after a rigorous review. Among the journal's authors you can find National University faculty, joint authorship of the University faculty with outside scholars, US researchers from outside the University and international writers.

National University's mission is to make lifelong learning opportunities accessible, challenging and relevant to diverse populations. In accordance with this mission, the National University research journal publication is an important benchmark in the University's maturity. Teaching, research and scholarship are interrelated; evidence shows that research enriches teaching and is capable of significantly improving student learning outcomes. JRIT is an annual multidisciplinary peer-reviewed publication of original research focused on new effective instructional approaches, methods and tools. It is intended to produce momentum to increase efficiency of learning and ensure better learning outcomes of our students.

The Journal is a forum to share faculty research and scholarship, which will ultimately benefit both the university academic community and our students. The Editorial Board is composed of top scholars and administrators from National University, as well as several internationally acclaimed scholars. The Review Board includes both internal and external reviewers.

All publications have been conditionally assigned in the following sections:

- General Issues
- Institutional Planning
- Online Learning
- Teaching and Learning
- Self-assessment and Reflection
- Leadership
- Projects and Grants Reports

In the **General Issues** we have two articles, *The Effect of Working Memory Capacity on Multimedia Learning: Does Attentional Control Result in Improved Performance?* by Peter E. Doolittle and Laura Levi Altstaedter from Virginia Tech, and *New Educational Paradigm in Transitional Societies* by Vladimir Nikitin and Liudmyla Parashchenko from Ukraine. The first discusses individual differences in working memory capacity (WMC) and how they affect student learning within multimedia instructional environments. The results of two experiments indicated that students with high WMC recalled and transferred more information than students with low WMC after engaging in a multimedia tutorial. The second suggests new educational institutions in the countries of East Europe should be created within a democratic educational system in the context of market competition. These institutions should be integrated in the network of global innovative establishments, which can be used as models for transformation of the entire educational system.

The **Institutional Planning** section is represented by two articles. The first, *Developing a Strategic Plan for Implementing the Continuous Improvement Process of the School of Education at National University* was prepared by C. Kalani Beyer from National University. This article presents a strategic plan of the School of Education for implementing continuous

improvement of online course delivery. This plan focuses on the future direction which online education should take at National University, and provides a means to integrate innovative delivery of instructional material and strategies, as well as techniques to continuously assess the quality of instruction. The second, *Online Performance-based Management and Evaluation System as an Instrument to Manage the Quality of Institutional Performance at the University of Technology, Jamaica* by four authors from the University of Technology, Jamaica, Sandra A. C. Glasgow, Jennifer Ellis, Nicola Johnson, and Valeri Pougatchev, describes the rationale for the development of an Online Performance-Based Management and Evaluation System (OLPBMES) at their University, the roles of each of the partners in the process, some particular technical solutions, and security solutions of the system. This approach will allow the institution to respond promptly to real-world challenges and opportunities that might affect its short- and long-term strategy and may provide an accurate diagnosis of the educational reality and an objective assessment of the impact of intervention policies to society.

The **Online Learning** section includes five articles. In *Designing Learning Experiences for Comparability across Delivery Methods*, Dee L. Fabry presents issues and barriers that affect effective online course design. She raises the question of how to design comparable courses across delivery methods in order to ensure that goals, objectives, and learning outcomes are met. A design process and matrix provides guidelines for mapping consistency across course delivery methods.

Piet A. M. Kommers from the University of Twente and Ralph W. Hooreman from Eindhoven School of Education, The Netherlands, in their article *Mobile Phones for Real-Time Teacher Coaching* argue that mobile phones and online PDA's (personal digital assistants) became ubiquitous in our leisure, professional, and educational settings. They illustrate how the PDA and a wireless earpiece allow teacher training to become more vivid and responsive and indeed promote additional learning effects, when compared to the traditional coaching feedback after a lesson.

Martin Ebner from the Technical University of Graz, Austria, in his article *Introducing Live Microblogging: How Single Presentations Can Be Enhanced by the Mass* discusses a fairly new approach is communication through so called microblogging channels. Mobile devices with Internet access can be used to send short messages from a microblog which can be used to improve face-to-face lectures.

National University faculty E. George Beckwith and Daniel T. Cunniff outline an example of an accelerated, eight-class-session course detailing effective multimedia instructional techniques in their *Accelerated Learning: Online Multimedia Techniques in Hybrid Classes* article.

A collaborative work by the Norwich university faculty Darryl J. Mitry and the National University faculty David E. Smith produced the article *The Search for Student and Faculty Online Authenticity*. In this paper the authors examine the primary questions of authenticity in online university education and presents implications and recommendations. They claim that the true potential of online programs will not be realized until institutions adhere to the higher academic standards of student identification, employ fully credentialed faculty expertise, and thereby establish a system that satisfies the dual objectives of both student and faculty authenticity.

The largest section is **Teaching and Learning** which presents seven articles in various areas: mathematics, engineering, business and education.

Nikolai N. Bilotskii from Kiev National Pedagogic University and Igor Ya. Subbotin from National University employ the inter-subject approach in illuminating the process of logical and cognitive development of some widely used calculus concepts in their article *Inter-subject Connections in Teaching Mathematics: Isometries of a Number Line and Some Fundamental Properties of Functions*. They believe such a general approach is really effective in meaning clarification of main concepts in calculus course.

Zhonghe Wu from National University conducted a study in which he compared Chinese and U.S. mathematics teachers' knowledge and confidence in integrating technology. The study described in the *Comparison Study of Teachers' Knowledge and Confidence in Integrating Technology into Teaching Mathematics in Elementary School in the U.S. and China* paper found differences in using technology in teaching mathematics between the two groups of teachers.

*Heuristic Component to Teaching Methods of High School Teachers* written by Olena Skafa from National University in Donetsk, Ukraine, presents some ideas of heuristic tasks and methods applicable to higher school teaching of mathematics.

John L. Elson from TUI University, and Clark Mount-Campbell and David D. Woods from the Ohio State University in their *Expert Problem Solving in a Manufacturing Virtual World Simulation* are calling for developing new research methods and methodologies that will increase the expertise and knowledge of engineering graduates. Their paper provides an overview of simulations used in education and in particular those being used in engineering education.

Donald A. Schwartz from National University in his paper *The Impact of More Rigorous Grading on Instructor Evaluations: A Longitudinal Study* discusses a unique opportunity to study the effect of an anti-grade inflation initiative and its impact on instructor ratings for all of the university's business school classes over a six-year period. The results of the study clearly contradict the contention that more rigorous grading begets lower ratings from students.

*The Game Frame of Reference as a Precondition for Students' And Teachers' Self-Realization* by Natalie Losyeva from National University of Donetsk, Ukraine, discusses theoretical aspects and practical experience of teaching in based on teachers' and students' self-realization, and demonstrates the use of cognitive didactic games as a means for joint creative activity and interpersonal communication that can contribute toward that self-realization.

*Learning Outside the Classroom: A Qualitative Study* by Ron W. Germaine from National University investigates teacher candidates' learning as a result of a cultural immersion experience they participated in outside the classroom. The study yielded themes that provide evidence of transformational learning, modeled action research for candidates, and provided evidence of alignment between candidates' learning and course learning outcomes, program goals, the institutional mission, and the standards of external accrediting agencies, including WASC and NCATE.

In the **Self-assessment and Reflection** section, *A Study of Instructional Practices: The Case for Reflection and Research* by Peter Serdyukov and Nataliya Serdyukova from National University is a result of a several years' investigation of the faculty instructional practices which, when coupled with reflection, can be a powerful tool for improving teaching and enhancing student learning outcomes. Their article presents the findings of a research targeting teaching methodology and learning characteristics in several different courses, both onsite and online, addressing strategies, technologies and student demographic characteristics, such as age and gender.

The **Leadership** section contains two articles. *School Psychologists: Educational*

*Leaders for Tomorrow* by Linda K. Smedley and Diana Wheeler, National University, discusses school psychologists' specialized leadership role in the educational system. The paper by Ellen Kaye Gehrke, National University, *Developing Coherent Leadership in Partnership With Horses—A New Approach to Leadership Training*, offers a new perspective in leadership development by demonstrating how engaging horses as partners in leadership training can lead to more coherent and sustainable leadership effectiveness.

Finally, in the **Projects and Grant Reports section**, Pradip Peter Dey, Ronald P. Uhlig, Mohammad N. Amin, Arun Datta, Gordon W. Romney, Thomas M. Gatton, Mudasser F. Wyne, and Albert P. Cruz from National University offer a paper *Teaching Mathematical Reasoning in Science, Engineering, and Technology* on a method of teaching rapid reconciliation of intuition and controlled mathematical reasoning to engineering students in order to overcome inappropriate use of the intuitive mode of cognitive function.

The Editorial Board invites the readers to discuss publications presented in this issue and suggest topics that might be of interest for academic community at National University and outside. We will start publishing letters from the readers in the next issues.

*Peter Serdyukov*  
*March 1, 2009*

# General Issues



# **The Effect of Working Memory Capacity on Multimedia Learning: Does Attentional Control Result in Improved Performance?**

Peter E. Doolittle and Laura Levi Altstaedter

## **Abstract**

Do individual differences in working memory capacity (WMC) affect student learning within multimedia instructional environments? High and low WMC students, as measured by the operation span (OSPAN) task, engaged in a multimedia tutorial addressing lightning formation or car brake use. The results of two experiments indicated that students with high WMC recalled and transferred more information than students with low WMC after engaging in a multimedia tutorial. In addition, the multimedia principles of coherence (Exp 1) and signaling (Exp 2) were also assessed for validation. Each of the experiments failed to validate the previous multimedia learning principles. These results are consistent with a general individual differences WMC effect but inconsistent with previous finding regarding the coherence and signaling effects.

## **Key Words**

Working memory capacity, multimedia learning, coherence principle, signaling principle

## **Introduction**

The world has become saturated with multiple forms of media: television, radio, mp3 players, DVD players, and web-based audio and video. These multiple forms of media, or multimedia, have also infused themselves into both formal and informal instructional environments and have been demonstrated to have a significant impact, both negative and positive, on the nature of learning. For example, multimedia has been demonstrated to have a negative impact on learning and performance when a student's visual attention is split between an animation-based tutorial depicting the cause of lightning and a simultaneously presented text-based description of the lightning tutorial (Mayer & Moreno, 1998). In contrast, multimedia has been demonstrated to have a positive impact on learning and performance when a student's attention is guided toward specific goals for reading and viewing an illustrated, text-based tutorial of the cause of lightning, such as when students are told to focus on learning the steps involved in creating a stroke of lightning before engaging in the tutorial (Harp & Mayer, 1998).

If multimedia can both support and interfere with learning, might individual differences in attention influence learning and performance in multimedia instructional environments? In support of this question, there exists a body of literature demonstrating that attentional control affects learning and performance (Daneman & Carpenter, 1980; Oberauer, Süb, Schulze, Wilhelm, & Wittmann, 2000; Unsworth & Engle, 2007). Within this literature, "attentional control" has been defined as the ability to maintain information in working memory while effectively retrieving task relevant information from long-term memory (Feldman Barrett, Tugade, & Engle, 2004), and it has been measured by working memory capacity (WMC) (Kane, Bleckley, Conway, & Engle, 2001; Kane & Engle, 2003). Thus, the present study explored whether individual differences in WMC affect learning and performance in multimedia instructional environments.

## Working Memory Capacity and Individual Differences

Individuals need to have the ability to dynamically retrieve, maintain, manipulate, and update information in order to successfully complete complex cognitive tasks (Baddeley & Hitch, 1974). While investigating this dynamic memory model, Daneman and Carpenter (1980) concluded that complex memory tasks and working memory capacity are positively correlated; in other words, they found that global and local measures for reading comprehension and working-memory span tasks that involve information processing and storage are positively correlated (Daneman & Carpenter, 1980). In this study, participants were asked to complete a task that involved reading a series of sentences (processing) while remembering the last word in each sentence (storage). Unlike previous storage-only working-memory span tasks (e.g., digit span, word span), this storage + processing working-memory span task included reading, an additional processing task that increased working-memory load complexity. In this sense, this type of complex storage + processing working-memory span task is thought to be more accurate at estimating the cognition needed to perform complex cognitive tasks than simpler span tasks that only involve storage and not processing of information (Daneman & Carpenter, 1980; Unsworth & Engle, 2007).

Over the past 25 years, researchers investigating the constitution of WMC and the effects of individual differences in WMC have used this type of complex storage + processing memory span tasks as a measure of WMC. It has been found that high WMC can be considered a good predictor of primary memory maintenance and secondary memory search (Unsworth & Engle, 2007), attentional control (Kane et al., 2001; Rosen & Engle, 1997), long-term memory activation (Cantor & Engle, 1993), general fluid intelligence (Conway, Cowan, Bunting, Theriault, & Minkoff, 2002; Kane et al., 2004), resistance to goal neglect (Kane & Engle, 2003; Roberts, Hager, & Heron, 1994), and resistance to proactive interference (Kane & Engle, 2000; Lustig, May, & Hasher, 2001). Therefore, it can be concluded that attentional control—being able to actively maintain information in working-memory, as well as being able to effectively and efficiently search for task-relevant information in long-term memory while completing a task, whether or not under conditions of interference or distraction—is the basis of WMC (Feldman Barrett et al., 2004; Unsworth & Engle, 2007).

This emphasis on attentional control as the basis of WMC has resulted in research focused on the effects of individual differences in WMC—that is to say, high and low WMC—on participants' performance in complex cognitive tasks. Researchers found that variations in WMC and in complex cognitive task performance were positively correlated. More specifically, it has been demonstrated that participants with high WMC perform better than those with low WMC on tasks involving Scholastic Aptitude Test performance (Turner & Engle, 1989), reasoning (Conway et al. 2002; Kyllonen & Christal, 1990; cf. Buehner, Krumm, & Pick, 2005), mnemonic strategy effectiveness (Gaultney, Kipp, & Kirk, 2005), lecture note taking (Kiewra & Benton, 1988), storytelling (Pratt, Boyes, Robins, & Manchester, 1989), reading comprehension (Daneman & Carpenter, 1980), computer language learning (Shute, 1991), language comprehension (Just & Carpenter, 1992), and vocabulary learning (Daneman & Green, 1986).

## **Domain-General and Domain-Specific Working Memory Capacity**

A stable construct sensitive to individual variation has been identified through research on WMC and individual differences in WMC. However, a topic that has yet to be elucidated is whether WMC is influenced by task specificity or whether it has its basis in general underlying processes. Researchers studying the correlation between verbal and spatial measures of WMC, as well as verbal and spatial measures of ability, have found that these two types of measures are positively correlated, thus providing support to a domain-specific perspective on WMC; in contrast, researchers have found little or no correlation between spatial ability and verbal WMC, or between verbal ability and spatial WMC (Daneman & Tardif, 1987; Morrell & Park, 1993; Shah & Miyake, 1996). Additional support for the domain-specific perspective on WMC arises from explanatory and confirmatory factor analysis studies, whose results revealed that verbal ability and verbal WMC measures, as well as spatial ability and spatial WMC measures, have yielded separate independent factors (Friedman & Miyake, 2000; Handley, Capon, Copp, & Harper, 2002; Kane et al., 2004; Shah & Miyake, 1996).

Other research studies, however, support a domain-general WMC perspective. A study involving a latent-variable approach to verbal and spatial WMC that examined several measures of verbal and spatial WMC, short-term memory, and reasoning (Kane et al., 2004) found that, given the extensive shared variance (70%–85%) between verbal and spatial WMC tasks, WMC could be considered mainly domain-general, despite the fact that the researchers found a small domain-specific factor. The results of Kane et al. provided further support to previous latent-variable approaches to verbal and spatial WMC, in which it was concluded that verbal and spatial WMC constitute a single underlying factor (Ackerman, Beier, & Boyle, 2002; Oberauer et al., 2000, 2003). Other studies that confirm the domain-general perspective include those by Kane and Engle (2003), who found that maintenance of information (e.g., goals, representations) and avoidance of distraction (e.g., irrelevant stimuli, prepotent responses) depended on general controlled attention, as well as those of various other researchers, who found that, in tasks that demand attention-control for success (e.g. dichotic-listening task, antisaccade task, Stroop task), high WMC participants had better general performance than low WMC participants (Conway, Cowan, & Bunting, 2001; Kane & Engle, 2003; Unsworth, Schrock, & Engle, 2004; cf. Kane, Poole, Tuholski, & Engle, 2006). As Kane et al. (2004) pointed out, researchers have yet to reach consensus regarding the domain-specific or domain-general nature of WMC, and it is possible that this may never occur.

## **Working Memory Capacity in Multimedia Instructional Environments**

Working memory capacity is a measure of an individual's ability to control attention in order to maintain representations in working memory and to search for and retrieve relevant information from long-term memory. WMC effects have been most consistent in tasks that require information maintenance, require long-term memory search, or involve interfering or distracting stimuli (Feldman Barrett, Tugade, & Engle, 2004; Unsworth & Engle, 2007). The previously reviewed WMC tasks (e.g., reading span, operation span, counting span) and the complex cognition tasks (e.g., antisaccade, dichotic listening, reading), however, are all single-media tasks, involving only visual *or* auditory information. Conversely, multimedia tasks generally include tasks with both a visual component (e.g., pictures, animation) and a verbal component

(e.g., text, narration). Further, the multimedia learning literature, as with WMC, is based on the combination of attentional selection of stimuli, retrieval of relevant information from long-term memory, and active processing and integration of representations (see Mayer, 2001, 2005; Reed, 2006).

While it is evident that WMC and learning in multimedia instructional environments require similar processing (i.e., attention, retrieval, integration), the nature of individual difference effects of WMC on learning in multimedia instructional environments is unclear; thus, two experiments were designed to assess the individual differences effect for learning in multimedia environments. In Experiment 1, high and low WMC participants engaged in a tutorial on the cause of lightning in one of two conditions: visual animation with auditory narration (AN) or visual animation with auditory narration that includes irrelevant background graphics, sounds, and seductive details (ANSD). Previous research has indicated that participants in the AN condition tend to outperform participants in the ANSD condition, the coherence effect (Harp & Mayer, 1998; Mayer & Jackson, 2005; Moreno & Mayer, 2000). In Experiment 2, high and low WMC participants engaged in a tutorial on how car brakes work in one of two conditions, visual animation with auditory narration (AN) or visual animation with auditory narration that includes visual signaling (ANVS) in the form of key words located spatially contiguous to their referent and a spotlight effect to focus attention on the germane aspect of the animation. Previous research examining this signaling effect has been inconclusive, with some research supporting the cues to focus learner's attention and some research not supporting the inclusion of cues (Harp & Mayer, 1998; Mautone & Maher, 2001). Both of the present experiments were designed to assess whether a general individual differences effect of WMC for learning in a multimedia instructional environment exists and to verify previously supported principles of multimedia learning.

## **Experiment 1**

The purposes of Experiment 1 were to test the general individual differences WMC hypothesis: that high WMC participants would outperform low WMC participants on measures of recall and transfer after engaging in a multimedia tutorial and, to validate the coherence principle, that students' recall and transfer of information is inhibited when a multimedia tutorial includes extraneous words, pictures, sounds or music (Moreno & Mayer, 2000). These extraneous items, termed "seductive details," may inhibit recall and transfer by activating inappropriate schemas or distracting the learner (Harp & Mayer, 1998; Mayer & Jackson, 2005; Sanchez & Wiley, 2006). In Experiment 1, extraneous graphics and sounds were added to a tutorial on how lightning forms.

### *Method*

#### *Participants and Design*

The participants were 106 undergraduate students (74 men and 32 women) with a mean age of 19.7 years, including 6 freshmen, 34 sophomores, 48 juniors, and 18 seniors. They were enrolled in a non-major personal health class and received course credit for participation. Participants were taken from a larger pool of 201 students who were administered the OSPAN (Operation Span) working memory span test. Of these 201 students, only those that scored in the upper or lower quartiles were included as participants. The experimental design was a  $2 \times 2$  factorial

design with working memory capacity (high WMC, low WMC) and multimedia group (animation + narration [AN], animation + narration + seductive details [ANSD]) as between-subject variables. Participants were assigned to either the high ( $n = 54$ ) or low ( $n = 52$ ) WMC group based on their OSPAN performance. Participants were then randomly assigned to either the AN ( $n = 58$ ) or ANSD ( $n = 48$ ) multimedia group.

### *Materials and Apparatus*

*Working memory capacity OSPAN task.* WMC was measured using the OSPAN operation-span task (La Point & Engle, 1990; Turner & Engle, 1989). The OSPAN requires participants to solve a series of basic math problems while attempting to remember a series of unrelated words. Specifically, participants were shown a series of math-word sentences in the form of “IS  $(3 + 7) - 4 = 5$  ? Bird” or “IS  $(8 - 4) / 2 = 2$  ? Grass.” Participants were required to read the math statement aloud and respond aloud “yes” or “no” as to whether the math statement was true or false. After reading and solving the math statement, and without pausing, participants then read the unrelated word aloud. For example, given the second example above, the participant would say, “Is eight minus four divided by two equal to two? Yes. Grass.” Participants viewed and read aloud one math-word sentence at a time on a computer screen and clicked a “Continue” button to advance to the next math-word sentence. Participants viewed and responded to a set of two to six math-word sentences before they were asked to recall the unrelated words from that set, in order, and type the words into a text box on the computer screen.

The OSPAN score was determined by counting the number of words recalled for those sets in which the participant recalled all words, in order, correctly; thus, if a participant recalled *all* four words from a four math-word sentence set, in the proper order, the participant would receive four points. Participants viewed 15 sets of math-word sentences, three sets each that contained two to six math-word sentences, for a total of 60 math-word sentences. The order of the math-word sets and the math-word sentences within each set were randomized for each participant. Potential scores ranged from 0 to 60. Participants were assigned to the high WMC group if they scored in the upper quartile and to the low WMC group if they scored in the lower quartile of the original 201 students’ scores. The mean OSPAN scores for the high WMC and low WMC groups were 30.50 ( $SD = 4.72$ ) and 5.00 ( $SD = 3.02$ ), respectively.

*Recall and transfer tests.* The recall test included answering the following question on the computer: “Please provide an explanation of what causes lightning.” The recall question was provided on its own screen with a response box located directly below it. The transfer test involved answering four questions used by Moreno and Mayer (2000, p. 119) and included “What could you do to decrease the intensity of lightning?”; “Suppose you see clouds in the sky, but no lightning. Why might this happen?”; “What does air temperature have to do with lightning?”; and “What do electrical charges have to do with lightning?” The four transfer questions were all provided on the same computer screen, and each question was followed by its own response box.

*“What Causes Lightning?” tutorial.* The multimedia tutorials consisted of Flash animations based on Mayer and Chandler’s (2001) animation depicting how lightning forms. This depiction included drawings of cool air moving from an ocean to land; the air becoming heated, rising, and forming a cloud; the cloud rising above the freezing level and forming ice crystals; the ice

crystals rising and falling to create electrical charges in the cloud; the negative electrical charges dropping to the bottom of the cloud and then down toward the land; the positive electrical charges rising up from the land to meet the descending negative charge; and finally, the positive charges moving up this charged pathway to form lightning. The verbal accompaniment to this visualization is in Appendix A, and a screen shot of the animation is in Appendix B. The lightning tutorials were presented on iMac computers with 15-inch screens and Altec Lansing headphones. Two versions of the content were constructed based on the same lightning animation and verbal content: The AN version contained the lightning animation and an auditory narration of the verbal content, while the ANSD version contained the same lightning animation and auditory narration but with extraneous sounds (i.e., wind, rain, electrical charges, thunder) and images (i.e., darkening skies, excessive clouds, lightning flashes). Each version lasted 145 seconds.

### *Procedure*

All data collection and media presentations were completed on wireless laptop computers. Participants first completed the OSPAN task. Next, following a brief introduction, they pressed the Enter key and viewed the appropriate version of the “What causes lightning?” tutorial given their multimedia group assignment (AN or ANSD). Following the viewing of the tutorial, and after pressing the Enter key, participants were given 5 minutes to complete the recall test. Finally, after completing the recall test and after pressing the Enter key, participants were given 15 minutes to complete the transfer test.

### *Scoring*

*Recall test.* Two trained raters evaluated each participant’s recall response (inter-rater reliability,  $r = .90$ ) and computed a recall score by counting the presence of 8 idea units. One point was given to participants for the inclusion of each of the following idea units, regardless of wording: “(a) air rises, (b) water condenses, (c) water and crystals fall, (d) wind is dragged downward, (e) negative charges fall to the bottom of the cloud, (f) the leaders meet, (g) negative charges rush down, and (h) positive charges rush up” (Mayer, Heiser, & Lonn, 2001, p. 191).

*Transfer test.* Two trained raters evaluated each participant’s transfer responses (inter-rater reliability,  $r = .82$ ) and computed a transfer score by counting the total number of valid answers across the four transfer questions. Acceptable answers were determined by those established by Mayer et al. (2001). Acceptable answers to the first transfer question, “What could you do to decrease the intensity of lightning?” included decreasing the quantity of positively charged particles on land and increasing the quantity of positively charged particles next to the cloud; acceptable answers to the second transfer question, “Suppose you see clouds in the sky but no lightning, why not?” included the cloud not rising above the freezing level and ice crystals not forming; acceptable answers to the third transfer question, “What does air temperature have to do with lightning?” included the necessity of warm land and cool air, and the bottom part of the cloud being below the freezing level while the top of the cloud is above the freezing level; and finally, acceptable answers to the fourth transfer question, “What causes lightning?” included differences in electrical charges within the cloud and differences in temperature within the cloud.

### *Results and Discussion*

Experiment 1 was designed to (a) evaluate the general individual differences WMC hypothesis that students with high WMC will recall and transfer more from multimedia tutorials than students with low WMC, and (b) confirm previous results related to the coherence effect that student who receive multimedia messages embedded with irrelevant words, pictures, sounds or music will recall and transfer less from multimedia tutorials than students who receive multimedia messages without irrelevant elements. These two questions were analyzed using two 2 (high WMC, low WMC)  $\times$  2 (AN, ANSD) factorial designs based on the recall and transfer data.

#### *Individual Differences WMC Effect*

According to a general individual differences WMC approach, students with high WMC should recall and transfer more information from the multimedia tutorials than low WMC students as a result of high WMC students exhibiting better attentional control and resistance to distraction. This general individual differences WMC effect was confirmed for recall, as high WMC students recalled more idea units than low WMC students (see Table 1), resulting in a significant main effect for WMC,  $F(1,102) = 6.57$ ,  $MSe = 3.78$ , Cohen's  $d = 0.49$ ,  $p = .01$ . Similarly, for transfer, high WMC students generated more valid transfer responses than low WMC students, resulting in a significant main effect for working memory capacity,  $F(1,102) = 10.97$ ,  $MSe = 2.12$ , Cohen's  $d = .64$ ,  $p = .00$ . These results are consistent with the predications of the general individual differences WMC hypothesis; high WMC students outperformed low WMC students on recall and transfer after engaging in a multimedia tutorial.

Table 1  
Means and Standard Deviations for Recall and Transfer Scores for High and Low Working Memory Capacity Students in Experiment 1

	Recall		Transfer	
	M	SD	M	SD
Low WMC	4.11	2.02	2.26	1.27
High WMC	5.08*	1.81	3.20*	1.61

*Note:* Max recall score = 8. Max transfer score = 8. \*  $p < .05$

#### *Coherence Effect*

According to the cognitive theory of multimedia learning (see Mayer, 2001), students' recall and transfer based on multimedia tutorials should be inhibited by the presence of extraneous words, pictures, sounds and music (seductive details), the coherence effect. The ANOVA for recall data resulted in no significant main effect between students who engaged in a narrated animation without seductive details and students who engaged in a narrated animation with seductive details (see Table 2),  $F(1,102) = 0.73$ ,  $MSe = 3.78$ , Cohen's  $d = 0.17$ ,  $p = .39$ . The ANOVA for transfer data also resulted in no significant main effect between students who engaged in a narrated animation without seductive details and students who engaged in a narrated animation with seductive details,  $F(1,102) = 0.10$ ,  $MSe = 2.12$ ; Cohen's  $d = 0.06$ ,  $p = .74$ . These results are inconsistent with prior research (see Harp & Mayer, 1998; Mayer & Jackson, 2005; Moreno &

Mayer, 2000; Sanchez & Wiley, 2006) and do not provide support for the coherence effect. The present experiment, however, may not have provided sufficient extraneous material to either activate inappropriate schemas (Harp & Mayer, 1998) or produce adequate distractions (Mayer & Jackson, 2005; Sanchez & Wiley, 2006). The present experiment used additional on-screen graphics and background sounds as seductive details; however, Moreno and Mayer (2000) found that the addition of background sounds did not consistently inhibit students' recall and transfer performance.

Table 2  
Means and Standard Deviations for Recall and Transfer Scores for Students in Differing Multimedia Groups in Experiment 1

	Recall		Transfer	
	M	SD	M	SD
AN	4.76	2.02	2.77	1.48
ANSD	4.43	1.94	2.68	1.56

Note: Max recall score = 8. Max transfer score = 8. \*  $p < .05$

*Differential Multimedia Group Effects on Individual Differences in WMC*

There were no interactions between WMC and the multimedia groups (i.e., AN, ANSD) for recall,  $F(2,102) = 0.37$ ,  $MSe = 3.78$ , Cohen's  $d = 0.18$ ,  $p = .53$ , or transfer,  $F(2,102) = 0.12$ ,  $MSe = 2.12$ , Cohen's  $d = 0.24$ ,  $p = .72$ . Therefore, there was no indication that multimedia group affected high and low WMC students differentially.

**Experiment 2**

Experiment 1 provided evidence of a general individual differences WMC effect in which participants with high WMC recalled and transferred more information from a multimedia tutorial than participants with low WMC. The purpose of Experiment 2 was to provide an additional test of the individual differences WMC effect with different participants and different instructional materials. A second purpose of Experiment 2 was to validate the signaling effect. The signaling effect states that students' recall and transfer of information is facilitated by the presence of cues that guide the learners attention and highlight the structure of the information provided (Harp & Mayer, 1998; Mautone & Mayer, 2001). However, the findings regarding the signaling effect have been inconsistent. Harp and Mayer (1998) found that providing a learning objective prior to engaging in a multimedia tutorial increased students' recall and transfer (Exp 2); however, boldfacing and italicizing the main ideas within a written passage (Exp 1) and providing preview sentences and number signals (Exp 3) did not increase students' recall and transfer. Mautone and Mayer (2001) found that emphasizing key words or phrases in the narration by reading these key words more slowly and with a deep intonation increased students' recall and transfer (Exp 2); however, signaling the written text by providing section headers, a preview summary paragraph, transition or connecting words, and key words in boldface and italics (Exp 1), or providing colored arrows or summary icons (Exp 3) did not increase students'

recall, but did increase students' transfer. Experiment 2 was designed to extend the research base on signaling by exploring the effects of signaling by (a) including key words within the animation spatially contiguous with their referent and (b) including a spotlight effect to focus the learner's attention on the aspect of the animation that was relevant to the narration (see Appendix B).

### *Method*

#### *Participants and Design*

The participants were 105 undergraduate students (74 men and 31 women) with a mean age of 19.4 years, including 6 freshmen, 34 sophomores, 48 juniors, and 18 seniors. Participants were enrolled in a non-major personal health class and received course credit for participation. Participants were taken from a larger pool of 197 students who were administered the OSPAN working memory span test. Of these 197 students, only those that scored in the upper or lower quartiles were included as participants. The experimental design was a  $2 \times 2$  factorial design with working memory capacity (high WMC, low WMC) and multimedia group (animation + narration [AN], animation + narration + visual signaling [ANVS]) as between-subject variables. Participants were assigned to either the high ( $n = 53$ ) or low ( $n = 52$ ) WMC group based on their OSPAN performance. Participants were then randomly assigned to either the AN ( $n = 56$ ) or ANVS ( $n = 49$ ) multimedia group.

#### *Materials and Apparatus*

*Working memory capacity OSPAN task.* WMC was measured using the OSPAN operation-span task (La Point & Engle, 1990; Turner & Engle, 1989) using the same materials used in Experiment 1. The mean OPSAN scores for the high WMC and low WMC groups were 29.32 ( $SD = 5.62$ ) and 6.96 ( $SD = 3.06$ ), respectively.

*Recall and transfer tests.* The recall test included answering the following question on the computer: "Please provide an explanation of how a brake works." The recall question was provided on its own screen with a response box located directly below it. The transfer test included answering four questions used by Mayer and Anderson (1992, p. 449) and included, "Why do brakes get hot?" "What could be done to make brakes more reliable, that is, to make sure they would not fail?" "What could be done to make brakes more effective, that is, to reduce the distance needed to bring a car to a stop?" and "Suppose you press on the brake pedal in your car but the brakes do not work. What could have gone wrong?" The four transfer questions were all provided on the same computer screen and each question was followed by its own response box.

*"How Does a Car Brake Work?" tutorial.* The multimedia tutorials consisted of Flash animations based on Mayer and Anderson's (1992) animation depicting how car brakes work. This depiction included drawings of a foot pressing a brake pedal, a piston moving inside a master cylinder, brake fluid being pushed out of the master cylinder and expanding smaller pistons in the wheel cylinder, and the smaller pistons pushing the brake shoes against the brake drum. The verbal accompaniment to this visualization is in Appendix A and a screen shot of the animation is in Appendix B. The car brake tutorials were presented on iMac computers with 15-inch screens and Altec Lansing headphones. Two versions of this content were constructed based

on the same car brake animation and verbal content: The AN version contained the car brake animation and an auditory narration of the verbal content, while the ANVS version contained the same car brake animation and auditory narration but with key words within the animation (i.e., piston, master cylinder, wheel cylinders, smaller pistons, brake shoes, drum) spatially contiguous with their referent and a spotlight effect focusing the learner's attention on the aspect of the animation that is relevant to the narration (see Appendix B). The spotlight effect mimicked a light being shown on the portion of the animation currently relevant to the narration. This effect resulted in the relevant portion of the animation being fully visible, while the remaining aspects of the animation were lightly shaded. The animation from the foot stepping on the brake to the brake shoes pressing against the brake drum lasted 30 seconds; however, this 30 second animation was played three times in order to accommodate the narration. Thus, each multimedia instructional episode lasted 90 seconds.

### Procedure

All data collection and media presentations were completed on wireless laptop computers. Participants first completed the OSPAN task. Next, following a brief introduction, the participants pressed the Enter key and viewed the appropriate version of the "How does a car brake work?" tutorial based on their multimedia group assignment (AN or ANVS). Following the viewing of the tutorial, and after pressing the Enter key, participants were given 5 minutes to complete the recall test. Finally, after completing the recall test and after pressing the Enter key, participants were given 15 minutes to complete the transfer test.

### Scoring

*Recall test.* Two trained raters evaluated each participant's recall response (inter-rater reliability,  $r = .92$ ) and computed a recall score by counting the presence of 8 idea units. One point was given to participants for the inclusion of each of the following idea units, regardless of wording: "(a) driver steps on brake pedal, (b) piston moves forward inside master cylinder, (c) piston forces brake fluid out to the wheel cylinders, (d) fluid pressure increase in wheel cylinders, (e) small pistons move, (f) small pistons activate brake shoes, (g) brake shoes press against drum, and (h) drum and wheel stop or slow down" (Mayer & Anderson, 1992, p. 450).

*Transfer test.* Two trained raters evaluated each participant's transfer responses (inter-rater reliability,  $r = .89$ ) and computed a transfer score by counting the total number of valid answers across the four transfer questions. The acceptable answers were determined by those established by Mayer and Anderson (1992). Acceptable answers to the first transfer question, "Why do brakes get hot?" included friction causes brakes to get hot; acceptable answers to the second transfer question, "What could be done to make brakes more reliable, that is, to make sure they would not fail?" included maintaining a backup system or using a system to cool the brakes; acceptable answers to the third transfer question, "What could be done to make brakes more effective, that is, to reduce the distance needed to bring a car to a stop?" included using a brake shoe that is more sensitive to friction or providing a smaller gap between the brake shoe and brake drum; and finally, acceptable answers to the fourth transfer question, "Suppose you press on the brake pedal in your car but the brakes do not work. What could have gone wrong?" included that there may be a leak in the brake fluid line or that the brake pads are worn.

### *Results and Discussion*

Experiment 2 was designed to (a) evaluate the general individual difference WMC hypothesis that students with high WMC will recall and transfer more from multimedia tutorials than students with low WMC, and (b) evaluate the visual signaling effect that students who receive visual signaling will recall and transfer more from multimedia tutorials than students who do not receive visual signaling. These two questions were analyzed using two 2 (high WMC, low WMC)  $\times$  2 (AN, ANVS) factorial designs based on the recall and transfer data.

#### *Individual Differences WMC Effect*

According to a general individual differences WMC approach, students with high WMC should recall and transfer more information from the multimedia tutorials than low WMC students as a result of high WMC students exhibiting better attentional control and resistance to distraction. This general individual differences WMC effect was confirmed for recall as high WMC students recalled more than low WMC students (see Table 3), resulting in a significant main effect for working memory capacity,  $F(1,101) = 18.20$ ,  $MSe = 2.53$ , Cohen's  $d = 0.83$ ,  $p = .00$ . Similarly, for transfer, high WMC students transferred more than low WMC students, resulting in a significant main effect for working memory capacity,  $F(1,101) = 11.62$ ,  $MSe = 1.92$ , Cohen's  $d = .66$ ,  $p = .00$ . These results are consistent with the predictions of the individual differences WMC hypothesis: high WMC students outperformed low WMC students on recall and transfer after engaging in a multimedia tutorial.

Table 3  
Means and Standard Deviations for Recall and Transfer Scores for High and Low Working Memory Capacity Students in Experiment 2

	Recall		Transfer	
	M	SD	M	SD
Low WMC	4.80	1.64	2.87	1.52
High WMC	6.13*	1.51	3.80*	1.23

*Note:* Max recall score = 8. Max transfer score = 8. \*  $p < .05$

#### *Signaling Effect*

According to the cognitive theory of multimedia learning (Mayer, 2001), students' learning based on multimedia tutorials should be facilitated by the presence of cues that guide the learners' attention and highlight the structure of the information provided, the signaling effect (Mautone & Mayer, 2001). Specifically, the current experiment was designed to explore the effects of visual signaling by (a) including key words within the animation spatially contiguous with their referent, and (b) including a spotlight effect to focus the learner's attention on the aspect of the animation that is relevant to the narration. The ANOVA for recall data resulted in no significant main effect between students who engaged in a narrated animation with visual signaling and students who engaged in a narrated animation without visual signaling (see Table 4),  $F(1,101) = 0.00$ ,  $MSe = 2.53$ , Cohen's  $d = 0.02$ ,  $p = .96$ .

Table 4  
Means and Standard Deviations for Recall and Transfer Scores for Students in Differing  
Multimedia Groups in Experiment 2

	Recall		Transfer	
	M	SD	M	SD
AN	5.47	1.79	3.36	1.39
ANSD	5.46	1.60	3.31	1.51

*Note:* Max recall score = 8. Max transfer score = 8. \*  $p < .05$

The ANOVA for transfer data also resulted in no significant main effect between students who engage in a narrated animation with visual signaling and students who engaged in a narrated animation without visual signaling,  $F(1,101) = 0.02$ ,  $MSe = 3.01$ , Cohen's  $d = 0.04$ ,  $p = .86$ . These results do not provide support for a visual signaling effect based on integrating keywords into an animation and spotlighting aspects of the animation that are relevant to the narration.

#### *Differential Multimedia Group Effects on Individual Differences in WMC*

There were no interactions between WMC and the multimedia groups (i.e., AN, ANVS) for recall,  $F(1,101) = 0.06$ ,  $MSe = 2.53$ , Cohen's  $d = 0.27$ ,  $p = .80$ , or transfer,  $F(1,101) = 1.00$ ,  $MSe = 1.93$ , Cohen's  $d = 0.22$ ,  $p = .31$ . Therefore, there was no indication that multimedia group affected high and low WMC students differently.

## **General Discussion**

### *General Individual Differences WMC Effect in Multimedia Learning*

Theoretically, the results of both experiments demonstrate that the ability to control attention and avoid distraction, as measured by WMC, positively affects cognitive performance in a multimedia environment. Specifically, in both experiments students with high WMC outperformed students with low WMC after engaging in various multimedia tutorials. These results are consistent with predictions from both the domain-general and individual differences perspectives of WMC—that is, variances in WMC are due to a general underlying attentional mechanism, and individual differences in WMC systematically affect cognitive performance.

The present study extends the WMC literature by addressing WMC in a multimedia instructional environment. The previous WMC research focused on complex cognitive tasks that involved only single-media instructional environments, such as reading and vocabulary learning (Daneman & Carpenter, 1980, 1983; Daneman & Green, 1986), aural comprehension (Just & Carpenter, 1992), standardized test performance (Turner & Engle, 1989), and storytelling (Pratt, Boyes, Robins, & Manchester, 1989), as well as the dichotomous listening task (Conway, Cowan, & Bunting, 2001), antisaccade task (Unsworth, Schrock, & Engle, 2004), associative list task (Watson, Bunting, Poole, & Conway, 2005), baseball task (Hambrick & Oswald, 2005) and Stroop task (Kane & Engle, 2003). In each of these instructional environments, perceptual attention is focused on only a single modality, visual *or* auditory, while in a multimedia instructional environment attention must be focused on two modalities, visual *and* auditory.

The present study also extends the multimedia learning literature by identifying a specific individual difference variable of interest: working memory capacity. Previous research has

identified spatial ability (Moreno & Mayer, 1999) and prior knowledge (Cooper, Tindall-Ford, Chandler, & Sweller, 2001; Mayer & Sims, 1994; Ollerenshaw, Aidman, & Kidd, 1997) as individual difference variables that affect multimedia learning performance, to which WMC is now added. This general finding that high and low WMC systematically affect individuals differently leads to the question of how WMC differences may interact with specific multimedia learning principles. In addition, it is important that future research address which aspects of WMC (e.g., attention control, distraction avoidance, goal neglect, representation activation, knowledge search, knowledge updating) affect learning in multimedia instructional environments, and how.

The practical application of the general individual differences WMC effect relates to the generality of the benefits of learning in multimedia instructional environments. While there is significant research indicating the benefits of learning in multimedia instructional environments (see Mayer, 2005), there is emerging evidence that multimedia instructional environments may benefit some learners (e.g., high spatial ability, high prior knowledge, high WMC) more than others.

#### Coherence and Signaling Multimedia Learning Effects

The current experiments failed to validate previous findings regarding the coherence and signaling effects. In Experiment 1, there was no appreciable decrement in performance due to the addition of seductive details, background sounds, and irrelevant, graphics. In Experiment 2, there was no appreciable increase in performance due to the addition of visual signals, key words spatially contiguous with their referents, and a spotlight effect.

The lack of a coherence effect was somewhat surprising, although not all coherence effect research has been positive. Harp and Mayer (1998) and Mayer and Jackson (2005) did find a reduction of recall and transfer when additional but irrelevant text and pictures were added to an illustrated booklet describing the cause of lightning and waves, respectively. Mayer, Heiser, and Lonn (2001), however, found a reduction of recall and transfer when interesting but irrelevant text was added to an animation addressing the cause of lightning (Exp 1), but found only a reduction in transfer, not recall, when video clips were added (Exp 3). In addition, Moreno and Mayer (2000) found a reduction of recall and transfer when an interesting, but irrelevant, instrumental music loop was added to the background of an animation addressing the cause of lighting or function of car brakes (Exps 1 and 2) and when interesting but irrelevant mechanical sounds were added to the background of an animation addressing the function of car brakes (Exp 2). However, no reduction in recall or transfer was found when environmental sounds were added to the background of an animation addressing the cause of lighting (Exp 1). The current lack of a coherence effect may have been due to the use of background environmental sounds, as found in Moreno and Mayer (2000), along with the on-screen graphics.

Finally, Experiment 2 adds to the inconsistent literature findings regarding the signaling effect. Studies by Harp and Mayer (1998) and Mautone and Mayer (2001) have determined that providing a learning objective prior to students engaging in a multimedia tutorial and emphasizing key words or phrases in the narration by reading these key words more slowly and with a deep intonation increased students' recall and transfer; however, boldfacing and italicizing the main ideas within a written passage and providing preview sentences, number signals, section headers, preview summary paragraphs, transition or connecting words, colored arrows or summary icons did not increase students' recall, but doing so did increase students' transfer. In the current Experiment 2 there was no signaling effect for recall or transfer, based on the

inclusion of key words within the animation spatially contiguous with their referent, nor of a spotlight effect to focus the learner's attention on the aspect of the animation that was relevant to the narration.

### *Differential Effects of WMC on Multimedia Learning Principles*

The current study clearly finds no interactions between WMC and the coherence and signaling principles; that is, high and low WMC student were not differentially affected by the multimedia principles. These findings are in contrast to Sanchez and Wiley (2006), who found that low WMC students were more affected by seductive details (coherence effect) than high WMC. The lack of a differential effect in the current study across both multimedia principles—coherence and signaling—supports the conclusion that there exists a “general” individual differences WMC effect and that the generalizability of the multimedia learning principles is in question. Specifically, the current results indicate that high WMC positively affected all groups of students in similar and general ways and that the lack of findings related to the multimedia principles held for both the treatment groups as a whole and the high and low WMC subgroups.

Overall, the current study provides support for a general individual difference WMC effect related to learning in multimedia instructional environments. This effect adds to the list of identified multimedia learning individual difference variables: prior knowledge, spatial ability, and working memory capacity. The same studies, however, found no support either for the specific coherence and signaling effects tested, or for differential effects of WMC on multimedia learning principles.

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## **Appendix A**

### **Verbal Content for Each Experiment**

#### **Experiment 1: What causes lightning?**

Cool moist air moves over a warmer surface and becomes heated. Warmed moist air near the earth's surface rises rapidly. As the air in this updraft cools, water vapor condenses into water droplets and forms a cloud. The cloud's top extends above the freezing level, so the upper portion of the cloud is composed of tiny ice crystals. Within the cloud, the rising and falling air currents cause electrical charges to build. The charge results from the collision of the cloud's rising water droplets against heavier, falling pieces of ice. The negatively charged particles fall to the bottom of the cloud, and most of the positively charged particles rise to the top. Eventually, the water droplets and ice crystals become too large to be suspended by updrafts. As raindrops and ice crystals fall through the cloud, they drag some of the air in the cloud downward, producing downdrafts. When downdrafts strike the ground, they spread out in all directions, producing the gusts of cool wind people feel just before the start of the rain. A stepped leader of negative charges moves downward in a series of steps. It nears the ground. A positively charged leader travels up from such objects as trees and buildings. The two leaders generally meet about 165 feet above the ground. Negatively charged particles then rush from the cloud to the ground along the path created by the leaders. It is not very bright. As the leader stroke nears the ground, it induces an opposite charge, so positively charged particles from the ground rush upward along the same path. This upward motion of the current is the return stroke. It produces the bright light that people notice as a flash of lightning. (Moreno & Mayer, 1999, p. 368)

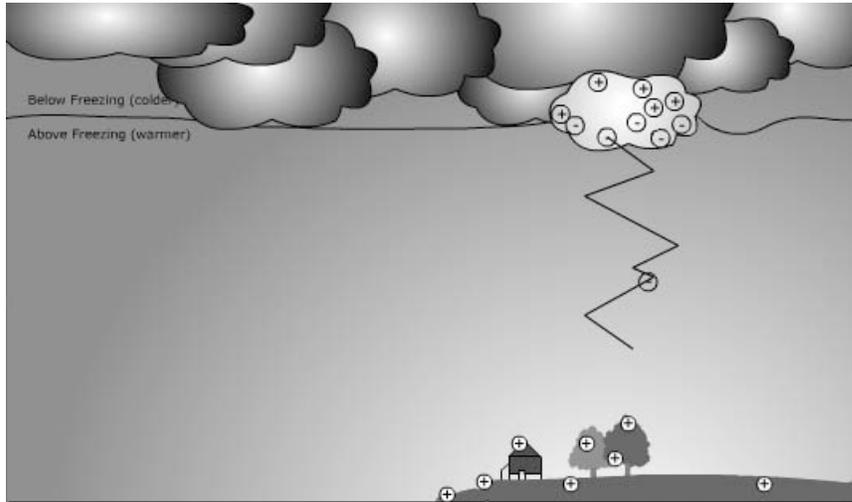
#### **Experiment 2: How does a car brake work?**

When the driver steps on the car's brake pedal, a piston moves forward inside the master cylinder. The piston forces brake fluid out of the master cylinder and through the tubes of the wheel cylinders. In the wheel cylinders, the increase in fluid pressure, makes a set of smaller pistons move. These smaller pistons activate the brake shoes. When the brake shoes press against the drum, both the drum and the wheel stop or slow down. (Mayer & Anderson, 1992, p. 446)

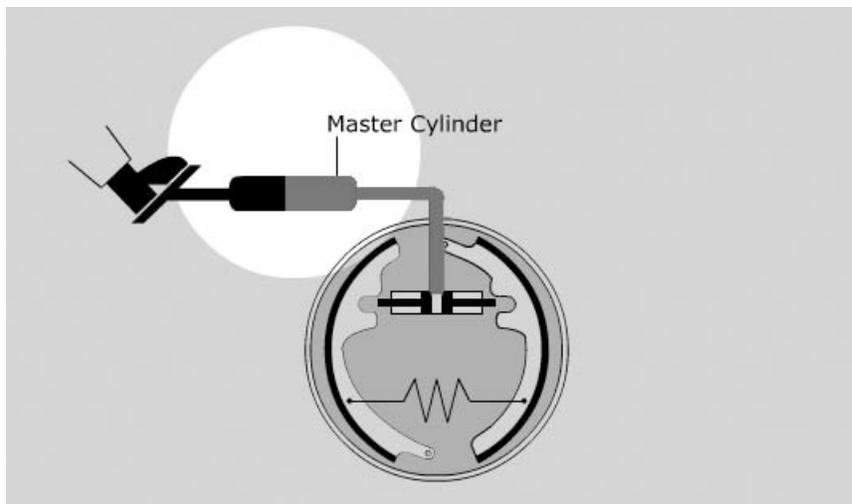
## Appendix B

### Sample Animation Screen Capture for Each Experiment

Experiment 1: What causes lightning?



Experiment 2: How does a car brake work?



(Screen capture includes the spotlight effect and spatially contiguous keywords.)

# **New Educational Paradigm in Transitional Societies**

Vladimir Nikitin and Liudmyla Parashchenko

## **Abstract**

Creating a democratic educational system in the context of market competition for the countries of East Europe demands more fundamental analyses of history and modern problems of education than was necessary for the educational reforms that took place in transitional societies. The main forces of the new educational system should be the multiplicity principle of educational forms and topical organization of educational space. It is necessary to establish new, advanced educational institutions, integrated in the network of global innovative establishments, and use them as models for transformation of the entire educational system.

## **Key Words**

Transitional societies, education, educational reforms, educational content, educational paradigms

## **Problems and Paradoxes of Educational Reforms in Ukraine**

Ukraine, as well as Russia, has lately been going through the process of many cardinal changes—transition from planned, industrial, directive, closed society to a market-oriented, technological, democratic, open one. The two countries have made this transition in different ways. Russia, after a period of collapse and transformations of the main social structures, started to return to directive management to restore integrity, and so to state control over the educational system. Ukraine, on the other hand, is trying to create a new entity in the conditions of acute political competition.

Active experimentation in education started in these countries in the aftermath of major social changes resulting in the creation of new educational approaches and institutions based on the ideas of “developing education,” “schools of self-determination,” or “development of intellectual functions.” These experiments have remained where they started, and they haven’t influenced changes in educational space in general yet. At the same time, adoption of the Western experience has become mass, although mostly at the level of privileged schools.

In Ukraine the reforms cannot come until political competition is balanced by new institutions, but many questions are being actively discussed, including educational reforms. Everything gradually reformed by Western society in the second half of the 20th century while creating the system of democratic education in the context of market competition has to be decided in Ukraine right away.

The era of declared equality and the system of free universal education with mandatory job placement after high school graduation is over now. The sudden entry into the free enterprise society, market competition, and diversity of educational institution forms with considerable advantages of rich parents’ children wasn’t well prepared for; as a result, mass corruption in education ensued. The transition from the idea of “educational conveyor” to the idea of “educational supermarket” happened too rapidly and imprudently. A bitter feeling of the loss of the intelligent and effective Soviet educational system and ensuing catastrophe has formed in the minds of parents, officials, and teachers. It is not obvious for most, however, that the Soviet system that had been effective in the 50s and 60s cannot work in the new conditions.

That is why parents, officials, and teachers in every way support a chimerical blend of the

remains of the Soviet system with market relationships. At the same time, it is clear that cardinal educational reforms cannot be carried out totally, on a national scale, because doing so will ruin the backbone of society structure, the last stronghold of its unity and distinctness.

It has become obvious that it's not very difficult to draw up a new system of education based on international patterns, though it is much more difficult to get rid of the old system. Education is a continuous process; it can't be stopped to carry out reforms. Millions of people preserving older forms of thinking still work in the system, and social demands to carry out mass reforms seem to have no solution.

In this situation all problems and paradoxes of the modern reforms of education of the global world have shown up in Ukraine in aggravated forms (Reform Strategy 2003). Here are three of them:

- *Cardinal educational reforms are not supported by the majority.* The necessity for the reforms is not obvious. All attention is concentrated on the questions of upgrading the existing forms. Here is a typical arguments: 'We were well taught, we achieved a lot, therefore it is necessary to restore what has been lost in the last years and maybe reinforce techniques.' (Judging by the Western press, people can't earnestly articulate the direction and meaning of educational reforms in that part of the world either.)
- *New content of the education is not sharply grounded.* There are many approaches and numerous criteria, but they are unconvincing. More scientific knowledge, more technological skills, more practical orientation, more ecological and multicultural consciousness, strengthening civilian positions— how do we unite all these in view of space-time restrictions of educational programs and individual educational institutions?
- *Needs of the job market and structure of graduates are not coordinated.* The market changes all the time, but colleges go on producing lawyers, economists, and managers who are not needed in such a quantity, plus their level of preparation is low. Professional hunger comes to Ukraine. How do we satisfy it without having the former planning instruments that could influence the whole system of education and without trying to foresee the future?

The problems of educational reforms in Ukraine are more or less typical for the majority of countries around the world. There is no sense in solving them in Ukraine by simple copying existing examples, as the modern Western system gave the answers to the bygone questions in different situations, and their mere replication would not provide even for the present, not to mention the future. Therefore, there is a reason to respond to the new challenges straightforwardly while certainly remembering successful precedents.

At the same time, the situation of transition demands more fundamental analyses of history and modern problems of education than was necessary for the changes that took place in the developed societies.

### **Need for New Educational Paradigms**

What determines the leap and change of educational paradigms? (1) Accumulation of mutations at the level of educational practices; (2) gaps between people's tools and transformations in social life and production. (3) Changes in the picture of the anticipated future.

From here come the major directions of the reform preparation—summarizing experiences, exploring markets, and outlining the direction for the future. At this time any real shift of educational content is connected with the emergence or development of new ideal entities and forms. These include new concepts, objects, items; they may also integrate new approaches and, first of all, explication of the theory that forms a basis of various educational paradigms.

European education is a result of gradual rethinking and reduction of Christian teaching, first in church fathers' comments, then in the university, in experimental and research universities, and now in project and program types of organization. This article pays particular attention to higher-frame forms of education because we believe that these forms put demands to the other ones and transform them (Djurinskiy 2003).

The change of the forms of educational paradigms can be done using the example of the university as presented in the following way:

- Scholastic (techniques of working with a form, *dispute* as the ultimate form of skill presentation, *comment* as the leading genre of work, oriented toward educating lawyers and theologians).
- Philological (techniques of working with a text, *dialogue* as the ultimate form of skill presentation, *translation* as the leading genre of work, oriented toward educating philosophers and philologists).
- Empirical (techniques of working with natural materials, *experiment* as the ultimate form of skill presentation, *systematization* as the leading genre of work, oriented toward educating naturalists and surveyors).
- Theoretical (techniques of working with models, *objective knowledge* as the ultimate form of skill presentation, *experiment* as the leading genre of work, oriented toward educating researchers).
- Project (techniques of working with ideal constructions, *project of changes* as the ultimate form of skill presentation, *imitation* as the leading genre of work, oriented toward educating designers and organizers).

The project type of university became widespread in the second half of the 20th century. Observing the trend of type changes, one can maintain that the idea of the project-program university was based on designing, but already oriented at the perspective form, programming and educating managers with strategic historical and cultural thinking is being realized now.

We support the traditional viewpoint on education: To be considered an educated person, one should be able to answer the following questions:

- How can provide for himself or herself and family in the conditions of the changing job market, in the conditions of developed forms of market exchanges, and when new specialties and specializations as well as new demands appear all the time?
- How can one live with the others in multicultural conditions? Most of social conflicts today are related to this issue.
- How can one live with himself or herself in the conditions of numerous self-identifications and self-definitions?
- How can one live with God and Truth in the conditions of collisions of the world images?

Knowing a lot as isn't enough to answer these questions. I knew many people with academic degrees who still could not find their answers (and quite often they didn't even search). And I knew average people who were thinking and who found their answers. The problem of education now is complicated by the fact that these questions have to be answered many times and at any time today. But these very questions should be addressed to the system of education itself:

- How does the modern system of education prepare one to work in the changing job markets, and how does it solve the problem within itself?
- How does the modern system of education provide the chance to live in the multicultural world, and how multicultural is it?
- How does the modern system of education provide possibilities of changes of self-identifications and self-definitions, and how is it capable of changing its understanding of itself and of its future?
- How does the modern system of education meet the challenges of numerous competitive images of the world, and how does it form a holistic picture of its own existence, and of the problems of truth?
- And an additional question: How do the answers to the questions agree among themselves in the system of education, and who works with them?

Such an approach to the problem relies on the assumption that a generating system and its products are similar in their main characteristics. In other words, a closed system cannot generate people open to the world, and a planned system cannot cultivate an ability to program one's life trajectories (Stoll, Fink 2005). Most educational institutions are concerned with the answer to the first question; the new situation of multiculturalism forces a response to the second question; the third and the fourth questions are tackled by the new educational institutions that have to claim their place and mission. In Ukraine all these questions have to be answered in their entirety, or the reforms should be forgotten.

### **Educational System Transformation Trends**

The existing system of education by virtue of its rootedness in the scientific paradigm is oriented toward the development of practically the only type of thinking that may be conditionally named as object-logical thinking. Other types of thinking have been considered secondary and didn't have much influence on the content of educational programs and evaluation of students' achievements. Today we can hear voices calling for the need to develop and evaluate different and numerous types of thinking and understanding (Educational Quality Monitoring, 2005). Doing so would avoid inequality in evaluation of students' achievements, make human resources more structured and effective, and create possibilities to establish new practices that are so necessary in Ukraine.

To accomplish this, however, it is necessary to at least create a sensible and working model of different types of intellect and a model of a world of activities based on the former. Apparently, the old nomenclature of professions does not work anymore. Today it is claimed that professions based on the possibilities of entering big technological circles, such as show business and development of new industries, as well as professions based on the ability to create a unique

product in teams gathered specially for the task, are added to the world of mass and free professions. Ukrainian system of education mainly serves for reproduction of the mass professions—managers, officials, and teachers (Basic Principles, 2005).

And here in the system of *managing* the education the problem situation opens up that has no means to control preparation of the new professions, yet it is afraid to give them the right for self-organization.

The idea of the diploma validated by the state authority remains central for the organization of the system of education in the country and, at the same time, is the obstacle in the way to creating its new forms. There are grounds for preserving this idea—many frauds in education, for example—but in the conditions of corruption the state diploma does not guarantee a high level of graduates either. What can be a way out of the situation?

- First, the existing system of education cannot be reformed in its entirety and at once. The new system of education should be cultivated alongside.
- Second, adoption of the world experience is possible and necessary to set a standard level and literacy forms of the informational society for the countries of the global world—for example, gradual adoption of the Bachelor’s program.
- Third, it is necessary to establish new advanced educational institutions integrated in the network of global innovational institutions and use them as models for transformation of the entire system of education.
- Fourth, the main principle of the new system of education should be the principle of plurality of educational forms and topical organization of the educational space.

But there are still questions without answers:

- How do we get rid of the old forms of education, especially the developed form of pedagogical education?
- What can be done to orient the content of education at in the condition of crisis of cultural examples?
- How do we achieve realization of the idea of plurality in the conditions of losing inner educational resources within the boundaries of consumer society ideology?

Evidently, for Ukraine the most advantageous is the creation of the type of educational institutions or their network based on the idea of plurality of educational systems.

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# **Institutional Planning and Assessment**



# **Developing a Strategic Plan for Implementing the Continuous Improvement Process of the School of Education at National University**

C. Kalani Beyer

## **Abstract**

This article presents the strategic plan of the School of Education at National University for implementing the continuous improvement of online course delivery. This strategic plan derives from the need to establish a future direction to which online education should take at National University. This strategic plan provides a means to infuse innovative delivery of material and instructional strategies, techniques to assess the quality of instruction continuously, and means to share innovation and assessment results among administrators and faculty in the organization. As a result, the strategic plan meets the qualities of a future vision for teaching and learning.

## **Key Terms**

Strategic plan, online instruction, assessment, premier status, continuous improvement, content management

## **Introduction**

While National University has been a leader in delivering online instruction for a long time, in the last three years online delivery has grown rapidly. The question for National University is no longer whether online education will continue to expand but what form it will take (Grantz & Hugstad, 2004; Stallings, 2002). In 2004, Dr. Jerry C. Lee, chancellor of the National University System and president of National University, established the President's Commission on Online Education. He tasked this commission with examining the state of the art in online education and then providing guidelines for creating a framework that would support the goal of continuing National University's role as a leader in online education. There were five sections in the report from the President's Commission: (1) training, teaching, and learning; (2) delivery, course design and content, and technology; (3) assessment and evaluation; (4) support and student services; and (5) marketing (President's Commission, 2005). This paper focuses on the second and third sections.

The purpose of this paper is to share the development of a strategic plan by the School of Education at National University for meeting the challenge of the continuous improvement of instruction. According to Bates (2000), it is rare that institutional strategic plans adequately address a future vision for teaching and learning. A strategic plan that addresses this future vision needs to include ways to infuse innovative delivery of material and instructional strategies, techniques to assess the quality of instruction continuously, and means to share innovation and assessment results among administrators and faculty in the organization (Hartman, Dziuban, & Moskal, 2007). The strategic plan of the School of Education provides a model to ensure that the goal of making online education at National University one of the top five providers in the nation becomes a reality (Online Learning, 2007). This paper reviews the growth of online education at National University; investigates the Premiere E-Learning Project (PEP), particularly the success of the School of Education; introduce the Continuous Improvement Process (CIP); and outlines the strategic plan of the School of Education.

## **Growth of Online Instruction**

In 2003, the Alfred P. Sloan Foundation wanted to find out how many students are learning online. To discover the answer, the Foundation funded a series of national surveys of online learning among U.S. higher education institutions. These reports substantiated that the online growth rate was substantially above the annual rate of increase in the overall population of higher-education students (Allen & Seaman, 2003, 2004, 2005, 2006).

During the past five years, online enrollment at National University has even outpaced the growth experienced nationwide. In December 2001, National University was averaging 100 courses every month, with 1,500 students enrolled. By the end of the FY 2005, 18,602 students were enrolled in 1,095 online courses. Today, National University offers nearly 350 online courses each month (approximately 6,500 students per month), and 66% of the University's active students take at least one of their courses online, while 42% of the University's students enroll online for a majority of their courses (National University Office of Institutional Research, 2007).<sup>1</sup> In December 2007 Cynthia Larson-Daugherty, president of Spectrum Pacific Learning (SPL), reported in a memo that half of the students taking courses at National University are taking them online and that there is a continuous growth in online enrollments, with current students in class (SIC) averaging nearly 6,000 students a month (Larson-Daugherty, 2007).

Dr. Thomas Green, provost of National University, when asked what accounts for the growth of online instruction at the school, stated<sup>2</sup>:

First, there is direct demand: students like the convenience, including not having to commute, park, etc. Second, since most of our students who take online classes are also taking onsite classes (only about 16% of our students to date have taken their entire program online), one of several things might be happening. We know that low enrollment classes that have an online counterpart are being cancelled; this is really a resource issue. We also may not be offering all the courses a student wants or needs when he/she wants it, so they go online. (personal communication, November 3, 2007)

Dr. Green went on to add that while National University consciously and purposefully planned for an increase in online delivery, the university had expected the online growth to come primarily from the global marketplace. While some of that happened, most of the growth appears to have come at the expense of onsite programs: Current onsite students have moved online for the convenience, low-enrollment classes have been canceled as students have migrated online, and new students are choosing to take their courses online (Green, 2007).

## **Premier E-Learning Project**

One of the organizational changes that National University made in 2002 was the creation of

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<sup>1</sup> National University offers its classes in a one-month format. In essence, each month is equivalent to what traditional universities refer to as a semester. Consequently, based on 350 courses a month, National University offers 4,200 online courses in a year.

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SPL, a for-profit affiliate within the National University System to develop and administer the E-Learning system.<sup>3</sup> In Fiscal Year 2007, the university reassessed its E-Learning program and began the Premier E-Learning Project (PEP), an initiative to restructure online course content, formats, and delivery systems through a collaborative effort of SPL and the schools within the university system. . National University's PEP approach was based in part on learning theorists, such as Robert Gagné, who established guidelines and best practices for designing effective instruction:

Drawing from Gagné's Nine Events of Instruction and other theories, SPL has developed a parallel philosophy, the Effective E-Learning Model dubbed e2L, which focused on online learning and directed that online course content must target all types of learners: visual, auditory and kinesthetic. (Castle, Hieu, Tyler, & Vasquez, 2008, p. 2)

The outcome of this effort was to have every concept, theory, and application in an online course demonstrate a mixture of presentation mediums to ensure the active engagement of learners, so they will be better able to retain learning and apply what they have learned. Based on the preconditions of the review of the literature, National University identified three elements that a PEP'ed course should include:

(a) content that helps the learner achieve the desired learning objectives; (b) instructional methods that effectively communicate the content; (c) media elements that effectively deliver the content and instructional methods; and (d) a clear and directed focus on the promotion of new knowledge and skills. (Castle et al., 2008, p. 3)

Specifically, the PEP was to bring 400 courses up to premier status over a four-year period. Each school in the university was assigned the goal of PEP'ing 26 courses per year. The PEP process started slowly in the School of Education. While the school had selected a PEP coordinator, who developed guidelines for this process, faculty were reluctant to get on board. Only four courses were PEP'ed by the School of Education in Fiscal Year 2007. In May 2007, the associate dean decided to lead the school toward successfully PEP'ing courses by getting actively involved in the process. After PEP'ing two courses for a new program, with the help of the PEP coordinator and the director of support services from SPL, a PEP training CD-ROM was developed and presented to faculty at the Fall Assembly (one of two times a year to which faculty from across the state of California and the campus in Henderson, Nevada, gather to meet). Each faculty member received a personal CD-ROM containing a PowerPoint presentation that explained each step of the PEP'ing process, a sample course that had been PEP'ed, and templates for Syllabus, Course Outline, Course Calendar, and Course Navigation (a guide for SPL to use in navigating the creation of the PEP course). Throughout Fiscal Year 2008, 55 courses were PEP'ed by faculty in the School of Education, thus exceeding the required two-year goal of 52 courses. Thirty-five faculty members were involved in PEP'ing at least one course.

Even though the School of Education made up for lost time during Fiscal Year 2008, there were concerns about the PEP process both from members of the School of Education and

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<sup>3</sup> Spectrum Pacific Learning (SPL) works with E-College, the vendor that hosts National University's online courses, by providing a Helpdesk for students, faculty training, client services, and account management. Before a course is placed online, SPL works with faculty to populate the shell with course content based upon E-College's template.

members of other schools. The concerns were related to who “owned” the material in the curriculum for online PEP’d courses; whether the Contract Exhibit Checklist was intended to be requirements or guidelines; and to what extent faculty would be involved with developing and designing courses.<sup>4</sup> In February 2008, Dr. Thomas Green, provost of National University, sent a memo to all faculty and deans, addressing some of the concerns faculty had regarding the PEP process. In this memo, he first assured faculty they had ownership of the curriculum, which included creation, termination, and appearance of the courses placed online as PEP’ed courses. He also reminded faculty that SPL is a vendor and as such does not control the content of courses or the elements of PEP’ed courses. Second, he presented options whereby faculty—through working with the Center for Teaching Excellence, online and PEP coordinators, SPL, and E-College—could obtain training in order to perform the role as course developer or instructional designer.<sup>5</sup> He reminded faculty that SPL provides excellent services, stating that SPL has the expertise and technology to apply best practices in the creation of online courses by producing narrated lectures, embedding streaming videos, and creating audio-visual kinesthetic (AVK) activities. Third, he noted that not every course needs to look the same or use the same activities (including AVK elements). These decisions should to be made among the faculty, with primary input from program leads and in conjunction with the online and PEP coordinators and subject matter experts (SMEs). Fourth, he argued that there should still be some consistency in delivery and design. “The ultimate goal should be to produce online courses that best support student learning, i.e. are rich with multisensory content, are highly interactive, and rigorous. However—and to be very clear—courses do not need to be identical to meet these criteria” (personal communication, February 4, 2008).

In this memo, Dr. Green also presented several goals for Fiscal Year 2009: (1) Continue to work with the Center for Teaching Excellence and all involved parties to complete a seamless and in depth training program. (2) Explore the feasibility of creating a specific location to support online course development. Such a development center would include hardware, software, and technical support and may be replicated at other campuses. (3) Explore the possibility of hiring a university instructional designer, ideally with strong academic credentials. This person would work closely with SMEs, provide training for faculty, and staff the course development center (personal communication, February 4, 2008).

### **Continuous Improvement Process**

On March 14, 2008, Dr. Green announced that “by mutual agreement between the University and SPL (Spectrum Pacific Learning), we have discontinued the PEP effective March 5, 2008.”

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<sup>4</sup> When online courses were first developed for National University, faculty were provided with a course shell and allowed to upload files that ultimately became the course. Under the PEP process, faculty were to turn over files to SPL, who would convert them into elements of the PEP course. The Contract Exhibit Checklist provided guidelines to which the Department Chairperson and the Subject Matter Expert agreed would be elements of the course but it also had some stipulations to which faculty thought interfered with their academic freedom. SPL was often accused of making the stipulations in the Content Exhibits Checklist into requirements.

<sup>5</sup> The Center for Teaching Excellence was established in 1992 by Dr. Jerry Lee, Chancellor of National University. It was originally named the Center for the Improvement of Teaching and Faculty Development. While its name has changed, its purpose has always been to coordinate and support the design and delivery of faculty development programs throughout the university and the goal of helping faculty provide an exceptional learning experience for all students.

He went on to declare that “the project is being replaced by a continuous improvement process (CIP) that will allow us to continue to develop courses at a premier standard as well as provide for the ongoing upgrading of our online courses.” He emphasized that “all the requisite resources will be in place to implement the plan.” He acknowledged that “we do not want to lose any of the momentum or quality that has resulted from the PEP, so we will continue to develop premier online courses and upgrade our existing courses in partnership with SPL.” He was hopeful that the CIP would enhance National University’s leadership in online design and delivery and provide a valuable resource for faculty who teach online (Green, 2008).

At subsequent meetings with deans of National University, Dr. Green presented an elaboration of CIP and why it needed to replace PEP. Primarily, the movement from PEP to CIP involves exchanging a project for a process. As a project, PEP had been doomed to fail because targeting 100 courses a year did not begin to reach the 400 courses the university had online when PEP began two years previously.<sup>6</sup> Since PEP’s inception the number of online courses had grown to 700. At that rate the university would never reach the point when all online courses would be at a premier level. Furthermore, as time elapsed, the early PEP’ed courses would need to be revisited. Consequently, it made sense to devise a process for continuous improvement of online courses. According to Dr. Green’s vision of CIP, course leads would have the responsibility for revising courses.<sup>7</sup> Where it would be necessary to add elements in order to bring the course to premiere status, training would be provided to give them knowledge and skills to continuously improve the course, including the technological skills needed to build the course without having to use the services of SPL. Technological equipment would be provided by the university to enable this process.

Dr. Green offered a vision that would also involve the use of NU-FAST, a website where faculty can keep folders of material for use in either onsite or online courses. As faculty have access to training and technology with which they could create their own videos, AVK activities, narrated lectures, relevant resources, and important material, they would deposit these files into their own folders. Dr. Green referred to these folders as “buckets” of material that faculty can drag into their online course. Obviously, collaboration between faculty members to share material in their “buckets” would be encouraged.

### **Overview of School of Education Strategic Plan**

The School of Education strategic plan for continuous improvement utilizes the following processes: PEP, CIP, E-Companion supplements, Content Management Initiative (CMI) from E-College, NU-FAST, and the Accountability Management System (AMS) of Task Stream. From the previous discussion, it should be clear what PEP and CIP entail. The other processes are described here.

E-Companion supplements make an online shell available to an instructor of an onsite class to use as supplementary materials. Having the upgraded online PEP version of the course

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<sup>6</sup> As of the end of March 2008, the second year of the four-year PEP plan, only 100 courses were fully PEP’ed. The yearly plan of 100 courses per year was to be reached by the six schools PEP’ing 26 courses per year. Thus, PEP was only half successful even with a modest goal.

<sup>7</sup> Course Leads are faculty who oversees a course, which includes continually improving the course as well as hiring, training, and staffing part-time faculty to teach the course. In most cases, Course Leads are also the SMEs since they originally developed the course for online delivery.

available to onsite instructors ensures that the newest materials will be used in both online and onsite modalities.

CMI is an effort to provide an improved platform for managing content through E-College. It does so by enabling faculty to control or manage individualized content in a personal repository (Dr. Green's "bucket"). In addition, specific content items can be locked to prohibit instructors from editing content that course leads intend to be required no matter who teaches the course (Larson-Daugherty, 2007). CMI would work hand in hand with NU-FAST.

NU-FAST is a high-capacity server developed to support National University faculty by providing a place to store course material that can be shared with other faculty and students. Each faculty member has access to two folders. One is designed for other faculty to access and the other is for students. The course lead is the only person who is able to add, delete, or modify material in his or her folder. NU-FAST would serve as the depository for each faculty's "bucket."

AMS is a feature of Task Stream, a website the School of Education uses for hosting assessments and E-Portfolios. AMS specifically equips the School of Education to pinpoint exactly where learning outcomes and program standards are addressed within a course, enabling data to be accumulated as a way to determine performance of each student enrolled in a course.

### **Components of the School of Education Strategic Plan**

The strategic plan of the School of Education includes four components. First, continuous improvement will be achieved by elevating all School of Education courses to the premier level. Primarily, this will be accomplished by using the steps from the Premier E-Learning Project. As of June 2008, 11 of the 30 courses offered either 11 or 12 months each year have been PEP'ed. The other 19 courses will be top priority to be PEP'ed during Fiscal Year 2009. An additional 30 courses have been identified as a part of the university's top 400 courses; they will also be PEP'ed by the end of Fiscal Year 2009. During Fiscal Year 2008, 55 School of Education courses were PEP'ed. While many of these courses were new, 38 different faculty have PEP'ed at least one course, resulting in more than one-third of the full-time faculty having PEP expertise. This expertise will ensure that the goal of PEP'ing all School of Education courses by the end of Fiscal Year 2009 can become a reality.

A second component of this strategic plan relates to the use of E-Companion supplements. As each online course is PEP'ed, E-Companion shells will be provided for onsite instructors to use to supplement their instruction. More important, by using an online supplement, onsite instructors will be able to use the online gradebook feature, which means the assessments for their assignments will be available for determining accountability through use of the AMS program in Task Stream. It is the goal of this strategic plan that by the beginning of Fiscal Year 2010, all courses taught by School of Education faculty will be at the premier level, whether online or onsite through the use of E-Companion supplements, and capable of yielding data for determining the success of students enrolled in School of Education courses in meeting both the learning outcomes and standards of the course. With these data, course leads will be able to review the courses and make the changes necessary to improve the quality of the course and enhance student learning.

A third component of this strategic plan is to obtain from SPL files that were created for the online courses and move them into the folders of the course lead. With the advent of a

university instructional designer and technological equipment, faculty will be encouraged to create additional files to place in their own “bucket.” Should faculty decide that all they wish to do is create new material on paper, they can still submit the material to the dean of the School of Education or the CIP coordinator and, after administrative approval, have SPL create the material and provide the instructor with the file for his or her “bucket.” Through either approach, faculty would have additional resources to share between fellow instructors and meet the needs of CIP.

Fourth, the School of Education will utilize course teams and online coaching. Course teams were implemented i to coordinate the work being done by instructors of a common course.<sup>8</sup> These teams were developed to ensure that course leads receive suggestions and assistance with the upgrading of their course from individuals who also teach the course. Online coaching was devised to ensure that continuous improvement involved improving the teaching of the premier level course. The following are the goals of online coaching developed by Dr. Stuart Schwartz: identify best practices for online instruction in university courses by observing online instructors and by reviewing the literature; provide positive feedback to faculty members who are using best practices; share best practices with all members of the school; and provide feedback and suggestions to faculty members who are not utilizing best practices and assist those individuals who desire to improve their online teaching (personal communication, January 29, 2008).

## **Conclusion**

The strategic plan of the School of Education at National University for continuous improvement meets the qualities of a future vision for teaching and learning. Following the work already established by PEP, this strategic plan provides a means to infuse innovative delivery of material and instructional strategies into all online courses of the school by the beginning of Fiscal Year 2010. Moreover, through the use of E-Companion supplements, the online course templates are seen in the School of Education as “course masters” for both online and onsite offerings. New faculty are given “read-only” access to the online course master templates in order to teach an onsite course, with the understanding that they can add to the course master content materials but not remove or exclude some content items. This arrangement provides consistency between online and onsite courses as well as between instructors and ensures complete updating and improvement of all courses taught by the School of Education. Given that this effort to upgrade all online courses will occur within a three-year period, it will be quite an accomplishment. The online upgrade, when coupled with making E-Companion supplements available to all onsite instructors, makes this feat even more remarkable. Furthermore, this strategic plan has embedded techniques to continuously assess the quality of the instruction delivered. Utilizing Task Stream’s AMS software enables the school to assess how well students meet the learning outcomes and standards expected in the course. Finally, this strategic plan provides the means for faculty and administrators to share both innovations made in courses and the assessment results. Through CMI and NU-FAST, faculty will be able to continuously improve instruction and share innovations. Course teams and online coaching will also provide faculty with the means to both share innovations and guide best practices in the teaching of courses.

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<sup>8</sup> Last year these programs were created and piloted by Dr. Stuart Schwartz of the Special Education Department at National University.

While elements of this strategic plan are already in place, it will take at least a year for all of its components to be operational. This strategic plan will face many challenges during this time. The first challenge will be to keep the course leads involved in improving their courses after bringing them to premier status. A second challenge will be convincing students that in spite of the increased rigor in premier courses, they are benefiting from the quality of the improvements. A third challenge will be ensuring that onground instructors are prepared to properly utilize the E-Companion supplements, which will require training and engagement with course leads. A final challenge will be to monitor activities between faculty and the coordinators of SPL, Task Stream, and NU-FAST in order to realize continuous improvement and assessment results.

The purpose of this paper has been to share the development of the strategic plan of the School of Education of National University. Mirroring or copying a strategic plan by another institution is never successful. Sharing how this strategic plan developed, however, may assist other institutions seeking to develop a strategic plan of their own that leads to continuous improvement of instruction.

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# **Online Performance-Based Management and Evaluation System as an Instrument to Manage the Quality of Institutional Performance at the University of Technology, Jamaica**

Sandra A. C. Glasgow, Jennifer Ellis, Nicola Johnson,  
and Valeri Pougatchev

## **Abstract**

This paper describes the rationale for the development of an Online Performance-Based Management and Evaluation System (OLPBMES) at the University of Technology (UTech), Jamaica, the roles of each of the partners in the process, some particular technical solutions, and security solutions of the system. We consider this web application as a base for a full management system for educational institutions that includes strategic, academic, and financial planning and management components. This approach will allow the institution to respond promptly to real-world challenges and opportunities that might affect its short- and long-term strategy. This system provides an accurate diagnosis of the educational reality and an objective assessment of the impact of intervention policies to society. The information produced by OLPBMES can then be used as a social control tool to press those responsible for managing the educational system to produce necessary improvements.

## **Key Words**

Online Performance-Based Management and Evaluation System, 360-degree principle of evaluation, quantifiable objectives, key performance indicators, strategic planning, .NET technology, Multitier Architecture, role-based security

## **Introduction**

One definition of performance-based management is “a systematic approach to performance improvement through an ongoing process of establishing strategic performance objectives; measuring performance; collecting, analyzing, reviewing, and reporting performance data; and using that data to drive performance improvement” [3]. Flowing from that definition are the six steps to establishing a performance-based management program:

- Step 1: Define the organizational mission and strategic performance objectives.
- Step 2: Establish an integrated performance measurement system.
- Step 3: Establish accountability for performance.
- Step 4: Establish a process/system for collecting performance data.
- Step 5: Establish a process/system for analyzing, reviewing, and reporting performance data.
- Step 6: Establish a process/system for using performance information to drive improvement.

Performance-based management is not an end in itself. Rather, it is a means to generate valuable management information, partly for ongoing monitoring purposes but mainly to celebrate positive and commendable behavior and achievement, encourage continued excellence, and, where necessary, focus management and employees’ attention on areas where improvements are needed. An effective performance-based management system should therefore contribute to developing the full potential of staff members, improving accountability at all levels, and having the necessary information to identify areas for career enhancement and promotion opportunities, as well as for instituting sanctions, where necessary.

The process occurs between staff members and their immediate supervisors, who must have received the appropriate training in the University's performance review, planning, and development process. Regular performance feedback and constructive advice are needed to ensure that performance is measured accurately and that personnel decisions are equitable, development needs identified and development plans auctioned.

Performance-based management is a process that provides for communication undertaken in partnership between staff members and their immediate supervisors. It involves establishing clear expectations and understanding about

- the essential job functions the individual is expected to perform
- how the individual's job contributes to the goals of the University
- what "doing the job well" means in concrete terms
- how the individual and the supervisor will work together to sustain, improve, or build on existing job performance
- how job performance will be measured
- how barriers to performance may be identified and removed

One of the key ideas in our research and development of new systems for the university is that we do not reject and, if possible, we do not rebuild systems currently in use by the University, which are serving well and don't need a general modification. Maintaining access to the information resources of these systems, and to the experience and skills of the personnel of the University who use them, is an integral part of the process of the computerization of university life.

An essential part of the system is security, which protects confidential information from unauthorized actions. We have created several mechanisms to warranty full security protection of sensitive information, including identifying users, granting or denying access to the system, and protecting the data that's stored on the server.

### **The UTech Experience (old system)**

The University has always had a system of performance-based management, including student and peer evaluation for academic staff. However, student evaluation results were not included in the mainstream evaluation process, as those scores were kept by supervisors and used in an ad hoc manner. Focus groups were used to determine the main points of concern for the different categories of staff. The main concerns expressed included

- adequacy of the appraisal instrument to serve all categories of staff
- the fear that lack of resources to achieve the University's goals might affect an employee's performance score
- ease of use of the system
- lack of alignment with promotions processes
- absence of incentives in existing scheme

As a result of these concerns, in any given year only about 10% of appraisals were returned to the Human Resources Department, not allowing for adequate and timely analysis. The University's desire to remain relevant and competitive spurred it to engage a consultant to design a new Performance-Based Management and Evaluation System (OLPBMES) with the

capability of building a high-performance culture, allowing the University to respond to its real-world challenges.

### **The OLPBMES (new system)**

The University of Technology, Jamaica has taken a bold new approach to strategic planning, utilizing the Balanced Scorecard as a strategic management tool [1]. It is envisioned that this system will integrate the formerly ad hoc approach and provide the senior management team with the data and tools to drive performance improvement. To this end, the previous appraisal system was completely revamped to align with the strategic planning process and a system of rewards and sanctions, to be developed. Heads of faculties/divisions/departments were given the responsibility of ensuring that each staff member develops performance objectives that relate to department or divisional or faculty plans and ultimately are in sync with the University's corporate plan.

Focus groups comprising deans, heads of divisions, and union and employee representatives were formed to examine what was being proposed for the new system and to give feedback to their constituents, and to the Project Steering Committee. While the OLPBMES has been implemented for all staff of the University, for academic staff, it has been developed in conjunction with the University's Ordinance XV1 Academic Staff Grading, Appointment, Promotion and Tenure.

The University's approach of developing its performance-based management and evaluation system internally, as an Internet Application, satisfies its requirements for flexibility, ease of use, and responsiveness to internal and external forces. Generally, the new system is able to:

- provide appropriate information on each staff member's performance
- align objectives and resources across the University
- allow staff members the opportunity to identify their contributions to the achievement of the University's objectives
- allow for consultation and agreement between the staff member and supervisor regarding the procedures to be used
- facilitate timely appraisals and analyses
- provide ongoing constructive feedback to the staff member
- provide information to affect decisions for confirmation or tenure
- equip the management of the University to identify and reward good performance
- inform decisions regarding granting of incremental salary increases
- assist in recommendations for promotion
- provide information for sanctions to be taken where necessary
- give staff members the opportunity to comment on the process and the output and make an appeal where necessary
- contribute to professional development planning
- provide the University with feedback on institutional deficiencies in areas such as supervision, evaluation, professional support or performance improvement

## Process for Measuring Staff Performance

Staff appraisals in the OLPBMES are based on both quantifiable objectives and competencies.

### *Quantifiable Objectives*

*Quantifiable Objectives/targets* are related to specific results. These objectives have been identified at the corporate (University) level and have been further cascaded down to the faculties, schools, divisions, departments and the individual level. *Weights*  $\{W_i$  – see *Appendix D* $\}$  reflecting the relative importance of the various targets/objectives are established by the University for the faculties, schools, divisions and departments. However, weights for individual objectives/targets are established and agreed upon by both the supervisor and member of staff at the beginning of the review period. At the end of the period, the results are evaluated on a scale of 0-10 (see *Appendix C*). Quantifiable objectives and weights play a vital role in the system. *Appendix B* presents a distribution of weights for all categories of staff.

### *Competencies*

Competencies describe the knowledge, skills and behaviors required for individuals to perform work roles effectively and to achieve success in their job. Competencies play an important role in assessing performance.

- Five core competencies have been identified for all categories of staff
- Eight functional competencies have been identified for academic staff
- There are five functional competencies for administrative staff, six for technical staff, and four for ancillary (cleaning and grounds) staff.

Detailed information on some of these competencies is presented in *Appendix A*.

At the start of the period, supervisors and staff members discuss the expected performance standards to ensure clarity of expectations. Deans and Heads of schools determine the weight for each competency. We identify a *core* and a *functional* competency for each category of staff (see *Appendix A*). The weights are assigned based on the level of importance to job success. At the end of the evaluation period the evaluation is performed using descriptors outlined in the competency levels and the performance rating scale ( $R_i$  and  $A_i$  – see *Appendix D*) as a guide.

It is important to note that indicators  $W_i$ ,  $R_i$ ,  $A_i$  as well as *detailed definitions of levels* of performance represent the *set of controls* of the OLPBMES for achieving the University's goals, which are consistent with the vision articulated in the university's strategic plans and with academic policy.

In keeping with this approach, the OLPBMES has an interface that allows the management of the University to update the *key performance indicators* in the strategic plan without rebuilding and recompiling the OLPMBES. This approach satisfies one of the main requirements of the System – to be flexible and sensitive to the changing strategic priorities of the University. Actually we have created a Universal Framework Software, which is adaptable to any size or type of organization, educational or not. It has the capacity to grow as the organization grows and structures plans and policies change.

### *360-Degree Evaluation*

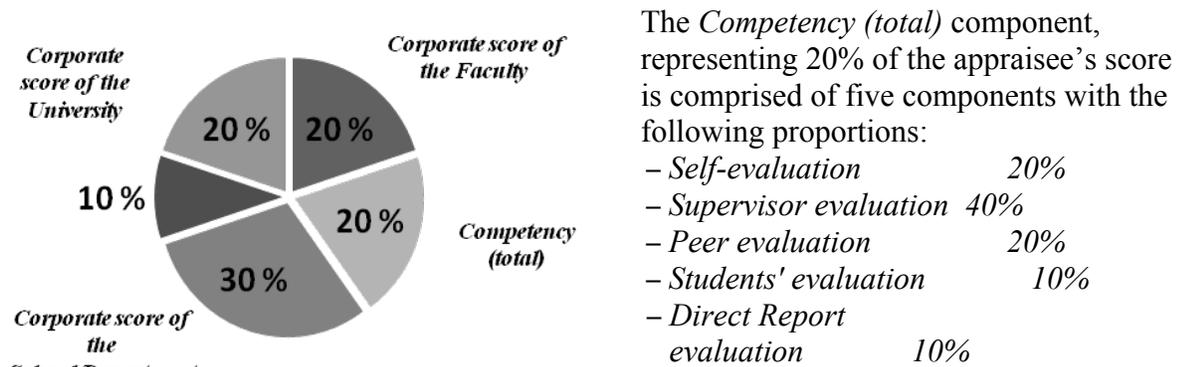
360-degree evaluation has become a feature of many university appraisal systems. It is a process whereby staff members are rated on their performance by people who can attest to the quality of their work. These may include direct reports, peers, supervisors, students, and for some staff, clients—all persons who are credible and who are willing to be included in the feedback process. The staff member usually completes a self-assessment of his or her own performance, which is also used in the process.

Using 360-degree feedback can bring the following individual and organizational benefits:

- It provides individuals with an opportunity to learn how their colleagues perceive them, leading to increased self-awareness.
- It encourages self-development.
- It increases understanding of the behaviors required to improve personal and organizational effectiveness.
- It promotes a more open culture where giving and receiving feedback is an accepted norm.
- It increases communication within the organization.
- It can be a powerful trigger for change.

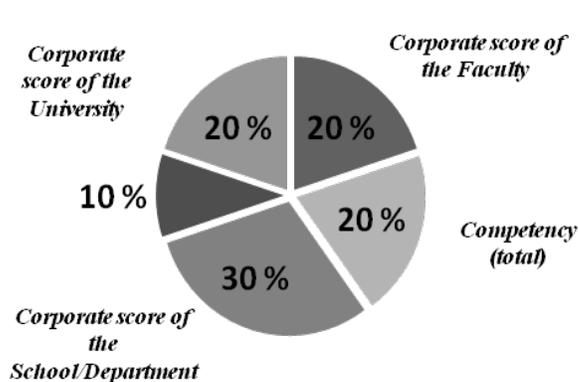
In designing the OLPMBES we believed that an appraisal process that included 360-degree evaluation would be a key component in creating and sustaining a collegial environment where teamwork is critical. It is intended that the performance appraisals of all academic staff and senior administrative staff will include the 360-degree feedback mechanism.

The following charts illustrate how the 360-degree mechanism will figure in the overall appraisal of a senior faculty member and a dean of a faculty.



**Figure 1**  
360° Evaluation of the Senior Academic Staff of a Typical School/Department

All these components and their weights are adjustable—e.g.,  $W_i$ ,  $R_i$ ,  $A_i$ , detail definitions of levels as described above. They are elements in the set of controls of the OLPBMES.



In this case, the Dean's evaluation components are similar to those of senior academic staff but different from those of lower levels of academic staff who have no direct reports:

- Self-evaluation 20%
- Supervisor evaluation 40%
- Peer evaluation 20%
- Students' evaluation 20%

**Figure 2**  
360-Degree Evaluation of the Dean of a Faculty

### **Roles & Responsibilities of Partners of the System**

The partners in the Performance Management and Evaluation System—staff members, supervisors, peer evaluators, reviewers, and students—each have an important role to play if the system is to be effective. They are supported by the Human Resources Department.

#### *Staff Member*

For the performance-based management system to achieve its maximum benefit, staff members must play an active role and will

- have input into developing and agreeing to individual performance plans
- discuss work assignments, challenges etc. with supervisors

Staff members are encouraged to:

- maintain and/or improve job knowledge and skills and take ownership for their performance and deliverables
- ask questions, make suggestions and ask for help when needed and identify areas for improvement during the evaluation period

Staff members conduct a self-evaluation of the performance outcomes achieved in relation to their assigned duties and responsibilities and focus on previously agreed performance targets and competencies required of the position. In conducting a self-evaluation, staff members are expected to become more aware of their performance, provide objective feedback on areas of competence, and play an active role in their own development.

During the evaluation period, academic staff members are required to prepare a portfolio comprising the elements outlined below, which form part of the evaluation of the established quantifiable objectives and competencies.

#### **Teaching philosophy and activities:**

- broad aims and objectives
- instructional strategies used
- quality of notes and delivery

- evaluation of learning outcomes
- appropriate use of innovative technologies
- methods used in assessment of students' work
- subject and course management—interaction with students and other staff

**Curriculum development activities:**

- development of new subjects and or modified courses
- delivery development—e.g., online/flexible delivery

**Administrative responsibilities:**

- submission of work
- liaising with colleagues across the University on administrative and student support matters

**Professional development:**

- professional development undertaken
- further professional development needs/plans
- level of participation in staff training activities

**Contributions made to the school/faculty and the University:**

- level of responsibility employed in leading developments/initiatives
- nature of involvement in student recruitment
- nature of involvement in school and course publicity
- organization of school social activities and other activities designed to foster good relationships among staff and students
- demonstration of collegiality in service (being able to work respectfully with others within the University)
- level of involvement in University's strategic planning

**Contribution to the profession:**

- level of involvement in professional activities—e.g., attendance at lectures, seminars, meeting, conferences
- level of involvement in professional societies

**Research, Consulting, Publication:**

- applications for grants
- grants received
- publications
- consulting
- evidence of involvement with industry and development of industry links

**Community involvement:**

- participating in public service activities

### *Supervisors*

Supervisors are critical to the success of any performance-based management system. They perform the role of the assessor and are responsible for

- agreeing with the staff member on a written performance plan that is in keeping with the corporate and faculty/ school/division/departmental plan
- conducting regular reviews to allow for timely performance feedback and guidance
- evaluating staff members on the basis of how well they performed and documenting online the evaluation using the OLPBMS
- celebrating successes achieved by the staff member and making recommendations for recognition and reward for staff members who make significant contributions
- taking appropriate actions for those who have not performed at the required standard
- encouraging staff members to improve their skills and undertake the challenge of more complex assignments
- providing training to staff members that is essential for them to perform their duties

### *Peers*

The procedures to be used for peer evaluation are subject to agreement between the supervisor and the staff member. The persons selected as peers are responsible for assessing the individual on the established competencies. The evaluation involves the use of an evaluation panel consisting of two representatives suggested by the supervisor and two suggested by the staff member. The persons selected are normally member of the staff member's school/faculty/division. However, representatives may be chosen from another school/faculty/division in cases where the staff member is involved in a collaborative program. Persons who are selected should be in a position to comment on the individual's performance.

### *Students*

Students will be asked to evaluate, online, academic staff using the Instructor Evaluation Web Form or paper-based form, which focuses on the quality of the learning experience that instructors provide for their students as well as identifying areas where improvement is needed. The score for the student evaluation is based on the average scores for the selected courses/modules taught by the lecturer.

### *Reviewer*

The reviewer is the assessor's supervisor and has the primary role of ensuring equitable treatment of all staff members by

- reviewing the supervisor's assessment to ensure objectivity in the administration of the system
- approving recommendations for training, promotions, sanctions. or any other actions recommended by the supervisor
- resolving conflicts that may arise between the staff member and the supervisor

### *Human Resources Department*

The Human Resources Department has the overall responsibility for the management and administration of the OLPBMES. It ensures that all the partners adhere to established guidelines in order that the integrity of the system is maintained.

The department also carries out the following functions:

- acts as a resource centre providing guidance, support, and training to the partners
- monitors, reviews, and audits the system
- ensures that appropriate follow-up action is taken
- analyses and reports on individual, departmental, and institutional performance
- ensures proper records are kept

### *Development Plan and Performance Report*

At the end of the appraisal session, the supervisor and staff member discuss the staff member's development needs in line with his or her long-term career and professional development goals. They also agree on a personal development plan that identifies development activities for the following period and specific resource support, for example, training activities. All this information is entered into OLPBMES online within the predetermined appraisal period. Beyond this period each participant in the system may view this information, but not modify it. The performance report is a record of the performance review, planning, and development meeting and includes the following:

- review of performance for the previous 12 months
- performance agreement for the succeeding 12 months
- agreed actions
- development plans
- overall assessment and comments by the reviewers
- comments by the staff member

Following the completion of the performance review, performance agreement, and development plan, the performance report is completed and signed off by the supervisor and staff member. A copy of the report is kept in the database of the system as well as in a confidential file in the supervisor's office with the original placed on the staff member's personal file in the Human Resources Department.

### **Information Resources of the OLPBMES**

Information resources of OLPBMES are based on the Human Resources database (HRDB) and University portal—Student Integrated Administration System (ISAS). ISAS provides information to students about their assignments and exam results on-line. HRDB is built using the FoxPro database and has successfully served the staff of the HR department and management of the University for many years. ISAS is built using MS SQL-Server 2000 database and developed using VB6/ASP programming languages/environment. OLPBMES is based on other more contemporary platforms, which we will describe below. An integration of these three different information systems is a problem for developers.

Our solution is based on the idea of creating a “pool of elementary information objects.” generally shown in Diagram 1:

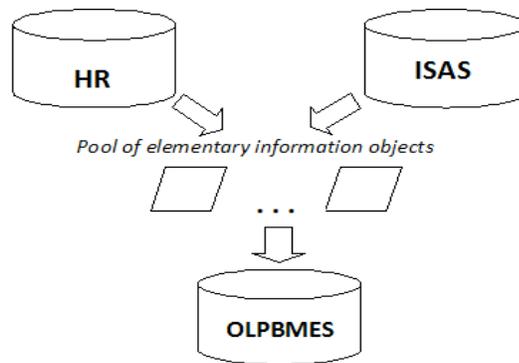


Diagram 1

In this approach information is collected from HR and ISAS automatically by software specially designed for that purpose. This software creates a set of mutually independent elementary information objects. They can be considered a *buffer* between real information resources and database-destination OLPBMES. In fact the process of getting information from HR and ISAS is a one-way street, which means that it inherits valuable data from the “parent” system and populates the OLPBMES, without affecting the data processes of the parent. That buffer is platform independent and allows the integration of different information systems of the University, which, although developed under different operating systems, still successfully operate as a unified information system of the university. Some aspects of that solution are described in [4].

A significant component of the OLPBMES is an Online Module/Instructor Evaluation System (in our terminology module is a subject, such as “Introduction to Programming”)—OLMIES. This system provides evaluations of modules delivered by departments/schools and of lecturers by students. We appreciate the importance of that feedback from the students, which is a valuable component of overall evaluation for academic staff. The OLMIES is flexible, anonymous, secure, efficient, and customizable. It is a database-driven system with strong data mining and reporting capabilities that aid effective decision making, described in [6].

### Security Solutions in the OLPBMES

Security is an essential part of the OLPBMES. This system has been developed for all members of staff of the University, including academic/nonacademic, administrative, technical, ancillary staff, and so on with different responsibilities and areas of responsibility. We have to evaluate a contribution to the success of the University by everybody. Because the system serves all of us, with a single Internet interface and common data storage, it must be possible to restrict access to the resources. Our solution is based on the concept of the “role” of the currently logged-on user, which is described below conceptually with some specific examples in code.

Let us assume that you have a set of known users who have been placed into specific groups named *SPHS\_Lecturer* (lecturers from the School of Pharmacy & Health Science) or *DSM\_Lecturer* (lecturers from the Department of Science & Mathematics). Using *role-based security* (or simply RBS), it is possible to programmatically determine the role/roles of the

current user interacting with a given type or type member. In our system we associate one user with one or more roles.

The process of getting access to the system by user is comprised of the following two steps:

1. *Authentication*. The *StartPage.aspx* asks user to enter a University ID and checks whether the user is a member of the university community using the main data storage of the system—MS SQL Server. If the data entered by the user does not match the list of UTech IDs, it informs the user of this and does not allow progress into the system.

2. *Authorization*. At that level we use a standard ASP.NET 2.0 *Login Control*, which provides an out-of-the-box Web User Interface (UI) for the purpose of credential validation. Beyond offering the traditional UI, the Login control makes use of the specified membership provider to perform validation. Given all of this intrinsic functionality, we built a *Login.aspx* file with *no* code whatsoever, providing and nesting subelements into `<asp:Login>` tag, that map to the contain control.

An ASP.NET 2.0 uses a *Membership* class, which can be configured to perform user validation with various *membership providers*. The providers that ship with the Framework provide a “canned” implementation of data storage for user information. In this case we can use our own data store of user information, in parallel with an *.mdf* database under *App\_Data* folder (see Diagram 2) in the system project, which is created by Framework and can be seen in the Solution Explorer. The default membership provider is the local instance of Microsoft SQL Server. This out-of-the-box behavior is catalogued within the `<membership>` element in the *machine.config* file, which is located in the `C:\WINDOWS\Microsoft.NET\Framework\v2.0.50727\CONFIG:`

```
<connectionStrings>
  <add name="LocalSqlServer" connectionString="data source=.\SQLEXPRESS;Integrated
    Security=SSPI;AttachDBFilename=|DataDirectory|aspnetdb.mdf;User Instance=true"
    providerName="System.Data.SqlClient" />
</connectionStrings>
..... (1)
<membership>
  <providers>
    <add name="AspNetSqlMembershipProvider"
      type="System.Web.Security.SqlMembershipProvider, System.Web, Version=2.0.0.0,
      Culture=neutral, PublicKeyToken=b03f5f7f11d50a3a"
      connectionStringName="LocalSqlServer" enablePasswordRetrieval="false"
      enablePasswordReset="true" requiresQuestionAndAnswer="true" applicationName="/"
      requiresUniqueEmail="false" passwordFormat="Hashed"
      maxInvalidPasswordAttempts="5" minRequiredPasswordLength="7"
      minRequiredNonalphanumericCharacters="1" passwordAttemptWindow="10"
      passwordStrengthRegularExpression="" />
  </providers>
</membership>
```

Most of these attributes are thankfully self-describing. These settings can be overridden by settings of the *web.config* file in the application. Using *.mdf* internal database in our

application allows us to provide a high level of security for sensitive information like *username*, *password*, *secret question/answer*, etc., converting and storing them in the DB into *hash* encrypted version, using settings (1), with an actual value (password, for example) in the database like this:

`“UF4s4VbBvLooupH4Bvv2dlIZZWM=”`

This means nobody (including *Database Administrator*) can use this information to gain illegal access to the specific functionalities of any user of the system. Under ASP.NET, these two security needs are addressed in part by tweaking various settings within a server side by XML *web.config* file. This flat text-file resides in a root directory of the project, and a set of *web.config* files in the subfolders of it. Each *web.config* files identifies an access policy to the subfolder including that file (2) and (3).

A structure of the OLPBMES is a set of ASP.NET pages with their code-behinds, classes, server controls, services, and so on, which are located in the Root Directory (RD) of the System Location Area (SLA)—let’s call it *Level 0*. The SLA has a hierarchical structure and consists of several levels, depending on the level of security needs to be supported: *Level 1*, *Level 2*, and so on. The level below Level 0 is identified by set of folders with specific names: *President*, *Vice-President*, *Faculty\_FHAS* (Faculty of Health and Applied Science), *School\_SPHS* (School of Pharmacy and Health Science), etc. and reflects a real set of University units. These folders are root folders for *Level 1*, and lead hierarchical structure of folders, ASP.NET pages, and configuration *web.config* file reside below Level 0. Folders on that level have the same structure identifying next level, Level 2. Level 2 is the highest level of accessing to the specific functions associated with manager/supervisor privileges. Persons who can achieve that level are granted rights to evaluate their staff and units conducted by them. This solution can be continued further. In this project we don’t need a structure with more than two levels. The “entrance door” to that level is a folder named “ExclusiveAccess.” A fragment of the *SLA* is presented in Diagram 2:

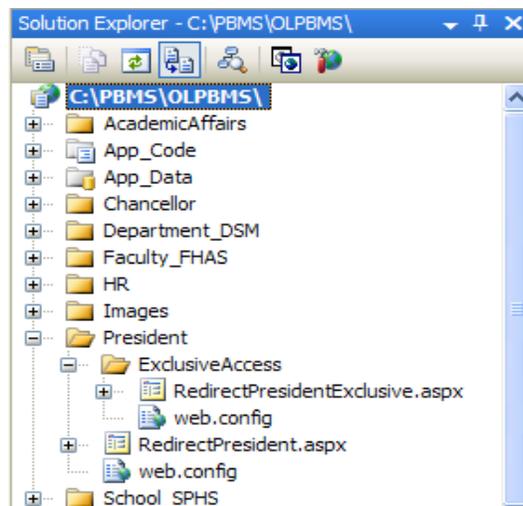


Diagram 2

Folders on Level 1 and on Level 2 have an XML web.config file, which describes credentials for users of the system. In this file the <authorization> element contains an <allow> subelement to control who can access a particular resources. Additionally, the <authorization> element contains a <deny> subelement to explicitly *deny* access to a particular resources. The <allow> and <deny> subelements each support a users attribute that can be assigned to the “?” token (to specify anonymous users) as well as “\*” (to specify all users). An example of content of *web.config* file for folder *President* (Level 1) is shown here (fragment of it):

```
<?xml version="1.0" encoding="utf-8"?>
<configuration xmlns="http://schemas.microsoft.com/.NetConfiguration/v2.0">
  <system.web>
    <authorization>
      <allow roles="President" />
      <allow roles="SystemAdministrator" />
      <allow roles="HR_Senior_Director" />
      <allow roles="FHAS_Dean" />
      <allow roles="SPHS_HOS" />
      <allow roles="DSM_HOD" />
      <allow roles="SPHS_Lecturer" />
      <allow roles="DSM_Lecturer" />
      <deny users="*" />
    </authorization>
  </system.web>
</configuration>
```

(2)

In that example only users with roles, presented in the file will be accepted, but others (*line* <deny users="\*" />) will be rejected.

Here is an example for folder *President/ExclusiveAccess* (Level 2):

```
<?xml version="1.0" encoding="utf-8"?>
<configuration xmlns="http://schemas.microsoft.com/.NetConfiguration/v2.0">
  <system.web>
    <authorization>
      <allow roles="President" />
      <deny users="*" />
    </authorization>
  </system.web>
</configuration>
```

(3)

In this example only the user with the role “President” can get access to the resources of that folder, and users with any other roles will be rejected.

Resources on both levels are presented by pages *RedirectPresidentExclusive.aspx* and *RedirectPresident.aspx*. These ASPs accept the set of *Session* objects with data necessary for executing requested pages and redirect the user to them. This means a user who is not associated with some specific role can be restricted to the requested page. If somebody who really does know a URL of a restricted ASP page tries to access it without access rights, the system will redirect him or her to a *Login.aspx* page asking for a username and password. The set of

*web.config* files, the System Location Area, *.mdf* internal database, MS SQL Server application database, navigation controls, and classes are the basis for full implementation of security issues.

*Navigation* is a fundamental component of the OLPBMES. In conjunction with security policy it allows for the system to provide set of various *Menus* for different categories of users and their roles. We use the ASP.NET menu rich control, which binds that control to a data source programmatically. In OLPBMES we consider a two-level menu of information as two sets of rows, which are located in two tables *mnuLevel1* and *mnuLevel2* in the database, shown in Diagram 3 below.

Each record of the table *mnuLevel1* has a “one-to-many” relationship with the set of records in the table *mnuLevel2*. A snapshot of C# code-behind of ASP page shows an algorithm for building the data recourse for ASP.NET *Menu control*, presented below:

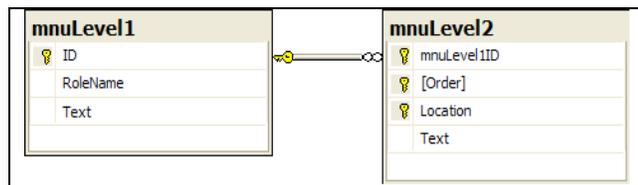


Diagram 3

Each authorized user associated with some specific role has a set of items (records) of menu level #1 in table *mnuLevel1*, matched with a value of the column with name *RoleName*.

```

string sqlTable1 = "SELECT L1.[ID], L1.[Text] AS Text1 FROM mnuLevel1 AS L1 WHERE
    RoleName = '" + uRole + "'";
string sqlTable2 = "SELECT L2.[Location], L2.mnuLevelIID, L2.[Text] AS Text2 " +
    "FROM mnuLevel2 AS L2 INNER JOIN mnuLevel1 AS L1 ON L2.mnuLevelIID = L1.[ID] " +
    "WHERE L1.RoleName = '" + uRole + "'";
SqlDataAdapter da = new SqlDataAdapter(sqlTable1, con);
DataSet ds = new DataSet();
Try
{ con.Open();
  da.Fill(ds, "mnuLevel1");
  da.SelectCommand.CommandText = sqlTable2;
  da.Fill(ds, "mnuLevel2");}
Finally
{ con.Close();
}
DataRelation relat = new DataRelation("Relations", ds.Tables["mnuLevel1"].Columns["ID"],
ds.Tables["mnuLevel2"].Columns["mnuLevelIID"]);
ds.Relations.Add(relat);
..... (4)
protected void BuildNavigationMenu(MenuItem item, DataSet dataSet, DataRow r)
{
  NavigationMenu.Items.Add(item);
}
    
```

```

DataRow[] childRows = r.GetChildRows(dataSet.Relations[0]);
foreach (DataRow childRow in childRows)
{
    MenuItem itemL2 = new MenuItem(childRow["Text2"].ToString(),
        childRow["Location"].ToString());
    item.ChildItems.Add(itemL2);
}
}

```

Using this algorithm, we can generate any dynamic menu for any category of user without rebuilding and recompiling an application. The *generator menu* is a part of functionality of the *Assistant of the System Administrator/System Administrator (ASA/SA)* and is a flexible solution for the process of creating new users with the requisite privileges.

Let us illustrate this idea, for example, using the head of the Department of Science and Mathematics (role: *DSM\_HOD*). We need to generate a fragment of his menu for evaluation of the academic, administrative, technical, and ancillary staff of the department. The Assistant of the System Administrator, using his interface, adds a record into table *mnuLevel1*:

<i>ID</i>	<i>Role Name</i>	<i>Text</i>
~\ChoiceError.aspx?P=DSM3	<i>DSM_HOD</i>	Evaluation of

Then he/she adds six records into table *mnuLevel2* in columns *mnuLevelIID*, *Order*, *Location*, and *Text* accordingly:

<i>mnuLevelIID</i>	<i>Order</i>	<i>Location</i>	<i>Text</i>
~\ChoiceError.aspx?P=DSM3	1	~\Department_DSM\ExclusiveAccess\RedirectDSMExclusive.aspx?D=S	members of the Department of Science and Mathematics Senior Academic staff
~\ChoiceError.aspx?P=DSM3	2	~\Department_DSM\ExclusiveAccess\RedirectDSMExclusive.aspx?D=A	members of the Department of Science and Mathematics Academic staff
~\ChoiceError.aspx?P=DSM3	3	~\Department_DSM\ExclusiveAccess\RedirectDSMExclusive.aspx?D=S	members of the Department of Science and Mathematics Senior Administrative staff
~\ChoiceError.aspx?P=DSM3	4	~\Department_DSM\ExclusiveAccess\RedirectDSMExclusive.aspx?D=T	members of the Department of Science and Mathematics Senior Technical staff
~\ChoiceError.aspx?P=DSM3	5	~\Department_DSM\ExclusiveAccess\RedirectDSMExclusive.aspx?D=A	ancillary staff in the Department of Science and Mathematics

The algorithms (4) and menu data, entered by ASA/SA to the SQL Server database, shown above, generate an information resource for *NavigationMenu* item of ASP.NET menu control. After that, at run-time ASP.NET generates a JavaScript program and renders HTML code to the final DHTML code, sending it to the client browser. A fragment of the browser's screen is presented with the output in Diagram 4, where you can recognize a first-level menu on the left-hand side, each item of which dynamically generates a drop-down menu on the second part of menu.

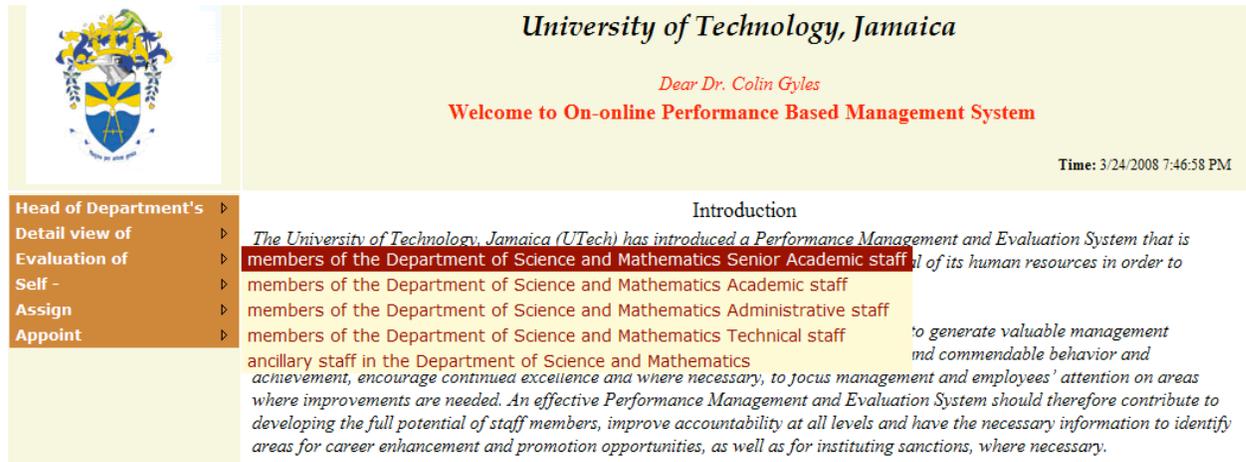


Diagram 4

### Project Development Environment and Tools

The development environment tools (MS Visual Studio .NET 2005) and programming (Visual C# 2005, ASP.NET 2.0, XML, SQL) allow us to build a scalable, robust and reliable web application based on up-to-date Multitier Architecture. Created by Microsoft, .NET technology is an integrated suite of components that combines the “building blocks” of the web—markup languages and HTTP—with proven object-oriented methodology.

It is also important that the Active Server Pages (ASP.NET) that we have used in building our system are not interpreted, like many other web-development tools, but are instead compiled into assemblies. All code-behind programs, classes, controls, services, and so on were created using C# 2005 programming language. Other reasons to select ASP.NET 2.0 as main tool for development of the system [2] were:

- It is integrated with the .NET 2.0 Framework.
- It is compiled, not interpreted.
- It is multilanguage.
- It is hosted by the Common Language Runtime.
- It is object-oriented.
- It is multidevice and multibrowser.
- It is easy to deploy and configure.

OLPBMES uses a MS SQL Server 2005 database as storage of data. This DB is more fully integrated to .NET technology, flexible, and extensible than any other relational database products.

## Conclusion

As a relatively young university, the University of Technology, Jamaica has made great strides improving the robustness of its strategic planning process and aligning it with a measurement and evaluation system in order to create a performance culture in the University. In this regard, the leadership of the University played a critical role in designing and deploying the system to ensure its effectiveness. It is acknowledged that even clearly stated and well-defined goals and expectations would be of little value unless the University, its divisions, departments, units, and individual members were apprised of performance against goals in a timely and useful fashion. Effective feedback, therefore, is a crucial ingredient in the system, and this is facilitated by way of periodic reporting of progress and results against identified objectives and expectations.

An important objective in developing the OLPBMES was to more closely “connect” each staff member to the strategic planning and evaluation process. Employee involvement is one of the best ways to create a positive culture that thrives on performance measurement. Through the Project Steering Committee, staff at all levels had an opportunity to provide input into all phases of creating the performance-based management system and by so doing to create “buy-in.”

The intention of the OLPBMES is to provide a robust yet flexible online tool for the University to measure how well it is achieving its vision, mission, and strategic targets, providing a mechanism for communicating with each staff member their individual contribution to the success of the institution. How this will tool succeed in achieving these objectives is too early to tell, as the system has yet to be fully implemented across the University. A key element in this project is yet to come—an evaluation to measure the outcomes and effectiveness of the system.

A practical experience of using OLPBMES in the University of Technology, Jamaica proves that we have selected an effective way for improving the evaluation process of the University staff. The general issues and security solutions of that project were presented on the International Conference CATE-2008 in Greece [5, 7].

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## Appendix A

### Detail Definitions of some Core and Functional Competencies for an Academic Staff

<b>Core Competencies</b>	
<b>Customer Focus</b>	Understands the perspective of the customer both internal and external; willingness to meet or exceed the needs and expectations of customers and anticipate their future needs; acts professionally when dealing with others, treats all persons respectfully; takes personal responsibility for correcting problems.
<b>Teamwork</b>	Cooperates and communicates well with others to accomplish joint tasks and common objectives.
<b>Functional Competencies</b>	
<b>Teaching preparation</b>	Plans learning outcomes and where appropriate collaborates with colleagues within the context of the curriculum. The ability to enhance learning through formulating learning outcomes, creating effective teaching materials and appropriate methods of module evaluation.
<b>Management of Learning Experience</b>	Being able to deal with students from varying backgrounds and skill levels; using feedback from students and their experiences to aid in the learning process; provides a clear sense of direction for students through effective coaching plans; being able to evaluate an individual's learning process; uses various methods of supervision to suit specific needs of students and provide guidance

## Appendix B

### Distribution of Weights of Some Categories of Staff of the University

		Administrative Structure									Academic Structure									
		Executive Management			Senior Management		Management		Administrative support		Ancillary	Management					Academic staff			
		President	Vice-presidents	Senior Directors	Directors, Doctors	All managers, Faculty administrators		Faculty office	School/Dept. office	Others (Non-academic)	All categories	Deputy President	Vice-President (Graduate stud.)	Associate Vice-Presidents	Deans	University Librarian	Head of School Department	Professor	Associate Professor	Senior Lecturer
	1	2	3	4	5	6	7	8	9		11	12		14	15		17	18	19	
Corporate score	1	80	40	40	40	30	20	20	20	10	60	40	40	40	40	30	30	20	20	20
Faculty score	2					20	20	10						30		20	20	20	10	10
School score	3							10							30	10	20	30		30
Division score	4		40	40	30				10	10	20	40	20	10	10					
Department/Unit	5								10	10			20		30					
Individual	6				10	30			40	50						20	20	20	20	20
Competencies score	7	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
<b>Total:</b>		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

**Appendix C**  
Levels for the Teamwork objective in the core competency  
of the Academic Staff

<b>Consistently exceptional performance</b>		<b>Usually surpasses acceptable standards</b>		<b>Generally meets acceptable standards</b>		<b>Occasionally does not meet acceptable standards</b>		<b>Seldom measures up to acceptable standards</b>	
<b>Level 5</b>		<b>Level 4</b>		<b>Level 3</b>		<b>Level 2</b>		<b>Level 1</b>	
<b>10</b>	<b>9</b>	<b>8</b>	<b>7</b>	<b>6</b>	<b>5</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>
<i>Contributes to the creation of an open and trusting environment that promotes effective teamwork</i>		<i>Provides necessary guidance and support to team members</i>		<i>Actively and willingly participates in team activities</i>		<i>Provides support to only some team members</i>		<i>Avoids working in a team</i>	
		<i>Keeps team members informed and up-to-date, and shares all relevant information</i>		<i>Shares information and knowledge and seeks assistance from others when necessary</i>		<i>At times shares information with others</i>		<i>Does not share information with others</i>	
<i>Has a collaborative approach to decision making, involving all team members</i>		<i>Motivates team to achieve targets and objectives</i>		<i>Is supportive of team decision making</i>		<i>Occasionally supports team decision making</i>		<i>Resists collaborative decision making</i>	
		<i>Insists on mutual respect; treats people with dignity</i>		<i>Respects all members of the team</i>		<i>Respects only some person's points of view</i>		<i>Lacks respect for the points of view of others'</i>	

Consistently exceptional performance		Usually surpasses acceptable standards		Generally meets acceptable standards		Occasionally does not meet acceptable standards		Seldom measures up to acceptable standards	
Level 5		Level 4		Level 3		Level 2		Level 1	
10	9	8	7	6	5	4	3	2	1
<i>Contributes to the creation of an open and trusting environment that promotes effective teamwork</i>		<i>Provides necessary guidance and support to team members</i>		<i>Actively and willingly participates in team activities</i>		<i>Provides support to only some team members</i>		<i>Avoids working in a team</i>	
		<i>Keeps team members informed and up-to-date, and shares all relevant information</i>		<i>Shares information and knowledge and seeks assistance from others when necessary</i>		<i>At times shares information with others</i>		<i>Does not share information with others</i>	
<i>Has a collaborative approach to decision making, involving all team members</i>		<i>Motivates team to achieve targets and objectives</i>		<i>Is supportive of team decision making</i>		<i>Occasionally supports team decision making</i>		<i>Resists collaborative decision making</i>	
		<i>Insists on mutual respect; treats people with dignity</i>		<i>Respects all members of the team</i>		<i>Respects only some person's points of view</i>		<i>Lacks respect for the points of view of others'</i>	

## Appendix D

### Competency Objectives for Academic Staff

Objectives (weight 20%)	Agreed weight	Rating	Actual score
<b><i>Core competencies</i></b>			
<i>Customer focus</i>	<b>W<sub>1</sub></b>	<b>R<sub>1</sub></b>	<b>A<sub>1</sub></b>
<i>Teamwork</i>	<b>W<sub>2</sub></b>	<b>R<sub>2</sub></b>	<b>A<sub>2</sub></b>
<i>Integrity</i>	<b>W<sub>3</sub></b>	<b>R<sub>3</sub></b>	<b>A<sub>3</sub></b>
<i>Accountability</i>	<b>W<sub>4</sub></b>	<b>R<sub>4</sub></b>	<b>A<sub>4</sub></b>
<i>Innovation</i>	<b>W<sub>5</sub></b>	<b>R<sub>5</sub></b>	<b>A<sub>5</sub></b>
<b><i>Functional competency</i></b>			
<i>Teaching preparation</i>	<b>W<sub>6</sub></b>	<b>R<sub>6</sub></b>	<b>A<sub>6</sub></b>
<i>Management of learning experience</i>	<b>W<sub>7</sub></b>	<b>R<sub>7</sub></b>	<b>A<sub>7</sub></b>
<i>Appropriate use of technology</i>	<b>W<sub>8</sub></b>	<b>R<sub>8</sub></b>	<b>A<sub>8</sub></b>
<i>Curriculum development and review</i>	<b>W<sub>9</sub></b>	<b>R<sub>9</sub></b>	<b>A<sub>9</sub></b>
<i>Research skills</i>	<b>W<sub>10</sub></b>	<b>R<sub>10</sub></b>	<b>A<sub>10</sub></b>
<i>Handling administrative tasks</i>	<b>W<sub>11</sub></b>	<b>R<sub>11</sub></b>	<b>A<sub>11</sub></b>
<i>Leadership</i>	<b>W<sub>12</sub></b>	<b>R<sub>12</sub></b>	<b>A<sub>12</sub></b>
<i>Professional development</i>	<b>W<sub>13</sub></b>	<b>R<sub>13</sub></b>	<b>A<sub>13</sub></b>
		<b>Total score:</b>	<b>T</b>

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# Online Learning



# Designing Learning Experiences for Comparability Across Delivery Methods

Dee L. Fabry

## Abstract

This paper presents issues and barriers that affect effective online course design, current research concerning guidelines for designing effective online courses (Koszalka & Ganesan, 2004; Bannan-Ritlan, 2002; Hirumi, 2005; and Northrup, 2001), and traditional research-based instructional design guidelines for course design (Kemp, Morrison, & Ross, 1998). It then raises the question of how to design comparable courses across delivery methods in order to ensure that goals, objectives, and learning outcomes are met. A design process and matrix provide guidelines for mapping consistency across course delivery methods.

## Key Words

Online course development, traditional classroom delivery, design and development, distance education

## Introduction

With the proliferation of e-learning in colleges and universities, instructors and learners are faced with new decisions concerning how and when they want to teach and learn. The online learning environment can be intimidating to those with limited technology skills (Martyn, 2003). Some students prefer the traditional face-to-face classroom, while others enjoy the flexibility of the online option. Instructors, too, have their own preferences for teaching. Regardless of the method of course delivery, designers have the opportunity to design and develop courses across delivery modes that can provide opportunities for increased learning in any environment. One of the challenges for designers is to develop courses that adapt instruction to fit with the characteristics of a particular learning situation (Snelbacker, Miller, & Zheng, 2005). Whether the course is delivered online, on ground, or in a hybrid format, curriculum and instruction principles should drive the selection of course materials, learning events, and assessments.

Research indicates traditional classroom courses are often retooled for the online learning environment (Koszalka & Ganesan, 2004), and this process often fails when the linear-designed instructional framework is followed (Simonson, Smaldino, Albright, & Zvacek, 2003). When professors are asked to design online courses using packaged course management systems (CMS), such as eCollege, with little training on the features and how these features affect learning, the result is courses that do not align well with learning outcomes. However, according to Koszalka & Bianco (2001) when instructional purposes are kept in mind and guidelines for the effective design of online courses are followed, the results are well-designed online courses that successfully engage learners and provide multiple opportunities for learning and interaction (as cited in Koszalka & Ganesan, 2004).

Snelbacker, Miller, and Zheng (2005) suggest that while distance education does have unique characteristics, the well-defined research-based principles and guidelines for the design and development of traditional courses can be modified for use in e-learning environments. The question that then needs to be addressed for those designing online, on ground, and hybrid courses is, what are the guidelines for ensuring that learning outcomes are met across delivery modes?

## **Problem and Purpose of the Research**

Koszalka and Ganesan (2004) presented a taxonomy for designing online courses that are developed in CMS environments. This taxonomy provides useful guidelines to those tasked with designing and developing new distance education courses. It describes common CMS features and categorizes them into information, instruction, and learning elements with examples of their value for teaching and learning. The authors' intent was to "provide guidelines that prompt developers to think strategically about their use of CMS features and make appropriate decisions that will support and enhance course teaching and learning goals" (Koszalka & Ganesan, 2004, p. 248).

What happens, then, when the online, on ground, and hybrid courses are concurrently designed and developed? What guidelines are available to those tasked with producing a course that aligns the informational, instructional, and learning elements across delivery modes? At this point, research does not provide us with effective strategies and guidelines in this area. We can, however, extrapolate guidelines from the research to-date on systematic instructional design and effective online course design.

The goals of this research are twofold. One is to present course design guidelines that direct the concurrent design and development of online, on ground, and hybrid courses. The second is to provide a matrix that, when followed, provides a way to ensure comparability in meeting the learning outcomes for students in both learning environments while retaining the effective instructional strategies for each.

## **Background**

### *Issues in Designing Online Courses*

Challenges in designing effective online courses include a lack of knowledge of the features and tools available in course management systems and a need for faculty to understand the role of student-centered learning to increase student learning. Koszalka and Ganesan (2004) acknowledged that CMS's used in the development of online classes, can distract the developer from aligning information, instruction, and learning to the course goals and objectives. The multiple features and tools are enticing to use, but they do not equate to good design.

The automation of easy-to-populate templates appears to be an efficient method to build a course, but online courses often suffer from an ill-informed selection of features that are not aligned to course learning objectives (Gilbert & Moore, 1998; Kidney & Puckett, 2003). The developer, whether a professor or a subject-matter expert, is often confused or uneducated about the features in the CMS and how these tools can best be used to create learning opportunities. The reality is that the misalignment of CMS features to learning outcomes can, and often does, cause the learner frustration (Moore & Kearsley, 2004).

Another concern in creating quality online learning is that faculty in the e-learning environment still teach using a teacher-centered pedagogy where lectures constitute the delivery method for presenting information to the learners (Zemsky & Massey, 2004; Barret, Bower, & Donovan, 2007). These researchers suggest that instructors must change their pedagogy to a learner-centered teaching style. Thus, students can play an active role in their learning process when the technology tools are utilized for maximum effectiveness. Miller (2007) reported that students in learner-centered online courses both master concepts better and produce higher-quality projects than those in non-learner-centered online courses. Chou (2001) reported that

learner-centered instructional design, along with constructivist approaches, enhanced student learning.

Shifting from traditional to online teaching requires a thoughtful consideration of how best to use a learner-centered approach in the delivery of online instruction to optimize instructor-learner interaction (Brown, 2004). In general, navigating through course material that has not been carefully designed can be frustrating and challenging for students. For distance education, learner-centeredness is the focus and is strongly associated with student satisfaction (Fulford & Zhang, 1993; Gunawardena & Duphorne, 2001; Swan, 2001). Course developers, then, need to address the issues of effectively utilizing the CMS features and tools in order to create a student-centered learning environment that optimizes interactivity.

### *Guidelines for Designing Effective Online Courses*

Current research on the effective design of online courses is abundant (Collis, 1999; Hirumi, 2005; Miller & Miller, 2000; Snelbacker, Miller, & Zheng, 2005; Koszalka & Ganesan, 2004; Zhang, 2004). The research, in general, however, cautions that with the rapid proliferation of course offerings, many are not instructionally sound (Morrison & Anglin, 2006; Hirumi, 2005). To create instructionally sound courses, research-based principles must be applied.

The American Distance Education Consortium (ADEC) published the *ADEC Guiding Principles for Distance Learning* (n.d.b.) after evaluating web-based learning environments. They concluded that the principles for distance education design are foundational to high-quality learning, no matter where the learner is located, and may be applied to distance and face-to-face learning. These guidelines state that distance learning development design for active learning considers (a) desired learning outcomes, (b) appropriate instructional strategies and technologies, (c) needs, (d) learning goals, (e) learning styles of the students, and (f) the nature of the content.

Hirumi (2005) analyzed six sets of e-learning guidelines and concluded that certain elements need to be specified to produce high-quality learning environments. These elements had not been addressed by published guidelines he reviewed. Hirumi was particularly concerned with the lack of guidelines for learner-centered practice. His guidelines are: 1.) Align learning objectives with assessment criteria. 2.) Design learning events that are based on and aligned to the learning outcomes. 3.) Specify expectations for timely and appropriate feedback to ensure optimal instructor-learner interaction. 4. Design and sequence instructor-learner, learner-learner, and learner-content interactions for effective learning opportunities. 5.) Use research-based motivational design theory such as Keller's ARCS Model to motivate students to learn.

His synthesis suggests that alignment is a key to designing effective learning. In his model, the learning objectives are aligned to the assessment criteria, and the learning events are then aligned to the learning outcomes. This loop ensures a consistency in the design and development process that is essential for producing effective learning opportunities. In addition to alignment, he discusses the need for designing and sequencing instructor-learner, learner-learner, and learner-content instructional events that are student centered. These events must have multiple feedback opportunities that result in student satisfaction. Alignment and learner-centered design are two essential elements needed for producing effective learning environments.

Research-based principles for the design and development of online courses exist, as well as research that calls for more granular guidelines. More traditional instructional design models can also provide significant information to guide course development.

Morrison, Kemp, and Ross (1998) presented an eclectic instructional design model that is both flexible and adaptable. They acknowledged the role of technology in both the design and

delivery of knowledge and instruction. Their process, like that of Hirumi, supports the alignment of learning outcomes to materials and assessments. The instructional objectives need to be clearly stated while the strategies align back to the objectives. The evaluation in this model also aligns to the objectives. Morrison et al. suggest that the instructional strategies should be designed in a manner conducive to learning for each student in a learner-centered environment that provides multiple opportunities for practice and application. Their design model includes: 1.) State instructional objectives for the learner. 2.) Sequence content within each instructional unit for logical learning. 3.) Design instructional strategies so that each learner can master the objectives. 4.) Plan the instructional message and delivery. 5.) Develop evaluation instruments to assess objectives. 6.) Select resources to support instruction and learning activities.

### *Connecting Design to Pedagogy*

In 1987 Chickering and Gamson distilled extensive research on effective classroom pedagogy. This substantive body of evidence produced what is referred to as the seven principles. Effective pedagogy:

1. encourages contacts between student and faculty
2. develops reciprocity and cooperation among students
3. uses active learning techniques
4. gives prompt feedback
5. emphasizes time on task
6. communicates high expectations
7. respects diverse talents and ways of learning

In 2006, Chickering and Ehrmann connected the seven principles to technology use. They concluded that the integration of new technologies should be consistent with the seven principles. The power of the technology is in the tools and their multiple capabilities and how the instructor implements them to support student learning. For example, principle one states that good practice encourages contacts between the instructor and the learner. When this principle is applied to the communication tools in distance education, features such as announcements, e-mail, chat sessions, assignment feedback, and document sharing provide incredibly powerful opportunities for communication and interaction to support student learning.

Designers need to consider, then, how to adapt instruction to fit with the characteristics of a particular learning situation. However, when the course is delivered utilizing multiple methods, the characteristics of each environment need to be identified and the selection of information, instruction, and learning opportunities should be aligned to meet the goals and objectives of the course. Curriculum and instruction should drive the selection of resources and activities to support teaching and learning.

### *Creating and Implementing a Blended Process to Ensure Comparability*

After synthesizing the research on effective design principles in distance learning, instructional design, and pedagogy, the author developed a process for designing online, on ground, and hybrid courses that blended the research findings in effective online course development and instructional design models. This process integrates the work of Hirumi and Morrison et al.

utilizing the principles of alignment of learning objectives, instructional events, and assessments and learner-centered design. It keeps the learning objectives in focus while attending to the need for optimal interaction which research shows is critical to student success.

The blended process for designing online and on ground courses includes: 1.) Clearly state the learning objectives. 2.) Design and sequence a variety of learning events/content/resources that are aligned to the learning objectives and that support instruction and individual learning styles. 3.) Specify expectations for timely and appropriate feedback to ensure optimal instructor-learner interaction. 4.) Design and sequence instructor-learner, learner-learner, and learner-content interactions for effective learning opportunities. 5.) Design and align formative and summative evaluations that align with learning objectives. 6.) Use research-based motivational design theory to support a student-centered learning environment.

### **An Example of Applying the Process in Practice**

This process was applied to the concurrent design and development of a course at National University in Southern California. In 2007 a team of lead faculty members were tasked with conducting a review of the six core courses in the Masters of Arts in Teaching program. The results of the review indicated that one of the core courses was poorly aligned to both the internal and external criteria (Schubert, Fabry, & Begin, 2008). The course lead then analyzed multiple data to begin a course revision. The challenge presented was to design the online, on ground, and hybrid course to provide comparability in meeting learning outcomes and providing consistent learning experiences.

The course lead began the course design process by conducting a needs analysis via the student evaluation and instructor course content feedback for a one-year time period. These data clearly showed a course that was out of date. Further research provided information concerning how the course could be revised. A new approach to the content was selected, followed by a new textbook. Learning objectives, also termed learning outcomes, were written and the process presented in Table 3 was followed to design the online course first.

Each of the features and tools available in the CMS was analyzed to determine the opportunity for interaction. Column A in Table 4 indicates the type of interaction opportunity that each tool provided. Learning events were designed and sequenced to provide learners with multiple opportunities to obtain, practice, and apply new knowledge. Assignments and assessments were aligned to the learning outcomes and grading rubrics for each assignment were created. After the initial design was completed, two instructors who would be teaching the new course reviewed the online course design using the internal and external criteria to determine alignment to course learning outcomes. Adjustments were made and the first version of the course was completed.

Table 1  
Matrix for Creating Comparability

A. Online: Course Management Feature	B. Hybrid: Course Supplement	C. On Ground: Course
<i>I. Communication</i>	<i>I. Communication</i>	<i>I. Communication</i>
a. Announcements [Instructor-learner	a. Announcements [Instructor-learner	a. Verbal or written memos [Instructor-learner

interaction]	interaction]	interaction; learner-instructor]
b. E-mail [Instructor-learner; learner-instructor; learner-learner]	b. E-mail [Instructor-learner; learner-instructor; learner-learner]	b. Face-to-face [Instructor-learner; learner-instructor; learner-learner]
c. Threaded Discussions (Asynchronous) [Learner-learner; instructor-learner; learner-instructor]	c. Threaded Discussions (Asynchronous) [Learner-learner; instructor-learner; learner-instructor]	c. In-class discussion and/or reflective journals [Learner-learner; instructor-learner; learner-instructor]
d. Chat (Synchronous) [Learner-learner; instructor-learner; learner-instructor]	d. Chat (Synchronous) [Learner-learner; instructor-learner; learner-instructor]	d. In-class discussion [Learner-learner; instructor-learner; learner-instructor]
e. Feedback via assignments and electronic gradebook [Instructor-learner; learner-instructor]	e. Feedback via assignments and electronic gradebook [Instructor-learner; learner-instructor]	e. Written and/or verbal feedback [Instructor-learner; learner-instructor]
f. Virtual office hours [Instructor-learner; learner-instructor]	f. Virtual office hours [Instructor-learner; learner-instructor]	f. Face-to-face office hours [Instructor-learner; learner-instructor]
<i>II. Information</i>	<i>II. Information</i>	<i>II. Information</i>
a. Lectures (PowerPoint, videos, print-based) [Instructor-learner]	a. Lectures (PowerPoint, videos, print-based) [Instructor-learner]	a. Face-to-face, PowerPoint, Video [Instructor-learner; learner-instructor]
b. Readings: Textbook, posted or linked articles, w websites [Instructor-learner]	b. Readings: Textbook, posted or linked articles, w websites [Instructor-learner]	b. Textbook, hand-outs, of articles [Instructor-learner]
c. Interactive Learning Activities (Game-like experiences to reinforce skills) [Learner-self]	c. Interactive Learning Activities (Game-like experiences to reinforce skills) [Learner-self]	Not available
<i>III. Instruction</i>	<i>III. Instruction</i>	<i>III. Instruction</i>
a. Advanced organizers: graphic organizers, pretests, quizzes, interactive “games” [Instructor-learner]	a. Advanced organizers: graphic organizers, pretests, quizzes, interactive “games” [Instructor-learner]	a. Advanced organizers: graphic organizers, pretests, quizzes, [Instructor-learner; learner-instructor]
b. Assignments [Instructor-learner]	b. Assignments [Instructor-learner]	b. Assignments [Instructor-learner]
c. DocSharing [Instructor-learner;	c. DocSharing [Instructor-learner;	Not available

learner-learner]	learner-learner]	
<i>IV. Learning</i>	<i>IV. Learning</i>	<i>IV. Learning</i>
a. Readings, assignments, discussion threads, group work, feedback, presentations, DocSharing, Weblibliography, assessments [Learner-self; learner-learner; learner-instructor]	a. Readings, assignments, discussion threads, group work, feedback, presentations, DocSharing, Weblibliography, assessments [Learner-self; learner-learner; learner-instructor]	a. Readings, assignments, group work, class discussions [Learner-self; learner-learner; learner-instructor]

The next task was to design the on ground course. The course lead analyzed each of the required readings, course materials, assignments, and assessments to determine if the event could be used as it was designed for the on ground learning environments or if it needed to be adapted.

One example was the online discussion threads. The question arose of how to create a peer-interaction exchange so important in the development of critical thinking skills. This element appeared to be missing in the on ground component. It was determined that the prompts for the online threaded discussions could be used as the prompts for the reflective journal assignments in the on ground course. This meant that students were having comparable assignments and would be able to apply what they had learned in their readings. The missing learning element of peer input and feedback in the on ground course was resolved by having discussion time during class to explore the prompts in greater depth. This type of analysis was conducted for each learning event in the online course presented in Table 1 Column A. At this point of the design process, the online and on ground courses had assignments, assessments, and materials that were correlated.

A third option for students at National University is the hybrid course. This learning environment combines the online and on ground learning environments. For example, the class may meet once a week or one time at the beginning of the course and then for the last course meeting. The online course supplement is used to conduct the hybrid course. Specifically, in a course management system (CMS), an online supplement can be made available to on ground instructors and students. This online supplement includes all lectures, assignments, and additional support materials contained in the online course. The benefits of this supplement to the on ground instructor are (a) information and instructional opportunities are consistent for all students; (b) course materials are readily available; (c) students are responsible for printing out materials needed for each session; (d) any student missing a class has access to the course lecture, assignments, and other information; (e) communication via e-mail can be sent to individual students, groups, or the entire class as needed; (f) the automated grade book records and communicates grades in an ongoing basis; (g) students can submit assignments electronically via the DropBox feature which has a time stamp; (h) DocSharing provides an area where both the instructor and student can post papers, articles, and presentations for sharing; and (i) the Weblibliography for the entire course can be built by the entire class.

The online course was analyzed to determine if the elements aligned to the needs in the hybrid course. Column B in Table 1 shows what elements were selected for use in the hybrid course.

Using this matrix allowed the designer to create and/or select content, resources, and learning events that were comparable across all three delivery methods. For example, returning to the Threaded Discussion example, in Row 1c – Threaded Discussions, the prompts were written for the online course aligned to the learning outcomes. The online student responds to the prompt in the Threaded Discussion area where students post their response and then engage in interaction with their peers and the instructors. The hybrid course, depending on the number of times it meets, can conduct the discussion online also. The on ground instructor introduces the prompt via the online supplement in class and facilitates small group discussion of the issue. The on ground students then access the online supplement during the week to post and discuss the prompt. The addition of the online supplement provides the on ground instructor and the students with a powerful tool that has the potential to increase communication and learning. Other features in the CMS provide additional opportunities for increased learner-instructor and learner-learner interactions.

The combination of the blended design process and the matrix provided the course designer with two tools to ensure comparability in the design and development of course content, learning events, and assessments. A final review of the courses was completed and the course was sent to the Graduate Council for approval.

### **Challenges, Problems, and Concerns**

This course design process and matrix were implemented in the design of a course at National University in the Teacher Education Department. The designer received the full support of administration, instructors who had taught the course, and students who participated in focus groups. One of the challenges in taking on such a large design task was to ensure that opinions and voices were heard. The collaborative effort involved several levels of stakeholders at the university.

It is essential that course design receive input and feedback from those teaching the course, taking the course, and supporting the delivery of the course. Multiple viewpoints result in a course that keeps learning outcomes in focus and incorporates a range of learning events that meet a variety of teaching and learning styles. While this sounds like a daunting task, the reality is that the process results in a course that does provide the learner with comparable lectures, readings, assignments, and assessments and learning opportunities. Carefully and thoughtfully designed courses that adhere to the guidelines for effective design and good practice result in increased student learning and satisfaction.

### **Summary**

The online learning environment affords educators an unprecedented opportunity to reach students anytime and anywhere. It gives the learner the opportunity to take advantage of higher education because of convenience and accessibility. While this new landscape provides unlimited teaching and learning options, we need to be cognizant of the challenges that arise when designing and developing courses.

Not everyone wants to participate in learning via distance education; that includes instructors and learners. As we design courses, one issue we do need to consider is this: Are we providing learners with comparable learning experiences regardless of the delivery method?

This design research looks at the issues concerning designing and developing courses for the online, on ground, and hybrid learning environments in order to ensure that learning outcomes are met via the design process. The concern of equality in learning is at the heart of this design process.

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# Mobile Phones for Real-Time Teacher Coaching

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## Abstract

Mobile phones and online PDA's (personal digital assistants) became ubiquitous in our leisure, professional, and educational settings even before we envisioned their potential contributions. This article illustrates how the PDA and a wireless earpiece allow teacher training to become more vivid and responsive and indeed promote additional learning effects, when compared to the traditional coaching feedback after a lesson. To benefit more from mobile communication, we need to analyze how novice teachers benefit in their growing competencies. This is especially so in respect to acquiring the complex skills and competences required for teaching; it is crucial that both observational and unbiased performance parameters be taken into account. The study that underpins this article demonstrates that synchronous coaching has great potential to be complementary to the traditional asynchronous approach more commonly used in teacher training programs, in which a coach or supervisor is physically present in a classroom observing a trainee teacher.

## Key Words

Learning community, mobile learning, synchronous coaching, teacher training

## Introduction

Synchronous coaching has great potential to be complementary to the traditional asynchronous approach of teacher training programs in which a coach or supervisor is in the classroom observing a trainee teacher.

As definition of "coach," we may say that the coach is the person who dedicates his or her attention to guide a novice in complex skills and decision making. In this article we use the term *coach* as a more or less neutral term for a person who guides from the sidelines. There are numerous examples of the "whispering coach" used for training purposes in particular settings such as Formula 1 racing and in various television settings. Based on the findings reported in this article, we suggest that the whispering coach has potential to be of value in many educational settings.

The rationale for real-time coaching for novice teachers is that trainees need to be appropriately supported so that they can learn "on the job" and develop the skills and expertise to deal with the many challenging classroom situations they will confront. It is often the case that trainee teachers, especially in the early stages of their career, can be confronted with lessons that may be poorly organized and structured. Appropriate coaching or supervision ideally ensures that such situations do not lead the trainee teacher to feelings of failure. Coaches not only need to be excellent teachers themselves but also gifted as coaches for this domain.

The article presents the findings of a research study that used mobile phones for real-time coaching of trainee teachers. The research found that compared to the traditional asynchronous coaching, synchronous coaching has the advantage of allowing the coach to direct the trainee's attention to aspects of the complex task while it is being performed so that no lessons are "sacrificed" to partial deficiencies and the trainee is protected from the traumatic experience of having a lesson fail. The article closes with recommending the next steps for teachers who really want to apply this type of coaching as part of the "learning community."

## Background

Soufflage is already extensively used in sports. For example, since the end of the 1990s, drivers in Formula 1 car racing have been kept informed wirelessly about the progress of the race. In the MTV-program *Can't Get a Date*, individuals who have unsuccessfully searched for a suitable match are coached synchronously with the aim of “conquering” a desirable partner. Nowadays, it is possible to whisper instructions synchronously (directly) to a trainee teacher via a wireless earpiece. This technique offers other coaching options than the regular asynchronous forms of coaching, in which the trainer discusses the quality of the pedagogical action with the trainee after the lesson. The direct, synchronous coaching method proposed here allows the precise steering of action during the lesson.

The use of synchronous coaching in the training of teachers is novel, if one considers that this form of coaching has not yet been implemented in teacher training curricula. An interesting question arises: Does synchronous coaching via an earpiece form a valuable addition to the traditional asynchronous coaching of trainee teachers? In our study, the trainer coaches by whispering instructions that directly reach the trainee via an earpiece. One option is to send the instructions through the Internet that connects the trainer's computer to the trainee teacher's computer; the last five meters between the trainee teacher and his or her computer are bridged with a Bluetooth connection. Alternatively, the synchronous instruction can be done through two walkie-talkies, one carried by the trainer and the other by the trainee. The trainer pushes a button to whisper, and the trainee receives this information via an earpiece connected to the walkie-talkie. A main advantage of this second option is that less equipment is required. The trainee also only hears a sound via the earpiece when the trainer pushes in the button to say something. In the first option the line is continuously open, so the trainee teacher constantly hears background noise via the earpiece even when the teacher trainer says nothing. We experimented briefly with the first option and then used the second one throughout the rest of our experiments.

The article aims at providing you with insights on how the effects of asynchronous coaching were achieved and to what extent the findings can be generalized to the broader spectrum of teacher training. Given this brief background, this article will first review the contemporary literature on the role of coaching in teacher education, and then we discuss why we prefer the term *coaching* to *supervision*. Second, the article discusses related issues of the nature of the “learning community” and its impact in successful learning. The article goes on to present an experimental study that investigated the use of synchronous coaching using Bluetooth technology with a group of trainee teachers. The article explains the methodology and findings. The article closes by discussing the limitations of the study, the merits of the technology for learning and classroom performance, and the implications for further research.

## Main Factors in Coaching in Teacher Education

Teacher education is a wide process that involves both the needed professional skills and a theoretical understanding of how group dynamics and the learning process works. Essentially, the transition from supervision to coaching emerges when a particular skill/attitude proves to be a roadblock that needs a particular process of guided (coached) training. The coach can be an officially appointed in-service mentor. However, peer trainee teachers can also take up this role. Depending on the urgency and recidivism of the lacking skills, the coaching may fade away for a

while even if the manifest skills have not completely been proven; a phase of growing awareness may be needed to help the trainee get accustomed to the skill to be acquired.

Coaching another student may have important effects as well. Similar to collaborative learning in general, coaching makes students aware of why certain heuristics hold. Later research has shown that correct didactic skills do not guarantee that they survive in the longer run. Even we may observe how so-called “natural talents” in teaching fall back dramatically a few years later. The reason is that those who need to restructure their social reflexes from the beginning, are in a much better disposition for being a ‘continuous’ learner in the long run. In other words: We need at least a more precise apprehension of how early career learning needs to be conveyed.

The role of “gestalt” is similar to perception and social apprehension in general. A gestalt is the mechanism of fast template matching between a situation and a person who is prepared to intervene. Thus, it is an efficiency measure: Some features of a situation trigger a complete scenario (such as “these kids are going to ‘test’ me”) and can result in a rather emotional and drastic reaction from a novice teacher. If the teacher interprets the trigger correctly, it is likely that the young teacher will show the pupils that he or she understands the situation and is not going to compromise attention and discipline from that very moment. If, however, a subtle feature (without the intention to sabotage the lesson) is interpreted wrongly, the didactic climate may unnecessarily switch to a grim situation dominated by disciplinary actions when in fact they are not needed at all. The same role of Gestalt may occur when, for instance, the young teacher ignores total anarchy by taking a “friendly” smile of one of the students as a sign of positive climate. In other words: Yes, gestalts are necessary in order to filter and “understand” complex situations. However, if a Gestalt dominates too much, the student teacher will miss the real important signs and fail fundamentally.

Synchronous coaching is undertaken in this research in order to make the novice teacher immediately aware of the signal value of students’ and his or her own behavior. Common sense already teaches us that teacher behavior is not exclusively rational and not intentional even. A teacher’s behavior is often the result of previously experienced reflexes, emotions, routines, and intuitions. This nonintentional behavior manifests especially in situations in which there is no time to consider alternative behavior. If the coach, on the basis of behavior indicators, concludes that the behavior is in contradiction with the ideally accepted behavior, then he or she can immediately draw the attention of the teacher to this situation by whispering instructions. As soon as the teacher has adjusted his or her behavior on the basis of the “whispering” and has experienced the positive reactions of the students, room is created to get a mental grip on the situation once again. The teacher also has more cognitive capacity to prepare for the continuation of the lesson. The behavior that was originally present at the level of naïve perception becomes stepwise more fluent and automatic; it is as if more and more diverse situations become submissive to the broader categories that played a role in the initial training stage. The consequence is that the speed of closure takes over its flexibility. In terms of teacher training the trainee reaches a higher level of efficiency; however he or she may decline opportunities to differentiate among situational nuances.

A second step is to regain flexibility by breaking the emerged “gestalts” and becoming sensitive to the more delicate cues that are vital for adapting didactic decisions. It is as if the nonintentional association (gestalt) is lifted from the reflex level to the level of overview and insight through whispering intervention. In terms of cognition, this is called “rising to schema level” (Korthagen, 2005). A characteristic of this “higher” behavior level is that the trainee can

now establish relationships between the actual and desirable behavior so that the behavior develops positively over a period of time.

### **The Learning Community as Social and Its Intellectual Basis**

Collaborative and peer-based learning has a diverse and even controversial status in learning cultures around the world (Sim, 2003). Western Europe, the United States, and Israel have fully embraced the idea by Lev Vygotsky (1962) that communication and social presence is an essential link between the concrete and the abstract (conceptual) layers in learning. Vygotsky in his early theorization made the important step to excavate the evolutionary role of the peer group common sense to make students alert to self-manifestation and allow others to give a direct reaction on a learning performance.

Student learning communities like can be seen in seasonal campus parties express an existential need for personalized learning, such project-oriented work, portfolios, and so on. As curricular and institutional learning emerge, the student campus festival as extraneous event will fade away. Our project in mobile (synchronous) coaching in teacher education is based on this notion: Real-time feedback by a peer or a coach adds a vital learning climate and needs to be analyzed for its actual learning effects.

### **Learning and the Need for Coaching**

The regular coaching of trainee teachers is asynchronous: The trainee teaches in a plenary mode while being observed by the school practice supervisor and receives feedback in the form of a discussion in which the development of competencies of the aspiring teacher is central. The quality of the manifested pedagogical action is measured with an institutional competence assessment inventory. This assessment instrument (see Pisters, Bakx & Lodewijks, 2002), developed for plenary lesson situations, is based on seven underlying competencies:

1. Interpersonal competence
2. Pedagogical competence
3. Subject content competence
4. Organizational competence
5. Competence in the cooperation with colleagues
6. Competence in cooperating with external actors like parents etc.
7. Competence to reflect and develop

The underlying assumption is that the level of manifested ideal behavior shown by the trainee teacher can be observed and rated (5-point Likert scale) to the scale of underlying competencies:

1. Pedagogical
2. Subject matter oriented
3. Organizational
4. Interpersonal

5. Cooperation among colleagues
6. Cooperate with external partners
7. Reflection and professional development

A big advantage of the asynchronous alternative is that the student has the time to learn from mistakes and to experiment to a certain extent within the limits of the available educational experience. Compared to the asynchronous alternative, the synchronous method has the potential advantage of enabling the student to confront problems that may arise in the classroom while at the same time protecting the student whose classroom may have disciplinary problems. Synchronous coaching, in other words, assists the trainee teacher by suggesting pedagogical interventions immediately so the trainee does not lose control in the classroom or is unable to confront challenging situations.

At critical moments, the coach can draw the attention of the young teacher to what is going on within the students and send him or her a direct hint on what to do now and how to proceed further, to let the trainee experience the success of the complementary intervention. Comparable practices of whispering in the ears via an earpiece are seen in several areas nowadays:

1. In top sports, including the Formula-1 racing, where besides asynchronous supervision, synchronous coaching is also applied. We assume on the basis of the theory mentioned below that the quality of the pedagogical action of trainee teachers is also improved through immediate coaching.
2. In presenters and program leaders who are seconded by directors and professionals.
3. In coaching of parents by family therapist who attempts to repair disastrous miscommunication with the partner and with the children.

It may be expected that the coaching of trainee teachers will be improved by the similar integration of synchronous coaching. A certain amount of routine arises, and as the young teacher develops more, a broader and more adequate behavioral repertoire arises whereby attention for other aspects of teaching becomes available. Falling into “new” routines is called “level reduction,” whereby observation and reaction of the teacher are steered through gestalts. Functioning at gestalt level is characterized by a higher level of fluency, so that attention is completely free for other aspects of the pedagogical situation (Lampert, 1989).

We have stressed that synchronous coaching can guard trainee teachers against traumatic confrontations in the classroom. In addition, it can be stated that the essential competence of recognizing the lesson situations and the choice of appropriate teaching reaction through a synchronous intervention brings it closer to the real practice. The short period between observation, pedagogical reaction, and feedback has the advantage of being remembered better. There is a second argument for further investigations into the possibilities of synchronous coaching of teachers based on the report by Kulik and Kulik (1988), who indeed established that immediate feedback is preferable to delayed feedback. Mason and Bruning (1999) stated as a condition that “cognitive overload” should be avoided (Sweller, 1999, 2003). Accordingly, it may be expected that teacher behavior is steered better through the synchronous intervention than through the traditional (delayed) feedback.

## **Whispered Hints**

“Learning to teach” demands a lot from a trainee teacher. For example, the abilities to deal with students and offer structured lessons according to the teacher’s competence develops over the years. An additional factor demanding attention, the synchronous intervention, may pose a threat for the occurrence of an overload. A synchronous intervention should be short and clear to avoid cognitive overload. This is achieved by whispering only the key words from the indicator on which the teacher behavior was considered to be less competent. The synchronous intervention serves as a reference point during a discussion. The coach refers to the behavior indicator, which he or she had whispered, eventually supplemented with video material of the lesson. The trainee remembers the moment at which the specific behavior indicator was whispered, so that the process of awareness is continued further. The discussed gestalt perspective in this context stresses the relationship network between actual and desired behavior. It has to be remarked that coupled to feedback theory, in connection with the timing of feedback, that during synchronous intervention knowledge arises that in the asynchronous discussion serves as prior knowledge. We expect that synchronous coaching forms a valuable addition to the regular asynchronous coaching.

## **The Research Methodology**

To test this expectation, two conditions were investigated. The hypothesis of this study was formulated on the basis of the plan above: synchronous coaching has an additional positive effect over asynchronous coaching on the quality of the pedagogical action of the trainee teacher in plenary teaching situations.

### **Experimental Setup**

The participants were 40 randomly selected second- and third-year bachelor of education students. They were divided into two groups. The 20 students in Group 1 received the synchronous experimental coaching. These students follow a four-year teacher education course, in order to get qualified for teaching in the lower grades of the secondary school. The other 20 students in Group 2 received the regular asynchronous coaching (asynchronous intervention). The average age of the participants who received asynchronous coaching was 21.8 years. After the experiment, each test subject underwent an interview in which these items were discussed. In this study, 20 written fragments were also used besides the two instruments described above.

Per fragment, based on one behavioral indicator, the teacher behavior can be stated to be competent versus noncompetent. The 20 fragments were filmed in two ways. The two versions differed from each other on the basis of two criteria. First, the sequence of filming the fragments was changed. Second, small changes were introduced in the fragments, without changing the indicator that points to noncompetent behavior. With regards to changes, one may consider using various groups of actors.

The 40 randomly selected second- and third-year students were individually presented with 20 fragments on paper. Per fragment, the teacher behavior was referred to as noncompetent based on one behavior indicator. From the 20 situations described on the paper, 8 were radically

altered in consultation with educational experts because the indicator upon which the teacher behavior could be labeled as noncompetent was insufficiently clear.

Based on the described situations, the test subjects were required verbally to mention the indicator referring to noncompetent teacher behavior. An observer scored the quality of the explanation using the 5-point scale of an existing competence inventory. Prior to the experiment, it was tested whether the observations of the observer corroborated those of the experts. The experts were associated with the teacher training program and had the task of establishing the level of competence of the teachers. Cohen's kappa for inter-rater reliability was 0.67.

### Experimental Procedure

The 20 students in Group 1 were subjected to the synchronous intervention, whereas the remaining 20 students (Group 2) were subjected to the asynchronous condition.

In the synchronous condition 20 video fragments (Version 1) were presented to Group 1. These video fragments were recorded on the basis of 20 described fragments. Once a fragment was over, the screen went blank and the test subject showed a fellow student and the observer his or her ideal teacher behavior. The video fragment particularly showed teacher behavior that was incorrect on the basis of one behavior indicator. The test subject must show that he or she is able to rectify the incorrect teacher behavior. If in the observer's opinion the quality of the pedagogical action deserved a score of less than 5, then the key words of the appropriate behavior indicator were whispered.

After the experiment, the test subjects of Group 1 were involved in an individual interview. The measuring instrument "acceptation/appreciation with regard to synchronous coaching" was discussed. The test subjects were required to indicate whether wearing the earpiece was comfortable or whether they were distracted from the actual lesson by the synchronous intervention, and finally whether they were able to convert the synchronous intervention into concrete action. In the asynchronous condition, the remaining 20 test subjects were involved in a discussion of whether, in the observer's opinion, the manifested teacher behavior was of low quality. This meant that the discussion was directed at the fragments based on whether the teacher showed behavior that received a score of lower than the maximum score of 5 from the observer. The used procedure was further completely identical to that for the synchronous coaching.

### Post-Test

The test subjects were exposed once more to the video fragments (Version 2). Once again, after each fragment they were required to show how they would act in a comparable situation. Each video fragment once again contained noncompetent behavior on the basis of one exact behavior indicator. The procedure was comparable with that of the experiment. However, Version 2 of the video fragments differed from Version 1 in two criteria. At first, the sequence of the fragments on the video was changed. Second, there were minor alterations in the fragments without changing the indicator pointing to noncompetent behavior. One may consider employing various groups of actors for this purpose.

## Results

To determine the underlying structure of the “competence assessment,” principal component analyses were conducted. To investigate whether synchronous coaching had a more positive effect on the quality of the pedagogical action of the trainee teacher in plenary teaching situations, the following were analyzed:

1. In which condition was the progression the highest from the average of the 20 fragments?
2. Is there an observable difference in the conditions pre- and post-test per fragment?
3. Is there an observable progression (pre- and post-test) per condition and per fragment?
4. Is the total effect size acceptable?
5. Would the students who scored low in the pre-test develop more positively through synchronous intervention than in the asynchronous variant?
6. Are certain competencies unsuitable for exposure in synchronous coaching?

An overview of the average of the 20 fragments, conditions, and situations is provided in Table 1. It can be clearly observed that the synchronous intervention had a more positive effect than the asynchronous condition on the quality of the pedagogical action. In the synchronous progression it is 1.48, whereas in the asynchronous condition the progress is only 0.59.

Table 1

Mean Competence Score Before and After the Synchronous and Asynchronous Interventions

Moment/condition	Synchronous	Asynchronous
Pre-test	2.06	2.17
Post-test	3.54	2.76

## Findings

Synchronous coaching has proved to be more beneficial than asynchronous coaching on the quality of the pedagogical action of the trainee teacher. This conclusion can be refined with the knowledge that the reliability of the competence assessment and the effect size of the results are adequate.

### *Overview of Main Effects*

The test subjects who were exposed to the two conditions were comparable during the pre-test, taking into account the quality of the pedagogical repertory. The synchronous condition led to an improvement in the quality of pedagogical action in 19 of the 20 situations. In the asynchronous condition this was the case in 12 of the in total 20 situations. Measured over all the situations, the total progression in the synchronous condition was 1.48 and in the asynchronous condition 0.59. In conclusion it can be stated that the synchronous condition had a more positive effect than

asynchronous coaching on the quality of the pedagogical action. Theoretically, this means that there was no cognitive overload (Sweller, 2003) and that the teacher established relationships between the actual and the desirable behavior through synchronous instructions (Dolk, Korthagen & Wubbels, 2000).

#### *Analysis per Test Subject*

Coaching is mainly meant for improving the teacher behavior of less-competent teachers. Less-competent teachers who receive synchronous coaching developed better than those who were exposed to the asynchronous variant. Both groups of test subjects reached a higher progress than the average teacher. Teachers who were noncompetent during the pre-test were comparable with the average teacher during the post-test. On the basis of the results of this study, it is not possible to establish a cause for the fact that teachers presented poorly during the pre-test. Pedagogical competencies may be deficient. However, the limited acceptance/appreciation with regard to synchronous coaching could have also influenced the manifested pedagogical action. In our next study, we will pose the question of whether the associated learner characteristics such as personality traits and teaching orientations influence the success of synchronous coaching (Vermetten, Lodewijks, & Vermunt, 2001).

#### *Analysis per Competence*

The competencies interpersonal competence and organizational competence are suitable for synchronous coaching. For pedagogical competence this is doubtful, and for subject content competence this is not at all the case, and an asynchronous approach will have a more positive effect on the pedagogical action. A reason for this is that the trainee teacher does not comprehend the whispering of key words of the behavior indicator on the basis of which the pedagogical action can be regarded as noncompetent, and thus the reference point fails to not arise. There is also a danger of cognitive overload if whispering increases.

### **Conclusion**

The opportunistic embedding of mobile communication in teacher training is courageous; however it needs a systematic analysis before any added value can be assessed clearly. For this reason the topic of this article was chosen to focus on some results of synchronous versus asynchronous coaching. As the synchronous variant proved to be more effective in terms of acquiring teaching competencies, the question emerged of how the synchronous and asynchronous coaching should finally be arranged. This combined understanding still needs more detailed experimentation. The key issues that will be encountered is the measurement of “understanding,” “manifest competencies,” and a prescriptive model on how coaching interventions need to be interlaced with self-regulation. We hope this journal article mitigates the controversies between the behaviorist and the cognitivistic paradigms as such.

### **Discussion**

We have seen that mobile communication in education is in fact a panacea with a wide variety of new opportunities and challenges. The scope of our study is whether and how a more direct feedback during in-service training among novice teachers can complement the longer tradition

in the reflective feedback style. Yes, it may be admitted that we perceive communication as an ever-increasing load. This holds for conversational and corresponding communication at large. The source of this project is our intuition that experts are in a permanent need to increase competencies by sharing, inducing, and consolidating what had been created by colleagues rather than (re)inventing the wheel.

The mobile phone as a peer-to-peer communication device has shown its elegance the last decade. Still, important steps need to be taken before the actual benefits can be harvested. We expect our pilot study to be a vital precursor to where these educational “cherries” can be found and expect many still to come.

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# Introducing Live Microblogging: How Single Presentations Can Be Enhanced by the Mass

Martin Ebner

## Abstract

Web 2.0 technologies pervade our daily life as well as educational settings. A fairly new approach is communication through so called microblogging channels. Mobile devices with Internet access can be used to send short messages from a microblog. Combined with social network environments, applications such as Twitter, Jaiku, Pownce, and Plurk enrich our ways of communication. At Graz University of Technology (TU Graz) some research work has been done to investigate using microblogging tools to improve face-to-face lectures. The study described in this paper took place at a large international conference on e-learning, where a Twitter channel was established for discussion among the participants of the conference and those from outside. This stream was also used to “tweet” (post on Twitter) statements during the keynote presentations. By viewing the tweet-channel via an additional projector, the audience was able to follow the live-blogging session synchronously to the ongoing speech.

## Key words

Microblogging, m-learning, e-learning, e-learning 2.0, cloud computing, technology-enhanced learning, informal learning

## Introduction

*"Our students have changed radically. Today's students are no longer the people our educational system was designed to teach."*  
Marc Prensky (2001)

As Mark Weiser wrote, “The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it” (Weiser, 1991).

Nowadays Web 2.0 applications pervade our everyday life and change our way of working with the Internet (O'Reilly, 2005). The average user of the Internet has become a powerful component of the web: The user is the content anywhere anytime. In other words, if there is an Internet access, the dream of Tim Berners-Lee (1989) that anyone can contribute to the WorldWideWeb has come true. These innovations have had a great impact on e-learning. Stephen Downes coined the term e-Learning 2.0 in 2005 and described the use of Web 2.0 technologies for learning purposes. The expression “A<sup>3</sup>” (anytime, anywhere, anybody) including interaction (Preece, Sharp, & Rogers, 2002) as well as communication possibilities becomes a reality more and more.

Web 2.0 applications are used increasingly in higher education. Weblogs (Luca & McLoughlin, 2005; Farmer & Bartlett-Bragg, 2005), wikis (Augar, Raitman, & Zhou, 2005; Caddick, 2006), and podcasts (Evans, 2007; Towned, 2005) influence the daily lecturing and learning process and reveal the potential of a more active approach (Ebner, 2007).

One the one side, the use of Web 2.0 technology helps overcome the barriers of publishing content on the World Wide Web in principle; on the other side, the infrastructure increases steadily. Today's connections to the Internet in West European countries are fast, fail-

safe, and no longer expensive. Statistical data<sup>9, 10</sup> indicate that nearly the whole population of the European Union has access to the web. From this point of view, it is only a matter of time before the whole population will be actively using the Internet. By getting more and more familiar with technologies through appropriate infrastructure, learners of tomorrow will deal with the Internet in a different way.

As Internet technologies and education move closer and closer, the result will be ubiquitous learning: u-Learning. A driving force in digital learning will be mobility, as has been claimed since the early years of online learning. Learning from anywhere used to be restricted to places with internet access via by personal computers. Now mobile devices like the N-serie of Nokia or the iPhone have WiFi capabilities and internet access is just restricted to the range of the mobile network. Thus, the basement has been established for mobile learning (m-learning) to become possible for the masses. Motiwalla (2007) points out that mobile computing devices have become ubiquitous on today's college campuses and influence the daily behavior of higher education. A study at TU Graz found that every first-year student owns at least a mobile phone—about 20% with WiFi and about 15% already using theInternet on their mobile devices (Ebner et al., 2008).

Beside the increasing technical component a look must be taken at Gartner's Hype Cycle<sup>11</sup> for emerging technologies. two terms seem to be especially interesting in the context of mobile learning: "cloud-computing" and "microblogging." Cloud-computing refers to Internet-based developments that help manage our daily processes. The cloud (a metaphor for the Internet) stores and distributes applications on different places (servers) for the users without their deeper understanding. Microblogging should be seen as a new communication possibility that allows communicating with many people simultaneously.

This paper concentrates on microblogging. After a short introduction to m-learning in general the term microblogging is explained. A study is presented on how microblogging can enrich presentations by doing it live.

## M-Learning

M-learning environments enhance e-learning solutions, which have their main advantage in the independence of location and time (Holzinger, Nischelwitzer, & Meisenbergre, 2005). Even more, the use of mobile technologies can enhance motivation, which is vital for learning processes (Holzinger, 1997) as well as explicit didactical use. Also, Traxler (2007) mentioned the importance of m-learning:

Looking at mobile learning in a wider context, we have to recognise that mobile, personal, and wireless devices are now radically transforming societal notions of discourse and knowledge, and are responsible for new forms of art, employment,

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<sup>9</sup> Eurostat: Internet Access withing European Union

[http://epp.eurostat.ec.europa.eu/portal/page?\\_pageid=1996,45323734&\\_dad=portal&\\_schema=PORTAL&screen=welcomeref&open=/isoc/isoc\\_ci/isoc\\_ci\\_in&language=de&product=EU\\_MASTER\\_information\\_society&root=EU\\_MASTER\\_information\\_society&scrollto=0](http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1996,45323734&_dad=portal&_schema=PORTAL&screen=welcomeref&open=/isoc/isoc_ci/isoc_ci_in&language=de&product=EU_MASTER_information_society&root=EU_MASTER_information_society&scrollto=0) (last visited July 2008)

<sup>10</sup> Statistics Austria:

[http://www.statistik.at/web\\_en/statistics/information\\_society/ict\\_usage\\_in\\_households/028945.html](http://www.statistik.at/web_en/statistics/information_society/ict_usage_in_households/028945.html) (last visited July 2008)

<sup>11</sup> <http://www.gartner.com/> (last visited September 2008)

language, commerce, deprivation, and crime, as well as learning. With increased popular access to information and knowledge anywhere, anytime, the role of education, perhaps especially formal education, is challenged and the relationships between education, society, and technology are now more dynamic than ever.

Traxler identified various categories of m-learning (Traxler, 2007):

- Technology-driven mobile learning
- Miniature but portable e-learning
- Connected classroom learning
- Informal, personalized, situated mobile learning
- Mobile training/performance support
- Remote/rural/development mobile learning

Mobile devices can be implemented in teaching and learning settings in a plurality of forms (Kukulska-Hulme & Traxler, 2005, p. 31)

- Connectivity for spontaneous communication and collaboration among learners
- Beaming of stored information from device to device
- Location-awareness, giving instant information about projects within sight
- Portable sound-recording and voice-recording
- Cameras for taking photos and making video clips

Bearing these aspects in mind, m-learning is not restricted to short messages or text lines on the screen. M-learning must be seen as enhancement and enlargement of the classroom. Learning on the move simply by providing thoughts, pictures, and so on will help support learning on demand and informal learning as well. Ally (2007) describes it as follows:

Because of the increasing use of mobile technologies in society and by the younger generation, learners will demand course materials be delivered on mobile technologies to be accessed from anywhere and at anytime. At the same time, today's and tomorrow's learners will be nomadic and continuously on the move. As learners move from one location to the next, they must be able to use the infrastructure in the different locations to access learning materials. Hence, learning materials must be designed for easy access by the nomadic learners using mobile technology regardless of where they are located and which network infrastructure they are using to access information.

### **Microblogging**

One of the most important and still growing fields of Web 2.0 technologies is the weblog: A frequently updated website whose content is been created mostly by one person, consisting of data entries in reverse chronological order (Walker, 2005). A microblog can be seen as a weblog that is restricted to 140 signs per post but enhanced with social networking facilities. McFedries (2007) mentions that microblogs should be used for “posting short thoughts and ideas to a personal blog, particularly by using instant messaging software or a mobile phone.”

However, typical microblogging applications are providing the following features:

- A possibility to update the microblog with 140 characters for each entry
- A possibility to blog via mobile device, web interface, or even different desktop clients
- A social network consisting of followers (people who are reading one's updates) as well as the possibility to follow anyone
- A possibility to send messages direct to follower (not public)
- A possibility to answer messages and discuss statements

Several applications support microblogs. The most famous ones are Twitter,<sup>12</sup> Jaiku,<sup>13</sup> Pownce,<sup>14</sup> Plurk,<sup>15</sup> and the open-source tool Identi.ca<sup>16</sup>. Independent of the tool that is chosen, updated postings, ideas, opinions, or quick notifications are leading to a new kind of mobile working, today's prime example of Mobile 2.0 (Griswold, 2007). Java et al. (2007) have pointed out that microblogging facilities can be used in three ways: information sharing, information seeking, and friendship-wide relationship. The power of microblogging can be summarized as the fastest mobile exchange with people of similar interests all over the world.

### Design of the Study

At TU Graz several studies about the use of microblogging tools have been carried out to support teaching and learning processes in higher education. In a very early stage, an expert group of e-learning professionals exchanged their actual works, literature, and thoughts by using Jaiku (Ebner & Schiefner, 2008), and subsequently Jaiku was used to enhance a big lecture (Ebner & Maurer, 2008). Additional works investigating the use of microblogging tools in education (Grosbeck & Holotescu, 2008) are pointing out the strengthening of communication in such a way.

In this paper the answer to following research question is addressed: "Can microblogging enhance a live event?" To investigate the possibilities, a Twitter stream was established during one of the biggest e-learning conferences: the ED-MEDIA 2008<sup>17</sup> in Vienna. The microblogging tool Twitter was chosen because it is the most used and well-known worldwide. A channel for administration purposes called ED-MEDIA<sup>18</sup> was created, and all conference participants were invited to follow this account; in the end more than 100 users did so. Furthermore, the Twitter stream was projected at the main meeting point during coffee breaks using the desktop application TwitterCamp.<sup>19</sup> To address the research question, the stream was projected on the wall during the keynotes of the conference. In this way the online conversation between all Twitterers was made visible to those who were not able to tweet among the audience.

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<sup>12</sup> <http://twitter.com> (last visited: September 2008)

<sup>13</sup> <http://www.jaiku.com/> (last visited: September 2008)

<sup>14</sup> <http://pownce.com/> (last visited: September 2008)

<sup>15</sup> <http://www.plurk.com/> (last visited: September 2008)

<sup>16</sup> <http://identi.ca/> (last visited: September 2008)

<sup>17</sup> <http://www.aace.org/CONF/EDMEDIA/> (last visited: September 2008)

<sup>18</sup> <http://twitter.com/edmedia> (last visited: September 2008)

<sup>19</sup> <http://www.danieldura.com/code/twittercamp> (last visited: September 2008)

Furthermore all participants were invited to use the Hashtag #edmedia08, which could be tracked by the tool Twemes.<sup>20</sup> The URL of Twemes extended by the Hashtag displayed all current tweets, bookmarked links at del.ici.ous,<sup>21</sup> and photos at Flickr<sup>22</sup> containing the Hashtag.

Figure 1  
Installation in the Lecturing Room



Figure 1 shows the installation in the lecturing room; on the left side the presentation slide of the keynote is displayed and on the right the actual tweets of the people blogging about it.

The following section analyzes a segment of this live Twitter stream to point out how the participants were using this facility.

### Discussion

In the keynote session about 150 people attended the presentation, which lasted about 45 minutes. The first tweet concerning the keynote was recognized 7:47 AM and the last one at 9:01 AM. The live blogging session thus stretched across 74 minutes.

Table 1 shows all activities of the twitter stream during this time; 54 tweets were posted, which means 0,73 per minutes or 3 tweets every 4 minutes.

<sup>20</sup> <http://twemes.com/> (last visited: September 2008)

<sup>21</sup> <http://delicious.com/> (last visited: September 2008)

<sup>22</sup> <http://www.flickr.com/> (last visited: September 2008)

Table 1  
Tweets during the Keynote

Number	Tweets	About Presentation	Discussion	Links	Comments
1	1	1			
2	3		1	1	1
3	4	2		1	1
4	2	1			1
5	6				6
6	2			1	1
7	10	3	1	2	4
8	16	2		8	6
9	1			1	
10	9	3		3	3
$\Sigma$	54	12 (22%)	2 (4%)	17 (31%)	23 (43%)

Ten users made their contributions to the channel, with an average of more than 5 posts during the session. If a closer look is taken at the content of the tweets, four major categories can be pointed out:

- *Concerning the presentation:* These tweets had a strong relationship to the presentation. For example, the speaker was cited by the tweet: “great--everything you do is public”; “Don’t be ashamed of it, just make sure that’s really good #edmedia08.”
- *Discussion:* These are postings between two or more users. For example: “#edmedia08 @walthern you will find your presentation here . . .”
- *Links:* These contributions contain links to various resources. For example: “#edmedia08 peter currently talking about OpenLearn <http://www.open.ac.uk/openlearn/home.php>”
- *Comments:* The last category includes statements, mainly in reaction to the speaker’s presentation, but also feelings, thoughts, and opinions. For example: “#edmedia08 we often 'seem' to spend lots of time make things 'easier' for the student—but learning should be challenging—a contradiction.” It was interesting to notice that questions from outside also appear in the twitterstream.

Table 1 shows that nearly two-third of all tweets contained links or personal statements. Other findings included:

- *Archiving:* One-third of all contributions contained links to external resources. Videos, images, and webpages were published and in that way enhanced the speech. Interestingly, whenever the speaker pointed to a project or something similar, the hyperlink to that online resource popped up on the twitter stream a short time later posted by a tweeterer. Instant link sharing seemed to be one of the most interesting features of a live blogging tool. Afterward, many nonparticipants thanked contributors for this work, because of the archiving effect. All shared resources are still available on the web and can be retrieved at any time.

- *Comments:* The most important category was participants' personal statements, comments, feelings, opinions, and thoughts. There was no real discussion, but seeing such comments in real time to the running presentation enhanced the words of the keynote speaker. This simple possibility turned the presentation into an interactive, highly attention-evoking act. It seemed there was not just one person speaking; the whole audience discussed and provided opinions. The previously hidden thoughts of the participants had been given a way to become visible and thus helped to deepen the presented subject.

Figure 2 shows a part of the twitter livestream during the session. Looking on this aspect of m-learning, it can be concluded that the tweets were sent from various devices (laptops as well as mobile phones) through different media (web interface as well as mobile client).

Figure 2  
Screenshot of the Livestream During the Keynote Presentation



## Conclusion and Outlook

This paper provides an example of how microblogging tools can be used to extend the traditional face-to-face presentation. It is imaginable that such an implementation can also be done in a usual lecturing room. Especially for the improvement of the learner-lecturer interaction in large

classrooms (cf. Bligh, 1971; Gleason, 1986), live blogging can help overcome the major problems of that venue, as enumerated by Anderson et al. (2003):

- Feedback lag: missing feedback of the learners
- Student apprehension: fear to ask, speak because of the huge lecture classes
- Single speaker paradigm: The only-one-speaker syndrome (learner-lecturer), leading to less active participation

Of course, a lot of research will be necessary to transfer the conference setting to the lecture room, but these first attempts show improved audience feedback and greater interactivity. Furthermore, a major challenge is to get lecturers themselves to comment on contributions and discuss them. In the future, we will motivate the speakers to do so and maybe also to give the presentation a complete new design.

A further step is also to get the World Wide Web more involved into the live event by providing more information for those who cannot attend. In the end it can be underlined that the use of mobile technology in combination with new web technologies leads to an enhancement of the live presentation. The thoughts of the participants make the event a more interactive one and the situation invites many people to offer their opinions. A kind of silent discussion presented additionally to a live presentation enriches the talk in a new and meaningful way.

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# Accelerated Learning: Online Multimedia Techniques in Hybrid Classes

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## Abstract

Online course enrollment has increased dramatically over the past few years. The authors cite the reasons for this rapid growth and the opportunities open for enhancing teaching/learning techniques such as video teleconferencing and hybrid class combinations. The authors outline an example of an accelerated learning, eight-class-session course detailing effective multimedia instructional techniques.

## Key Words

Hybrid, accelerated, multimedia, video teleconferencing

## Introduction

As online course enrollment increases across the nation at both the high school and college levels—but particularly for working adults at the college level—accelerated classes could be significantly enhanced from a student-learning perspective. This enhancement could be accomplished by combining the economy and face-to-face interaction available via Internet-based video teleconferencing systems with the organization and multimedia aspects of online platform programs. The integration of these two educational delivery systems in support of a given class combines the multimedia instructional approach with the advantage of the student being able to access the class from a home, office, or vacation location at a time of his or her choosing. It also allows face-to-face interaction and discussion in scheduled synchronous modes to better replicate the reality and human relations aspects of the classroom. In addition, for those students who feel they need some time onsite with the instructor, a *hybrid* class, in which some of the sessions are held in the classroom and some are split between online sessions and Internet video teleconference systems, provides the best and greatest flexibility of both the online and the onsite worlds.

## Literature Review

### *Hypermedia Applications and Online Programs/Internet Video System Integration*

The rationale for using online programs and Internet video teleconferencing systems in accelerated programs is that these systems are technologically capable of supporting multimedia instructional approaches. Learning theories, especially Howard Gardner's multiple intelligences (Gardner, 1993), advocate multimedia instructional approaches to enhance learning. *Multimedia* is the combination of various types of media, such as video, sound, text, graphics, color, and so on, to better communicate and display the characteristics of a thought, function, principle, or concept. Multimedia information can be further enhanced by using *hyperlinking* techniques that allow the instructor or student to access any number of multimedia resources instantly by clicking on a word or phrase. When multimedia information is accessed by hyperlinking techniques, the resulting integration is called *hypermedia*. Online classes, in particular, are

designed with hypermedia applications that allow information from anywhere on the Internet or the instructor's or student's computer to be accessed instantaneously in a nonlinear manner, thereby greatly enhancing the flexibility of when and how the information can be accessed. Hypermedia applications also enhance the quality of the accessed information, the speed with which it is accessed, since the website/file location is identified in advance.

The research of Picciano (2006) has supported Gardner's findings and has found that multimedia applications additionally enhance and support brain functioning research, especially learning related to sensory stimulation. Moss-Kanter (2001) did research showing that the digital technology advances of today have made the digital divide less of a problem than the social divide and made the case that society needs to make the commitment to using digital learning capabilities as an equalizer to enhance learning for people in poor neighborhoods and less-developed countries. Hoffman and Bayerl (2008) did research in schools where accelerated learning was the primary format for learning. Citing one particular impoverished school in Wilmington, California, they found that the accelerated learning program significantly improved students' learning effectiveness, with one hundred percent of the school's juniors and seniors passing the California High School Exit Examination (the statewide rate is 90% pass). The dropout rate was zero, and the attendance rate was 97%. In a school in Salt Lake City, the accelerated format for 52 students showed that all but one passed the state proficiency exam, and students obtained college scholarships, grants, and financial aid totaling over \$450,000.

*Learning Theories, Online Programs/Internet Video System, and Hypermedia Integration*  
*The Multiple Intelligences Theory*

Gardner (1993) postulated that people learn via a variety of intelligences, not just the verbal and mathematical, as previously believed. An instructor using the traditional instructional techniques of lecturing supported by textbooks could readily communicate with the verbally and mathematically intelligence learner. Chalk or similar boards as well as transparencies placed on a lighted projection glass plate are also adequate for displaying written and charted information for the verbal and mathematical learner. However, when other intelligences postulated by Gardner, such as *spatial* (reasoning related to space, navigation, location), *musical* (reasoning related to music), *bodily-kinesthetic* (reasoning related to bodily movement), *interpersonal* (reasoning related to relationships to others), and *intrapersonal* (reasoning related to personal, internal aspects) are considered, traditional classroom instructional techniques fall short.

A hypermedia instructional approach, such as that inherently designed for online programs or incorporated in a part-online and part-onsite hybrid program, is arguably a feasible and economical approach to addressing the multiple intelligences in instruction. Although hypermedia and Internet video conferencing techniques can and should be used in an on-ground classroom setting, it is often the case that not every student has a computer with Internet access at her/his desk. Moving to a hybrid approach allows each student to use a home or office computer for access and thereby partake in the advantages that hypermedia and Internet video conferencing offer. With such computer access, given that the online/hybrid curriculum or video conference agenda have been designed for a hypermedia lesson plan, all of the multiple intelligences learning styles can be addressed for the maximum learning enhancement of all students—including those with disabilities. Research supports using computers and hypermedia techniques. In a five-year study, researchers at SRI International (2000) found that students under multimedia instructional approaches outperformed comparison non-technology-using students in communication skills, teamwork, and problem solving.

### *Constructivist Learning Theory*

Constructivist teaching is based on research showing that learning is deeper and more meaningful when students are actively involved in the learning process rather than passively receiving information (Armstrong & Chen, 2002). The *constructivist* view, which appears to support the finding by Armstrong and Chen (2002), as represented by John Dewey and Lev Vygotsky, holds that learners generate their own knowledge through experience-based activities rather than lectures given by teachers (Roblyer, 2003). Roblyer also found that multimedia development and web-based learning offer ideal conditions for supporting constructivist curriculum goals such as providing vivid visual support that helps students develop better mental models that enhance problem solving. These visual media help make up for student deficiencies in such learning prerequisite areas as reading; they also help involve and motivate students by utilizing graphics and other media that students find interesting and attractive.

### *Constructivism and Multimedia/Hypermedia*

Distinct advantages are realized when using a multimedia-rich environment. Students can develop pattern recognition skills from videos and access information in all media modes in a random manner, taking them out of the traditional sequential environment and into one in which they can explore the domain from multiple perspectives (Cognition and Technology Group, 1990).

Research suggests that a number of concepts can be explored using hypermedia's cognitive flexibility capability (Kozma, 1991). For example, a learner may be interested in researching information about land navigation. Searching in this area could turn up information about magnetic principles, topography, compass usage, terrain orientation, coordinate systems, and celestial navigation. The student researcher could follow one or all of these links, all of which would provide further links. The researcher might also have an opportunity to view a video showing participants actively engaged in the sport of orienteering or to participate in simulations using triangulation to determine a given location. This Internet hypermedia experience would most likely stimulate the student researcher to form mental models or associations between various ideas and then to construct meaning between these relationships.

### *Constructivism and the Multiple Intelligences*

Considering the definitions and characteristics of the theories of multiple intelligences and constructivism we've outlined, it could be postulated that the two theories complement one another, in that an individual could use a combination of her or his multiple intelligences engaging multimedia/hypermedia tools to *construct* an individual view of the world. As we've seen, research would seem to indicate that multimedia/hypermedia techniques using technology are more effective in helping learners construct their knowledge of the world than the traditional lecture approach supported by textbooks. This enhancement is accomplished by providing more effective visualization and simulation of the real world.

### *Hybrid Classes and Hypermedia/Multimedia*

The positive and enthusiastic feedback we've received from online students, along with the advocacy by learning theorists for using such applications, offers strong support for adapting hypermedia technology applications using a hybrid of onsite and online curricula/video

teleconferencing techniques. Considering that hybrid classes with an online/Internet video component, by definition and prerequisite, require the instructor and all the students to have modern computers with multimedia applications and Internet connections for the online portion of the class, excuses cannot be made that access to equipment and the Internet is not readily available and thus that hypermedia instructional techniques are not feasible. All the tools and technology are there for the instructor and student. The hybrid class approach addresses the usual obstacles of too little technology, too little training, and too little time being available to utilize the proven instructional advantages of hypermedia and multimedia instructional techniques.

Given that most students take online/hybrid classes because doing so allows them more flexibility as to the place and time of instruction, a balance would have to be maintained between aspects of the class that allow students to access and do the assignments at a time of their choosing with aspects of the course (such as synchronous chats and Internet video conferencing) where they would need to participate at a specific time specified by the instructor. Though some flexibility in time would have to be sacrificed, the face-to-face interaction with the instructor and students in the onsite sessions or the video conferencing sessions—especially when reviewing and discussing complex subjects or multimedia projects—would more than compensate by providing instant feedback to student questions and requests for clarification.

## **Research Method**

### *A Hybrid Experience Using Hypermedia*

The research for this study was gathered by a qualitative study in which the instructors asked questions of students while observing their reactions in both an online and an onsite class environment. At the time this research was completed, National University (NU) was piloting the integration of the Blackboard online instructional platform/system and the iLinc Internet-based video teleconferencing system with an onsite classroom approach (hybrid) to test the belief that combining these instructional delivery systems would significantly enhance learning in NU's one-month-per-course accelerated program. One of the authors recently taught a hybrid technology class of 12 students—all adult teachers seeking a master's degree—at an offsite location in the mountains 24 miles from campus. Of the nine class sessions, three were conducted using a combination of online and video conferencing, and six were conducted onsite in a classroom at a middle school. Multimedia/hypermedia instructional techniques were used in all modes—onsite, online, and Internet video teleconference.

### *First Class Session*

The first class was conducted onsite, and the concepts of multimedia and hypermedia instruction were demonstrated by using a hyperlinked PowerPoint presentation to review the course syllabus. Hands-on instruction was then used to allow the students to develop a basic and relatively simplified PowerPoint presentation of their own on the classroom computers. Next, the students used the classroom computers with headsets to access the Internet and log on to an iLinc video teleconference demonstration. The students were shown how to use the iLinc menu to “raise their hands” to gain the attention of the instructor facilitator to give them access to speak, and they were shown how to use the text tool to send text messages to provide pertinent information while the video and audio portion of the session was active. They were advised to

obtain a headset with a microphone so that they could talk as well as listen and exchange text messages.

### *Second Class Session*

The second class session was conducted via iLinc. Students were arranged in groups of four and allowed to choose a location (their school, the middle school classroom, or their home) from which they would access and participate in the iLinc class. The instructor conducted the session from his home. The students were grouped in order to promote collaboration in the initial Internet iLinc session and to reduce the fear of using a new technology tool, for which they had received instruction and a demonstration the night before. The instructor believed that the group, working together, would be better motivated and also more capable of solving any technical or menu problems posed by accessing the iLinc session. All groups were successful in accessing the session and in using both the audio and text communication portion of the class session. Since the students had not yet obtained a webcam, they could not participate in two-way live video; however, they could see the instructor live via his webcam.

### *Third Class Session*

The third class session was conducted in the middle school classroom, and the first item on the agenda was a critique of the iLinc session. Students were pleased that they, as group problem solvers, had figured out the technical challenge of accessing the iLinc session and had been able to negotiate the iLinc menu to communicate during the session. They were excited about being able to participate in the class from a variety of locations (one group came to the middle school classroom, one group participated from their primary school site, and one group participated from a student's home). They pointed out how valuable this approach would be in subsequent winter classes when the National University professor might not make it to class (as happened the previous year) because of mountain road closures due to snow or ice. Students were often snowed in as well, and the iLinc hookup would allow them to attend class from home. After the iLinc critique, the students were shown how to use hyperlink techniques to access multimedia instructional material on the Internet as well as various files on their computers.

### *Fourth Class Session*

In the fourth class session, students participated as individuals from locations of their choice. The session was conducted via the Internet using a combination of online webquest assignments as well as an iLinc video teleconferencing session in which the instructor presented a PowerPoint tutorial on designing and conducting webquests. Two students gave multimedia PowerPoint presentations on assigned chapters in the textbook, after which they answered questions. A *webquest* is an inquiry-oriented activity in which some or all of the information that learners interact with comes from resources on the Internet, optionally supplemented with videoconferencing (Dodge, 2003). The session was recorded for two students who could not participate because they had to attend their schools' back-to-school nights. They were able to sign on to the iLinc website the next day and view the session, including the PowerPoint presentations and accompanying question-and-discussion period.

### *Fifth Class Session*

In the fifth class session, the second iLinc session was critiqued by the students, who reported no significant access or menu usage problems. The two students who did the PowerPoint presentations reported that the iLinc menu was easy to use. The students who viewed their presentation affirmed that it was easy to follow, and the two students who were absent and had reviewed the recorded session said they felt as if they were actually watching it live, and they very much appreciated the session being recorded for them.

### *Final Class Sessions*

The sixth, seventh, and eighth classes were conducted onsite, where students studied and practiced multimedia presentations using hypermedia instructional techniques to develop webquests for their classrooms and back-to-school night presentations for their various schools. The final class used online instructional techniques to discuss various aspects of accessing the Internet and video conferencing and to complete an exam on using technology, multimedia, and hypermedia technology applications to enhance both instruction and learning.

## **Data and Analysis**

The instructor's assessment based on student reaction and comments during the course is as follows:

- These adult students, who have full-time teaching jobs during the day and family demands in the evening, commented that attending a 4½-hour class two nights a week, combined with the homework between classes, really placed them under a time crunch, resulting in a great deal of pressure. Being able to attend the several class sessions from their classrooms or homes and saved them a great deal of time while reducing a significant amount of pressure.
- The students, as a result of using technology in a meaningful and useful way (i.e. using the Internet and their computers to communicate with their classmates and the instructor to receive class instruction at a place of their choosing), excited them while giving them confidence in their abilities to use leading-edge technology successfully.
- The excitement and confidence generated from using the online instruction and the Internet video conferencing systems fed into the students' use of multimedia and hypermedia instructional techniques. Three of the class members put together a hypermedia PowerPoint presentation for their back-to-school night events and commented on how easy the process was and how much their principals and peers were impressed.
- The usual negative questions and skepticism found in normal onsite class members about the value and utility of technology and related instructional techniques vanished after the second class session, when students used the video teleconferencing system to receive the class instruction.
- The majority of the class, based on a first-night objective assessment of their existing technology skills, did not know how to do a PowerPoint presentation, develop a basic Excel spreadsheet, or attach a file to an e-mail. Because they were so turned on about technology and so highly motivated by using technology so effectively in the online

and video conferencing portions of the class, they became proficient and overcame all of these weaknesses midway through the class.

### **Conclusion/Recommendations**

When a university puts in place an academic program at an accelerated pace primarily for working adults, every possible proven instructional technique that enhances learning while reducing the time required to learn should be used. The results of this study and the research of the cited references—particularly those of Gardner, Picciano, and Hoffman and Bayerl—provide strong evidence that hybrid courses using multimedia applications in an accelerated format does enhance learning. In addition, since working adults, many with families, have a finite amount of time to earn a living, spend time with their family, and take classes toward a degree, the hybrid accelerated delivery mode should be considered by all universities serving adult learners. Multimedia and hypermedia instructional techniques have been proven by a large body of research, some of which has been referenced in this article, to enhance and speed learning by addressing all of the multiple intelligences of the learner.

Online programs, which must use technology and computers for delivery of the instruction, utilize multimedia and hypermedia techniques as a matter of course. Online instructional programs—if their design, development, and implementation are sound and utilize their technology potential—are superior in their instructional potential to onsite programs for adult learners in accelerated courses. In an onsite course, computers may not be available and the instructor may not have the technology tools that allow each of the multiple intelligences to be addressed.

Hybrid courses, in which at least some of the sessions are conducted online and therefore must use hypermedia and multimedia instructional techniques that potentially address all of the learner's multiple intelligences, can likewise be expected to be more effective than onsite courses. Onsite, the instructor may be limited to the lecture mode with the typical chalk or dry erase board for information presentation. Because hybrid courses are just now beginning to be used, there has been insufficient time to gather enough empirical data to fully prove the case. However, based on our experience in the last six months with hybrid courses, we predict the case will be made.

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# **The Search for Student and Faculty Online Authenticity**

Darryl J. Mitry and David E. Smith

## **Abstract**

The online learning approach has developed as a powerful alternative for faculty to lead academic studies. In many ways, online education has been successful, but the rapid growth of distance education programs remains controversial. Major issues have persisted. This paper examines the primary questions of authenticity in online university education and presents implications and recommendations. The conclusion is that the true potential of online programs will not be realized until institutions adhere to the higher academic standards of student identification, employ fully credentialed faculty expertise, and thereby establish a system that satisfies the dual objectives of both student and faculty authenticity. Satisfying this dual objective will raise the confidence of regulators and provide real academic currency for the graduates.

## **Key Words**

Online education, course development, traditional classroom delivery, distance education

## **Introduction**

Online education has mushroomed and become a significant part of college and university programming (Ames, 2007; Carnevale, 2005). In many ways, online education has been extremely successful and attracted tens of millions of students, but the rapid growth of these Internet-based distance education programs remains controversial. Two major criticisms of online courses are the authenticity of programs and the inability to ensure that the person on the connection is indeed the student enrolled in the program (Foster, 2008). Cheating may occur no more often online than in campus environments, but it is still a problem (Grijalva, Kerkvliet, & Nowell, 2007). Cheating on tests and assignments appears to be easily accomplished over the Internet.

Without the ability to authenticate students' work, program validity remains continually suspect. Understandably, university faculties have been interested in overcoming this weakness (Young, 2000, 2008). College and university administrators in the United States have become increasingly interested in this issue because growing criticisms have attracted the attention of legislators (Johnstone, 2005). In fact, the new Higher Education Act contains language that will require an institution with online programs to prove that the student enrolled is indeed the same person submitting the work for credit (Foster, 2008).

A few colleges have already implemented hardware or software in the attempt to satisfy the forthcoming requirement. Currently, there are three different tech based systems that institutions are evaluating. The following is a review of these methods and description of the implications.

## **System One**

One example of an identifying technology is SecurExam Remote Proctor, promoted by a company called Secure Software (Kopf, 2007). This particular online proctoring system plugs

into the student's computer and consists of a mirrored sphere attached to a platform for scanning fingerprints, plus a microphone with a camera. The sphere reflects the live-action student image and a 360-degree view of the student's immediate environment. Presumably, any student contemplating cheating on an exam by having someone else answer the exam would be discovered and chastened. The student knows the capability of the equipment and is therefore discouraged.

However, while such monitoring might discourage students, it could not prevent a student from arranging for someone else to answer the exam by remote methods or by camouflaging the "hired assistant," hiding him or her away from view of the camera. Drawbacks include:

1. The view can still be obscured by objects in the room such as a large desk or other obstruction. The monitor would see the likeness of the enrolled student but that is not a guarantee the person viewed is the student actually answering the exam questions.
2. Dual keyboards can be used, where one is active but hidden or remote and the other is in view but actually inactive. This could also circumvent the "video watchdog."
3. For audio responses to an oral exam, the student could instead use one of the new invisible micro buds to listen to answers broadcast to the earpiece from a collaborator out of view. Such equipment is readily available.

Therefore, a digital fingerprint and video imaging monitoring do not enable one to know unequivocally that the student in view of the camera is actually the person taking an exam.

### **System Two**

Pennsylvania State University's online institution, called World Campus, is testing another monitoring system they call Webassessor. This system uses a web camera along with software that attempts to recognize students' typing styles. Presumably, typing speed and pauses between certain letters are specific identifiers. College or university proctors, using this approach, are able to view a student's face, keyboard, and general workspace while the computer software judges the student's identity based on the style of keystrokes. However, there is reason to question the reliability of such information. All things considered, there are significant deficits in this method. Note that the system can also be circumvented in much the same way as the System 2. Any student determined to cheat has opportunity to do so.

### **System Three**

Another approach to solving the student identity question is being used by some universities and colleges as they collaborate with Acxiom Corporation. The Acxiom system uses personal "challenge questions." The company gathers information from existing databases, including criminal files and property records, then uses these data to ask students personal questions. The questions involve such items as the student's previous addresses and former employers. Only when a student answers all the questions correctly, is he or she permitted to take the exam. This is a step toward authenticity but there is still the possibility to circumvent the intention of the

system. None of these systems can really “make sure” and guarantee the student on the Internet is personally taking the exam without assistance or substitution. The enrolled student may have a collaborator nearby but not within view of the camera. Alternatively, the collaborator may always be substituted for the person enrolled on university records. Even if the keystroke method of identification were accurate, it would not detect such subterfuge.

In addition, there is criticism concerning the appropriateness of assessment. For example, not all student evaluations are traditional exams. Even more criticism concerns the issue of privacy, because the students are subjected to having their extensive personal information, fingerprints and personal images data banked on the purveyors’ servers. It would be much preferable not to force students into a process where their homes and personal privacy are so intrusively monitored, recorded and saved on corporate computer servers. These types of privacy issues are not inconsequential and may be cause for future litigation.

### **Another Solution for Authenticating Students**

With some reflection, a solution appears to be much simpler than these Orwellian techno-systems by simply requiring a student assessment at live-proctored locations. Such on-ground assessments have a long history of adequately providing positive student authentication. If the student has not been doing the work in the online course, he or she would not be able to pass a good comprehensive assessment. There really is no substitute for a live proctor and a truly rigorous comprehensive assessment (Mitry & Smith, 2008).

The authors of this paper are reminded of a certain graduate online degree program that requires students to assemble on-ground for personal identification at the end of their program. All the students take a comprehensive and rigorous assessment, which includes constructing written essays and providing answers in oral examination. It would appear that the current technological systems are no match for this type of live encounter. Given the apparent weaknesses of the tech-based systems, these alternatives are not a sufficient substitution for a proctored comprehensive assessment. This nontechnical method appears to be a better choice.

### **The Dualistic Aspect of Total Authenticity**

Considering the value of such processes reveals another area of authenticity that is extremely important: the authenticity of the online instructor and the academic rigor in courses programs. Moreover, the authenticity of the programs is dependent on the thoroughness of academic currency within the teaching faculty. Many of the online programs employ part-time instructors whose credentials and background are less than that customarily required of a full-time faculty member (Carr, 2001). Obviously, employing sub par part-time faculty lowers institutional costs but it also lowers academic quality. Therefore, there is a need to authenticate not only the student identity but also the equivalency of the online instructors to full-time faculty. Unfortunately, hiring adjunct instructors with lower-level credentials has become commonplace. Students are not the only ones cheating. Universities and colleges that lower costs by hiring less-credentialed instructors are also cheating academia, the students, and society at large.

Numerous empirical findings confirm that the primary factor involved in academic authenticity is the faculty expertise per time period devoted to students, which translates into

faculty salaries (Carr, 2001). It should not be surprising that the single largest cost component for online programs may be faculty salaries. Therefore, many online courses have been assigned to less-qualified adjunct instructors whose compensation is much lower. Comparisons show that equal-quality online distance learning is possible only when the online faculties are truly equivalent to traditional on-ground learning environments (Mitry & Smith, 2008). According to Young (2000), “high-quality instruction is more costly and time-consuming on the Internet than in a traditional classroom” and “good teaching is possible online only by lowering student-to-instructor ratios and taking other steps to counteract the disadvantages of teaching at a distance.”

### **Implications of Using Quality for Strategic Advantage**

The best way for quality-conscious universities to compete is to loudly proclaim and identify the actual credentials and terminal degrees of all their online professors and to distinguish clearly the authentic standards of quality. Over time, this method might lower the overall enrollment but only marginally, while it would also result in significantly increasing online enrollments in the quality-conscious universities and decreasing enrollments in the programs of the exploitive institutions—as would be preferable.

The online environment is changing and growing in importance, but the authentic programs and institutions must distinguish their product from the deceptive marketing of the exploitive institutions. Using the strategy of differentiation, rigorous academic standards of equal quality can be maintained, and the product can be successfully marketed in a globally competitive environment. However, many programs have been operating by depreciating faculty and substituting lower standards of academic quality. University administrations need to support their full-time faculties and encourage them to assert appropriate authority over the real quality standards and hiring practices for online instructors. That will mean somewhat higher costs because “you get what you pay for” in the marketplace, but the added cost will not make the programs unprofitable.

A reputation for quality is an attraction to potential students and they seek to enroll in colleges and universities that are recognized for the best quality of instruction and academic programs. Therefore, the administration can justifiably publicize their institutions’ academic authenticity and improve their online reputations. The business faculty can help by participating with the administration and showing how to succeed using this strategy within the arena of higher education. Otherwise, the public and the scholars will both lose.

Diploma inflation with self-defeating policies of retention at any cost, and the preponderance of “accredited” semi-degree mills continue to flourish and prosper at the expense of honest institutions and students (Bartlett, 2008). Conversely, establishing a system that satisfies the dual objectives of both student and faculty authenticity will not only raise confidence of regulators in the quality of these online programs but also provide real academic currency for the graduates.

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# Teaching and Learning



# **Inter-subject Connections in Teaching Mathematics: Isometries of a Number Line and Some Fundamental Properties of Functions**

Nikolai N. Bilotskii and Igor Ya. Subbotin

## **Abstract**

In this article, we employ the inter-subject approach in illuminating the process of logical and cognitive development of some widely used calculus concepts: odd, even, and periodic functions. We utilize the inter-subject connections in rising general reasoning that helps formulate clear and methodically correct definitions of these objects. As it will be shown, such general approach is really effective in meaning clarification of main concepts in calculus course.

## **Key Words**

Inter-subject connections, odd functions, even functions, periodic functions

## **Introduction**

In the process of developing mathematics and mathematics education, a variety of inter-subject connections have been brought about in the frame of one branch or even one topic. To support this statement, it is enough to mention the crucial influence of Descartes' and Fermat's ideas on the development of algebra, geometry, and analysis.

Lev Vygotsky (1996) emphasized the central role of concept development in learning. Clear and full understanding of main concepts is a key component in the learning process. Inter-subject connections are really efficient in intensifying the learning process and building strong knowledge retention.

In this article, we employ the inter-subject approach in illuminating the process of logical and cognitive development of some widely used calculus concepts: odd, even, and periodic functions. We utilize the inter-subject connections in rising general reasoning that help formulate clear and methodically correct definitions of these objects.

The above-mentioned concepts have something in common. First, we can use certain types of symmetry while exploring them. Knowing a part of the symmetrical object and the way the reflections are performed, one can easily restore the entire object. For a function on the real numbers, that means that the entire graph can be formed by copying one particular portion, repeated at regular intervals. It means that one can get all needed properties of the entire function by studying a small part of the graph of such function. That is why the classes of odd, even, and periodic functions play a central role in pre-calculus and calculus courses.

Second, ironic as it sounds, it is not easy to find rigor and methodically satisfactory definitions of these classes of functions in the popular calculus texts and e-sources. Sometimes a textbook tries to avoid the definitions of these concepts (see for example, Johnston & Mathews, 2002). In any case, this is a source of many ambiguous situations that need to be clarified.

## Preliminary Examples and Comments

Let's consider some examples supporting the above statement.

**Example 1** (retrieved from <http://mathworld.wolfram.com/OddFunction.html>)

*An odd function is a function for which  $f(x) = -f(-x)$ .*

*An even function is a function  $f(x)$  such that  $f(x) = f(-x)$ .*

*A function  $f(x)$  is said to be periodic (or, when emphasizing the presence of a single period instead of multiple periods, singly periodic) with period  $p$  if  $f(x) = f(x + np)$  for  $n = 1, 2, \dots$ .*

These definitions contain no information about the domain of the functions. As we will show below, this should be a very important and downright necessary element of the definition.

**Example 2** (Larson, Hostetler, & Edwards, 2006, p. 27)

*... a function is even if its graph is symmetric with respect to the  $y$ -axis, and is odd if its graph is symmetric with respect to the origin.*

This example is taken from a very popular and well-written Calculus textbook. The authors tried to make the notions clear and visual. However, some functions, such as the Dirichlet function and the function  $y = \sin \frac{1}{x}$ , have graphs that are not possible to draw. The same kind of remarks can be expanded on some periodic functions.

**Example 3**

(retrieved from <http://planetmath.org/encyclopedia/EvenoddFunction.html>)

*Let  $f$  be a function from  $\mathbb{R}$  to  $\mathbb{R}$ . If  $f(-x) = f(x)$  for all  $x \in \mathbb{R}$ , then  $f$  is an even function. Similarly, if  $f(-x) = -f(x)$  for all  $x \in \mathbb{R}$ , then  $f$  is an odd function.*

It follows from these definitions that any function with the domain that is a proper subset of  $\mathbb{R}$  cannot be odd or even. However, there are many simple examples contradicting this statement.

**Example 4** (Finney, Weir & Giordano, 2001, p. 56)

*A function  $f(x)$  is periodic if there is a positive number  $p$  such that  $f(x+p) = f(x)$  for every value of  $x$ . The smallest such value of  $p$  is the period of  $f$ .*

This definition gives no information about the function's domain. What does "for every value of  $x$ " mean?

**Example 5** (Young, 2007, p. 126).

*An even function is symmetric with respect to y-axis or vertical axis and  $f(-x) = f(x)$ .*

What does it mean for a function to be “symmetric with respect to y-axis or vertical axis”?

**Example 6** (Borowski & Borwein, 1991, p. 415)

*[An odd function is] changing sign but not absolute value when the sign of the independent variable is changed, so that  $f(x) = -f(-x)$ .*

In both above examples 5 and 6, the authors do not say anything about the domains. Also in the first definition it is not clear what “... or vertical axis” means.

Unfortunately, this list could be continued.

The following examples provide us with much better definitions. However, they have some common methodical flaw: they do not specify the required key restrictions on the domain of the function.

**Example 7** (Aufmann, Barker, & Nation, 2005, p. 230)

*The function  $f$  is an even function if  $f(-x) = f(x)$  for all  $x$  in the domain of  $f$ .  
The function  $f$  is an odd function if  $f(-x) = -f(x)$  for all  $x$  in the domain of  $f$ .*

**Example 8** (retrieved from [http://en.wikipedia.org/wiki/Even\\_and\\_odd\\_functions](http://en.wikipedia.org/wiki/Even_and_odd_functions))

*Let  $f(x)$  be a real-valued function of a real variable. Then  $f$  is even if the following equation holds for all  $x$  in the domain of  $f$ :  $f(-x) = f(x)$ .*

*Let  $f(x)$  be a real-valued function of a real variable. Then  $f$  is even if the following equation holds for all  $x$  in the domain of  $f$ :  $-f(-x) = f(x)$ .*

*A function  $f$  is periodic with period  $P$  greater than zero if  $f(x + P) = f(x)$  for all values of  $x$  in the domain of  $f$ .*

*If a function  $f$  is periodic with period  $P$ , then for all  $x$  in the domain of  $f$  and all integers  $n$ ,  $f(x + nP) = f(x)$ .*

**Example 9** (Finney et al., 2001, p. 15)

*A function  $y=f(x)$  is an  
even function of  $x$  if  $f(-x) = f(x)$ ,  
odd function of  $x$  if  $f(-x) = -f(x)$ ,  
for every  $x$  in the function's domain.*

## Supporting Theoretical Reasoning

In our opinion, these “short” definitions have a common significant shortcoming: they fail to focus attention on some restrictions following from the fact that the domain of a function has to be preserved by a corresponding group  $M(\mathbb{R})$  of rigid motions of a number line. Perhaps, the authors of such definitions assumed such kind of restrictions as self-evident. However, while this is clear for a well-prepared person, it is not obvious for a beginner.

Let’s talk about it in more detail. Let  $D \subset (-\infty; +\infty)$  be a nonempty subset of the real number set  $(-\infty; +\infty) =: \mathbb{R}$  (the number line). Recall that a one-to-one correspondence  $\varphi$  of the set  $D$  in itself is a transformation of the set  $D$ ; it is denoted by  $\varphi: D \leftrightarrow D$ . The set of all such transformations  $G(D) = \{\varphi: D \leftrightarrow D\}$  form a group  $G(D)$  by the operation of the transformations composition. An arbitrary subgroup of  $G(D)$  is also a group of transformation of  $D \subset (-\infty; +\infty)$ .

If  $D = (-\infty; +\infty)$ , then  $G(D)$  is a group of transformation of the number line  $\mathbb{R} := (-\infty; +\infty)$ . We will denote it by  $G(\mathbb{R})$  or  $G((-\infty; +\infty))$ .  $G(\mathbb{R})$  includes the transformations of  $D \subset (-\infty; +\infty)$  on itself, and such transformations also form a group. Consider, for instance, the group of rigid motions (the group of isometries)  $M((-\infty; +\infty)) \subset G((-\infty; +\infty))$  where

$$M((-\infty; +\infty)) := \left\{ \varphi \in G(\mathbb{R}) : |\varphi(x) - \varphi(y)| = |x - y| \forall \{x, y\} \subset \mathbb{R} \right\},$$

for which the transformations  $\varphi$  on  $(-\infty; +\infty)$  keep the distance  $\rho(x, y) = |x - y|$  between points  $x$  and  $y$  from  $\mathbb{R} = (-\infty; +\infty)$ .

It is well known that any rigid motion on the plane can be considered a glide reflection, a rotation, or a combination of both. Based on this statement or just using common sense, it is worth nothing to conclude that any rigid motion of the number line is also a translation, or a reflection, or their combination. Employing the notion of the derivative and some basic facts from calculus, it is not difficult to prove this statement and determine the analytic forms for the elements of the group  $M((-\infty; +\infty))$ , i.e., isometries  $\varphi \in M((-\infty; +\infty))$ . Let  $\varphi \in M((-\infty; +\infty))$  be an arbitrary rigid motion,  $\varphi(x)$  be a differentiable function and  $\{x_0, x\}$  be an arbitrary pair of real numbers such that  $x \neq x_0$ . Then:

$$\left( \frac{|\varphi(x) - \varphi(x_0)|}{|x - x_0|} = 1 \right) \Rightarrow \left( 1 = \frac{|\varphi(x) - \varphi(x_0)|}{|x - x_0|} \rightarrow |\varphi'(x_0)| = 1, x_0 \neq x \rightarrow x_0 \right),$$

$|\varphi'(x)| = 1 \forall x \in (-\infty; +\infty)$ , and, therefore  $\varphi(x) = \pm x + \omega$  where  $\omega$  is a real number. If we assume that the following two statements  $\{x \in \mathbb{R}: \varphi'(x) = 1\} \neq \emptyset$  &  $\{x \in \mathbb{R}: \varphi'(x) = -1\} \neq \emptyset$  hold, we come to a contradiction with a well-known corollary from a Lagrange Theorem: *the derivative  $\varphi'(x)$  of a differentiable function  $\varphi(x)$  cannot have a nonremovable discontinuity.*

The latter helps us to get the analytic form for the elements  $\varphi \in M((-\infty; +\infty))$ . That is to say,

$$\forall \varphi \in M((-\infty; +\infty)) \exists \omega = \omega_\varphi \in \mathbb{R} : \\ (\varphi(x) = -x + \omega \forall x \in (-\infty; +\infty)) \text{ or } (\varphi(x) = x + \omega \forall x \in (-\infty; +\infty)).$$

We can now describe the structure of this group  $M((-\infty; +\infty))$ . It is a simple and well-known result, but we would like to provide the reader with an opportunity to briefly look over the elementary justification of this fact.

Consider the following elements of the group  $M((-\infty; +\infty))$ :

*The reflection  $s : s(x) = -x \forall x \in \mathbb{R}$  of the number line with the respect to the origin ( it is clear, that  $s^2 = s \circ s = e$ ,  $s^{-1} = s$  and  $S(\mathbb{R}) := [\{e, s\}, \circ]$  is a subgroup of order 2 of the group  $M((-\infty; +\infty))$ );*

*The translation  $tr_\omega : tr_\omega(x) = x + \omega \forall x \in \mathbb{R}$ ,  $\omega \in \mathbb{R}$  (it is obvious that  $tr_\omega^{-1} = tr_{-\omega}(x) = x - \omega \forall x \in \mathbb{R}$  and  $\forall \omega \in \mathbb{R}$ ).*

Note that each translation is determined by a real number  $\omega$  and that's why the group of these translations is isomorphic to the additive group of real numbers  $\mathbb{R}_+$  of the real number field  $\mathbb{R}$ . Every element of this group generates an infinite cyclic invariant subgroup in the group  $M((-\infty; +\infty))$ . The elements of this cyclic subgroup can be written as  $tr_{n\omega}$  for some  $n \in \mathbb{Z}$ ,  $tr_{n\omega} := tr_\omega^n = tr_\omega^n(x) = x + n\omega \forall x \in \mathbb{R} \forall n \in \mathbb{Z}$ .

Based on the above reasoning, it is easy to prove that an arbitrary element of  $M((-\infty; +\infty))$  is a product of two elements of the special types listed above. So, it worse nothing to conclude that *the group  $M(\mathbb{R})$  is a semi-direct product  $M(\mathbb{R}) = \mathbb{R}_+ \rtimes S(\mathbb{R})$  of the normal in  $M(\mathbb{R})$  group of translations  $\mathbb{R}_+$  and the group of reflections  $S(\mathbb{R})$  (a group of order 2), and the latter transforms every element of  $\mathbb{R}_+$  into its inverse.* That demonstrates the key role of the two basis rigid motions of the number line: the reflection and the translation.

Next, we are going to consider some properties of a real function  $y = f(x)$  with the domain  $D = D(f) \subset \mathbb{R}$  connected to the group  $M(\mathbb{R})$  of rigid motions. We will begin with the following definitions.

*We say that a function  $y = f(x)$  with the domain  $D = D(f) \subset \mathbb{R} = (-\infty; +\infty)$  is invariant symmetric over a subgroup  $A \subset M(\mathbb{R})$  (or it is preserved by a subgroup  $A \subset M(\mathbb{R})$ ), if*

- 1)  $\varphi : D \leftrightarrow D \forall \varphi \in A$ , i.e. the set  $D = D(f)$  is invariant over  $A \subset M(\mathbb{R})$ ;
- 2)  $\forall \varphi \in A : f(\varphi(x)) = f(x) \forall x \in D$ , i.e. the values of the functions  $y = f(x)$  and  $y = f(\varphi(x))$  coincide for an arbitrary  $x \in D$  and its image  $\varphi(x) \forall \varphi \in A$ .

Similarly, a function  $y = f(x)$  with the domain  $D = D(f) \subset \mathbb{R} = (-\infty; +\infty)$  is antiinvariant or antisymmetric over a subgroup  $A \subset M(\mathbb{R})$ , if:

- 1)  $\varphi: D \leftrightarrow D \quad \forall \varphi \in A$ , i.e. the set  $D = D(f)$  is invariant over  $A \subset M(\mathbb{R})$ ;
- 2)  $\forall \varphi \in A: f(\varphi(x)) = -f(x) \quad \forall x \in D$ , the values of the functions  $y = f(x)$ ,  $y = f(\varphi(x))$  are additive inverses for an arbitrary  $x \in D$  and its image  $\varphi(x) \forall \varphi \in A$ .

The term "antisymmetric function" is sometimes used for odd function, although some meanings of antisymmetric are essentially  $f(y, x) = -f(x, y)$ .

### Some Illustrations and Applications

We will illustrate these notions with some known examples.

- A function  $y = f(x)$  with a domain  $D = D(f) \subset \mathbb{R} = (-\infty; +\infty)$ , which is preserved by the subgroup  $S(\mathbb{R}) \subset M(\mathbb{R})$ , has a domain  $D = D(f)$  symmetric over the origin and is an even function. Examples:  $y = x^2$ ,  $y = |x|$ ,  $y = \cos x$ .
- A function  $y = f(x)$  with a domain  $D = D(f) \subset \mathbb{R} = (-\infty; +\infty)$ , which antisymmetric over the subgroup  $S(\mathbb{R}) \subset M(\mathbb{R})$ , has a domain  $D = D(f)$  symmetric over the origin and is an odd function. Examples:  $y = x^3$ ,  $y = x$ ,  $y = \sin x$ .
- A function  $y = f(x)$  with a domain  $D = D(f) \subset \mathbb{R} = (-\infty; +\infty)$ , which is preserved by the subgroup  $Tr_\omega(\mathbb{R}) \subset M(\mathbb{R})$  with the fixed  $\omega \in \mathbb{R} (\omega \neq 0)$ , has a domain  $D = D(f)$  invariant over the step  $\omega \neq 0$  and is periodic with a period  $\omega \neq 0$ . Examples:  $y = \sin x$ ,  $y = \cos x$  with  $\omega = 2\pi$ ,  $y = \operatorname{tg} x$  and  $y = \operatorname{ctg} x$  with  $\omega = \pi$ ,  $y = \{x\}$  with  $\omega = 1$ .
- A function  $y = f(x)$  with a domain  $D = D(f) \subset \mathbb{R} = (-\infty; +\infty)$ , which is preserved by the subgroup  $\langle tr_\omega(\mathbb{R}) \rangle \lambda S(\mathbb{R}) \subset M(\mathbb{R})$  with the fixed  $\omega \in \mathbb{R} (\omega \neq 0)$ , has a domain  $D = D(f)$  symmetric over the origin and invariant over the step  $\omega \neq 0$ , is even and periodic with a period  $\omega \neq 0$ . Example:  $y = \cos x$  with  $\omega = 2\pi$ .
- A function  $y = f(x)$  with a domain  $D = D(f) \subset \mathbb{R} = (-\infty; +\infty)$ , which is antiinvariant over the subgroup  $\langle tr_\omega(\mathbb{R}) \rangle \lambda S(\mathbb{R}) \subset M(\mathbb{R})$  with the fixed  $\omega \in \mathbb{R} (\omega \neq 0)$ , has a domain  $D = D(f)$  invariant over the step  $\omega \neq 0$  and is antiperiodic with a period  $\omega \neq 0$  (an antiperiodic function is a function for which  $f(x + \omega) = -f(x)$  for some number  $\omega \neq 0$  and for each  $x$  and  $x + n\omega$  from the domain of  $f$ ). Examples:  $y = \sin x$  and  $y = \cos x$  with  $\omega = \pi$ .
- A function  $y = f(x)$  with a domain  $D = D(f) \subset \mathbb{R} = (-\infty; +\infty)$ , which is preserved by the subgroup  $\langle tr_\omega(\mathbb{R}) \rangle \lambda S(\mathbb{R}) \subset M(\mathbb{R})$  having a fixed  $\omega \in \mathbb{R} (\omega \neq 0)$  and antiinvariant

over the subgroup  $S(\mathbb{R}) \subset M(\mathbb{R})$ , has a domain  $D = D(f)$  symmetric over the origin and invariant over the step  $\omega \neq 0$ , is odd and periodic with a period  $\omega \neq 0$ . Examples:  $y = \sin x$  with  $\omega = 2\pi$ ,  $y = \operatorname{tg} x$  and  $y = \operatorname{ctg} x$  with  $\omega = \pi$ .

- A function  $y = f(x)$  with a domain  $D = D(f) \subset \mathbb{R} = (-\infty; +\infty)$  which is preserved by the subgroup  $\mathbb{Q}_+ \lambda S(\mathbb{R}) \subset M(\mathbb{R})$  where  $\mathbb{Q}_+$  is the additive group of rational numbers, is an even periodic function whose period is an arbitrary rational number  $\omega \neq 0$ . Example: the Dirichlet function:

$$\circ \quad d(x) = \begin{cases} 1, & \text{if } x \in \mathbb{Q}; \\ 0, & \text{if } x \in \mathbb{R} \setminus \mathbb{Q}. \end{cases}$$

- A function  $y = f(x)$  with a domain  $D = D(f) \subset \mathbb{R} = (-\infty; +\infty)$ , which is preserved by the subgroup  $\mathbb{R}_+ \subset M(\mathbb{R})$  or the entire group  $M(\mathbb{R})$  and has the domain  $D = D(f) = (-\infty; +\infty)$ , is a periodic function whose period is an arbitrary real number. Example:  $y = c, c = \operatorname{const} \forall x \in (-\infty; +\infty)$ .

As we can see from all of these definitions and examples, the restrictions on the domains play a critical role. It was already mentioned that the authors of the texts might consider these restrictions obvious, but they were no so obvious for the beginners who just have been introduced to these concepts. Students often forget to pay attention to them while testing functions for being odd or even. In the best scenario, it results in extra work and/or incomplete proof. For example, working on the problems involving the functions like

$$y = \frac{1}{x-1}, \quad y = \frac{1}{\sin x - 1}, \quad y = \frac{1}{\cos x - 1}, \quad y = \frac{1}{\cos^2 x - 1},$$

students usually just try to check the conditions  $(\forall x \in D: f(-x) = f(x))$  or  $(\forall x \in D: f(-x) = -f(x))$ . However, in these cases it is sufficient to check the condition  $\forall x \in D(f): -x \in D(f)$ , which is much easier.

While testing the following functions on being periodic

$$y = \sin \frac{1}{x}, \quad y = \operatorname{ctg} \frac{1}{x}, \quad y = \sin x^2, \quad y = \frac{x+10}{(x-1)(x+2)},$$

students often try to look for a number  $\omega \neq 0$  in order to satisfy the condition  $\forall x \in D: f(x+\omega) = f(x-\omega) = f(x)$  and forget to check the symmetry of the domain  $D = D(f) \subset \mathbb{R} = (-\infty; +\infty)$ . However, this condition could play a key role in simplifying the solutions of some problems. Let us illustrate this by considering the following simple justification of the well known fact that an arbitrary nonconstant rational function

$$f(x) = \frac{a_0 x^n + a_1 x^{n-1} + \dots + a_{n-1} x + a_n}{b_0 x^m + b_1 x^{m-1} + \dots + b_{m-1} x + b_m}, \quad a_0 \neq 0, b_0 \neq 0, \quad n \in \mathbb{N} \cup \{0\}, m \in \mathbb{N} \cup \{0\},$$

$$a_i \in \mathbb{R} \quad (i = 0, 1, \dots, n), \quad b_j \in \mathbb{R} \quad (j = 1, 2, \dots, m),$$

is not periodic. Indeed, assuming the contrary, we easily come to the conclusion that a polynomials  $a_0x^n + a_1x^{n-1} + \dots + a_{n-1}x + a_n$  and  $b_0x^m + b_1x^{m-1} + \dots + b_{m-1}x + b_m$  must have an infinite numbers of roots, i.e. are equal to 0. Contradiction.

One more remark: We think that a special attention should be given to the logical quantors. There is no necessary using the symbols  $\forall$  or  $\exists$ , but an appropriate verbal clarification must be given. Sometimes the expression  $x \in A$  can be interpreted in different ways. The students, especially the beginners, can understand it as “for each  $x \in A$ ” or “for some  $x \in A$ ”.

In our opinion, the following definitions from (Шкіль et al., 2000) are well founded methodically.

*A function  $y = f(x)$  with a domain  $D = D(f)$  is called even, if  $\forall x \in D: -x \in D$  and  $\forall x \in D: f(-x) = f(x)$ .*

*A function  $y = f(x)$  with a domain  $D = D(f)$  is called odd, if  $\forall x \in D: -x \in D$  and  $\forall x \in D: f(-x) = -f(x)$ .*

*A function  $y = f(x)$  with a domain  $D = D(f)$  is called periodic with a period  $\omega \neq 0$ , if there exists a real number  $\omega \in \mathbb{R} \setminus \{0\}$  such that  $\forall x \in D: x + \omega \in D, x - \omega \in D$  and  $\forall x \in D: f(x + \omega) = f(x - \omega) = f(x)$ .*

## Conclusion

In the process of developing mathematics and mathematics education, a variety of inter-subject connections have been extensively realized in the frame of a branch or even a topic. In the article we showed the effectiveness of the inter-subject approach in developing some widely used calculus concepts: odd, even, and periodic functions. We applied the inter-subject connections, employing some algebraic and geometric ideas in developing general reasoning that helped formulate clear and methodically correct definitions of these analytic objects.

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# **Comparison Study of Teachers' Knowledge and Confidence in Integrating Technology into Teaching Mathematics in Elementary School in the U.S. and China**

Zhonghe Wu

## **Abstract**

This study compared Chinese and U.S. mathematics teachers' knowledge and confidence in integrating technology and investigated how teachers' confidence is affected by their knowledge of using technology in teaching mathematics. The study found differences in knowledge of using technology in teaching mathematics between the two groups of teachers and that teachers' knowledge had an impact on their confidence. Chinese teachers seemed to have stronger confidence in integrating technology than their U.S. counterparts.

## **Key Words**

Teacher education, educational technology, comparison study, mathematics

## **Introduction**

In our increasingly information-rich, digital era, integrating technology into mathematics teaching has become a major task for teachers. No longer are mathematics teachers using only the traditional ways to deliver content. To meet today's challenges, teachers must create a variety of approaches to engage students in exploring and constructing mathematics knowledge in a meaningful way that could empower them with problem-solving abilities and build both conceptual understanding and procedural development at a high proficiency level. According to the International Society for Technology in Education (ISTE, 2002), within a sound educational setting, technology can enable students to become problem solvers and decision makers: "The teacher is responsible for establishing the classroom environment and preparing the learning opportunities that facilitates students' use of technology to learn, communicate, and develop knowledge products" (ISTE, 2002, p. 4). However, teachers' decisions in using technology are often influenced by their knowledge and confidence. To integrate technology effectively, teachers should have strong confidence in technology and be equipped with solid knowledge and proficient skills.

As technology rapidly develops, it is important to examine how different educational systems provide technology-supported learning opportunities for their students and how teachers' knowledge of integrating technology becomes part of their professional repertoire (ISTE, 2002). Although there is growing evidence that comparative studies promote teachers' awareness of their own teaching practices (An, 2004; Ma, 1999; Stigler & Perry, 1988), too little research probes the differences in teachers' confidence and knowledge in using technology for teaching mathematics in different cultural and educational systems.

The primary goals of this study are to compare mathematics teachers' confidence in integrating technology and to investigate how this confidence is affected by their knowledge and teaching experience. Research questions in this study are: (1) What are the differences in teachers' confidence in integrating technology in mathematics teaching? and (2) How is their confidence affected by their knowledge and teaching experiences in using technology?

## Theoretical Framework

### *The Importance of Integrating Technology in Mathematics Teaching*

Teaching mathematics well is a complex endeavor (NCTM, 2000). Research in mathematics education has repeatedly shown that too few children have adequate mathematics skills with understanding (National Research Council, 2001). To help students understand mathematics conceptually, mathematics teachers need to develop a variety of strategies to make mathematics concepts visual, live, connected, and meaningful (An, Kulm, & Wu, 2004). In recent years, researchers have started paying attention to the effects of integrating technology to enhance student learning (Groves, 1994; Norris, Sullivan, Poirot, & Soloway, 2003; Oppenheimer, 2003; Thompson & Thompson, 1987). The National Council of Teachers of Mathematics (NCTM, 1989), the first professional organization to create national standards for appropriate uses of technology in mathematics areas, recommends that in mathematics classrooms:

- Appropriate calculators are available to all students
- A computer is available for demonstration purposes.
- Every student has access to a computer for individual and group work.
- Students learn to use the computer as a tool for processing information and performing calculations to investigate and solve problems.

Under the influence of these recommendations, classroom teachers have been integrating technology in mathematics teaching and connecting mathematics to real-world situations with pictures, animation, and sense making (Albrecht & Firedrake, 1998; Dunham & Dick, 1994; Rojano, 1996; Wallace, 2004). McNabb (1999) found that in many schools, students who supplemented teacher-led instruction with individualized computer-assisted drill-and-practice did better in mathematics than students who received conventional instruction. In addition, the new technology made calculating and graphing easier; it changed the very nature of the problems that mathematics can solve and the methods mathematicians use to solve them.

Technology can provide unlimited opportunities for both teachers and students in mathematics education. The importance of using technology is recognized by NCTM (2000): "It is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning." Furthermore, technology allows students to engage in learning in a meaningful way as never before possible, a fact confirmed by the research finding that technology empowers new solutions and opens new doors to learning opportunities (Valdez & McNabb, 1997). The NCTM (1989) defines *mathematical power* as the abilities to explore, conjecture, and reason logically, as well as the ability to use a variety of methods effectively to solve non-routine problems. In addition, "For each individual, mathematical power involves the development of personal self-confidence" (p. 5). This self-confidence will in turn enhance teachers' confidence in teaching with technology integration and empower their abilities of effective teaching in mathematics classrooms.

### *The Influence of Teachers' Knowledge on Their Confidence in Integrating Technology*

Numerous studies have revealed that teachers' confidence is related to their beliefs and their knowledge (Bebell, Russell, & O'Dwyer, 2004; Campbell & White, 1997). In the technology-rich teaching environment, teachers have opportunities for exposure to a variety of teaching resources and to enrich their skills in using technology, which will promote changes in their

beliefs and confidence in teaching and learning. In turn, the changes in their beliefs and confidence will encourage teachers to discover new strategies in teaching and learning of mathematics and advance their teaching practices.

NCTM (2000) indicates that the effective use of technology in mathematics teaching depends on the teacher. With technology integration, teachers should change their role from information gatekeepers to facilitators, guides, and co-learners, with the student as explorer, producer, cognitive apprentice, and sometime teacher (Jonassen, 2000; Jones, Valdez, Nowakowski, & Rasmussen, 1995). In addition, teachers should have expanded knowledge for selecting and developing instruction using technology (NCTM, 2000). What is the necessary knowledge that mathematics teachers should acquire and possess? According to *Technology Connections for School Improvement: Teacher's Guide* (McNabb, 1999): teachers must re-skill in the four technology-related proficiency areas: basic uses of technology, instructional uses of technology, administrative uses of technology, and professional development uses of technology. These four components set standards and draw on challenging content and instructional strategies for teachers. Teachers are the key to facilitating student learning in the technology-rich classroom. With sound skills and knowledge of technology, teachers can play an important role in making decisions that enhance students' learning.

## Methods

### *Subjects*

The participants in the study were 113 elementary mathematics teachers from both the United States and China: 43 from seven schools Southern California, and 70 from ten schools in Southern Jiangsu in China. All teachers in China teach mathematics at first- to sixth-grade levels. Most of them teach mathematics only, with teaching experience ranging from 1 to 36 years. The teachers from the U.S. teach at kindergarten to sixth-grade levels. They have multiple subject assignments at their schools and have teaching experience from 1 to 32 years.

### *Procedure*

The participants were given a survey containing 25 questions regarding their beliefs and confidence and knowledge of integrating technology in teaching mathematics in spring 2005. The Chinese version of the survey was translated by researchers in the United States and the completed surveys were verified and collected by Chinese colleagues in China. The U.S. survey was distributed and collected by pre-service teachers at two universities in their field work experiences.

### *Instrument*

A survey was designed by the author of this study. Some items were constructed according to the *Technology Connections for School Improvement: Teacher's Guide* (McNabb, 1999). The 25 questions consisted of 5 confidence-related questions on a Likert scale, 4 calculator-related questions with 2 on a Likert scale, 3 knowledge-related open-ended questions, and 13 beliefs-related questions in both multiple-choice and open-ended formats. The goals of the survey were to examine the differences in mathematics teachers' beliefs and confidence in using technology and to investigate the impact of their knowledge of technology use in mathematics teaching on

their confidence and beliefs. However, in this report, only teachers' confidence and knowledge results are reported. The beliefs results will be reported in another article.

### *Data Analyses*

Quantitative methods were used in this study. An independent t-test was used to investigate the statistical difference between the two groups' confidence levels in using technology, as measured by questions 1–5. The Pearson correlation test was used to identify the relationships among confidence, calculator use, teaching experience, and grade level taught. To use valid data, the Pearson correlation test eliminated samples that did not provide complete information about teaching experience or grade level. The numbers of samples in the Chinese group was 70; in the U.S. group it was 43.

## **Results**

The study found differences between the two groups in knowledge of using technology in teaching mathematics and in the impact of that knowledge on their confidence. Chinese teachers seemed to have stronger confidence in integrating technology than their U.S. counterparts.

### *Comparing Teacher Confidence between U.S. and Chinese Teachers*

To assess teacher confidence in integrating technology in mathematics teaching, an independent t-test was used to compare the differences of confidences between the two groups of teachers. The SPSS outputs in Table 1 and Table 2 show that the mean scores of confidence between the two groups are significantly different ( $t\text{-test} = 3.440$ ,  $df = 75.79$ ,  $p = 0.01$ ,  $d = 0.135$ ). The Chinese teacher group was found to have a mean score of 20.9221, with a standard deviation of 2.55346; scores ranged from 13 to 25. The U.S. teacher group was found to have a mean score of 18.8542, with a standard deviation of 3.64365; scores ranged from 11 to 25. The significant difference in confidence levels between the two groups would suggest that Chinese teachers have stronger confidence in using technology.

Table 1  
Mean Scores of Confidence Between the Two Groups

Country	N	Mean	SD	SD Error
China	77	20.9221	2.55346	.29099
U.S.	48	18.8542	3.64365	.52591

Table 2  
Independent Test of Confidence between the Two Groups

Levene's Test for Equality of Variances		t-test for Equality of Means							
	F	Sig.	t	df	Sig. (2- tailed)	Mean Differen ce	Std. Error Differen ce	95% CID	
								Lower	Upper
Score (equal variances not assumed)*	7.858	.006	3.440	75.79	.001	2.068	.601	.870	.3265

\*The Levene's test identified unequal variances between the two groups. The reported results therefore do not assume equal variance.

*Correlations among Confidence, Using Technology, Experience, and Grade Levels*

The Pearson correlation test was used to identify relationships between any two of the four variables within each group.

*Correlations in the Chinese group.* Table 3 indicates that correlation between Chinese teachers' confidence and their years of teaching experience is significant and that the two variables are negatively linearly related; that is, more confidence is associated with fewer years of teaching experience. A similar result was also found between the confidence level and grade level, in that the lower-grade teachers tended to have more confidence.

Table 3  
Chinese Teacher Group

	Confidence	Not Using Calculator	Years Teaching	Grades
Confidence	1			
	70			
Not Using Calculator	-.198 .100 70	1		
		70		
Years Teaching	-.369 .002 70	-.063 .603 70	1	
			70	
Grades	-.235 .050 70	.048 .694 70	.310 .009 70	1
				70

*Correlations in the U.S. group.* Table 4 shows that correlation between U.S. teachers' confidence and their years of teaching experience is significant and that the two variables are negatively linearly related—more confidence is associated with fewer years of teaching experience. In addition, the correlation between U.S. teachers' confidence level and grade level is significant and the two variables are positively linearly related: the higher the grade level, the more confident. It is also interesting to note that the correlation between U.S. teachers' grade levels and the degree of not using calculators is significant and that the two variables are negatively linearly related, which indicates the lower grade teachers tended to use calculators less.

Table 4  
U.S. Teacher Group

	Confidence	Not Using Calculator	Years	Grades
Confidence	1			
Not Using Calculator	.43 -.283 .066 .43	1		
Years Teaching	-.314 .041 .43	-.086 .582 .43	1	
Grades	-.409 .041 .43	-.532 .000 .43	-.180 .247 .43	1

*Difference in Means from the Pearson Correlation Test*

The results in Table 5 indicate the differences between the two groups of teachers in confidence, nonuse of calculator, years of teaching experience, and grade levels. Chinese teachers have a relatively higher mean score of 21.0857 in confidence, while U.S. teachers have a mean score of 18.488; Chinese teachers have a lower mean score of 5.5857 on not using calculators, while U.S. teachers have a mean score of 6.2558 on that measure; Chinese teachers have a higher mean score of 12.2143 in teaching experience compared to a U.S. mean score of 11.0116. Both groups had the same mean score for the grade levels.

Table 5  
Descriptive Statistics of Chinese and U.S. Teacher Groups

	Mean		Std. Deviation		N	
	Chinese	U.S.	Chinese	U.S.	Chinese	U.S.
Confidence	<b>21.0857</b>	18.4884	2.35749	3.64739	7 0	43
Not Using Calculator	5.5857	<b>6.2558</b>	1.56495	2.01297	7 0	43
Years	<b>12.2143</b>	11.0116	8.74418	9.66491	7 0	43
Grades	3.5286	3.8605	1.80756	2.58734	7 0	43

*Chinese and U.S. Teachers' Knowledge on Using Technology*

*Existing knowledge and skills.* Results from questions 10 and 11 indicate that about 34% of Chinese teachers were familiar with Authorware, 31% of them knew how to use Flash, 60% were familiar with PowerPoint, 25% knew Word, 9% knew Excel, and 8% knew the Internet. Each of the following tools were mentioned by fewer than 4% of teachers: e-mail, Geometric Sketch Pad, Front Page, textbook software, overhead projector, blackboard, manipulatives, oral computation cards, large pictures for instructions, and counting machine. About 18% of Chinese teachers did not indicate any of names of technology they are familiar with and use in instruction.

In contrast, 13% of the U.S. teachers were familiar with computers and calculators, and 15% knew about classroom uses for overhead projectors, digital cameras, television, video, and tape players. Regarding software, 15% of them are familiar with PowerPoint and 4% with Excel. About 31% of U.S. teachers use computer games in their instruction, including Mighty Math—Comical School Rock, Reader Rabbit—Personalized Math, Math Blasters, Gigi Math, Math Trek, Game Test, Trouble Toggle, and Orchard. 35% of U.S. teachers did provide names of technology they are familiar with or using in their instruction, and only 3% of teachers mentioned each of the followings: Word, SPSS, Internet, textbook support sites, websites, and HM sites.

*New knowledge and skills needed.* About 20% of Chinese teachers want to learn Photoshop, 47% want to learn Flash, 13% want to learn PowerPoint, 12% want to learn Authorware, and 34% want to learn Front Page. Fewer than 4% of teachers said they want to learn 3D, internet, Geometric Pad, Excel, e-mail, textbook software, or multimedia. About 22% of teachers were not sure or did not provide any responses to this question.

In contrast, U.S. teachers indicated wanting to learn new programs/sites and use of software applicable to their grade level, including computer programs for simulation and for visualizing concepts, Quarter Mile (which provides practice in basic facts), Smart Board, LCD projection, and Carmen San Diego Math Detective for help with problem solving. About 13% of teachers would like to learn PowerPoint. However, some 63% of teachers were not sure or did not provide any names of technology they would like to learning.

## Discussion

The Chinese teachers in the study tended to have a stronger confidence in integrating technology to teach mathematics than the U.S. teachers did. The data analysis shows that a reason for this difference could be that more Chinese teachers are familiar with powerful computer programs for designing instruction, such as Authorware, Flash, and PowerPoint, with visual, dynamic, and animation features that can be used to design instruction step by step for conceptual understanding. In addition, Chinese teachers want to acquire more skills on challenging programs such as Front Page and Photoshop. In contrast, most U.S. teachers are familiar with computer games designed and predetermined by experts and for which teachers cannot provide their own input related to their instruction. The findings also show that only 15% of U.S. teachers know how to use PowerPoint, compared to 60% of the Chinese teachers, who are familiar with the program and use it to design daily instruction. This difference is a factor that can influence U.S. teachers' confidence. Moreover, 63% of U.S. teachers were not sure of or did not provide any names for technology they would like to learn, compared to only 22% of Chinese teachers. The lack of knowledge of technology in the U.S. teacher group led to lower confidence in using technology in teaching mathematics. Another possible factor that contributes to U.S. teachers' lack of knowledge in technology is that they teach all subjects and do not have enough time to learn and use technology to design instruction; as a result, they tend to use more computer games or predetermined programs in their instruction, while Chinese teachers teach only math so they have more time to prepare and design instruction using technology.

According to NCTM (2000), the effective use of technology in mathematics teaching depends on the teacher. "Teachers should use technology to enhance their students' learning opportunities by selecting or creating mathematical tasks that take advantage of what technology can do effectively and well—graphing, visualizing, and computing" (p. 26). Only with teachers' own input to design instruction using technology will they have more knowledge and stronger confidence in using technology.

The findings also reveal that relationship between with years of teaching experience and confidence in the two groups: more confidence is associated with fewer years of teaching. However, Chinese lower-grade teachers have more confidence, whereas U.S. higher-grade teachers have more confidence.

## Conclusion

This study compared U.S. and Chinese mathematics teachers' confidence in integrating technology in the classroom and investigated how teachers' confidence is affected by their knowledge of using technology in teaching mathematics. The findings from this study indicate the similarities and differences between the two countries in teachers' confidence and knowledge regarding integrating technology in mathematics teaching. Although the cultures have differences, a common ground for integrating technology in mathematics teaching is the goal of enhancing students' learning. Teachers should be acquiring new knowledge and skills that will make their teaching more effective in this ever-changing and developing digital era (An, 2004) and that will improve their ability to create and design instruction (NCTM, 2000). This process may enhance teachers' knowledge and in turn motivate a transition in their beliefs and

confidence. When equipped with strong confidence and solid knowledge, teachers can achieve greater success in mathematics teaching.

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# Heuristic Component to Teaching Methods of High School Teachers

Olena Skafa

## Abstract

The activity of high school teachers is very important today. They organize and implement innovative systems of teaching aiming at personal development. In order to manage this ability the teacher of mathematics must possess the skills of heuristic methods of teaching: from Socratic dialogs to building a system of purposeful questions and tasks for students' intellectual development. This article contains some ideas of heuristic tasks and methods applicable to higher school teaching.

## Key Words

Heuristic teaching of mathematics, heuristic guidelines, morphological method, brainstorm

## Introduction

Our era is the age of intelligence, information, and environment. Intellectual activity is the mechanism to guide societal development. How do we update the intellectual potential? The pedagogical ways of forming an intellectually developed person are determined by integration of study content and innovative systems and methods of students teaching.

The formation of of students' intelligence comes through the following phases: (1) accumulation of intellectually activity experience; (2) motivation, diagnosis; (3) awareness; (4) application; (5) practice; (6) generalization; and (7) transfer to a new environment. These phases are the same in the educational-cognitive heuristic activity of students. I therefore believe that the heuristic approach to teaching, including teaching of mathematics, is the most feasible and innovative method of teaching today (Skafa, 2004). Heuristic teaching of mathematics is aimed at forming the educational-cognitive activity of a student, mastering knowledge and skills through the student's building his or her own educational path for studying mathematics.

It should be noted that the cognitive activity of students plays an important role in their heuristic teaching process, as well as the ability of a teacher to channel this activity. The heuristic method is one of the basic ways for students to show their creative approach toward the study of mathematics.

## Heuristic Method of Teaching

This method is used to master the ways to acquire scientific knowledge, to develop a creative approach, to awaken interest, and to acquire fundamental and necessary knowledge—in other words, to develop intelligence. The heuristic method has a long history and was known at the times of Socrates' dialogues. Socrates was committed to empirical research rather than faith; he never gave ready statements but made his interlocutors produce notions and beliefs (Zhadanov, 2001). Socrates remains in history as a good teacher and the founder of one of the best methods of teaching: heuristic talk. This method applied to mathematics is called *heuristic discourse* (Polya, 1965).

“The true heuristic discourse,” as Semenov (1997) says, “is the dialogue but not its imitation as a pseudo-dialogue and anti-dialogue. Searching hypothesis, proof, making a plan of problem solution can be

successful only if a student starts discourse with a teacher and independence will arise from inner dialogue and the level of readiness and preparation for it.”

A heuristic dialogue addresses a problematic situation and has its characteristic features: contradiction, deficit of action reference basis, information, and awareness of the whole situation. But a dialogue is not aimed at solution of this problem. It is important for one to understand the collision, and that becomes the problem people face which is "worth" to be solved.

Dialogical teaching of mathematics is the most effective way to reflect the formation of a student’s intelligence. Heuristic discourse teaches a student to see the problem, put forth questions, consider facts, make conclusions, put forward hypotheses, and make a plan of the problem solution.

The success of heuristic discourse depends directly on skilled questions put by the teacher, which requires thinking over the proof and making a plan of the discourse with possible options for the answer. To implement this method successfully, the teacher must possess a high level of general and mathematics knowledge, a quick wit, expressive speech, and the ability to pose clear and precise questions and to change them if necessary.

The method of making *heuristic questions* was introduced by Quintilianus, the ancient Roman rhetorician and teacher. To find the facts about an event, we should pose the following seven key questions: who? what? why? where? by what? how? when? Pair combinations of questions give rise to a new question—for instance, how-when? The answers to these questions give birth to uncommon ideas and solutions regarding the object under investigation. Such questions are usually used during the organization of a “Socratic dialogue,” which results in “discovery” of the truth. They are considered to be most feasible, especially when applying the inductive method of notions formation and the study of theorems (Skafa, 2006).

The system of teacher’s questions and students’ answers should meet the following requirements.

- First of all the system of questions should be organized in such a way to achieve didactic, developing, and educative objectives set forth. This means that questions should lead students to:
  - achieve the correct proof;
  - form one of the heuristic ways of thinking (comparison, analogy, generalization, separation of essentials, concretizing, abstraction, encoding, modeling etc.);
  - collective creativity (the ability of precise and clear formulating of a thought, the ability to listen to and hear reasons of classmates and the teacher, the ability to comment, etc.).
- The system of questions should be successive, which is defined by the content of material and method used for proving.
- The questions should give incentives for free thinking. The pauses between the questions may vary. One should avoid short pauses.
- The questions should be precise and clear. The word under the logical stress should come first in the question, for instance, “Why are triangles equal?”
- One question should be asked at a time. Double questions are not appropriate: they mislead the students’ way of thinking and delay the response.
- The teacher should avoid prompt questions—questions containing the answer.

Let us consider some examples of organizing questions for heuristic teaching of mathematics.

### *Use of Heuristic Guidelines*

Heuristic guidelines of a specific kind, suggested by Larson (1983), can serve as the basis for devising questions for students. We can trace the following sets of general heuristics:

- consider the constituents
- draw a figure
- exploit the symmetry, periodicity
- direct the actions
- argue on the contrary, find contrary instances
- consider extreme cases
- consider several models of the problem and establish the connection between them
- consider threshold and utmost cases
- check the result (according to sign, dimension, interpretation content and character of change, sufficiency and excess of conditions, etc.)

These heuristics may serve as the source for making uncommon questions and systems of exercises for students. When a student meets the problem for the first time and his or her aim is to establish an algorithm of its solution, he or she treats this problem as uncommon. The system of exercises should be constructed without presentation of ready algorithms; a student should find them by solving the problems (using necessary heuristics, putting forward hypotheses of objects' characteristics. and establishing the connections between them). After finding the necessary algorithm it is again important to use necessary heuristics to verify the result, understand it in the right way, discuss the limits of the algorithm, and understand the field of its application.

*Example.* While investigating a function through its derivatives, we should bear in mind the theorem about the connection between the second-derivative sign and convexity. We know that students often confuse the meaning of this theorem, so teachers can suggest using “the rule of rain” to better remember it. The process of recollection of this theorem is substituted by the discussion of whether a jar collects water or not. We can reason in the following way if we use *modeling*: The second derivative is positive, so the first one is increasing, which means that the tangent to the graph is turning in the direction of angle increase. This means that the curve is convex downward, and vice versa. We can also reason using the physical interpretation. The second derivative is positive, so acceleration is positive too. Let's assume acceleration is positive and constant. This is a uniformly accelerated motion.

$$S = v_0 t + \frac{a t^2}{2}$$

The graph will be a parabola. If  $a$  is positive, the branches are directed downward, so the function is convex downward. Thus, heuristic guidelines allow us to form associations not with an arbitrary mnemonic image but with an image that is essentially adequate and serves, on the one hand, to formulate concepts and describe tasks and, on the other hand, to interpret resulting theories. Integrating it into the general picture and building associations with other, known mathematical facts, we can also use it to facilitate remembering. An experiment has shown that students who were told both about the mnemonic rule and model-based reasoning preferred modeling (Skafa, 2006).

#### *Problem Synthesis: Morphological Method*

Here we mean a systematic exhaustive search of various possible situations and relations of the objects mentioned in the problem description.

*Example.* Let's take a function and its derivatives. Traditionally, the following properties of a function are determined:

1. range of definition (whether it coincides with a given set)
2. range of function
3. set of zero
4. constancy of sign
5. continuity
6. periodicity
7. extremum presence (or absence)
8. asymptote etc. presence (or absence).

Respective properties of the derivative are marked as (1.1), (1.2) etc.; of the second derivative – (2.1), (2.2) etc. Relations are implication, equivalence, existence of a pair in a particular state etc.

Comparing pairs of properties, we can come up with various questions (sometimes unexpected):

1. Can a function that is defined throughout the axis have a derivative only in the rational number set?
2. Can the zero set of a function coincide with the zero set of its derivative? Can it be wider? Narrower?
3. Can a function and its derivative have identical extremum points?
4. A function has a minimum period of  $T$ . Can its derivative have a minimum period of  $T/2$ ?  $2T$ ?
5. A function is increasing (in the strict sense) in a certain range. Does it mean that its derivative is positive?
6. A function is differentiable in the range  $I$  and has a minimum at a point  $a \in I$ . Does it mean that it decreases in a certain range  $(a - \delta; a)$  and increases in  $(a; a + \delta)$ ?
7. Let's assume a derivative's graph has an asymptote. Is that line necessarily the asymptote to the function's graph?
8. Let's assume a function is positive in a certain range. Is its derivative necessarily positive? Is the converse proposition correct?
9. Can a function and its derivative have identical monotonicity intervals? convexity intervals? Are these intervals always the same?
10. If a function's graph has an inclined asymptote, does it follow that the derivative's graph has a horizontal asymptote?

The layout described above is a modification of the "morphological map" (the ordered exhaustion method) of possible solutions to a problem that was once offered by Zwicky (1967), a Swiss astrophysicist. It should be noted that the important part here is the approach—the ordered exhaustion of possible options, and not some rigid sequence.

*Example.* The following elements can be found in or derived from a triangle: sides' lengths, angles, medians, bisecting lines, altitudes, radiuses of inscribed and circumscribed circles. etc.

Questions: Which of these elements are sufficient for building a triangle? For computing its area?

Full exhaustion of options allows us to get a considerable number of questions and problems connected with building and calculating.

### *“Translation” Method*

New questions can be obtained from known problems by translating them into physical or geometrical language (physical or geometrical interpretation) or translating them from physical or other science language (modeling). Sometimes it allows for a simpler solution through using a model.

*Example.* Can Roll’s theory be translated into mechanics language?

Discussion results in a sophisticated definition: Between two equilibrium points there is at least one point of instantaneous stop.

*Example.* If the derivative is positive in a certain range, the function is increasing. Can this result be translated into mechanics?

Discussion gives students the idea of proving this proposition in mechanics language: given constant speed, motion is directed to where the point’s  $x$  coordinate increases.

*Example.* Let’s assume  $f(x)$  is a continuous function in  $[a; b]$  and  $\int_a^b f^2(x)dx = 0$ .

Then  $f(x) \equiv 0$ . How can this result be interpreted geometrically?

### *Variation Method*

New questions can be obtained by changing the parameters of a known problem. There are many ways to do this.

*Making a reverse question to the problem’s description.* The base problem is to solve a quadratic equation. Reverse question: Can you find all quadratic equations having following roots?

Another idea of a reverse question is to restore a rational inequality by its solution set (e.g., is there any rational inequality that has ... as its solution set?)

*Formulating the reverse question to a theorem.* Studying converse theorems is a rather traditional methodology. It would be wise for a teacher proposing such tasks to make sure some of the resulting assertions are false (otherwise the students may fall under the impression that a theorem can always be correctly reversed).

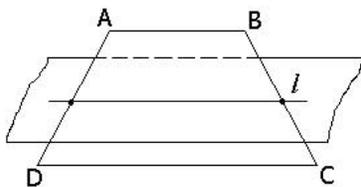
1. How can you formulate a theorem converse to Pythagorean theorem? To the Vieta theorem?
2. If the derivative is positive in a certain range, the function is increasing. Is the converse proposition correct?
3. It is known that a function continuous in a certain interval is bounded. Is the converse proposition correct?
4. Formulate and verify a proposition converse to Rolle’s theorem.

*Exchange the roles of elements in a definition.* Let us take a following statement: for any  $\varepsilon < 0$  within a given circle it is possible to build a system of nonintersecting squares so that the part of the circle not covered by them has an area less than  $\varepsilon$  (it follows from the squarability of the circle). Exchanging "circle" and "square" gives us a following statement: for any  $\varepsilon < 0$  within a given square it is possible to build a system of nonintersecting circles so that the part of the square not covered by them has an area less than  $\varepsilon$ .

*Mistakes Method*

A method offered by A. Osborn (1964), based on randomness, mistakes, and associations, aims at breaking the traditional negative attitude toward mistakes and substituting a constructive approach, using mistakes to add depth to educational process. A mistake is seen as a source of contradictions, phenomena, exceptions to the rules, new knowledge born in contrast to the commonly known. A mistake can be addressed not only in order to correct it but also to find out its causes and possible ways to come at it. Seeking out the links between mistake and "correctness" stimulates students' heuristic activity and leads them to understand the relative and variable nature of any knowledge. It would be useful to arrange for finding mistakes in all kinds of mathematical reasoning: in solving a problem, in a notion's definition. or in theorem proving.

*Example.* A mistake in a problem is seen as a source of argument resulting in new knowledge, born through contradicting the commonly known.

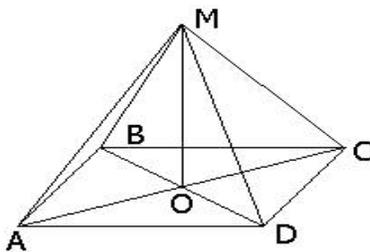


Problem. Prove that if a plane intersects a trapezium's plane along a line that contains its centerline, it is perpendicular to the base of trapezium.

Problem. (composed by students) What is the possible orientation of a plane relative to the bases of a trapezium, if it intersects the trapezium's plane along a line that contains its centerline:

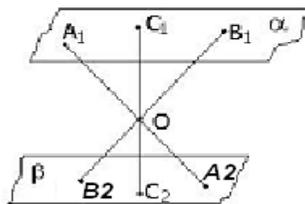
- (a) perpendicular to AB and DC;
- (b) parallel to AB and DC;
- (c) coincides with AB and DC.

Problem. ABCD is a parallelogram. There is a line OM, where O is the point of intersection of a parallelogram's diagonals, M lies outside the parallelogram's plane, MA = MC and MB = MD. Prove that line OM is parallel to the parallelogram's plane.



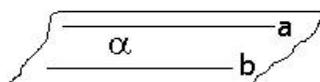
Problem (composed by students). ABCD is a parallelogram. There is a line OM, where O is the point of intersection of the parallelogram's diagonals, M lies outside the parallelogram's plane, MA = MC and MB = MD.

What is the orientation of line OM relative to the parallelogram's plane? parallel to (ABC); (b) coincides with (ABC); (c) perpendicular to (ABC).



Problem. Three segments,  $\hat{A}_1\hat{A}_2, \hat{A}_1\hat{A}_2, \tilde{N}_1\tilde{N}_2$ , do not lie in the same plane, intersect at point O, and are divided in half by that point. Prove that planes  $(\hat{A}_1\hat{A}_2\hat{A}_3)$  and  $(\hat{A}_1\hat{A}_2\hat{A}_3)$  are perpendicular.

Problem (composed by students). Three segments,  $\hat{A}_1\hat{A}_2, \hat{A}_1\hat{A}_2, \tilde{N}_1\tilde{N}_2$ , do not belong to the same plane, intersect at point O, and are divided in half by that point. What is the orientation of planes  $(\hat{A}_1\hat{A}_2\hat{A}_3)$  and  $(\hat{A}_1\hat{A}_2\hat{A}_3)$  in relation to each other? (a) parallel; (b) perpendicular; (c) they coincide.



Problem. A line that doesn't belong to a plane is parallel to two lines

belonging to that plane. Prove that those lines belonging to the plane can intersect.

Problem (composed by students). A line that doesn't belong to a plane is parallel to two lines belonging to that plane. What is the orientation of planes belonging to the plane in relation to each other? (a) intersecting; (b) skew; (c) parallel.

While finding out the causes and the ways to come at a particular mistake, the students, aided by the teacher, can draw a number of conclusions. Analyzing each description to find the link between mistake and "correctness" stimulates students' heuristic activity. They acquire skills in using both the "consequence finding" and "fitting to a notion" approaches, which enables the teacher to efficiently organize and manage their heuristic activities.

### *Brainstorming*

The main purpose of this method (Osborn, 1964) is to harvest as many ideas as possible through liberating the discussion participants from inertial thinking and stereotypes. In doing this, following requirements should be observed:

1. free expression of ideas (problems) by any group member
2. no criticizing of any ideas offered (critical review and selection will follow next)
3. free combining, varying and supplementing of ideas offered

Afterward the ideas harvested from teams are systematized and grouped according to common principles and approaches. Then the team considers any obstacles to implementing the selected ideas. Critical remarks are reviewed. Those ideas that weren't overturned by criticism or counter-ideas are eligible for final selection.

We have experimentally tested the efficiency of brainstorming as a means of composing questions and problems. It turned out to be rather high (Skafa, 2004) with the optimum group size being not more than 5–6 persons.

*Example.* To exemplify this, let us consider several results (problems composed by students) "brainstormed" from the following problem: *a polygonal area is defined by the coordinates of polygonal chain vertices, a point is defined by its coordinates. How can we determine if the point belongs to the area?*

1. There is a polygonal chain defined by the coordinates of its successive vertices. How can we define if a point defined by its coordinates belongs to the polygonal chain?
2. There is a line defined by its equations. How can we determine how many times it intersects the polygonal chain?

### **Conclusion**

Only through a combination of traditional and heuristic teaching methods and an in-depth approach to dialogic teaching with appropriate questions and heuristic task systems can a teacher properly shape the mental skills of students. In a situation like this, the teacher is reduced to an advisory role, stimulating students' original creative thinking and directing their professionally-oriented activities. This approach allows to change both the teacher's role (from informing to

managing) and the student's educational path (the information being learned is not just an objective but a means of developing professional skills) (Skafa, 2008).

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# Expert Problem Solving in a Manufacturing Virtual World Simulation

John L. Elson, Clark Mount-Campbell, and David D. Woods

## Abstract

Engineering educators are calling for developing new research methods and methodologies that will increase the expertise and knowledge of engineering graduates. Virtual world simulations have become the state of the art of simulating real-world experiences. This paper provides an overview of simulations used in education and in particular those being used in engineering education. Since there has been no use of simulations in industrial engineering in the classroom or in research, this paper tests the hypothesis that experts will perform significantly better than novices on a simulated real-world task in a manufacturing scenario involving use of industrial engineering knowledge. Teams of experts and novices were studied through their verbal protocols and process traces as they interacted to search for causes and possible alternatives to solve the problem of customer order backlog. Team behavior was compared to a canonical solution and differences between experts and novices statistically determined. Experts were found to perform significantly better than novices in the simulated environment. Possible reasons are discussed as well as directions for possible future research.

## Key Words

Virtual word simulation, expertise, industrial engineering

## Introduction

Engineering educators are looking for ways to increase levels of expertise (*Journal of Engineering Education*, 2006) and deliver education that will meet the needs of the engineer of 2020 (National Academy of Engineering, 2004). One of the current primary thrusts of engineering education is problem-based learning (Rover, 2007; Prince & Felder, 2006), and one methodology that fits this thrust is the virtual world simulation. Simulations have long been used in research, and Ward, Williams and Hancock (2006) provide an overview of the past and current uses. Recently simulations have been used in engineering education (Hodge, Hinton, & Lightner, 2001; Campbell et al., 2002; Alexander & Smelser, 2003; Dessouky et al., 2001; Mackenzie et al., 2001; Harmon et al., 2002; Davidovich, Parush, & Shtub, 2006). And in business education, simulations are now taking a premier spot: Harvard Business School Publishing (2008) shows four virtual world simulations on their website that were released in 2008. However, little research if any has been done in the area of industrial engineering (IE) education and the use of simulations.

Elson, Mount-Campbell, and Woods (2007) have provided an overview of expertise and simulations and recommend a research agenda for developing simulations in IE education. Elson (2008) used a virtual world simulation in the classroom to teach engineering ethics in an engineering management course. Following up on these two research efforts, this paper reports on research that focuses on comparing expert and novice problem-solving behavior using a virtual world simulation with an IE manufacturing scenario and problem. The primary purpose is to verify that the simulation (test problem) is a good representation of a real-world problem situation (target problem) by studying the problem-solving behavior of both novices and experts. The results show this to be the case, and we make recommendations for further research on how to employ simulations in teaching IE problem solving.

The next section discusses the experimental design and hypotheses followed by the section on data analysis and results. The final section provides conclusions and recommendations for further research.

### **Hypotheses and Experimental Design**

The far-reaching research goal is to acquire knowledge regarding how to optimally use simulations as a learning tool, particularly in IE education. Elson, Mount-Campbell, and Woods (2007) have suggested preliminary research that will validate a simulation as a challenging task that emulates a real-world problem by examining the differences in problem solving by experts and novices.

#### *Research Hypotheses*

The general hypothesis of this initial study is that experts will perform better than novices in solving a real-world problem that is ill-structured yet structurable (Benaroch & Tanniru, 1996). This hypothesis is general and will be tested in a specific domain (IE), with a specific problem situation. The general hypothesis is subdivided into four hypotheses regarding problem solving and shown in Table 1.

Table 2  
Research Hypotheses

Hypothesis 1 (H1)	Expert teams will make more correct decisions in solving the problem in the test situation than novice teams.
Hypothesis 2 (H2)	Expert teams will search for data and situation information better than novice teams in solving the problem in the test situation.
Hypothesis 3 (H3)	Expert teams will recognize and use data and situation information better than novice teams in solving the problem in the test situation.
Hypothesis 4 (H4)	Expert teams will use more domain knowledge than novice teams in solving the problem in the test situation.

#### *Research Task*

The task for this research is embodied in a scaled-world simulation, the Excellent Manufacturing Company, a fictitious organization that makes products for the construction industry sold to home improvement stores. The company employs 90 people, has sales of around \$13 million, and utilizes manufacturing processes of blanking, heading, plastic injection molding, assembly, packaging, and bulk packing. Participants play the role of IE consultants who are hired to solve a problem where the customer orders are backlogged and getting worse every day.

The problem occurs for one specific product line, the Plasti-Brack, a plastic-sheet metal item used in construction, produced by plastic injection molding the plastic part and stamping the metal part with a progressive die. The final part is assembled and then packed. There are six different items in the product line based on its angle. Figure 1 shows a sample drawing of the F90. The P90 is the plastic insert, the S90 is the steel bracket, and the F90 is the assembly of the

P90 and S90. Figure 1 also shows the process flow chart for the B-F90, which is the bulk packed F90. Table 2 summarizes the research problem and issues.

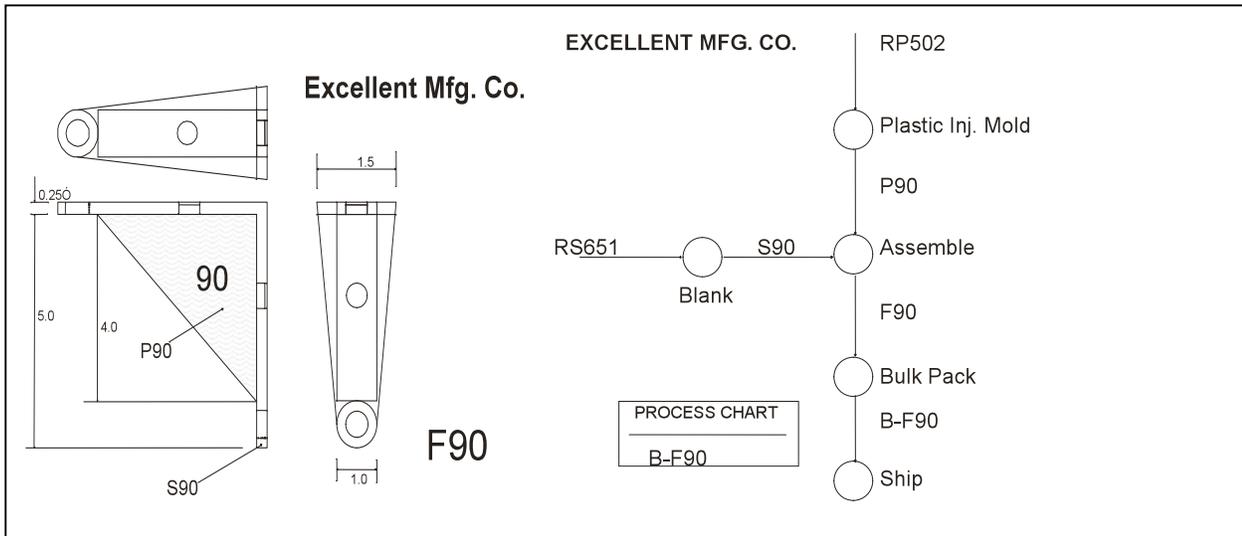


Figure 2  
Sample drawing of F90 and sample process flow of B-F90.

Table 2  
The Research Problem and Its Context

Customer orders backlog	Is increasing in the plastic injection molding machine group (MLD100), where six plastic parts are produced on four plastic injection molding machines
Capacity of MLD100 machine group	is being diminished by several causes: Tools for the six plastic parts are wearing—some closed cavities on three of six tools Excessively high scrap rates of the six plastic parts Poor raw material quality used for the six plastic parts Long setup times in the MLD100 machine group (4 hours) Recurrent machine breakdown of machine M101 in MLD100 machine group
Inadequate professional staffing	lack of expertise in quality and no quality department – responsibility is shared
Weekly schedule	The shop is working a single, normal shift, 8 hours per day, 5 days per week (40 hours)

The participants have three main activities: get information from various employees, get information from company production reports, and make decisions to reduce the order backlog. In order to get information, the participants move to various locations in the company where employees are located. They get information verbally from the virtual employees (via recorded messages) and from various information displays in these locations that provide information about production status. The participants can also request information from employees and receive it on a delayed basis. Table 3 shows the available decisions and actions.

Table 3  
The Available Decisions and Actions

Decision Category Location	Decision Choices
Capital spending—budget limit: \$325,000 Harvey Lund, manager acctg/IS	<ul style="list-style-type: none"> <li>• Overhaul M101 at a cost of \$100,000 or purchase replacement machine for a cost of \$250,000 or do nothing</li> <li>• Purchase new tools for P90, P100, P120A, P120B, P130, P135, each at a cost of \$25,000, or do nothing</li> <li>• Reduce setup time from 4 hours to potentially 1.5 hours per setup at a maximum cost of \$15,000 in changing the die platens and fastening mechanisms for all six tools, or do nothing</li> </ul>
Purchase of raw material: Mark Monnin, buyer	<ul style="list-style-type: none"> <li>• RP515 at \$0.28 per pound or</li> <li>• RP625 at \$0.30 per pound, or</li> <li>• Stay with status quo, RP502 at \$0.26 per pound</li> <li>• The quality ranking order is RP625 &gt; RP515 &gt; RP502</li> </ul>
Implement overtime in the MLD100 machine group: Bill Morton, plant manager	<ul style="list-style-type: none"> <li>• Up to two hours per day Monday through Friday</li> <li>• And/or up to 10 hours on Saturday, or</li> <li>• Stay at status quo: no overtime</li> </ul>
Scheduling of MLD100 group: Shop order quantities and/or machine assignments or status quo: Scheduling Room	<ul style="list-style-type: none"> <li>• A standard rotation of the six parts on the four machines</li> <li>or</li> <li>• Shop order quantities based on customer demand levels</li> </ul>

The interface design consists of various virtual locations in the Excellent Manufacturing Company, including the offices of the relevant personnel, the shop floor in the Mold100 machine group, the scheduling office control panel, and the Industrial Engineering office, from where all other locations could be accessed. Figure 2 shows screen shots of the Industrial Engineering office and Don Stump’s office. In each virtual location there are displays of system status information, decision input grids, or pop-up data provided by the virtual character in addition to verbal narrative reports consisting of their beliefs about the “problem” system or related systems or the company. Table 4 summarizes the display information and decision inputs. In addition to

the simulation interface for presentation of information, artifacts were created using the context information, including a fact sheet about the Excellent Manufacturing Company, organization charts, the sample process flowchart and drawing of F90, a memo from Tom Gunner discussing the current situation, a memo from Dick Tolliver discussing the cost system, a chart of machine speeds for the MLD100 group, and material handling data.

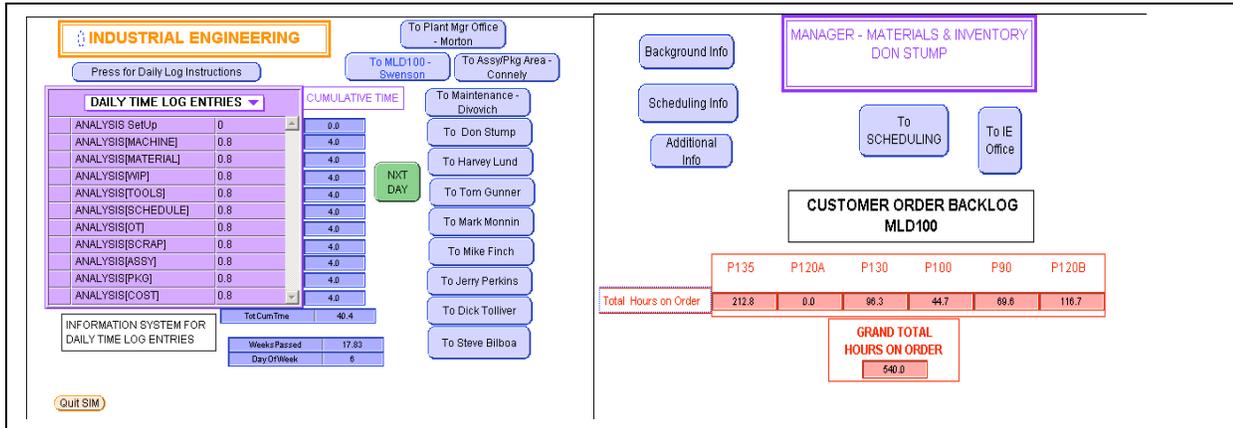


Figure 2

Virtual Industrial Engineering Office and Don Stump’s Office

*Research Participants*

There were three groups of participants: novices, domain experts, and nondomain experts. The novices were third- and fourth-year students from an Industrial Engineering program at a large midwest university. The experts were practicing industrial engineers with at least six years of experience. The nondomain experts were PhDs from other areas of knowledge. Within each grouping, the participants were formed into teams of two to facilitate talking aloud while performing the task. There were thirteen teams of novices, three teams of domain experts and two teams of nondomain experts. All of the novices had taken IE courses that covered the topics embodied in the simulation.

Table 4  
Display Information and Decision Inputs, by Location

Employee	Displays and Other Info
Bill Morton, plant manager	Overtime status
Scheduling Room	Scheduling status
Harvey Lund, manager acctg/IS	Capital spending status
Mark Monnin, buyer	Material on order status
Tom Gunner, manager engr.	Weekly production status
Bill Swenson, supv. MLD100	Current setup time, plastic part WIP, Tubs of mold scrap

	Closed tool cavities: P100, P130, P135
Dick Tolliver, accountant	Cost by part number (M,L,OH,Scrap), and MLD100 production amounts
Biff Connely, supv. assembly	Finished Goods WIP, Brackets WIP, Tubs of rejects
Don Stump, manager materials	Plasti-Brack order status in MLD100
Steve Bilboa, inventory analyst	Raw plastic inven., mat'l in use, tubs of regrind
Mike Finch, marketing analyst	Annual forecast by part (Plasti-Brack)
Jerry Perkins, process engineer	Process data and information
Pete Divovich, supv. maint.	Maintenance data and information

### *Research Methodology*

At the first session participants were given all the instructions, and all of the printed artifacts, and were given a brief tour of the simulation. They were instructed to talk aloud among themselves as they worked on solving the problem. During each session the talking aloud was tape-recorded, and the task steps and decisions that were made were recorded in a notebook by the researchers. The participants kept a log in a Word document and could ask for more information from any character in the simulation, which would be provided by the researcher at the next session. During each hour of research the participants were required to advance the simulation time by a minimum of two days or more. Moving ahead quickly to see possible consequences was an allowed activity.

A canonical expert solution was developed based on optimal search methods, complete domain knowledge, perfect inference ability, and perfect short-term recall ability. Two forms of the canonical solution were developed: one using heuristic decision making and the other incorporating a constrained optimization solution. The heuristic canonical solution was developed into a structure that consists of the hierarchical complete set of possible hypotheses, goals, warrants, data usage, and calculations for making inferences about the correct diagnoses and decisions to solve the problem. It includes only those goals and subgoals that relate directly to the primary backlog problem, the capacity issue, and the secondary considerations of product cost. The optimizing canonical solution was not used in the data analysis. since no teams used any form of optimization. The audio tapes were transcribed and developed into verbal protocols (Ericsson, 2006), and the process tracings were coded for analysis (Woods, 1993) for comparison to the coded canonical process tracing.

## **Data Analysis and Results**

### *Data Analysis*

The behavioral process tracings for each team were coded to identify the following five aspects: moves to virtual location; information that was accessed; calculations made; each decision that was made; and time advancement. The verbal protocols were also coded for analysis (Ericsson & Simon, 1984) and the following four types of verbalizations were identified: data used in

generating and rejecting hypotheses and goals and in making calculations; hypotheses, goals, and rejections of hypotheses that pertain to the problem structure; domain knowledge used to logically determine possible hypotheses, goals, and rejections; and statements of understanding, misunderstanding, or confusion about the system dynamics of the manufacturing process in the problem situation. Toulmin's (1958) system of informal argumentation (claim, data, warrants, backing, and rebuttal) was used to classify these four types of verbalizations. Each research hypothesis has at least one measurement variable (some have up to four) to test its validity.

Table 5  
Measurement Variables

Hypothesis	Measurement Variables
H1. Expert teams will make more correct decisions in solving the problem in the Excellent Manufacturing Company than novice teams.	<ul style="list-style-type: none"> <li>a) Number of correct decisions made</li> <li>b) Time difference between their occurrence in the participants' trace and the canonical trace</li> </ul>
H2. Expert teams will search for data and situation information better than novice teams in solving the problem in the Excellent Manufacturing Company.	<ul style="list-style-type: none"> <li>a) Time when the participants first accessed the virtual characters' oral reports (CORs) in the simulation</li> <li>b) Number of repetitions accessing the CORs compared to the canonical number of repetitions</li> <li>c) Number of presented requests for specific data</li> <li>d) Number of withheld requests for specific data</li> </ul>
H3. Expert teams will recognize and use data and situation information better than novice teams in solving the problem in the Excellent Manufacturing Company.	Number of data/information elements used in calculations or to make a claim per data elements accessed during search
H4. Expert teams will use more domain knowledge than novice teams in solving the problem in the Excellent Manufacturing Company.	<ul style="list-style-type: none"> <li>a) Number of requests to explain domain principles</li> <li>b) Number of valid domain principles verbalized</li> <li>c) Number of invalid domain principles verbalized</li> <li>d) Number of types of calculations made correctly</li> </ul>

For each test we developed the null test hypothesis ( $h_0$ ) that there are no differences among the means of the expert teams, the nondomain expert teams, and the novice teams. To test each null hypothesis of the measurement variables, a one-way analysis of variance (ANOVA) using Minitab was done with three treatments: novice teams, expert teams, and nondomain expert teams. Additionally, Fisher's pairwise comparison was done to test if the means of the three pairs are equal ( $h_0$ ).

### Results

The data used to analyze the hypotheses that use only behavioral process tracings was generated from the complete set of thirteen novice teams and five expert teams. For those hypotheses that use measurement variables based on verbal protocol analysis, a set of five novice teams was used for the data. For verbal protocol analysis to be valid it requires a relatively complete set of verbalizations of the cognitive process (Ericsson & Simon, 1984). Eight novice teams were eliminated due to sparse use of English (by non-native English speaking students) and large amounts of verbal disagreement. The average score of the representative set of the five novice teams used was as close as possible to the average score of the full set. The verbal protocols from the subset are representative of the cognitive process of the full set of novice participants.

Minitab-generated confidence intervals for Fisher's pairwise comparison for the three pairs of means (expert–novice, expert–nondomain expert, and nondomain expert–novice). The test hypothesis,  $h_0$ , was rejected if the confidence interval did not contain zero. The following is a summary of those results.

#### *Hypothesis 1(H1)*

The results, summarized in Table 6, show that a high percent of expert teams made the correct decisions and more closely match the timing of the canonical solution than do the novice teams. The percent of novice teams making correct decisions or making them in a timely manner is much lower than for the expert teams. This is the reason that the expert teams closed the gap and the final result was near the targeted objective of backlog.

Table 6  
Summary of Decisions Made

Decision	Novice Team Actions	Expert Team Actions
<b>Working OT</b> Canonical: 2 hr/day and 10 hr on Sat—start after 2 sim days, or after 2 hrs of lab time	<ul style="list-style-type: none"> <li>• 54% implemented OT (15 hrs/wk avg.)</li> <li>• Weighted average 8.1</li> </ul>	<ul style="list-style-type: none"> <li>• 100% implemented OT</li> <li>• 18.4 hrs/wk average</li> </ul>
	<ul style="list-style-type: none"> <li>• 46% did not use OT</li> <li>• Implemented after 39 sim days, or after 5 hours of lab time.</li> </ul>	<ul style="list-style-type: none"> <li>• 0% did not use OT</li> <li>• Implemented after 4.2 sim days, or after 2.5 hours of lab time</li> </ul>
<b>Purchasing new tools</b> Canonical: purchase all six	<ul style="list-style-type: none"> <li>• 15.4% bought all 6</li> <li>• 7.7% bought 4</li> <li>• 23.1% bought 3</li> <li>• 53.8% bought 0 Weighted average = 1.92 tools</li> </ul>	<ul style="list-style-type: none"> <li>• 20% bought all 6</li> <li>• 20% bought 4</li> <li>• 20% bought 3</li> <li>• 40% bought 2</li> <li>• Weighted average = 2.83 tools</li> </ul>

	<ul style="list-style-type: none"> <li>• 33% in 2<sup>nd</sup> lab</li> <li>• 67% in 3<sup>rd</sup> or 4<sup>th</sup> lab</li> </ul>	<ul style="list-style-type: none"> <li>• 82% in 1st or 2nd lab</li> <li>• 18% in 3rd or 4th lab</li> </ul>
<b>Replace or repair M101</b> Canonical: repair	<ul style="list-style-type: none"> <li>• 30.8% repaired</li> <li>• 46.2% purchased new machine</li> <li>• 23.1% did nothing</li> </ul>	<ul style="list-style-type: none"> <li>• 83% repaired</li> <li>• 0% purchased new machine</li> <li>• 17% did nothing</li> </ul>
<b>Reduce SU time</b> Canonical: implement in 2nd lab	<ul style="list-style-type: none"> <li>• 69.2% implemented setup reduction</li> <li>• 30.8% in 2nd or 3rd lab</li> <li>• 38.5% in 4th lab</li> <li>• 30.8% did nothing</li> </ul>	<ul style="list-style-type: none"> <li>• 100% implemented setup reduction</li> <li>• 50% in 2nd lab</li> <li>• 33% in 3rd lab</li> <li>• 17% in 4th lab</li> </ul>
<b>Scheduling</b> Canonical: Calculate EOQ's in 3rd lab Implement one time	<ul style="list-style-type: none"> <li>• avg. 6.6 decisions/team/lab.</li> <li>• 15.4% scheduling in 1st lab</li> <li>• 61.5% scheduling in 2nd lab</li> <li>• No use of optimization</li> </ul>	<ul style="list-style-type: none"> <li>• avg. 8.9 decisions/team/ lab.</li> <li>• 20% scheduling in 1st lab</li> <li>• 100% scheduling in 2nd lab</li> <li>• No use of optimization</li> </ul>

*Hypothesis 2(H2)*

The results of the tests of the four variables are:

*H2a. Timing.* Table 7 shows the average percent of the total CORs that were accessed cumulatively by lab period for the novice teams, the expert teams, and the nondomain expert teams.

Table 7  
Cumulative Percent of CORs Accessed by Time of First Access

	Novice Teams	Expert Teams	Non-D Expert Teams	F, p
Lab 1	67%	85%	81%	0.68, 0.520
Lab 2	73%	95%	100%	1.82, 0.196
Lab 3	85%	97%	100%	1.05, 0.375
Lab 4	89%	98%	100%	0.96, 0.405

The data indicate that expert teams on the average accessed more data earlier and more completely than did novices. However, the ANOVA indicates the results are not statistically significant, so the test  $h_0$  cannot be rejected.

*H2b. Repetitions.* The average of the absolute deviations is calculated for each team and used as the variable for the t-test. The averages for the novice group, nondomain expert group and domain expert group are 0.908, 0.847, and 0.712, respectively. The results of the ANOVA ( $F = 1.64, p = 0.260$ ) show no significant difference in the means among the three groups.

*H2c. Requests for presented data.* The average number of requests for data that were presented in the simulation for the novice group, nondomain expert group and domain expert group are 3.92, 5.00, and 2.00 respectively. The results of the ANOVA ( $F = 1.12$ ,  $p = 0.352$ ) show no significant difference in the means among the three groups.

*H2d. Requests for withheld data.* The average number of requests for data that were withheld for the novice group, nondomain expert group, and domain expert group are 2.83, 6.00, and 6.00, respectively, which excluded one datum (30 requests) from the novice data as an outlier. The results of the ANOVA ( $F = 3.66$ ,  $p = 0.053$ ) are approaching a significant difference in the means among the three groups. Fisher's pairwise comparison is significant (individual error rate = 0.05) and indicates rejecting  $h_0$  for the expert teams–novice teams pair only, which indicates that the expert teams did make more requests for withheld data than did the novice teams as expected.

With the exception of making more requests for withheld data by the experts, the overall statistical results for H2 are inconclusive that expert teams perform search for data better than novice teams.

### *Hypothesis 3(H3)*

The averages for the novice group, nondomain expert group and domain expert group are 0.226, 0.313, and 0.343, respectively. The results of the ANOVA ( $F = 5.79$ ,  $p = 0.033$ ) show a significant difference in the means among the three groups. Fisher's pairwise comparison is significant (individual error rate = 0.05) and indicates rejecting  $h_0$  for the expert teams–novice teams pair only. These results indicate that expert teams use more data that they have found than do the novice teams, as expected, and supports H3.

### *Hypothesis 4(H4)*

The results of the tests of the four variables are:

*H4a. Number of requests to explain domain principles.* The averages for the novice group, nondomain expert group and domain expert group are 2.38, 5.00, and 1.33, respectively. The results of the ANOVA ( $F = 1.58$ ,  $p = 0.239$ ) show no significant difference in the means among the three groups. These results indicate there is no difference in among the three groups in requesting explanations of domain concepts. It appears all groups have equal need to verify or understand some concepts based on additional information from outside sources.

*H4b. Number of valid domain principles verbalized.* The averages for the novice group, nondomain expert group and domain expert group are 10.6, 25.0, and 24.3, respectively. The results of the ANOVA ( $F = 6.98$ ,  $p = 0.022$ ) show a significant difference in the means among the three groups. Fisher's pairwise comparison is significant (individual error rate = 0.05) and indicates rejecting  $h_0$  for both the expert teams–novice teams pair and the nondomain expert teams–novice teams pair. These results indicate that expert teams verbalize more domain principles than do novice teams and that nondomain expert teams behave as domain expert teams. It is surprising that nondomain expert teams have the domain knowledge to make a significant number of statements of domain principles. This will be discussed later.

*H4c. Number of invalid domain principles verbalized.* The averages for the novice group, nondomain expert group, and domain expert group are 4.20, 4.50, and 1.67, respectively. The results of the ANOVA ( $F = 1.06$ ,  $p = 0.396$ ) show no significant difference in the means among the three groups.

*H4d. Number of types of calculations made correctly.* The averages for the novice group, nondomain expert group, and domain expert group are 2.20, 2.50, and 8.67, respectively. The results of the ANOVA ( $F = 8.33$ ,  $p = 0.014$ ) show a significant difference in the means among the three groups. Fisher’s pairwise comparison is significant (individual error rate = 0.05) and indicates rejecting  $h_0$  for both the expert teams–novice teams pair and the expert teams–nondomain expert teams pair. These results indicate that expert teams make more calculations than novice teams, as expected. Nondomain expert teams appear to behave as novice teams which is expected.

In summary of H4, two of the four tests in support the research hypothesis, as shown in Table 8.

Table 8  
Summary of Tests and Acceptance of Research Hypotheses

Test	One-way ANOVA		Fisher's pair wise comparisons				Conclusion
	F value	p value	family error rate	expert v novice	expert v nd-expert	nd-expert v novice	
H2. Expert teams will search for data and situation information better than novice teams in solving the problem in the EMC.							
H2a	$\leq 1.82$	$\geq 0.196$	---	---	---	---	Supports
H2b	1.64	0.260	---	---	---	---	
H2c	1.12	0.352	---	---	---	---	
H2d	3.66	0.053	0.117	Rej. $h_0$	---	---	
H3. Expert teams will recognize and use data and situation information better than novice teams in solving the problem in the EMC.							
H3	5.79	0.033	0.111	Rej. $h_0$	---	---	Supports
H4. Expert teams will use more domain knowledge than novice teams in solving the problem in the EMC.							
H4a	1.58	0.239	---	---	---	---	Supports
H4b	6.98	0.022	0.111	Rej. $h_0$	---	Rej. $h_0$	
H4c	1.06	0.396	---	---	---	---	
H4d	8.33	0.014	0.111	Rej. $h_0$	Rej. $h_0$	---	

### *Summary of Results*

Table 8 summarizes the results of the tests for each research hypothesis. In several of the research hypotheses, specifically H2 and H4, some tests fail to reject the null test hypotheses of equal means between the expert teams and novice teams. However, in these two research hypotheses, there is at least one test that successfully rejects the test null hypothesis and indicates there are reasons to accept the research hypothesis. The implications, conclusions, and recommendations regarding these results will be discussed next.

## **Conclusions and Recommendations**

The purpose of this section is to summarize the results of the data analysis, discuss the results and the conclusions that can be drawn from them, and recommend further research and use of the simulation for learning.

### *Summary of the Hypothesis Testing*

The results of the data analysis and hypothesis testing indicate that all of the research hypotheses should be accepted. There are several hypothesis tests that fail to reject to the null test hypothesis under some research hypotheses.

Under Hypothesis 2, three tests—timing of data access, repetition of data access, and requests for provided data—were not rejected at the level of 5% significance. One possible conclusion here is that all three groups used the same timing pattern for first access to data and needed to repetitively access the provided data and make requests, possibly because the research process of weekly episodes may have caused participants to forget data that was previously accessed. It is also possible that data were presented in an ambiguous manner causing expert teams and novice teams alike to seek clarification. In the timing of data access there are differences among the three experiment groups for percent CORs first accessed by lab period, but statistically are not conclusive. However, it is possible that a larger sample size would generate statistically valid results.

But there is another question to consider: Are these two tests valid for proving the hypothesis? In the real world we would expect experts to understand the data presented (if presented well) better than novices and therefore to have less need to repetitively access it or seek clarification. It is possible that the test situation does not mirror the real world in this respect. For the fourth test under H2, requests for withheld data, the results do support the research hypothesis, indicating some validity for this research hypothesis. The results for H2 motivate further research with larger sample sizes and a modified research process that reduces time between lab periods.

Under H4 two tests failed to be rejected—requests to explain domain principles and number of invalid domain principles verbalized. The averages in both of these tests appear to support the hypothesis, especially with the nondomain experts making the most requests and the domain experts verbalizing the least invalid domain principles. However, the dispersion of the data and hence the standard deviation of the distribution causes the tests to fail. One explanation for the failure of the test regarding requests to explain domain principles is that domain experts understand domain principles better and have less need to request explanation, while novices do not understand the domain principles and don't ask because they don't know what they don't know or are afraid to ask in order to keep from looking bad. A possible explanation for

verbalizing invalid domain principles is that novices do not have enough knowledge to formulate invalid principles or, again, may be afraid to verbalize in order to keep from looking bad. The results of the other two tests support the acceptance of research H4.

It is important to point out that the sample sizes of the three groups are very small and the results obtained should be considered in that light. Therefore, the results are not conclusive. They do, however, indicate that additional research with larger numbers of participants would be beneficial for providing better statistical evidence.

#### *Unexpected Research Results*

There are several categories of behavior that were unexpected in this research: behavior due to vividly presented information; the use of heuristic decision making rather than any form of optimization or rigorous analysis; and nondomain experts' behavior in several unexpected ways.

#### *Vividly Presented Data*

There are three instances in the simulation in which vividly presented information was presented by the characters: Morton regarding use of overtime, Lund regarding use of the capital budget, and Stump regarding use of scheduling. The manner in which the information is presented in these three CORs is an emphasis through voice tone and additional personal involvement, whereas the information presented in other CORs is matter of fact with little or no emphasis. A primary question is: Did this vividly presented information have any effect on the difference in behavior among the three research groups?

The first instance is Morton, the plant manager, who strongly cautions the participants to make sure that overtime is necessary before using it. He explains that he is very careful using overtime because employees hate to work extra time but like the extra pay, and when you remove the overtime they hate to lose the extra pay. The second instance of vividly presented information is Lund, manager of accounting, who discusses the capital budget. He says, "You don't have to spend all of it, you know; if you don't spend all of it that would be good." His voice tone is very gruff and is accented by his curt last statement, "That is all, you may go." The third instance of vividly presented data is Stump, manager of materials, who does the scheduling. He makes a point of initially telling the participants "do not mess with my schedule." After the simulation time is advanced two days, Stump then makes an appeal for help as he says, "I'm really busy, and I could use your help in scheduling."

In the first two instances, novice teams were hesitant to make decisions while the expert teams were not hesitant, indicating the novices were influenced by the vividly presented data while the experts were not. Unlike the other two instances of vividly presented information, in the case of Stump's appeal expert teams exhibited the same type of behavior as novice teams. The question of whether the vividly presented data affected the behavior is confounded with other possible causes, such as the availability of scheduling and its immediate feedback (in the minds of the participants), which seemed to be the decision most directly connected to influencing the backlog, and the challenge of the unexpected feedback about the status of the backlog. Participants took the attitude that doing scheduling is not incorrect, that they just had not figured out the right way to do it. Many teams, both novices and experts, expressed the fact that there was an optimal way to determine scheduling, which, in fact, there was not.

Studies have shown that vividly presented data affect behavior (Plous 1993). Nisbitt & Ross (1980) have shown that decision makers are affected more strongly by vivid information than by pallid, abstract, or statistical information. The results of this study indicate the possibility

of some connection between participant behavior and the manner of presentation of the information. Further research is suggested below.

### *Heuristic and Optimizing Decision Making*

Although teams attempted to find ways to optimize scheduling, or at least consider it, they did not attempt to optimize the total solution to the problem. This is contrary to the education provided to IE students, which provides much instruction on how to optimize solutions. The optimizing solution to the research problem, which provides the best solution to the problem, is generated by a nonlinear integer program and requires the decision maker to assess all the available information, make some assumptions about costs and yield rates (or requesting the information from the appropriate virtual employee), and construct the model. No team even contemplated this possibility. The teams instead used naturalistic (heuristic) decision making. Klein (1998) has shown that optimization does not take place in the real world and that instead, problem solvers use some sort of recognition process, heuristics, and mental simulation to determine the best approach.

Klein (2001) provides a number of barriers to performing optimization and suggests that optimization not be used as the standard for decision making and that instead the standard of comparison be based on those solutions generated by subject matter experts. It seems that in the simulated situation, as in the real world, the novices, the nondomain experts, and even the expert participants found it more suitable to avoid the barriers of optimizing and make do with the heuristic process.

### *Unexpected Nondomain Expert Behavior*

The nondomain experts performed in several unexpected ways, detailed at the end of the previous section. The same reasoning for their behavior applies to all the specific variables that were tested. The four nondomain experts have PhD's and were teamed up as follows: one team consisted of domain expertise in cognitive psychology and accounting; the other team consisted of domain expertise in economics and organizational development (OD). The OD participant on the second team also has extensive experience in developing and using system dynamics models. Three of the domains of the nondomain experts—accounting, economics, and organizational development—have some degree of overlap with the domain of industrial engineering. The experience in system dynamics also provides additional knowledge about systems and system behavior. This overlap of knowledge is one reason that the nondomain experts would behave as the domain experts. Another possible reason is the superior critical thinking skills that those with PhD's would have. Partial domain knowledge and high levels of critical thinking skills would allow these nondomain experts to behave like experts at times.

### *Recommendations for Future Research*

The current research has shown that the task embodied in the virtual world simulation is generally a representative IE structurable problem situation. The results speak only to the differences between experts and novices, where the novices struggled to structure the problem and solve it while the experts were able to do so. Follow-up research should be done in several areas that will inform the use of simulations in the classroom. Formal research as well as classroom research should be conducted. The areas in which we recommend changing or adding aspects to the current research are the participants, the simulation itself, using decision aids,

measuring domain knowledge, and comparing learning from the simulation to that from other forms of instruction.

#### *Research Participants*

Many of the novice participants were international students who did not have good English speaking skills. This restricted the data in terms of verbal protocol analysis and may have even limited the performance of these students. Future clinical research should use participants with English speaking skills at near native speaking ability in order to provide verbal data that accurately represent the cognitive process. Of course, classroom research would necessarily use the students enrolled, but English-speaking ability should be a variable.

#### *Simulation Modifications*

Even though the virtual employees had different voices and personalities, their characters were presented only verbally. Additional graphical representation of these employees would enhance the reality factor and perhaps increase the recall of these characters and who they are. Many teams within a session and between sessions could not remember which virtual employee said what or had what data. Similarly, the current research process consisted of the time between sessions of a week, and this tended to influence the participants' recall of what had taken place previously. Providing a graphical track record of recent activity would help alleviate this situation, but shortening the time between sessions to no more than two days would increase recall capability of recent activity. The final suggested change is to add the ability to control the vividly presented information of Morton, Lund, and Stump, providing several experimental conditions to obtain results of this effect on the performance of the participants.

#### *Research on Decision Aids*

For the third area of interest we recommend including the use of decision aids in the research similar to what others have studied in terms of how they affect performance in problem solving and decision making (Browne, Curley, & Benson, 1997; Spence & Brucks, 1997). Four types of aids to study and their effect on the decision-making process and the outcome of the problem solving are formal justification for decisions; decision structuring tools such as spreadsheet templates; question prompts; and knowledge mapping.

#### *Measuring Domain Knowledge*

A fourth recommendation for further research is to create and administer a domain knowledge test that would measure domain knowledge of the participants both prior to and after the research. It would provide a baseline for comparison of performance, and the correlation between the test results and performance could be calculated. This is also a critical feature in comparing the learning between different instructional methods.

#### *Comparison of Learning in a VWS to Learning from Other Methods*

This area of study is wide open, and little research has been done in comparative learning methods involving simulations. Clark and Mayer (2008) report that when it comes to learning there is more we don't know about simulations and games than we do. One major question to consider is "What are the alternative methods to using a virtual world simulation?" The other research area to explore is the effective design of the simulation and how it influences learning. The answers to these questions lie partly in pedagogy and partly in technology. These two areas

of knowledge must be integrated in such a way as to make the learning process effective. What might be pedagogically sound or necessary may not be implemented cost-effectively by technology (at least currently), and what can be implemented by technology may not be pedagogically sound.

### *Simulations vs. Case Studies*

Case studies are the closest teaching method to simulations. They provide real or virtual situations with corresponding data and information, and normally have well-defined learning outcomes. Research should include using a case study of the Excellent Manufacturing Company to compare to the simulation. Pre- and post-tests should be given and well-designed instructional activities utilized for both. The simulation version should be redesigned to meet the qualities proposed by Clark and Mayer (2008), which include making learning essential to progress, building in guidance, promoting reflection on correct answers, and managing complexity. And these same principles should be applied to utilizing the case study as well. Both the simulation and case study would benefit from using case method instruction guidelines proposed by Barnes, Christensen, and Hansen (1994). The only difference in activity between the two would be the dynamic feature of the simulation allowing students to try different solutions and dynamically experience the consequences. Care should be taken in keeping instruction methodology consistent to avoid the instructional problems of inconsistency encountered by Stepich, Ertmer, and Lane (2001).

### *Effective Design Of Simulations for Learning*

Finally, we propose that the Excellent Manufacturing Company simulation be used to study guidelines for effective simulation design. Clark and Mayer (2008) suggest the following areas for effective balance of motivational and learning elements: guidance for different instructional goals at different learning stages; simulation taxonomies for different learning outcomes; cost-benefit of simulations; personalities that prefer simulations; effective simulation interface; and level of interactivity. The research will likely require several rounds of modification and updating in a sequential fashion.

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# The Impact of More Rigorous Grading on Instructor Evaluations: A Longitudinal Study

Donald A. Schwartz

## Abstract

In 2001, the provost of National University in San Diego, California initiated a campaign to increase the quality of instruction and raise academic standards. As a way of reflecting the achievement of these goals, target class GPAs were established throughout the university. For undergraduate courses, the target GPA was set at 2.75, approximating a B-. At the graduate level, the target was set at 3.25, or about B+. Since class GPAs and instructor ratings are reported for every course, there were ample data with which to measure the impact of increased grading rigor on students' evaluations of their instructors. This paper takes advantage of this unique opportunity to study the effect of an anti-grade inflation initiative and its impact on instructor ratings for all of the university's business school classes over a six-year period. It was surprising to many faculty members (less so to administrators) that the results of the study clearly contradict the contention that more rigorous grading begets lower ratings from students—at least from the nontraditional type of students that attend this university.

## Key Words

Grade inflation, Grade point average (GPA), Target GPA, Instructor evaluations, Study production, Learning production, Expected grade.

## Introduction

While the author was unable to find any prior longitudinal studies of the type described in this paper, there have been many studies dealing with the correlation between students' grades and their evaluation of instructor performance. One of the more comprehensive reviews of prior studies was conducted by Stumpf and Freedman (1979). These authors reviewed 36 empirical studies of the grade-evaluation relationship; 31 dealt only with undergraduate classes, while the remaining 5 included graduate classes. The results of these studies were widely inconsistent. The majority resulted in some degree of positive correlation that ranged from weak to moderate, except for one small study (160 students in 12 classes) that showed a strong correlation ( $r = .85$ ,  $p < .01$ ). Those reporting positive correlation included Aleamoni and Spencer (1973), Barnoski and Sockloff (1976), Bendig (1953), Blass (1974), Brandenburg, Slinde, and Batista (1977), Brown (1976), Frey (1973, 1976), Frey, Leonard, and Beatty (1975), Gaverick and Carter (1962), Hocking (1976), Holmes (1971), Kelly (1972), Kovacs and Kapel (1976), Mirus (1973), Petty (1975), Pohlmann (1975), Pratt and Pratt (1976), Remmers, Martin, and Elliott (1949), Rubenstein and Mitchell (1970), Russell and Bendig (1953), Schuh and Crivelli (1973), Schwab (1975), Schwab and Forrest (1975), and Sullivan and Skanes (1974). Others reported near zero correlation: Elliott (1950), Endo and Della-Piana (1976), Frey et al. (1975), Miller (1972), Remmers (1928), Treffinger and Feldhausen (1970), Voeks and French (1960), and Stone, Schmitt, and Rabinowitz (1977). And two reported negative correlation: Rodin and Rodin (1973) and Whitely and Doyle (1976). Overall, the correlation coefficients in these studies fell within a very wide range, from  $-.75$  to  $+.85$ , with a median of  $.21$ .

Two years earlier, Feldman (1976) reviewed a different set of studies and found a somewhat narrower but still wide range of correlations,  $-.04$  to  $+.63$ . Stumpf and Freedman acknowledge that the wide variation may be confounded by other variables such as the instruments used, aspects of the samples, and the institutions studied. Nevertheless, they believe

that the literature supports the position that expected grades positively correlate with instructor ratings. They further opine that the argument that students are biased in their evaluations is a tenable one and that if administrators fail to consider this when making decisions about pay, promotion, and tenure, then easy-graders could be perceived as having an unfair advantage—leading to diminished faculty acceptance of student evaluations as a basis for performance evaluation. By way of personal observation, it would seem that with half the studies reporting a correlation of less than .21, there is as much evidence to suggest that a significant correlation does *not* exist as there is evidence to support that it does.

More recent studies by Marsh (1980), Marsh and Roche (1997), and McKeachie (1997) conclude that while in certain circumstances it may be possible for instructors to effect higher student evaluation scores by lowering work requirements or grading leniently, generally this is not the case. They suggest that many students rate easy graders as poor instructors.

In their review of related literature, Stratton & Meyers (1994) found several empirical studies—e.g. Capozza (1973), Mirus (1973), Nelson and Lynch (1984), and Zangenehzadeh (1988)—that show a positive correlation between students' expected grades and their rating of the instructor. As to a possible cause, they point out that the methodologies used in such correlation studies cannot determine whether higher grades are the result of instructors being motivated by student ratings to become more effective teachers, or whether instructors are simply buying higher ratings by lowering their grading standards.

Greenwald and Gillmore (1997) found a significant positive correlation (.45) between instructor ratings and course grades and asserted that a teacher can effect higher student evaluation scores by raising student grade expectations. However, McKeachie (1997) suggests that Greenwald and Gillmore did *not* prove that higher grades generally bias upward the ratings of the instructor. Rather, students give high marks to instructors from whom they have learned more and, having learned more, would expect a higher grade.

Sailor and Worthen (1997) focused on the correlation between grades and instructor ratings at each of three course levels: lower division, upper division, and graduate courses. They found essentially the same moderate positive correlation for lower and upper division courses, .29 and .28, respectively, but encountered an unexplained negative correlation of  $-.20$  for graduate courses.

Concerned about the fairness of using student ratings as the primary basis for evaluating faculty, Stapleton and Murkison (2001) conducted a study dealing with the correlation of instructor ratings to several variables, including *study production* (the amount of hours per week students said they studied outside of class), *learning production* (students' perception of how much they learned in this class compared to other classes), and *grade expectation* ("I expect the grade I receive for this course will be [from *much lower* to *much higher*] than the grade I think I deserve"). One of their hypotheses—that the higher the instructor excellence score, the higher the expected grade -- was substantiated in their view by a positive correlation coefficient of .26.

## **Background**

National University is a private nonprofit university founded in 1971 in San Diego, California. Its mission is to provide adult learners with affordable access to high-quality undergraduate and graduate degree programs. Of its 18,000 students, about half are in the San Diego County metropolitan area, and the other half are spread among more than a dozen campus locations throughout Northern and Southern California and Las Vegas. A unique feature of the university is its “one-month” format. Except for project classes and practica, each course is four weeks long, with students attending two 4½-hour classes per week, plus one or two half-Saturdays per month. Contact time ranges between 40 and 45 hours per course. Approximately 85% of the courses are taught by part-time faculty who teach three or four classes per year on average. The remaining 15% are taught by full-time faculty who average about seven courses per year.

At the time of the study, the university was divided into four schools/colleges: Education (the largest school), Letters and Sciences, Engineering and Technology, and Business and Management.. This study deals with the School of Business and Management, which at the time of the study had three academic departments: Marketing, Management and eBusiness (MME); Finance, Accounting and Economics (FAE); and Professional Studies (PS), which includes Criminal Justice, Forensic Science, and Public Administration programs. In essence, nonquantitative business courses are housed in the MME department, and quantitative courses in the FAE department.

By way of demographics, the average age of business school students at National University is 32. Slightly more than half are female; 48% are Caucasian and 52% are other ethnic groups, including African American, Hispanic, and Asian. About 5% are international students with student visas.

Though the business school offers some lower-division preparatory courses, such as financial and managerial accounting fundamentals, and micro- and macroeconomics, most of its undergraduate courses are upper-division courses in the school’s business and professional degree programs. Several graduate programs are offered, including MBA, MPA, and other professional degree programs.

## **The Instructor Evaluation Process**

In the case of onground classes, students are asked to complete an evaluation questionnaire on the last weeknight of every course before the Saturday final exam. Instructors step out of the room, and students are told that instructors will not be allowed to see the evaluations until after they have posted the grades for the course. All students’ handwritten comments are typed in order to preclude instructors from identifying the author of negative comments by his or her handwriting and possibly retaliating against that student in a subsequent class.

The instructor evaluation questionnaire from which instructor ratings were calculated remained unchanged during the period studied. Students use a 5-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree. Zero is used for Not Applicable. The instrument contains the following ten questions:

1. Course was well organized; class time was used effectively.

2. Stated course objectives were achieved.
3. Instructor gave clear explanations.
4. Instructor was receptive to questions.
5. Instructor stimulated critical thinking.
6. Instructor encouraged students to make independent judgments.
7. Method of assigning grades was clear.
8. Instructor was available for needed assistance.
9. This course gave me a deeper appreciation for this field of study.  
plus
10. Overall, I rate the instructor of this course an excellent teacher.

The resulting computer report for each class shows (a) the mean for each of the nine questions, (b) the mean of those means (anathema for statisticians), and (c) the mean response to the overall rating called for by Question 10. In arriving at the correlation coefficient, the average of the nine means was used rather than the mean of the overall rating. This choice was based on the premise that students answer the nine questions more thoughtfully and objectively than they do Question 10, which is perceived by some as being more a measure of instructor popularity than of teaching excellence. As it turns out, the .964 correlation between the two evaluation scores was close to being a perfect 1, so the use of either measure would have led to the same conclusion.

#### *Expected Grade vs. Actual Grade*

At the time students complete their evaluation of the instructor, they cannot be certain what grade the instructor will award, so if a student's evaluation of an instructor was influenced by his or her grade for the course, it would be the grade that the student expected to receive, rather than the grade he or she actually did receive. However, for most classes, students are able to gauge the instructor's level of grading rigor from their scores on midterm exams, assignments, and other grading factors. Indeed, Feldman's (1976) review of prior studies cited evidence of a close correspondence between actual and expected grades and found that in studies that used both, there was no substantial difference in results. Stumpf and Freedman (1979) found a similar close relationship between expected grades and actual grades.

#### *The Setting of Target GPAs*

In 2001, National University's provost initiated a campaign to combat grade inflation by calling upon instructors to increase rigor and raise their academic standards. As evidence of increased rigor, the provost announced GPA target maximums of 2.75 for undergraduate classes, and 3.25 for graduate classes. Graduate students are required to maintain a "B" average or 3.0 GPA. For undergraduates, the threshold is 2.0. Many of the faculty contended that when students who had been receiving A's and B's started getting B's and C's instead, they would reciprocate with lower instructor ratings, thus hurting the faculty member's chances of receiving merit pay increases. Some of the part-time faculty, either in ignorance or as a conscious effort to avoid possible student retaliation, went so far as to announce to their students, "There is a new university policy that limits the number of A's and B's that we instructors are permitted to give out." There was, of course, no such policy. It was explained a number of times in the months that followed that these were meant as approximate target figures, not absolute thresholds and that

the class GPAs for a given instructor would be looked on favorably if the average of the instructor's GPAs over several classes was reasonably close to these targets.

In the years following the setting of these targets, the performance of both full-time and part-time faculty has been measured in part by the degree to which GPA targets have been met. Even today, the department chairs in the business school receive monthly reports covering the past 12 months of classes that show both GPAs and evaluation scores of all of their faculty, both full-time and part-time.

### Data Analysis and Discussion

While most business school instructors teach both undergraduate and graduate courses, the students are of course different, graduate students being somewhat older and having more college experience. So their behavior with respect to evaluating instructors might differ from that of undergraduate students and thus produce different results. However, as shown by the lower trend line in Figures 1(a) and 1(b), the campaign to raise standards and increase rigor proved effective at both levels: Class GPAs dropped considerably in 2001 and 2002 as the initiative took effect, both for undergraduate and for graduate courses. Yet, the upper trendline representing student ratings of instructors was virtually flat in both cases.

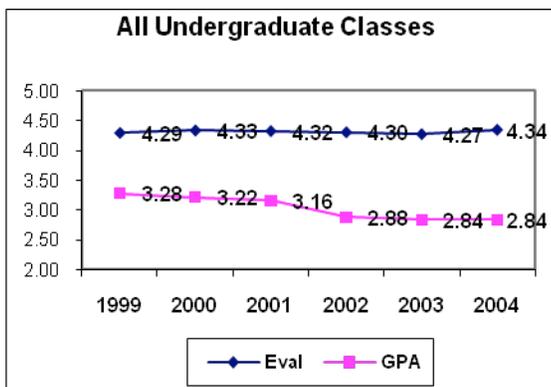


Figure 1(a)

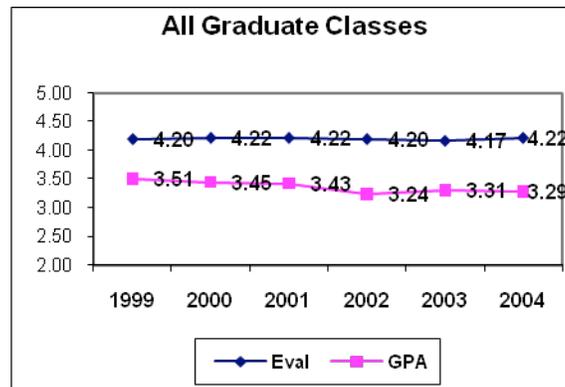


Figure 1(b)

To measure the degree of change, the years 2001 and 2002 were considered the years in which the initiative was launched and received particular emphasis by academic administrators. The prior two years, 1999 and 2000, are considered the “before years” and 2003 and 2004 are the two “after years.” To measure the degree of change in GPAs, the average of the GPAs for 1999 and 2000 was considered the “before” benchmark, whereas the average of the GPAs for 2003 and 2004 was considered the “after” figure. The percentage of change was calculated by dividing the difference between the “before” and “after” by the “before” figure. The same approach was used to measure the percentage of change in students’ instructor evaluations.

Over the six-year period of the study, the number of undergraduate courses remained steady at about 725. The average of the GPAs in these classes decreased 12.6%, from 3.25 (the average of 1999 and 2000) to 2.84 (the average of 2003 and 2004). In terms of letter grades, this

represented a drop from a B+ to a B-. Instructor evaluations, on the other hand, were virtually unchanged, declining just 1/10 of 1 percent.

At the graduate level, the number of classes increased somewhat from 518 in 1999 to 634 in 2004. GPAs declined from 3.48 to 3.30, a 5.2% decrease. That this decrease in GPAs was substantially smaller than the decrease for undergraduate classes was not surprising, given the much smaller distance between the “before” grades—which for graduate courses averaged 3.48—and the targeted GPA of 3.25. This 23/100 of a point distance was less than half the 50/100<sup>ths</sup> improvement needed to achieve the target GPA at the undergraduate level. However, as in the case of undergraduate courses, the instructor evaluations remained almost unchanged, declining from 4.21 to 4.20 or just 4/10 of 1 percent.

Thus, the analysis showed that while there was a significant decline in GPAs at both the undergraduate and graduate levels, the impact on student ratings of instructors was negligible in both cases.

The question then arose as to whether the impact might in fact be greater in certain types of courses, but might be masked by the use of aggregated figures for all classes without distinction as to type or other differential. To look into this possibility, the class-related data were disaggregated into two subgroups: nonquantitative courses vs. quantitative courses, and classes taught by full-time faculty vs. those taught by part-time faculty.

#### *Nonquantitative vs. Quantitative Courses*

Among the nonquantitative courses in the business school are Management, Leadership Marketing, and E-business, while quantitative courses include Statistics, Management Science, Economics, Accounting, and Finance.

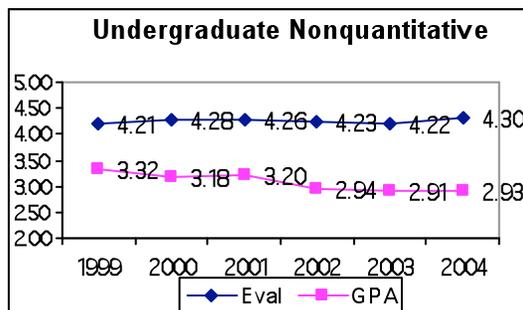


Figure 2(a)

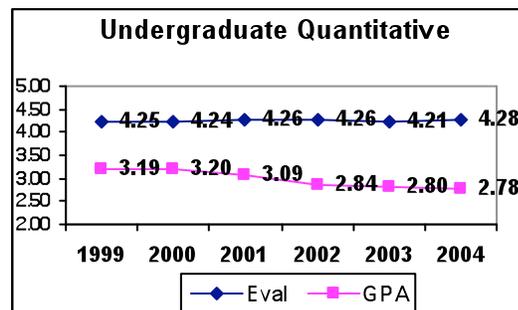


Figure 2(b)

At the undergraduate level, GPAs in nonquantitative classes declined 10.2%, while instructor ratings actually rose 4/10 of 1%. For quantitative undergraduate courses, the decline in average GPA was 12.7%, close to the overall school results, whereas the change in instructor ratings was nil, at 0.0%.

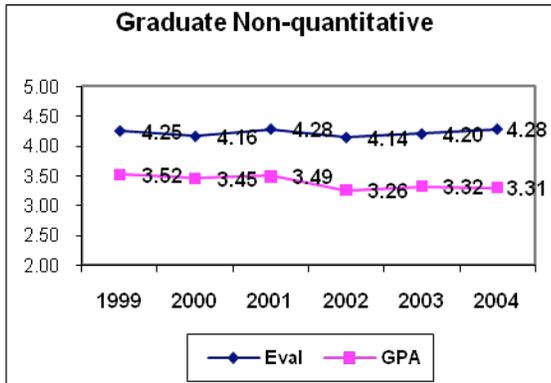


Figure 3(a)

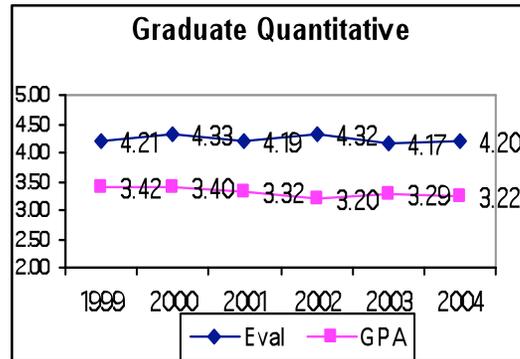


Figure 3(b)

At the graduate level, GPAs for nonquantitative courses—see Figure 3(a)—declined 4.9%. Instructor ratings bounced somewhat from year to year, but in the overall *rose* a very slight 8/10<sup>t</sup> of 1 percent, similar to the effect on ratings at the undergraduate level. For quantitative courses—see Figure 3(b)—the decline in the average GPA was 4.5%, accompanied by a decline in instructor ratings of 2%. This 2% decline in instructor ratings was by far the greatest percentage decline of any category, which some might consider evidence to support true downward pressure on instructor evaluations. However in statistical terms, the *r* correlation coefficient for the six years of GPAs matched against the corresponding instructor evaluations was an insignificant .01.

#### Full-time Faculty vs. Part-time Faculty

The 16.4% decline in GPAs for undergraduate classes taught by full-time faculty—see Figure 4(a)—was the greatest of any category, in letter-grade terms from a B+ to below a B-. Indeed, the GPA even fell below the 2.75 target. Yet the impact on instructor evaluations was again insignificant at 8/10 of 1 percent. The 11.8% decline for classes taught by part-time faculty—see (Figure 4(b)—was less pronounced than for classes taught by full-time faculty. The corresponding change in instructor ratings was nil, at 0.0%.

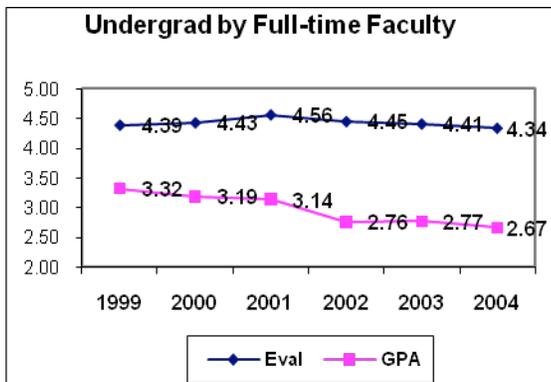


Figure 4(a)

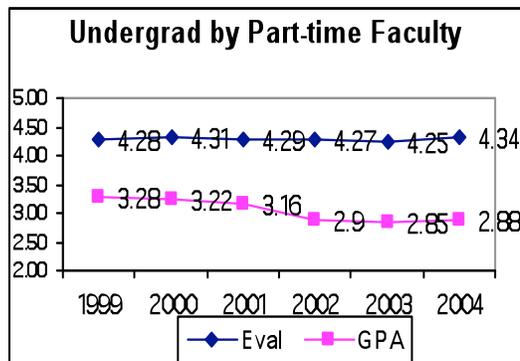


Figure 4(b)

At the graduate level, the 5.9% decline in the average GPA for classes taught by full-time faculty—see Figure 5(a)—was slightly more than the 5.0% decline for classes taught by part-time faculty shown in Figure 4(b). But in both cases, the decline in instructor ratings was negligible: 3/10 of 1% for full-time, and 1/10 of 1% for part-time faculty

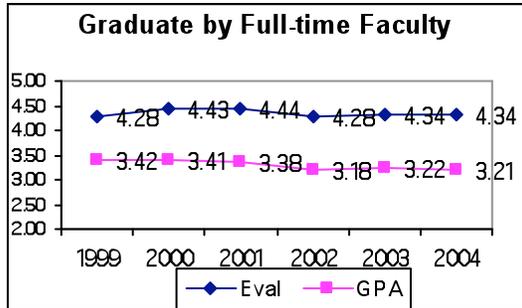


Figure 5(a)

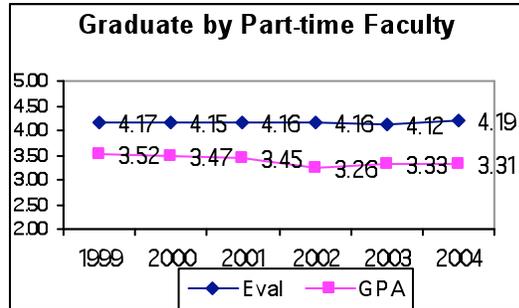


Figure 5(b)

### Summary of Findings and Conclusion

The data analysis dealt with 10 sets of variables: In addition to the major groupings of undergraduate vs. graduate courses, the data were subgrouped into quantitative vs. nonquantitative courses and also into classes taught by full-time vs. those taught by part-time faculty. In all ten cases, there was a significant decline in class GPAs. For the undergraduate courses, the decrease in class GPAs ranged from 10.2% for nonquantitative courses to 16.4% for quantitative courses. For graduate courses, the decreases ranged from 4.5% to 5.9%. Yet, in only one of the cases was there a decline in instructor ratings of more than 1%—i.e., 2.0%. But in all other cases, the decline in ratings was less than ½ of 1%.

Table 1  
Percentage of Change

Undergraduate Classes		% Change		<i>r</i>	Critical Value*
		GPA	Eval		
1a	All undergraduate classes	-12.6	-0.1	.13	
2a	Nonquantitative	-10.2	0.4	-.16	
3a	Quantitative	-12.7	0.0	-.06	
4a	Full-time	-16.4	-0.8	.34	
5a	Part-time	-11.8	0.0	.12	
Graduate Classes					
1b	All graduate classes	-5.2	-0.4	.28	
2b	Nonquantitative	-4.9	0.8	.40	
3b	Quantitative	-4.5	-2.0	.01	
4b	Full-time	-5.9	-0.3	.45	
5b	Part-time	-5.0	-0.1	.04	

\*Critical value at  $\alpha = .05$

Some variables could not be tested for lack of available data: With an average age of 32, ten years of work experience, a high ratio of married vs. single, and an even higher ratio of students who pay for their education themselves, National University's student body is labeled "nontraditional." There were no available data with which to determine whether so-called traditional students might be more likely to downgrade instructors for being tough graders. Nor could it be determined whether female students tend to react differently to increased grading rigor than male students, nor whether the gender of the instructor might make a difference. However, for the student and instructor profiles that existed in the business school during the period covered by the study, the results clearly contradict the contention that an increase in grading rigor begets lower student ratings.

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# **Game Frame of Reference as a Precondition for Students' and Teachers' Self-Realization**

Natalie Losyeva

## **Abstract**

Living in a time of change and reorientation in many fundamental aspects of life, an individual faces a problem of self-determination and self-realization as well as feelings of uncertainty. Heightened development and complexity of the modern man's personality requires special effective methodology for its successful implementation in the educational process. There is a growing demand for new interactive technologies in the educational process throughout the world. This paper discusses theoretical aspects and the practical experience of teaching in contribution to teachers' and students' self-realization, and it presents the use of cognitive didactic games as a means for joint creative activity and interpersonal communication that can contribute toward that self-realization.

## **Key Words**

Self-realization, teaching mathematics, interpersonal communication, joint creative activity, didactic game, analytic geometry

## **Introduction**

Our rapidly changing social life structure and unpredictable life conditions challenge every individual's self-determination and self-realization. Despite increases in scientific and technical innovations, the number of special research works devoted to high school students' and teachers' self-realization is relatively small.

Taking into consideration the uniqueness of each teacher and student, it is necessary to create a pedagogical environment that would provide for their positive, versatile, and adequate self-realization and would be a foundation for their subsequent prospects of development. However, not enough attention is given to the creation of corresponding organizational-pedagogical conditions in educational institutions. Hence, there is a relatively wide discrepancy between existing possibilities and the demand for students' and teachers' self-realization in the educational process.

The main purpose of this paper is to offer my personal opinion and experience concerning teaching of mathematics with a view to creating conditions for teachers' and student's self-realization. My assumption is that aspiration to self-realization is one of the chief motives of personal development that induce and direct individual activity. It is thus necessary for teachers to refrain from an authoritative style of thinking and to master a democratic style of pedagogical activity based on cooperation, interaction, and creation of conditions for self-realization. A teacher who focuses only on the cognitive side of educational activity has a few chances to educate, because filling "the room of knowledge" does not promote personal development. Under such conditions students function in an artificial world of disciplines and artificial forms of activity, with very little reference to professional activity. Instead of becoming proficient in a professional area, the student only receives pure knowledge of it.

Traditional study uses artificial forms developed specifically for "knowledge transfer," with lecture dominating among them. Moreover, traditional lectures are often cognitive-passive and develop critical thinking insufficiently. The activity structure by definition contains motive-purpose-means-method-result-correction of the subject of activity, resulting in the educational activity becoming much more effective. In the conditions of traditional study, the mechanism of goal setting

and goal achievement is not formed; goals and tasks are already generated and imposed by the teacher, and students at best accept the offered goals. The same could be said about decision making: Traditional study is not intended to create situations where a student could and should make the decision and learn to bear responsibility for it; most student exercises are clearly formulated, while most real-life problems are not. Thus, the reasons for underestimating potential possibilities of the student and enhancing his or her continuous social and psychological dependence can be found in conformist character of traditional pedagogical activity. Infantilism of many modern young men is a by-product of traditional education.

Unfortunately, there still is a prevailing thought among a great number of teachers that their focus should be knowledge transfer. Methods are mainly developed for this concept: All necessary information is regularly given at the lectures, and then by various means (such as a practical tasks, seminars, etc.) it has to be memorized. The educational process in high school is still very often reduced to direct reference to students' memory, and not enough attention is given to development of their activity and attraction to solving of actual problems. Much emphasis is placed on learning standard solutions to existing problems, but little time is spent in developing creative thinking in students.

Such expert training methods do not provide qualitative education, because quality is determined not by the knowledge checked at examinations but by the ability to find new decisions and independently obtain new knowledge. The aim of pedagogical activity of the modern teacher must shift away from the desire to give students a maximum of knowledge and toward a tendency to develop their creative potential and give a maximum of adaptability. The aim of the academic process is to create conditions for realization of student creative potential as soon as possible. The creative qualities of an individual are formed not by storing up everything given during lectures, but in the process of certain purposeful activity—activity generated by important personal requirements, activity accompanied by emotions that create an effective motive for it.

Hence, the system of student training should approach this pattern—that is, the focus should be personally significant purposeful activity instead of aspiration to simple memorization. Teacher should understand that the academic process should increase inquisitiveness in students; it should evoke interest instead of diminishing their desire to learn. Consequently, the system of specialist training should take into account conditions that cause emotions and use them widely in educational process. Otherwise, the study process will be uninteresting and, accordingly, results will be unsatisfactory.

### **Self-realization in the Educational Process**

Teachers, for the sake of their own self-realization and the self-realization of their students, have to reconsider methods of pedagogical activity and develop a curriculum that combines education with the learner's future activity. Students should feel their growing professional skill from the first year of study, so that each new skill they develop results not just from academic requirements. Such situation will lead to the occurrence of positive emotions that immeasurably increases the students' abilities and plays a huge role in improvement of training quality and self-realization.

I suggest that a cognitive didactic game may help teachers achieve these tasks. Games have special value in human life; people play from childhood until the end of their lives—only the forms of game may differ. Games are unmistakably connected with problem solving that demands self-

dependency, creativity, activity, joint efforts, and direct interactions. The problems of didactic games have emotional coloring and consequently are better perceived.

Interactive technologies can be used as a stimulating factor in student activity. Teachers who can design lessons that are interesting and captivating may expect learning to be more effective, as this approach deeply involves the learner and is seen as an entertainment instead of something tedious and uninteresting for students.

However, in order to see a positive side of using interactive technologies in the educational process, teachers should aspire to self-realization in professional-pedagogical activity and share the following valuable purposes: (1) joint creative activity, (2) dialogical (interpersonal) communication, and didactic games.

### *Joint Activity*

Joint activity allows its participants to make something important together. There is a situation of general creativity when participants make something new (objectively or subjectively), and each of them themselves as a creative person.

The problem of joint creative activity has three dimensions for the teacher. The first dimension is the organization of joint activity of students with each other. The second dimension is a joint creative activity of teacher and student. The third dimension is a joint creative activity of teachers. And if the first dimension does not directly concern problems of teacher self-realization (the teacher is the organizer but not the participant of joint activity of students), the other two dimensions are much more closely connected with teacher's creative self-realization. In joint activity of the teacher and the student, the student feels himself or herself as a subject of creativity (the student is doing something never done before). Is the teacher a subject of creativity under such circumstances? Yes, if he or she sees the educational aspect of joint activity—the teacher's creativity is in development of the student's personality. Creativity of the student is directed on changing the world around him or her, while creativity of the teacher is directed onto education and development of students. Similarly, in the process of joint creative activity with colleagues, various possibilities of creative self-realization open before the teacher. Therefore, valuable orientation on joint creative activity with students and colleagues is one of the major determinants of the teacher's self-realization in professional work.

### *Dialogical Communication*

Joint activity of people is possible only by means of their communication. Therefore, dialogical communication as another valuable orientation that defines the process of teacher professional self-realization. In pedagogical activity, communication through dialogue is considered as a condition of realization of subject-to-subject relations between the teacher and the student, unlike traditional subject-to-object (monologic) relations. While subjects are divided into active and passive in a monologic communication system, dialogical communication requires activity of all participants. The essential attributes of *interpersonal communication* include independence of dialogue, equality of interlocutors, and mutual understanding.

With independence of dialogue, partners do not intend to influence each other, creating optimum conditions for real influence on the development of personality, as freedom of self-determination is necessary for personal growth. It is freedom of self-realization, freedom to be yourself that plays the leading part in a dialogue. At the same time, assuming responsibility for oneself and one's freedom makes one more attentive and tolerant to opinion of others. Freedom of dialogue partners is not absolute; it is limited by an range of rights.

Equality of interlocutors as a “mutual recognition of each other's freedom” is the second attribute of interpersonal communication. Solving the most important communicative problem of matching the rights (rights agreement), scientists offer original model of “communicative rights of the person” together with “communicative responsibility of the person.”

The third attribute of communication is a personal contact between interlocutors on the basis of empathy and mutual understanding. Mutual understanding creates a contact rationale, but it is the empathy as emotionally intuitive comprehension by interlocutors of each other's private world that creates unity of a experience matching that is a deep basis of contact, “a dialogue connecting-link.” Other features of interpersonal communication—openness and interlocutors’ trust, their co-authorship—are deduced from the three abovementioned attributes.

This leads us to the conclusion that dialogical communication creates the most propitious conditions for creative self-realization of the person (especially for personalization). This circumstance, as well a deficiency of such communication in educational practice, gives every teacher a goal to organize a frame of reference for dialogical communication.

### *Game Frame of Reference*

Game frame of reference is the last of the three teacher's orientations on creative self-realization. *Game* can be defined as a form of reconstruction of the subject and social content of the future professional work or modeling of relation systems typical for this activity. Games are played by voluntarily accepted rules and are accompanied by feelings of enthusiasm, tension, and pleasure. For humanistic schools of the past and present, games have been one of cornerstones of their existence. Why is game playing so important for pedagogical activity?

First, games expand the sphere of pedagogical activity, enriching the professional position of the teacher with a so-called game positioning. Game communication is a powerful educational method that allows the teacher to do various maneuvers in both business and personal communication. At the same time, business behavior appears to be not entirely business, and personal not entirely personal. The students choose that sense from the teacher's game behavior that is more acceptable for them, thereby strengthening interaction between a teacher and a student. Everything is a little fib in games; everything is not about me and not about you—it is about a role and therefore I am *free* to accept or not to accept, to respond or not to respond the “educational signals” sent to me. Both the student and the teacher feel more free in a game; they have more space for self-realization.

Second, game creates possibilities for co-authorship and general creative development of the teacher and the student. Co-authorship in games provides:

- The subject-to-subject relations when the right and ability to make decisions is obtained by each participant in the creative process (irrespective of age and experience)
- Active position of all participants in the creative process
- Creation and preservation of the corresponding atmosphere, mood, and emotional background by participants in the creative process
- Preservation of everyone's individual style of creativity

The following set of recommendations can describe the teacher's behavior during the game:

- Provision of an atmosphere of friendly conversation
- Inspiration with internal feelings of interest, excitement, singularity, intrigue, and so on

- Refusal of categorical evaluation and criticism toward students
- Encouragement of original ideas
- Creation of conditions for exercises and practice
- Preservation of students' individual style of self-expression through refusal of direct demonstration, labeling and stereotypes, direct teaching
- Activation of the teacher's own self-expression

Hence, the possibilities of creative self-realization together with the student are opened for a teacher in games as perhaps in no other activity.

Learning should be based not on transmission of ready-made knowledge but on creation of conditions for creative activity, and business games are not only an effective way of knowledge mastering and skills formation but also a method of professional communication. With games, contradictions between the abstract nature of an academic subject and real professional activity are eliminated, and the competitive nature of business game stirs up the imagination, helping students to find the correct solution of the problem. In games it is easier to overcome stereotypes, generate certain principles of professional work, and correct a self-appraisal. While traditional methods are directed more to the intellectual sphere, the whole personality of the student is involved in games.

### **An Example: Games in Analytic Geometry**

I developed the business game “Curves Help a Person” for a course in analytic geometry. Its purposes are:

- To generalize and check students' knowledge and abilities in second-order curves; to learn to apply the received knowledge to solving practical problems using modeling of real practical situations
- To establish intersubject connections
- To improve students' outlook
- To present a concept of mathematics as a part of universal culture, emphasizing the importance of mathematical knowledge in history of civilization and modern society
- To develop joint activity skills, communicative skills, and responsibility for collective decision
- To stimulate an interest in analytic geometry

In this game, the student audience is divided into four groups (departments). Characters include employees, department heads, and the chief. The floor is taken by the chief, who emphasizes the fact that geometry is around us everywhere: radio masts consist of separate sections of one-sheet hyperboloid, high-voltage lines form catenaries, easement curves on railway tracks, etc. Geometrical lines and surfaces are used by people because of their properties that allow us to solve various technical projects most effectively.

Game participants are working at these enterprises as architects, designers, builders, biologists. and even astronomers. As an example, the astronomy department might receive an order like this: “The planets of the Solar System move around the Sun on ellipses; find the eccentricity of Venus’s orbit if it is known that the shortest distance from Venus to the sun is 107.5 million km, and

the greatest is 109 million km.” As another example, the chief might suggest that departments work as architects and to construct a bridge of a certain shape.

In another task, students are designers who must try to solve the problem of what distance from a bottom of a projector’s mirror a bulb should be arranged to make it reflect beams as a parallel bunch and form a 30 sq. mi circle on a wall. Finally, students are working as biologists are asked to solve a problem such as this: Calculate the length of the first coil of a snail shell if it is twirled in the spiral of Archimedes and the distance between coils equals 12 mm. In all these tasks, the work of departments is estimated at 100 points; a penalty of 25 points is imposed for each mistake, and the first team done receives a 50-point award.

It is necessary to design such games with the possibility for each player to make a decisions; the greater the freedom of choice, the more willingly players join a game.

At the end of a game, participants should discuss mistakes they made, find out why this or that decision was made, and what results it has brought. It is also possible to lead a discussion and to offer the following questions: Was the game interesting to play? What was its main problem? Why were such rules chosen? Did it meet conditions of reality? What would you change if you played the game again? What were the advantages of the game?

## Conclusion

Beyond any shadow of doubt, the need to modernize higher education has manifested itself. The valuable goals discussed in this article may be a response to the growing demand for new approaches in education. Engaging the students in joint activity, communication, and games provides more opportunity for them to be actively involved in the learning process. From my experience, students' egocentric tendencies in thought and social behavior decrease, their social sensitivity is sharpened, their orientation on perception of new information is formed, their threshold of perception of the standpoint of others decreases, their creative potential is actualized, and their adequacy of self-appraisal increases as a result of team play.

The educational function of business games is very significant because they provide a positive environment in which students are active participants rather than passive recipients of teaching, creating conditions for the development of the expert. Business games model real industrial or scientific activity and are an effective form of collective knowledge.

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# Learning Outside the Classroom: A Qualitative Study

Ron W. Germaine

## Abstract

This study investigated teacher candidates' learning as a result of a cultural immersion experience they participated in outside the classroom. Qualitative analysis of candidates' journals yielded themes that provide evidence of transformational learning. The study also modeled action research for candidates, and provided evidence of alignment between candidates' learning and course learning outcomes, program goals, the institutional mission, and the standards of external accrediting agencies, including WASC and NCATE.

## Key Words

Adult learning, transformational learning, diversity, action research

## Introduction

This paper presents the purpose, context, findings, and recommendations from an action research study that investigated the nature of teacher candidates' learning about diversity in an educational foundations course. The course, TED605, is part of a graduate program in which candidates earn a teaching credential.

## Purpose of the Study

The overarching purpose of the study was to discover from the perceptions of teacher candidates whether learning outcomes in a course were met through a specific assignment, and thus whether adaptations to teaching or to the assignment were needed. The assignment required candidates to interact with a group based on two considerations: The group should be one with whom the candidate had little or no previous contact, and thus "new" to the candidate; and the group should represent differences candidates might expect to find amongst future students.

The inspiration for the study came from colleagues' questions about whether candidates met the course learning outcomes by completing the assignment. Such questions are relevant and in broad agreement about the need for instructors to identify the extent to which students have met learning outcomes, and then to use evidence to inform teaching practice (Booth, 2007; Dietz, 2006; Leonard & Swap, 2004; Popham, 2008; Schmoker, 2007).

The action research nature of the study provided creative opportunity to enhance teaching and learning in the following ways:

1. The methodology and findings from the study were shared with students. By doing so, the study itself models an action research study for teacher candidates. As Darling-Hammond and McLaughlin (1995) stated, one of the characteristics of effective teaching is to model best practices for students. Additionally, Rock and Levin (2002) noted the need to enhance preservice teacher development by modeling and developing "the skills of inquiry, reflection, problem solving, and collaboration" (pp. 7–8).

2. The findings informed the instructor about whether students met course and program learning outcomes, and thus whether adaptations to teaching or to assignments were needed (Dietz, 2006; Popham, 2008).
3. The findings provided evidence for external reviewers about whether students met standards of regional and national accrediting agencies. The opportunity to provide such evidence is important for the University to demonstrate accountability not only to its own stakeholders but to external accreditors such as the Western Association of Schools and Colleges (WASC), the California Commission on Teacher Credentialing (CTC), and the National Council for Accreditation of Teacher Education (NCATE).

### **Context of the Study**

The study investigated student learning in an assignment within a program in which candidates earn a teaching credential at National University. The University is the second-largest private nonprofit institution of higher learning in California. For the past eight years, the University has prepared more credentialed teachers than any other single institution of higher education in the state (as cited in National University, 2008). In 2007, the University credentialed 2,067 teachers. Candidates are adult learners whose average age is 34.

The course in which the assignment took place is an educational foundations course, The Diverse Classroom. The term *diversity* tends to bring to mind cultural diversity, which in itself is an important justification for the course. As Koppelman and Goodhart (2005) have noted, never in the history of the United States have we had such a culturally diverse student population. However, the course and the assignment also address diversity more broadly. The goal of the course is for teacher candidates to learn about and demonstrate an understanding of the many differences they can expect to see amongst students in the classrooms where they will work. A primary theme for the course is relationships, including the importance of relationships amongst people, concepts, and disciplines (Schaeffer, 1982; Wheatley, 1999).

### **The Assignment**

The assignment, called a Cultural Immersion Experience, specifically directed candidates' learning to an encounter outside the classroom. Candidates were asked to become immersed with a group who represented differences they might expect to find in classrooms and with whom they had had little or no previous experience or contact. The range of groups with whom teacher candidates' interacted is broad, including the deaf culture, ethnic and religious groups, people with AIDS, homeless people, and students with special needs. The settings were in the community as well as in public schools.

While the assignment required interaction with a diverse group, candidates were encouraged to add a service dimension. For example, a candidate who had not knowingly met people with AIDS worked with Mama's Kitchen, an organization that delivers meals to homebound people with AIDS. Another candidate provided assistance in an inner-city school that serves the needs of homeless children.

The product expected of teacher candidates following the Cultural Immersion Experience had specific requirements. In addition to writing about their experience, teacher candidates were

to describe their own cultural background, the expectations of what they imagined they would experience prior to interacting with the group, questions they hoped they would be able to answer, and a pre- and post- self-assessment of their level of cultural understanding using the Banks (1999) or Salyer (1993) models of cultural development. Additionally, teacher candidates were expected to identify explicit connections about how their experience might influence their teaching. Before beginning the assignment, teacher candidates were also provided with the evaluation rubric that would be used to score their report.

### **Theoretical Framework for the Study**

The following review of literature establishes the relevance of learning experiences that take place outside the classroom, the relevance of the course learning outcomes, the need for teacher preparation programs to identify candidate dispositions that reflect the values of fairness and caring in nondiscriminatory, equitable ways, and the need to align course learning outcomes with program outcomes and external professional standards.

#### *Relevance of Learning Outside the Classroom*

The concept of learning outside the classroom has solid roots in the writings of many scholars, including Dewey, Vygotsky, Piaget, and Bandura. Dewey (1916) stated that theory, taught apart from experience, cannot be fully understood by students. He believed that interaction with the environment is an important key to meaningful learning. Vygotsky believed that social interaction plays a pivotal role in constructing understanding (Slavin, 2006), while Piaget observed that learners must be actively engaged if learning is to be meaningful (Slavin, 2006). Bandura's (1986) social learning theory proposed that future actions are guided by focused, relevant observations.

Within the context of National University, learning outside the classroom engages candidates in active learning that contributes to fulfilling the mission of the School of Education to prepare educators as lifelong learners, reflective practitioners, and ethical professionals.

Learning outside the classroom is relevant to adult learners. It models best practice and contributes to engagement in learning. Kuh, Kinzie, Schuh, and Whitt (2005) identified six practices common to high-performing colleges. One of the practices they identified is adapting the learning environment for educational enrichment. Learning outside the classroom contributes to enriched learning because it engages candidates in a setting of their own choosing in a way that connects theory with practice. Other key factors in making education relevant to adult learners include providing choices in their learning (Serdyukov & Serdyukova, 2004) and involving them directly in the learning process (Vella, 2000).

In 2006, the Department for Education and Skills in the United Kingdom published a Manifesto for Learning Outside the Classroom. While the primary focus of the manifesto is on P-12 education, the report stated, "Professional development in education outside the classroom should be accepted by Head teachers and staff as an important contributor to school improvement and to strengthening professional practice" (*Consultation*, 2000). The Manifesto saw learning outside the classroom not as an end in itself, but rather "a vehicle to develop the capacity to learn" (*Learning outside the classroom manifesto*, 2006, p. 3).

The Campus Compact, a coalition of more than 1100 college and university presidents in the United States has a similar purpose: to promote learning through civic engagement and

service learning (Campus Compact, 2007). Over 900 of Campus Compact members incorporate community learning into curricula (Campus Compact).

### **Relevant Learning and Dispositions**

One of the course and program learning outcomes is to use community resources, student experiences, and applied learning activities to make instruction relevant for learners (CalTPA, 2008). There is a need for teacher candidates' learning to go beyond theoretical knowledge so that they see connections between what is philosophically, emotionally, and practically meaningful and can make similar connections for the students they teach. The concept of relevant learning is developed in the literature and is usually referred to as *transformational learning*. Transformational learning connects knowledge in the cognitive domain, with the stirring of emotion in the affective domain, and practice in the experiential domain.

Transformational learning is learning that shapes the way learners think and act. It is learning that encompasses personal cognitive, affective, and experiential awareness to create personal and social meaning (Cranton, 1994). It is “becoming aware of one’s own assumptions and expectations and those of others, and assessing their relevance” (Mezirow, 2000, p. 4).

Transformational learning encompasses the six facets of understanding in which learners are able to give evidence of understanding through their ability to explain, interpret, apply, view a problem from more than one perspective, see issues through the eyes of others (empathy), and have the self-awareness of what they know and do not know (Wiggins & McTighe, 2005). Such understanding clearly does not mean that we know everything but that, within the limits of what we know, we see the connections to real world issues in ways that stir our passion to respond to the challenges and circumstances of our experience.

Sockett (2006) referred to transformational learning as authentic learning. He said that evidence of such learning should reflect the qualities of truthfulness, accuracy, precision of communication, impartiality, and caring. Evidence of learning at the level of transformational learning is at the heart of the Cultural Immersion assignment. Candidates are aware of the importance of such learning through the assignment instructions which require candidates to do a pre- and post-assessment of their cultural awareness, and through the evaluation rubric, which provides an assessment of candidates' learning.

#### *Purpose of Schools*

For learning to be relevant and transformational for candidates, it must be seen in relationship to the purpose of schools. It is clear that the purposes of schools include a focus on the academic growth of students and preparation for civic responsibility (DeRoche & Williams, 2001). The academic focus includes teaching reading, numeracy, and critical thinking skills, which together make up authentic literacy (Dewey, 1916; Schmoker, 2006). Preparation for civic responsibility includes teaching good citizenship and character development (Curriculum Development & Supplemental Materials Commission, 2006; DeRoche & Williams, 2001; Dewey, 1916).

Educators must recognize that the academic growth of students is not separate from the need for their civic development. Sockett (2006) noted, “The development of dispositions of character, intellect, and caring are at the core of professional teaching” ( p. 21). Indeed, the California Commission on Teacher Credentialing (and by extension, the University) is charged by law with evaluation of the moral character and fitness of all persons who wish to teach or

perform certified services in the public schools. Buffet (as cited in Leadership Now, 2007) stated the same concept more generally, “In looking for people to hire, look for three qualities: integrity, intelligence, and energy. And if they don’t have the first, the other two will kill you.”

Included in both the academic and civic components of education is an understanding and acceptance of diversity.

### *Diversity*

Learning outcomes for the Teacher Credential Program, for the course, and the expectations of the Commission on Teacher Credentialing (CTC) require that candidates adapt their teaching to the diverse needs, backgrounds, and abilities of students. One of the course learning outcomes states the following expectations for candidates’ understanding of diversity: “Students should be able to demonstrate through their assignments an understanding and acceptance of student diversity in relation to beliefs, social class, nationality, ethnic group, religion, and gender.” The definition of diversity is purposefully broad because of its many different forms; however, there is no doubt that the increased diversity from immigration outside of Western Europe has, and will continue to have a major impact on the ethnic and language diversities of schools (Koppelman & Goodhart, 2005).

The high need to prepare candidates for a diverse student population is evident in the findings by Desruisseaux (2006). He reported that public schools in California have a wide variation in ethnic and language diversity, with over 50% of English Language Learners (ELLs) attending 21% of the public schools. In effect, some schools have a greater number of ELLs than students whose first language is English. Additionally, Desruisseaux found that over 80 public schools in California have ELLs from more than 20 language backgrounds. The learning outcomes for the course and program purposefully identify diversity to recognize differences in language, skin color, and ethnicity and extend the meaning of an understanding of diversity to include recognizing/celebrating/honoring multiple differences *and* similarities.

### **Alignment with External Accrediting Agency Standards**

In keeping with the action research nature of the study, teacher candidates’ responses to this assignment form part of the evidence that indicates candidates’ learning at National University is aligned with state standards and the Education Code, and standards of external accrediting agencies, including the National Council for Accreditation of Teacher Education (NCATE) and the Western Association of Schools and Colleges (WASC).

The assignment learning outcomes flow from the course learning outcomes, which are aligned with program learning outcomes. The program learning outcomes are adopted directly from the TPEs articulated by the state credentialing agency.

The learning outcomes contribute to evidence that the Teacher Credential Program is in harmony with the California Education Code. The Code states, “There is an urgent need to teach and inform pupils in the public schools about . . . human relations education, with the aim of fostering an appreciation of the diversity of California’s population and discouraging the development of discriminatory attitudes and practices.”

The Cultural Immersion assignment clearly aligns with expectations of the law to prepare candidates to teach students about acceptance of diversity.

The assignment learning outcomes align with NCATE's Standard Three by virtue of its focus on diversity, the evidence it provides about candidates' dispositions, and the requirement of students to experience learning outside the classroom. NCATE Standard Three states, "The unit and its school partners design, implement, and evaluate field experiences and clinical practice so that teacher candidates and other school personnel develop and demonstrate the knowledge, skills, and dispositions necessary to help all students learn."

The assignment learning outcomes also align with WASC's Standard 2.3 which states that "the institution's expectations for learning and student attainment include . . . experience in the wider learning environment." A guideline for the Standard specifically states that "The use of information and learning resources beyond textbooks is evidenced in syllabi." The assignment, of course, requires students to interact with others outside the University classroom, by being in the community or in schools.

### **Methodology**

Popham (2008) noted that one of the purposes of assessment is for instructors to "collect evidence by which they can adjust their current and future instructional activities" (p. ix). The principle of assessment articulated by Popham guided the purpose and methodology of the study. In the plan for data collection and analysis, candidates' reports of their Cultural Immersion experience were gathered electronically, and qualitative analysis were used to search for themes in candidates writing. Qualitative methodology is the appropriate research design because it is used to "search for understanding of themes, patterns, or causal explanations through the lived experience of the study participants" (Kornuta & Germaine, 2006, p. 47).

The reports came from a population of 210 candidates who were in the researcher's classes, both online and onsite, during the period 2004 to 2007. Reports were initially read for grading purposes. Later, the reports were analyzed to code candidates' experiences and reflections into themes (Merriam, 1998).

### **Findings**

Of the 210 candidates who completed the Cultural Immersion assignment, 172 (82%) participated in their experience in a community setting. The remaining 38 candidates (18%) completed their experience in a classroom. Just over half of the candidates, 123 (59%), were in online classes, while 87 (41%) were in onsite classes. There were no apparent qualitative differences between online and onsite responses to the assignment. The same themes appeared in both settings. The representative excerpts provided below indicate that candidates' learning fits what the literature calls transformational learning, in which both head and heart are engaged.

Four themes emerged from analysis of the data: learning was both cognitive and affective; learning resulted in new personal insights, empathy increased, and learning led to insights and planned change in regard to teaching. Following are representative statements for each theme from candidates' reports.

### *Theme 1: Learning Was Both Cognitive and Affective*

- Being able to share [my experience] and learn from others about their own experiences has been vital to my personal and professional growth. My feelings about what kind of teacher I want to be are now strong and focused.
- The Cultural Immersion [assignment] represented one of the most challenging and motivating activities I ever did. We had to get informed, get involved, and therefore called to “care.”
- I take away a deeper and more detailed understanding of what it is to be culturally diverse, and what it may be like for students who feel they are outside of the culture majority.
- The cultural immersion project expanded my cultural horizon to a fuller understanding about the students I will teach. Perhaps practicing teachers should do this once a year so that they can understand and relate to the students on a closer level.
- I just completed my cultural immersion paper. I am emotionally exhausted by what I discovered. I have heard people say that they felt a “calling” to become a teacher. Well, after this project, I felt that I too had that mysterious “calling.” Even though the cultural immersion experience was short, for me it has been a journey that will last a lifetime.

### *Theme 2: Learning Resulted in Insights About Self*

- For me personally, attending the Mosque on a Friday was a huge step. I had never been to a religious service so different from the Pentecostal background I had been raised in . . . and honestly, I never wanted to. I don’t think anyone can even closely understand how huge this was for me. I’m thankful that I experienced it.
- [The Cultural Immersion experience] made me think even further about my own culture . . . just because we share a common language does not mean that we have the share the same culture.
- I began this program feeling that I am a pretty well-rounded person; I only wanted to learn the nuts and bolts of teaching and not the other stuff. These real-life experiences helped change that perspective to see the importance of building relationships.
- The cultural plunge helped me grow personally and professionally. I saw the need to recognize my own stereotypes, biases, and prejudices, and also to be aware of how they could impact my teaching of students.
- The immersion experience was helpful toward learning about other cultures; however I feel I learned more about myself than I did about the cultures.

### *Theme 3: Learning Led to Increased Empathy and Caring*

- The Immersion project was great because it forced me outside of my comfort zone, and made me realize what kids may feel when they walk through the door of a classroom.

- This experience opened my eyes to see similarities that people have, rather than just differences.
- In order to understand “diversity,” we could not have found a better way than “put our-selves into somebody else’s shoes.”
- The cultural immersion activity reaffirmed for me the importance of cultural sensitivity . . . in everyday interactions with students. If they [students] see tolerance and acceptance of differences modeled, they will be more likely to practice open-mindedness themselves.
- The cultural plunge was an excellent way to for me to gain understanding about where my students receive their values and beliefs.
- The cultural immersion that I experienced allowed me to step out of my comfort zone and identify with what a student might feel when stepping into a classroom that is culturally different from his or her own.

*Theme 4: Learning Led to Planned Change in “How I will do things in the future”*

- The experience changed my goal from teaching high school students to wanting to teach young children to read.
- The Cultural Immersion Project led me to reflect on how to apply our teaching methods to accommodate children who come from other countries.
- I learned that knowing everything there is to know about important historical events or literature means little if I cannot communicate or build relationships with my students.
- Having been an instructor for numerous years at the police academy and the military, I now feel I may have been too regimented in my style. Although I was successful at what I accomplished, this experience has made me look at inclusive teaching in a different light and has generated the confidence I needed in exploring a new career.

### **Limitations of the Study**

A limitation of this study is that the findings are written expressions of candidates’ thinking, and as such are indirect evidence of learning. What people say can be quite different from what they do. Kohlberg’s (1981, 1984) studies on moral development had a similar limitation, in that participants wrote about how they might respond to moral dilemmas—and of course the writing about and the “actual doing” can be quite different.

The study provides only a snapshot in time of candidates’ learning and dispositions. Comparing candidates’ learning at different points within the credential program, including reports of evidence from their classroom practice would be helpful in triangulating the findings and verifying application to practice. Additionally, quantitative evidence could be mined from candidates’ scores on the evaluation rubric to provide direct evidence of the learning outcome, which expects candidates to make instruction relevant for the learners they will teach (CalTPA, 2008).

## Application and Recommendations

One of the motives for undertaking the study was prompted by a question about whether a field experience early in the teacher preparation program could be beneficial to candidates if it were done in a community setting rather than in a school setting. Candidates' responses provide supporting evidence that the community experience was indeed beneficial to candidates.

Findings from the study serve as evidence to the instructor that the Cultural Immersion assignment led to transformational learning for candidates. Thus, evidence shows that a recommendation can be made to continue the assignment.

A summary of the findings from the study will be added to evidence from other courses and programs to show that CTC, NCATE, and WASC standards are being met. Additionally, the actual writing samples and evaluation rubric used to grade each assignment are available to internal and external reviewers.

A recommendation for further study flows from the limitations that the findings are based on indirect evidence and are a snapshot in time. It would be most interesting to follow up at a later date with candidates' site-based supervisors to discover whether the learning candidates said they experienced is evidenced in their actions within their schools and classrooms.

## Summary

This paper has presented the context, findings, and applications of an action research study that investigated the nature of teacher candidates' learning in a Cultural Immersion assignment. The assignment was given in the context of an educational foundations course in a teacher credential program at National University. A literature review provided a theoretical framework for the assignment to show that the learning outcomes are relevant and appropriate.

Findings showed that four themes were identified in candidates' writing and that their learning was transformational. Findings from the study helped inform the instructor about the relevance of the assignment to the growth and development of teacher candidates' understanding of diversity. Additionally, the findings will contribute to evidence of how the teaching and learning at the University align with State standards and the standards of external accrediting agencies.

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# **Self-Assessment and Reflection**



# **A Study of Instructional Practices: The Case for Reflection and Research**

Peter Serdyukov and Nataliya Serdyukova

## **Abstract**

Investigation of the faculty's own instructional practices coupled with reflection can be a powerful tool for improving student learning outcomes. Such an approach can be enhanced with the study of student profiles. This article presents the results of a research of teaching methodology and learning characteristics in several different courses, both onsite and online, addressing strategies, technologies and student demographic characteristics, such as age and gender. These findings can be used in educators' professional development.

## **Key words**

Instructional practice, reflection, analysis, teaching quality, professional development

## **Introduction**

Student learning outcomes depend to a great extent on the quality of teaching, besides many other factors. To ensure instructional quality, various methods are used, including the instructor's own reflection, which is a primary means of his or her professional growth and an effective method to improve individual teaching practices. This reflection, however, may not be sufficient for significant improvement of instruction and can be enhanced by the instructors' analysis of their own practices as well as practices of other instructors teaching the same class. This may lead to a better understanding of the instructor's own teaching style and methodology; discovery of both effective and ineffective practices; experimentation with new approaches, methods and strategies; and eventually the improvement of learning outcomes. Another approach that can be effectively combined with this analysis is a study of student characteristics. Knowing the learner will open ways to assess the effect of instructional actions and select the best strategies, thus differentiating instruction and improving its outcomes.

In this research we explored instructional practices of different faculty members teaching the same courses at the university level using student and instructor surveys. We will discuss the issues that need to be investigated in college teaching practices, some results of the survey, and their implications for teaching and learning. Such research may have a profound impact on the quality of teaching and learning. Its results can be integrated into faculty professional development events.

## **Rationale**

It goes without saying that student learning outcomes depend to a great extent on the quality of teaching, besides many other factors (McLeod & Reynolds, 2006; Jarvis 2006). To ensure instructional quality, various methods are used, such as student evaluations and comments, collegial visitations, administrative control, assessment, faculty professional development, regular course updating, and finally instructors' own reflection, which is a primary means of their professional growth and an effective method to improve individual teaching practices (Jay, 2003; Ferraro, 2000; Forde, McPhee, McMahan, & Patrick, 2006).

Research demonstrates there is relationship between teacher reflection and their professional behavior (Luttenberg & Bergen, 2008). This reflection, however, may not be

sufficient for notable improvement of the instruction and can be further enhanced by the instructor's analyzing own his or her own practices, which can be complemented by exploring practices of other instructors teaching the same class. Teachers, according to Schön's (1987) influential model, are "reflective practitioners"; they are also researchers. Therefore, such an analysis may have a profound effect on quality of teaching and learning (Killion 2000; Edwards & Hensien, 1999; Huffman, Thomas, & Lawrenz, 2003), especially when coupled with reflection.

Yet educators should also remember that teaching is a process including at least two participants: a teacher and a student. The results of teaching in the form of learning outcomes depend not only on the teacher qualifications but also on the students' individual characteristics. Coming to the class instructors are usually unprepared to meet all these people who look at them with anticipation, hope, and anxiety, and instructors' success depends on their cooperation, willingness to engage, and ability to cope with the class requirements. Hence it is critical to connect teaching to learner characteristics. "We may exhibit an admirable command of content, and possess a dazzling variety of pedagogical skills, but without knowing what's going on in our students' heads, that knowledge may be presented and that skill exercised in a vacuum of misunderstanding" (Brookfield, 2006). Needless to mention, this information may also significantly affect the quality of instructor-student interactions in the learning process.

Enhancing instruction through studying learner characteristics is consistent with the learner-centered approach in education (Alexander & Murphy, 1994). When planning the instructional process, the instructor usually assumes that everyone learns the same way. Actually, that is not exactly so. For the class to be effective, and for students to reach the projected outcomes, the teaching must match their group and individual characteristics. "An understanding of good ... instruction begins with a vision for the classroom" (Designing Effective Professional Development, 1999, pp. 2-4). The key to instructional effectiveness is to work around the participants rather than the content (Smith & Ragan 1999). Learner characteristics are the key factor in selecting and applying instructional strategies in one's teaching for better learning outcomes (Felder & Brent, 2005), along with a selected methodological approach, strategies, and tools. The instructor must know the target audience by identifying learner characteristics. This knowledge might be of a particular importance for online learning (Dabbagh, 2007) because of the physical separation of students from their instructor in place and time.

The more thoroughly instructors understand similarities and differences between students, the better chance they may have of meeting the diverse learning needs of all their students (Leng, 2002). This requires knowing quite a few things about one's audience and each individual student. It is important to adapt the course that one is or will be teaching and the preferred instructional strategies to the characteristics of the specific class. Some of these strategies can be obtained before the class starts, others in the process of learning, and still others in the end of the class. Whatever the case, the value of studying student characteristics and their reaction to the instructor's instructional actions even when the class is near its end offers the instructor a chance to reflect on his or her teaching and make better accommodations for the next class.

Identifying student group profile through a simple questionnaire can be an effective beginning of effective differentiated instruction. Smith and Ragan (1999) recognize four categories of learner characteristics: cognitive, physiological, affective, and social. Students have stable and changing similarities and differences in their essential characteristics. Research indicates that the identification of similarities and differences is a basic component of human

thought and that the concept of similarity is important to different forms of cognition, including memory and problem-solving (Marzano, Pickering, & Pollock, 2001; Gentner & Markman, 1997).

Learner characteristics can include:

- Demographic characteristics (age, race, and gender)
- Physiological characteristics (general physical condition)
- Existing skills, knowledge, and attitudes
- Aptitudes and talents
- Prior experience
- Learning Style
- Attitudinal characteristics
- Geographical location
- Current job category or position
- Value system
- Life/Career stage (Dick & Carey, 2004)

A model of quality teaching is thus based on *action learning*, which is a process of self-reflective, self-critical inquiry that seeks to improve the practitioners' knowledge of teaching, practice of teaching, and the learning outcomes associated with the teaching (Killen, 2003; Stringer, 1996). Action learning encourages teacher-practitioners to diagnose their teaching within an instructional context of teaching a class. Action learning thus seeks to increase the quality of teaching by understanding the instructional process and correlating it with students' characteristics that affect their performance. This leads to continuous teacher professional development as a researcher and practitioner, and to improved learning outcomes.

In our research we tried to identify student perceptions of some of the instructional strategies and tools used in their classes, time investment in learning, and two of the learner characteristics, the age and gender. Among social characteristics, gender and age may be the most notable (Nguyen, 2008; Garland & Martin, 2005). They were studied in correlation with instructional approaches. This article sums up our research conducted at National University in the last seven years. Some of the findings were published and presented at several conferences.

## **Methodology**

Instructional practices at National University (NU) were analyzed using a specially designed survey that was intended to assess, in a questionnaire format, the instructional methodologies and practices used in three different courses: math, physical science, and second- language methodology, taught both online and onsite. The questionnaire contained questions in the following general areas:

- Class instructional characteristics (strategies used in class, educational technologies applied, preferred activities)
- Student reactions (satisfaction, expectations met, usefulness, appealing factors)
- Adult learning characteristics (learning styles, preferences)

- Time expenses for various activities (reading, writing, doing assignments and preparing for tests)
- General/demographic (class, month, age, gender, ethnicity)

The research was based on the responses from 306 students to a survey administered in the three courses taught in 21 classes. Approximately two-thirds of the students were enrolled in online classes; the remaining third were onsite. The questionnaire with minor modifications was used for surveying both students and instructors. The intent was to compare student and faculty responses to the same questions and discover correlations and contradictions between them. The data from instructors, however, are not reported because the sample size at this point in the investigation is too small. Data were collected from 2003 through 2007.

## **Research**

The research was focused on several issues, including student choice of the National University program; instructional strategies and technologies used in the classroom; comparison between onsite and online formats; time investment for various activities; age and gender effects on instructional practices. National University uses a specific 1x1 model of accelerated learning that was discussed in our several publications (Serdyukova 2008, Serdyukov 2008).

It was interesting to learn how differently men and women reacted to online and onsite classes and how younger and older students responded to online versus onsite learning. Perceptions and attitudes toward accelerated online classes differ among gender and age groups (Serdyukov, Tatum, & Serdyukova, 2006). These results are presented here, along with implications and recommendations for offering online and onsite classes to men and women of different ages.

### *Student Choice of the National University Program*

It was found that student choice of the NU program was determined primarily by convenience of the learning delivery (especially in online classes) and the short-term course accelerated format (Serdyukov & Serdyukova, 2006). When surveyed on the reason for choosing a nontraditional, accelerated model of adult higher education provided by National University, students gave the following responses:

- Short (one-month long), accelerated courses: 71.8%
- Flexible time of study: 57.1%
- One-course-at-a-time format of the instructional process: 56.0%

The most obvious factor influencing students' satisfaction with distance learning is convenience of access (Thompson & McGrath, 1999). Students today are inclined to expect the convenience of access to learning services and other services (Ashburn, 2006). Convenience of learning has become a critical factor for learners (Lucking, Christmann, & Wighting, 2007), while accelerated programs that allow them to graduate sooner are attractive because it can affect their career.

### *Quality of Learning Outcomes as Compared to Other Programs*

It was proved there is no significant difference in the quality of student learning outcomes between National University accelerated, one-month-long and one-course-at-a-time programs and traditional semester-long programs offered at other schools (Serdyukov, Subbotin, & Serdyukova, 2003). This research was based on comparing Beginning Algebra courses taught at National University, DeVry University, and Los Angeles Community College by the same instructor using the same program, textbook and evaluation criteria but in two distinctly different formats. It would be interesting to compare other courses taught at National and other colleges to identify similarities and differences in learning outcomes and instructional methodology.

### *2.3. Instructional strategies and technologies*

One of the most important issues is the use of instructional strategies and educational technologies in the classrooms, including the online ones. The survey demonstrated that the use of instructional strategies and educational technologies varied across online and onsite instruction in all classes (Serdyukov, Tatum, Greiner, Subbotin, & Serdyukova, 2005). Table 1 shows the frequency with which different instructional strategies and educational technologies were applied in different classes taught in three selected subject areas, methodology, math, and science. Ratings were on a 5-point frequency of use scale ranging from 1 (never) to 5 (every class).

Table 1  
Frequency of Use of Strategies for Different Class Types

Strategies and Technologies	Classes		
	Methodology	Mathematics	Science
Class Strategy: Frequency of Use (1 = never, 5 = every class)			
Lectures	4.3	4.5	4.8
Workshops	3.1	3.2	1.9
Group discussions	4.6	3.8	2.8
Problem solving	4.0	3.8	2.8
Brainstorming	4.0	3.8	4.7
Role playing	2.7	1.7	1.5
Simulations	3.0	2.1	1.8
Case studies	3.5	2.4	1.7
Student presentation	3.3	2.7	1.8
Peer collaboration	4.2	3.3	---
Project development	3.8	3.3	1.6

Note: All differences greater than .7 are significant ( $p < .05$ ).

As seen in Table 1, math and science classes tend to use lectures, group discussions, problem solving and brainstorming more than other strategies. Methodology class also used these strategies but used a more varied approach due to the difference in the class content, instructional methodology and objectives that call for certain procedures and skills. For instance, problem solving definitely belongs to math and often science classes, yet it can hardly be applied in a methodology class.

Table 2 compares technology applications in various classes.

Table 2  
Frequency of Use of Technologies for Different Class Types

Educational Technology: Frequency of Use (1 = never, 5 = in every class)	Methodology	Mathematics	Science
Internet	3.5	2.2	1.4
PowerPoint	2.5	2.1	1.3
Multimedia	3.0	2.1	1.6
Overhead projector	2.1	2.1	4.0

Note: all differences greater than .7 are significant ( $p < .05$ ).

As seen in this table, instructors in methodology classes tend to use the Internet, PowerPoint, and multimedia more often than instructors of math and science classes, while science classes use the overhead projector more often. We attribute the difference in the use of technologies also to the class content, instructional methodology and objectives that call for certain procedures and skills. For instance, math and science classes more often use traditional chalkboard than technology due to the importance of problem solving in front of the class.

Table 3 compares online and onsite classes with respect to instructional strategies and technologies, as well as preferred activities and time expenses. As seen in the table, there were statistically significant differences between online and onsite courses for the use of problem solving (more frequent for onsite) and research projects (more frequently used online). The Internet, PowerPoint presentations, and multimedia were more frequently applied in online classes. Online students preferred working in groups and working with the instructor more than onsite students. Online students spent more hours writing, doing assignments, and finishing final projects than their onsite counterparts. This can be explained by the fact that online learning and communications are predominantly text based, whereas in an onsite class much is taught and learned through oral communication.

Table 3  
Comparison of Online and Onsite Classes for Strategies, Technologies, Activities, and Time

Strategies and Technologies	Class Format	
	Online	Onsite
Class Strategies: Frequency of Use (1 = never, 5 = every class)		
Problem solving	4.0	4.5
Research	3.4	2.7
Educational Technology: Frequency of Use (1 = never, 5 = every class)		
Internet	3.8	2.0
PowerPoint	3.0	1.7
Multimedia	3.3	1.7
Preferred Activities (1 = not at all, 5 = highly)		
Small group work	2.5	1.6

Work with instructor	2.8	2.3
Time log (average time per week in hours)		
Writing	8.1	4.2
Assignments	8.8	5.6
Final projects	10.7	5.0

Note: All differences between online and onsite are statistically significant ( $p < .05$ ).

Table 4 examines various student reactions to different instructional strategies and tools used in the classes surveyed. The reactions measured were satisfaction (how much the student liked using the instructional approach), expectation (to what extent the approach met the students' expectations), usefulness (how useful the approach was for their professional growth), and appeal (how appealing various factors of each approach were).

Table 4  
Relationships between Instructional Strategies/Tools  
and Student Reactions

Student Reaction Class Strategies/	Satisfaction	Expectation	Usefulness	Appeal
Presentation of new material				
Lecture	+	+	+	+
Workshops	+	-	+	+
Q&A	-	+	+	+
Group discussion	-	+	-	-
Problem solving	-	+	+	+
Brainstorming	-	+	-	-
Role playing	+	-	+	+
Simulation	-	-	-	-
Case Studies	-	-	+	-
Student presentations	-	-	+	-
Student demonstrations	+	+	+	-
Peer collaboration	+	-	+	+
Small-group work	-	-	-	-
Project development	-	-	+	-
Research	-	-	+	+
Tutoring	-	-	+	-
	-	-	+	-
Educational Technology	-	+	+	+
Internet	-	+	+	+
PowerPoint	-	+	+	+
Multimedia	-	+	+	+

Note: + designates a significant positive correlation, - indicates a significant negative correlation ( $r = \pm .2$  to  $.4$ ,  $p < .05$ ).

As seen from Table 4, there was a significant positive correlation between presenting new material in class and student satisfaction with the approach (i.e., the more this approach was

used, the higher is the student satisfaction level). Overall, satisfaction levels were positively related to approaches that imparted information or involved students.

The table shows significant positive relationships between expectations and approaches that involve the students except that more lecturing seems to lead to higher met expectation, and greater use of the Internet leads to lower levels of met expectations.

The most frequently used and positively evaluated approaches tend to integrate factual/theoretical sessions utilizing effective presentational styles (e.g., lectures with PowerPoint presentations) with longer practical activity session (e.g., problem solving, team work, group discussions, and student demonstrations).

*Online vs. Onsite Formats*

Comparison of instructional strategies, technology applications, preferred activities, and time expenses between online and onsite formats demonstrates significant differences.

Table 5  
Comparison of Online and Onsite Classes

Instructional Strategies	Instructional Format	
	Online	Onsite
Class Strategies: Frequency of Use (1 = never, 5 = every class)		
New materials	4.3	4.6
Lectures	3.7	4.5
Workshops	2.8	3.3
Q&A	4.0	4.5
Student demos	2.6	3.2
Small group work	2.5	3.4
Educational Technology: Frequency of Use (1 = never, 5 = every class)		
Video	2.8	2.3
Internet	3.8	2.4
Overheads	1.8	2.5
Multimedia	2.9	2.2
Preferred Activities (1 = not at all, 5 = highly)		
New material presentation	3.1	3.7
Problem solving	2.9	3.3
Q&A	3.1	3.6
Group discussion	2.8	3.4
Small-group work	2.1	3.2
Project development	2.6	3.0
Work with instructor	2.7	3.1
Talking about learning	2.8	3.3
Communication with peers	2.7	3.5
Time log (average time per week in hours)		

Reading	6.7	4.8
Writing	7.1	5.1
Communication with instructor	1.4	2.6
Total time online/in class	5.0	7.7
Total time for all tasks	18.2	22.3

Note: All differences between online and onsite are statistically significant ( $p < .05$ ).

As shown in Table 5, the use of instructional strategies, technologies, preferred activities, and study time varied across online and onsite instructional formats. In general, there was a greater use of modern technologies (videos, multimedia, and Internet) in online classes than in onsite classes; however, more frequent use of collaborative and group-oriented activities was found in the onsite classes. Onsite students tend to enjoy course activities more than online students who are engaged mostly in independent learning. Online students spend more time reading and writing due to the text-based form of online learning, but onsite students spend more time communicating with the instructor and devote more total time to the studies.

#### *Time in the Online Class*

A separate study to evaluate online student time expenditures was conducted by the authors in the 2005–2006 academic year. Student time expenditures in the online NU teacher preparation credential program were studied using a questionnaire conducted among 87 students and 19 faculty. Time expenditures were estimated per course and per week, and averages were calculated to determine how much time students spend in an accelerated online class on various activities. The results were then compared to those for similar onsite classes. Both formats were totally congruent in learning outcomes, content, most of the assignments and evaluation.

As seen in Table 6, most of the time in an online class is spent on assignments, the final paper, and reading. Less time is used in participating in threaded discussions, field activities (school visits, observations and teaching), and communicating with peers. In the onsite class most of the time is spent in the classroom and on traveling. Other major activities, such as doing homework assignments and reading, require almost the same amount of time in both classes, although a comparatively smaller time spent on assignments in the online class may point to a better effect for onsite classroom work. The main difference, as expected, was in the time spent by onsite students on travel and classroom presence, which commonly amounted to about 45 hours each. Remarkably, a student spends only 44.4% of the time in the online course than an onsite student (19.7 hrs./week less). The savings come from the absence of classroom time and travel, yet online students have to add time for threaded discussions, communicating with peers and instructors via e-mail, and resolving technical issues.

Table 6  
Online Student Time Expenditures by Hours

Activities	Online		Onsite	
	Week	Course	Week	Course
Classroom work	0	0	11.25	45.00
Travel	0	0	11.04	44.15
Reading	2.69	10.77	3.20	12.82

Doing assignments	4.67	18.68	4.22	16.88
Participating in online discussions	1.72	6.85	0	0
Communicating with peers	0.91	3.64	0.27	1.10
Communicating with instructor	0.38	1.55	0.11	0.43
Field activities	1.85	7.40	1.93	7.71
Writing a final paper	2.99	11.96	3.41	13.66
Resolving technical issues	0.52	2.10	0	0
<i>Total</i>	<i>15.74</i>	<i>62.95</i>	<i>35.44</i>	<i>141.75</i>

The load of studying onsite as compared to online seems to be far too high for a working student, who has to do the same amount of work outside the class besides attending lectures and traveling. Lack of face-to-face contact evidently calls for more online communication, both with peers and the instructor. It is clear that besides the convenience of online learning, time savings are significant, which is extremely important for working adult students. Roughly speaking, the time efficiency of this online program is 2.25, calculated by dividing actual time expenditures in the onsite course by the time in the online course. This is the greatest incentive for students to move online which, is reflected in the NU statistics showing a steady and significant annual increment in online enrollments.

Of what, then, do online students complain? The answer is, they do not compare online class expenses to the onsite ones but assess their time investment relative to their busy schedule on which learning takes a big toll: 15.74 hours a week are added to the already tight schedule. This time is taken from family, sleep, and job, which creates anxiety. Normally, clarification from the instructor in the beginning of the class that explains real time expenditures and compares them to the onsite student time losses helps elucidate the situation and alleviate the anxiety. Another effective strategy is to provide continuous support and immediate feedback for the online students building an important sense of affiliation that can help them resolve the conflicts before they aggravate and make learning overwhelming.

A study of the instructor time expenditures in an online class (Table 7) shows a different picture. Online instructor spends 29.67% time more on one class (7.98 more hours per week) than a classroom instructor, due to the more time-consuming preparation of the online course, more frequent individual communication with students via e-mail, and need to resolve technical issues. Onsite instructor spends more time in the classroom and offers F2F consultations, however spends less time on preparing to teach a class and does not have to resolve technical issues. The discussions in an online class—which are one of the major and, by far, most effective instructional tools—due to the written format take much more time than the discussions in an onsite class, virtually equal to classroom teaching time.

Table 7  
Online Instructor Time Expenditures by Hours

Activities	Online		Onsite	
	Week	Course	Week	Course
Preparing to teach the class	-	12.4	-	6.1
Mediating the discussions/teaching	11.12	44.5	11.25	45.0
Reading papers	8.17	32.7	7.82	31.3

Communicating via email/F2F consultations	7.02	28.1/0	0.57/2.05	2.3/8.2
Grading (finals)	-	19.5	-	14.6
Resolving technical issues	0,55	2.2	-	-
<b>Total</b>	34.85	139.4	26.87	107.05

These calculations demonstrate an evident time efficiency for online as compared to onsite learning (Serdyukova & Serdyukov 2006), but two questions are provoked. First, should online instructors be paid more for each class? Maybe, although there is another option for dealing with the instructor overload: reduce the overall annual teaching load. Second, should students be paying less? Theoretically yes. However, taking into account an increased efficiency of their learning with the same learning outcomes, tuition should probably be the same. Anyway, solutions lie in the hands of school administrators.

### *Age Differences*

Student age is one of the major factors affecting the changes in educational paradigms and in instructional approaches. As the adult student population in the United States has reached 39%, according to NCES (2005), age factors in college education need to be investigated. Due to their hectic lifestyles, adult learners rely less on traditional universities and methodology and look for alternative opportunities to obtain higher education. This situation has prompted the creation of new schools and programs offering nonconventional programs and course formats, as well as modification of traditional school offerings. Adults have a greater appreciation for the outcomes and conditions of learning than younger students, and they highly appreciate such benefits of education as accessibility, convenience, and flexibility (Serdyukov, Subbotin, & Serdyukova, 2003). However, this type of learning requires good study skills, time management skills, sufficient background education and a certain developmental level. The transformation they will experience demands a certain level of maturity and motivation and, in particular, high levels of cognitive development (Merriam, 2004).

There are differences between the physiological, psychological, and educational needs of younger and older students. Knowledge for adults is described as “practical intelligence, practical thinking, tacit knowledge, or situated learning and cognition” (Kasworm, 2003, p. 85). Adults live in the worlds of “work, family, self and community (Ibid., p. 86). Any effective educational program thus must be designed so as to implement age-specific instructional approaches and strategies. Adult students have many competing obligations, which invariably affect their learning. Even if learning is perceived as a valuable and high-priority activity, interference of daily distractions may be decisive in choosing study over other engagements.

Adults may be using different skills, strategies, environments, and interactions with faculty and their peers to achieve their desired outcomes. It is essential to identify these and other factors, because adults have complex and rich mental schemas that make their learning more personally meaningful to them. Adults tend to integrate new learning by making connections to existing knowledge schemas (Donaldson & Graham, 1999).

A Model of College Outcomes for Adult Students developed by Donaldson and Graham takes into account factors both outside and inside the collegiate environment (prior experiences and personal biographies, psychosocial and value orientation, life-world environment, adult cognition, the connecting classroom, and college learning outcomes). This model suggests that

adults may engage the new knowledge obtained in the college in different and perhaps more immediately helpful ways than traditional-age students. The model also raises the issue of whether colleges should accommodate adults' lifestyles and their talent for tackling the problems associated with learning and with limited time. In fact, colleges may need to design classrooms to enhance learning by using action research in real-world settings, addressing real-world problems or practices associated with work or family life, problem-based learning applications, opportunities for peer teaching, and chances to create learning that will benefit the community.

Other authors (Justice & Dornan, 2001) investigated aspects of meta-cognition and motivation that may distinguish the learning processes of adults in higher education from those of traditional-age students. Developmental changes in meta-cognitive and motivational variables and their relationship to course performance were examined for traditional-age (18–23 years) and nontraditional-age (24–64 years) male and female college students, who completed self-reported measures of study skills, motivation, and memory ability. Older students reported more use of two higher-level study strategies: generation of constructive information and hyper-processing. Negative correlations, especially for male students, were found between reported use of several strategies and midterm course performance. Developmental changes in the efficiency of strategy use and the lack of a match between strategy use and the type of course assessment are discussed as possible explanations for these findings. Findings of the study suggest that educators in higher education will need to respond using pedagogically sound strategies to differences in the motivation and learning processes of nontraditional students.

Table 8 shows how younger and older students responded to questions on online versus onsite learning. As seen in Table 8, the younger students (30 and under) consistently reported that the online courses used more group discussion, question-and-answer sessions, presentations of new material, and problem solving activities compared to the older students (over 30). In the onsite courses there was no difference between the younger and older students. The differences between younger and older students for the online classes are interesting because these students were in the same classes, yet their perceptions of what strategies were used were significantly different. The younger students were also more satisfied with their online experience than the older students. By contrast, the older students were more satisfied with the onsite classes.

Table 8  
Comparisons Between Instructional Format (Online vs. Onsite) and Age (30 and Under vs. Over 30)

	Instructional Format			
	Online		Onsite	
	30 and Under	Over 30	30 and Under	Over 30
1. Group discussion	4.5	3.4	4.2	4.1
2. Q&A	4.4	3.0	4.6	4.5
3. Presentation	4.4	3.9	4.6	4.6
4. Problem solving	4.5	3.5	4.5	4.4
5. General Satisfaction	4.2	3.8	3.9	4.2

Note: Data entries for items in rows 1-4 are ratings on a 5-point scale (1 = never use, 5 = use in every class). Data entries for item in row 5 is a rating on a 5-point scale (1 = not at all satisfied, 5 = very satisfied). Interactions in each row are statistically significant ( $p < .05$ ).

This may be because the younger students are more familiar and comfortable with the online technology and are more sensitive to the different strategies being used in their classes than their older peers. It is significant that the younger students are more satisfied with the online classes and the older students prefer the onsite classes. Again, this may have to do with the younger generation's higher comfort level with the technology.

Students 30 and under prefer group discussions and problem solving in online classes, whereas in onsite classes they appreciate new material presentations and Q&A to other strategies. Their satisfaction level is higher in the online classes than in the onsite ones. In the adult category preference in both online and onsite classes is given to presentation of new material. Their satisfaction level is higher in onsite classes than in online ones.

### *Gender Differences*

Researchers acknowledge that gender differences have little or no biological basis and believe gender differences to be a result of social, cultural, and environmental influences (Jovanovic & Dreves, 1996). Despite the gender stereotypes and gender rules, there is no argument against the facts that gender role assignments are gradually lessening and the genders are becoming more equal (Myers, 2002).

Although boys and girls differ in their physical, emotional and intellectual development, there is no evidence that these are linked. Therefore, it is unlikely that education performance is explained by biological differences. Social and cultural factors are the major reasons leading to gender differences in academic performance . . . These factors include students' familiarity with the subject, changes of career aspiration, gendered perceptions of specific subject, presentational styles of boys and girls, and teachers' expectation. Unlike biology, the social and cultural factors are changeable by modifying the context of education. (Gallagher, 2001, p. 21)

An important thing to remember when considering gender differences, however, is that men and women are genetically different. In addition, what biological heritage implies, social culture may accentuate (Myers, 2002).

A number of factors can create and affect gender differences in the classroom. There is an ongoing debate over whether observable differences in male and female behavior and cognition are the results of innate biological factors or learned cultural ones. The social constructionist theory, for instance, states that sex differences are learned and cultural in origin (Wood & Eagly, 2002). Having faculty members understand these differences and carefully select both the content and instructional strategies may help decrease the gender differences. The research shows not that males and females are—cognitively speaking—separate but equal, but rather suggests that social and cultural factors influence perceived or actual performance differences (Think Again, n.d.). If males and females are truly understood to be very much the same, things might change in schools, colleges and universities, industry, and the workplace in general.

Table 9  
Comparisons Between Instructional Format (Online vs. Onsite) and Gender (Male vs. Female)

Activities/Instructional Format				
	Online		Onsite	
	Male	Female	Male	Female
1. Peer collaboration	4.4	3.3	3.5	3.9
2. Small-group work	3.7	2.3	2.8	3.7

Note: Data entries in each row are ratings on a 5-point scale (1 = never use, 5 = use in every class). Interactions in each row are statistically significant ( $p < .05$ ).

Table 9 shows how men and women reacted to online and onsite classes. Males (more than females) reported frequent use of peer collaboration and small-group work in the online classes, but females (more than males) reported frequent use of peer collaboration and small group work in onsite classes.

### Discussion and Conclusion

The results of this project show that research of classroom practices may produce interesting and valuable information that has both theoretical and practical importance. Instructional methods and technologies are used differently in various classes. Online and onsite classes use various instructional strategies and educational technologies. Online and onsite classes are perceived differently by students. For instance, online classes use more video, Internet, and multimedia; onsite classes rely more on lecture, discussion, and group work. Students spend more time reading and writing in online classes, but onsite students spend more total time on class work and more time with the instructor. Onsite students spend more time in the classroom than online students spend on the computer.

There are clear age and gender differences in online and onsite education. Younger and older students tend to perceive the onsite classes in similar ways; however, the younger and older students have very different perceptions of what is happening in the online environment. It is significant that the younger students are more satisfied with the online classes and that the older students prefer the onsite classes.

The data on time expenses obtained in this research show that an online course is 2.25 more efficient than a comparable onsite course. While students definitely save time in this situation, online instructors invest more time in teaching, which takes a toll on them.

The gender differences in online and onsite learning do not seem unusual. Women tend to be more social than men, and therefore it is not surprising that they tend to be more responsive to tasks that have a social element (e.g., peer collaboration and small-group work in a classroom environment). The men, on the other had, seem to be more responsive to these tasks when they are conducted online.

This study indicates that educators should approach many aspects of teaching differently, such as selecting instructional strategies and technologies for their classes. It is especially notable in online and onsite formats, because they create different environments that have their own strengths and weaknesses. Moreover, instructors and curriculum developers should take into account the evidence that younger students approach online education differently than older

students, and accommodations should be made so that both groups achieve the best experience possible. The gender gap is not large, but it appears that more should be done to create online classes that accommodate women's desire for social interaction. Greater attempts should be made to simulate peer collaboration and group work online.

The research on instructional practices allows us to uncover many "secrets" of teaching and learning that may present unexpected challenges and solutions. Such research, coupled with individual and collegial reflection, can inform professional development activities and improve the quality of learning outcomes.

### **Future Research of Instructional Practices**

Based on the research of instructional practices, we can suggest the following topics for further exploration:

- Current instructional approaches and methodologies: How do they work in my classroom?
- Accelerated learning: pros and cons, and what we can use in our teaching?
- Teaching adults and ways to enhance their outcomes.
- Instructional design: how to structure and plan the course, the lesson, and the instructional process effectively?
- Effective presentation of the new material: modalities, formats and strategies.
- Student activities: effective methods and strategies for collaborative and individual work in onsite or online environments.
- Assessment and evaluation techniques: Which contribute to better learning outcomes?
- Educational technology: What, when and how to make it work best?
- Student learning styles and their multiple intelligences: how to use them all?
- Student attitudes and dispositions: how to affect them for better learning?
- Student motivation: how to raise it?
- Student needs and expectations in learning.
- Helping students do a good job: how to make students read course materials, instructor's announcements and e-mail, and peers' posts?
- How to improve students' writing skills?
- Communication in an online class and its effect on the learning outcomes.
- Effective time management in an online class.
- How to improve learning efficiency of online students?
- Teaching specific classes: What's special in my class delivery?
- Rational use of the course texts and other learning materials.
- Using web-based resources in the class.
- Modeling in teaching: instructor's teaching style.
- How to improve adult students' productivity in a long evening class?
- Comparing the same courses taught at National University and other colleges in the learning outcomes and instructional methodology.

There are certainly other venues, topics, and methods for exploring instructional practices to identify best practices and effective approaches.

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# Leadership



# School Psychologists: Educational Leaders for Tomorrow

Linda K. Smedley and Diana Wheeler

## Abstract

Challenges facing public education require school psychologists to use their skills as leaders and assume greater roles in improving educational opportunities for children. School psychologists have a unique expertise regarding issues of learning and are the most broadly trained school personnel who should assume a specialized leadership role in the educational system. Traditionally, school psychologists have been satisfied to accept a role of support staff in the educational process. By accepting and practicing wider activities in roles, including that of educational leader, they will have a greater impact on the future of our educational system.

## Key Words

School psychologists, leader, leadership, expansion of role, unique expertise, supportive role, visibility, specialized leadership

## Introduction

The profession of school psychology, as we know it today, began in the 1940s. Since that time societal, legislative, and professional changes have had an impact on the profession; however, little change has taken place in the daily routine of school psychologists. Identification for special education services completed on a one-to-one basis has been and continues to be their daily routine.

As a result of major legislation (IDEA '97 [Individuals with Disabilities Act 1997], IDEIA '04 [Individuals with Disabilities Education Act 2004], NCLB [No Child Left Behind]) in the last decade, there has been a change of focus in the role of school psychologists and reinforcement of the need for them to use all of their training in the new “territory” of general education. School psychologists have been given the opportunity to revamp their thinking about the role they take within the educational system. They have been known as the “sorters” for so long (Fagan, 2007) that they, as well as other personnel, especially administrators, assume there are no other paths to take.

As educators have become more aware of the diverse training of psychologists, no clear resolve has been made as to which tasks school psychology should perform. Surveys taken by school administrators, teachers (general and special education) and school psychologists themselves indicate a desire for role change (Hyman & Kaplinski, 1994). Other surveys show incongruence between teachers and administrators (status quo) and psychologists (expanded services) (Peterson, Waldron, & Paulson, 1998). This leaves school psychologists in a quandary regarding their professional expectations and future role identification.

As stated by Peter Serdyukov (2008), “we are living in a transition period characterized by widespread economic, political and social change, massive integration of technological innovations in all spheres of life, soaring growth of information and knowledge in all areas . . .” These societal changes have created a new era in education that emphasizes accountability, increased academic skills, and mandated academic testing. Future practices for school psychologists will need to relate more directly to curriculum, state standards, and meeting the requirements set forth in NCLB (High Plains Educational Cooperative, 2005). These new

requirements may create conflict within the role identification of the school psychologist who is unwilling to meet the needs of the future. Change, and resistance to it, is not new to education, but it is necessary for the evolutionary process.

### **Challenges to Change**

Individuals establish habits, and “the way we do things” creates stress when there becomes a need to change. When this need is not recognized, individuals press for the status quo. It becomes much easier to “do what they’ve always done” than do something new. People feel threatened with change. Most people enjoy the comfort of doing things the way they have always done them and enjoying the satisfaction of having confidence in knowing they do them well.

The thought of change may cause individuals to begin questioning their own abilities and skills. The perception they have of their own roles may be challenged, their expertise in a specific field may be called into question. Other barriers to change include fear: fear of the unknown, fear that a program may fail as other programs have done, or fear that the school environment will be unsafe if change is implemented. Challenges to the status quo may include a change in the social hierarchy of the organization. Union leaders, lead teachers, and department chairs are often the most senior members of the staff and are accepted as the “final word.” Change may threaten this structure and create entrenchment among the ranks of personnel. An often overlooked threat is that of financial resources. Change may require funding to be allocated to other areas of the budget and eliminated in areas of past supply. Personnel who in the past received incentives and positions of power, may feel threatened by a proposed change in policy or procedures (Zimmerman, 2006).

Publications are filled with materials related to the subject of change: examples of corporations that have gone through organizational changes, methodologies, and critiques of ways to make change acceptable. All agree that there are ways to combat the resistance. Good communication between management and staff is paramount. Individuals must feel that they are valued by the organization and are part of the decision-making process. When people are “left out of the loop,” they are more likely to resist the proposed changes and work against them. The provision of support is another component of acceptance of change. Administrators must support personnel when new ideas are being attempted. Without support, individuals feel that they are on their own and that what they are doing is not important enough to warrant the time and energy of management (Jackson, 2000). Educational personnel, especially, need to have a feeling of worth and value by administrators. When administrators do not support them and when they are not included in the decisions that are made, educators often become resentful.

Besides understanding the change process, Fullan (2001) states the single factor common to every successful change initiative is relationship building. The leader’s responsibility is to ensure that the organization develops relationships that help produce desirable results. These relationships must be based on genuineness and concern, not just a result of networking. Staff wants to be part of the school, to know the school’s mission, and to make a difference.

As has been stated, change takes many forms and produces many effects. It is important for all personnel, both management and staff, to understand the dynamics of organizational change: what it is and how it affects the organization as a whole. School psychologists must become familiar with these principles as they begin to make changes in their own roles. How they interact with administrators and teachers is critically important and will influence the

success or failure of the changes they want to introduce. If school psychologists want to change their roles in schools, they must begin to demonstrate and model the techniques they wish to implement. They cannot wait for others to lay a path for them. They must initiate the change themselves.

This is not a new proposal. The need for school psychologists to become change agents has been in the literature for a long time (Peterson, Waldron, Paulson, 1998). What is new is the urgency to move into the needs of the twenty-first century or to be replaced by others who are willing to use their skills.

The purpose of the study was to survey school psychologists to determine how they view their current roles in their districts. Their responses could indicate whether their current roles and skills would transfer to a new, changing future.

## **Role Identification**

### *Traditional Roles*

Beginning in the 1940s, the main role for practitioners was that of psychometrician, administering assessments to determine intelligence quotient (IQ score) and achievement scores (Fagan, 2008) for the sole purpose of determining eligibility for Special Education services. This role placed psychologists in a symbiotic relationship with special education and left little room for interaction with general educators. Although it may be perceived that mental health issues are the major role of school psychologists, this has not been the case. “Testing” has always been the main focus of their practice.

In the 1960s and 1970s, dissatisfaction began to grow among field practitioners regarding their restrictive roles and a desire for role expansion into the area of counseling and working with teachers began to grow. Unfortunately, resistance to change is a stronger force than is the power to make it happen.

By the 1980s and 1990s, Ysseldyke and others (2006) attempted to strengthen the consultative role of psychologists through training program guidelines proposed by the National Association of School Psychologists (NASP), federal legislation (IDEA '97, IDEIA '04, and NCLB), and initiatives allowing flexible and creative fiscal models for funding were an encouragement for psychologists to begin working in a consultative mode with general education teachers and other educators and administrators. Some state and local areas embraced the concepts and have made great strides in fostering role expansion for psychological services (High Plains Educational Cooperative, 2005); however, this is not a reality for the profession as a whole.

Overall, the major role of school psychologists today continues to be connected to Special Education students, programs, and teachers, just as it has been for the past 60-plus years. Fagan (2007) points out that psychologists are spending more time in Special Education–related activities but less time completing initial evaluations. This slight change may be due to added roles related to the need for other types of assessment, such as Functional Analysis Assessments (FAA), but also reflects the shortage of school psychologists available to service the number of at-risk students (Reschley, 2000).

### *Changing Roles*

The National Association of School Psychologists identifies 11 domains (skills) in which candidates are prepared for employment. As has been mentioned, most emphasis in schools has

been placed upon data-based decision making (Domain 1) with little concern for the other 10 skill areas. Special education will always have a need for school psychological services and assessments. The new expanded role for psychologists will come when general educators accept them to work side by side in their classrooms.

Reschly (2000) prophesized that traditional roles will continue, but the expansion of alternative assessment procedures and consultative processes will begin to open the door for school psychologists to utilize their abilities to a greater degree. Comprehensive mental health services is an area in which school psychologists have been severely absent, yet one in which they are not only greatly needed, but are the best prepared to serve the needs of students (Adelman & Taylor, 2000). The development of behavioral interventions is a task that fits the school psychologist's training and also places the psychologist in the general education arena.

The most current entry into the area of expanded roles has come through the legislative process (NCLB) by the encouragement of response-to-intervention (RTI). The latter opens the door for school psychologists to use multiple skills (domains) such as data collection and analysis, consultation and collaboration with general and special education personnel, intervention in academic and behavioral arenas, crisis prevention, and systems organization and policies. Research and evaluation will be the culminating result of the practice of these skills within the educational system.

#### *What Will Make It Happen?*

Ysseldyke (2000) identifies four prerequisites to the change that must take place. First, he states there must be commitment on the part of both school psychologists and university trainers. Training programs must assure their candidates are adequately prepared. Traditional assessment courses must be accompanied by newer, successful practices, such as curriculum-based assessment and measurement. The second prerequisite is clarity and consensus. Ysseldyke states that we often discuss the "big problems" (poverty, racism, family deterioration) that psychologists cannot resolve and do not focus enough on problems that are within our sphere (academic achievement in specific academics, truancy, behavior self-regulation). The third prerequisite mentioned by Ysseldyke is collaboration. Change can not be brought about in a vacuum; it takes collaboration among all stakeholders. The fourth and last requirement for change is conviction. Are school psychologists convinced they need to broaden their roles? If so, it is up to them to convince school administrators and teachers of this need. This is by far, the most challenging of the necessities for change.

## **Methodology and Findings**

### *Participants*

The participants were 108 school psychologists and psychological service administrators in Los Angeles and Orange Counties in California. The data were collected during the 2005–2008 school years.

### *Materials*

The primary instrument used in this study was a School Psychologist Role Survey (SPRS) created by the authors. The survey asked the respondents questions regarding the role of school

psychologists in their districts. The respondents rated the role activity on a Likert scale of 1 to 5, with 1 being strongly agree, 2 agree, 3 disagree, 4 strongly disagree and 5 undecided.

The SPRS asked participants to respond to 20 questions related to their professional activities. The selection of activities presented was based on the domains identified by The National Association of School Psychologists: data-based decision making and accountability, consultation and collaboration, effective instruction and development of cognitive/academic skills, socialization and development of life skills, student diversity in development and learning school and systems organization policy development and climate, prevention, crisis intervention, and mental health interventions, home/school/community collaboration, research and program evaluation, school psychology practice and development, and information technology. This is a very extensive and broad list of skills in which school psychologists are trained and ready to use in their professional routine.

### *Results*

The survey results are organized into two main sections. Those activities that can be classified as traditional roles are shown in Table 1. The responses to new role activities are shown in Table 2. Raw scores were converted to percentages. The percentages were combined into three categories of strongly agree and agree (SA & A), disagree and strongly disagree (D & SD), and undecided (UD).

### *Discussion of Findings*

The 20 professional activities directly related to the 11 NASP domains were divided into activities that traditionally identify the role of school psychologist and those newer activities that can broaden and strengthen the leadership role of school psychologists.

As can be seen in Table 1, the majority of school psychologists perform all of these traditional activities with the percentages ranging from a high of 90% to a low 67%. The activities receiving 80% or higher agreement were very traditional roles: maintaining cooperative working relationships with other professionals (90%); being identified with psychological and achievement assessments (84%); and being viewed as test administrators and support for special education programs (90%).

Table 1  
Traditional Roles Percentages

Questions	SA & A	D & SD	UD
1. School psychologists have been able to develop and maintain cooperative working relationships with other professionals.	90	7	3
3. School psychologists spend significant time on behavioral consultation with teachers and staff.	75	23	2
7. School psychologists are identified with psychological and achievement assessments at their sites.	84	8	8
8. School psychologists are skillful at linking assessment data to interventions.	77	21	2
13. School psychologists have provided teacher/staff in-service training.	76	18	5

14. School psychologists understand curriculum and state and local academic assessment issues.	68	25	6
15. School psychologists are viewed as test administrators and support for special education programs.	90	8	2
18. School psychologists spend time (other than during IEP meeting) consulting with parents.	73	24	2
20. School psychologist spend time working with parents on proactive strategies.	67	29	3
<i>Mean percentages</i>	<i>77.7</i>	<i>18.1</i>	<i>3.7</i>

The newer roles for school psychologists are presented in Table 2. The activities which received 80% or higher agreement include serving resource for coordinating mental health services (88%), being viewed as behavior intervention specialists (82%), and providing crisis consultation (89%). There was little agreement among the participants that they perform the newer roles in contrast to the uniform agreement that they perform the traditional roles. The mean agreement for newer roles is 54.8% compared to the 77.7% agreement in traditional roles. The median percentage for newer roles was 66% in contrast to the median percentage of 76% for traditional roles.

Table 2  
New Roles Percentages

Questions	SA & A	D & SD	UD
2. School psychologists are viewed as a valuable resource for coordinating mental health services and contacts.	88	9	3
4. School psychologists are viewed as behavior intervention specialists.	82	18	0
5. School psychologists work on preventative programs and screenings for students.	46	53	1
6. School psychologists are viewed as consultants for learning enhancement and academic success at their sites.	69	26	5
9. School psychologists are considered a resource to second language learners at their sites.	33	60	8
10. School psychologists translate research findings into recommendations at their sites.	66	30	4
11. School psychologists participate in program evaluation activities.	38	55	6
12. School psychologists are developers of interventions and program strategies.	66	18	6
16. School psychologists provide crisis consultation when needed.	89	7	4
17. School psychologists spend time counseling students on an ongoing basis.	60	37	2
19. School psychologists act as a resource for interpreting high stakes assessments at school sites or at the district level.	54	38	8
<i>Mean percentages</i>	<i>54.8</i>	<i>31.9</i>	<i>4.3</i>

The newer roles are compatible with leadership skills and places the school psychologist in a more viable leadership position in general education than the traditional roles. Only two of the nine traditional activities require leadership skills. Those activities are behavioral consultation (75% agreement) and in-service training (76% agreement). Nine of the eleven newer roles require leadership abilities: serving as a resource for coordinating mental health services (88%), being viewed as a behavior intervention specialist (82%), working on preventative programs (46%), serving as consultants for learning enhancement and academic success (69%), being considered as a resource for second language learners (33%), translating research findings into recommendations (66%), conducting program evaluation (38%), providing crisis consultation (89%), and serving as a resource for high stakes assessments (54%).

If school psychologists are to move beyond the common roles they have practiced in the past, they must begin to assert themselves in ways that may not be in their “comfort zone.” Activities that place the psychologist in a leadership mode need to be developed and cultivated. The school psychologist must move from the position of “helper” to that of “leader.”

School psychologists have a unique expertise regarding issues of learning and are the most highly trained school personnel to assume the leadership role in this process. First, by fine-tuning their assessment skills (Bracken, 2004) and then linking them carefully to effective interventions they will improve their present role. Second, by working on school-wide preventative screening and interventions along with a variety of mental health strategies they will have more impact on students of all abilities. The question is “Will they be leaders of change or will psychologists do as they have always done and find that others have taken their place?”

The discussion regarding roles has been ongoing for several decades. Why have the roles of school psychologists not changed? Why do school psychologists continue to spend the majority of their workday in the assessment process? Why has there been no change in the system? Why do psychologists not broaden their skills and take a leadership role in the education system? Are the changing roles emphasized in university programs? Do training programs encourage school psychology candidates to practice the roles needed in the future? Are innovative skills being presented in the university classroom?

Leadership is an attitude as well as a position. It often requires individuals to assert themselves in situations that may not be the most comfortable and secure. It also requires the self-confidence to be assertive and be able and willing to accept responsibilities. For school psychologists to bring their skills into the twenty-first century, they must accept the challenge of leadership positions. It is no longer possible for them to continue in traditional roles and at the same time expect to be agents of change. Psychologists must step out of the past and step into the future in order to survive professionally.

## **Conclusion**

It is clear from the literature and practice, two things must happen if school psychologists are going to become leaders in the educational domain of the twenty-first century: every psychologist must want to use all, or most, of the skills in which they are trained, and they must position themselves within the education organization in order to assure they use their training. The latter is very important. School psychologists can not wait for others to “knock on their door”; rather they must become a vital part of the school environment and demonstrate

leadership roles in whatever area is available or someone else will take over the job. We recommend that psychologists act decisively and quickly to gain solid footing as program leaders in general education. There is a need to publicize areas of expertise and explain how they can support the school in reaching its goals, especially those goals viewed as important by the school administration and leadership teams. School psychologists must be leaders of the change process to be effective in defining their roles or others will mandate their role for them.

Stephen Elliott (2000) points out,

[H]arder times are ahead because more is required and expected of school psychologists than ever before. More services requiring prevention, intervention, program evaluation, and alterative assessments are and will be increasingly needed. More students with diverse needs from diverse cultures are and will be increasingly occupying schools. More connections to the regular curriculum and concerns about accountability for all learners are and will be increasingly demanded. All these 'mores' translate into less time for all students . . . school psychologists will just have to work smarter and repeatedly demonstrate their effectiveness without losing a personal touch.

We recommend that training institutions systematically align NASP domains into their learning outcomes and professional standards. It is the training institutions that prepare school psychologists to meet future needs, and those needs can only be met if these individuals have leadership skills and the attitude to be a leader. Training programs must be convinced of the necessity to change, must create innovative courses that support these changes, and must assure that candidates have the dispositions to be leaders.

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# Developing Coherent Leadership in Partnership with Horses—A New Approach to Leadership Training

Ellen Kaye Gehrke

## Abstract

This paper offers a new perspective in leadership development by demonstrating how engaging horses as partners in leadership training can lead to more coherent and sustainable leadership effectiveness. The training experience provides a unique approach for students and corporate participants to develop sustainable changes in their awareness and actions regarding their leadership abilities and authenticity. Horses prove themselves as dynamic co-facilitators by providing participants genuine opportunities to engage with others in the present moment and obtain honest feedback regarding the congruence between what they say and what they do as leaders. This innovative work suggests how the application of equine partnered experiences (EPE) can help transform and motivate people so they are able to make better decisions, gain more clarity, experience more commitment to their life and work, and generally improve the coherence of themselves and those around them. Case examples are provided of actual training situations demonstrating the various outcomes related to increasing effective leadership and management.

## Key Words

Leadership training, equine facilitated learning, equine partnered experience (EPE), decision making, leadership effectiveness, nature-related experiential education, social systems dynamics, herd behavior, equine facilitated psychotherapy, psychophysiology, organizational leadership, leadership coaching, cross-cultural training

## Introduction

A problem with most management education today is that it is primarily oriented toward analytical conditioning. Thinking is rewarded more than intuitive development. Quantitative analysis is often more valued than qualitative observation. However, as the recognition of the importance of developing social and emotional intelligence grows, there is a greater need to emphasize and encourage the heart-brain-body connection (Goleman, 2006). In education and training the balance is beginning to shift from being primarily cerebral toward incorporating more experiential approaches fostering the growth of more balanced and holistic leaders. It is not unusual to hear more discussion about the relationship of the heart and body, particularly the education of managers who provide leadership across cultures and nations (Senge, Scharmer, Jaworski, & Flowers, 2004). It is commonly accepted that continuous change and transformation is the norm in our global economy and that it is difficult to manage these changes and transformations in ways that “stick.”

The author’s developmental work, as presented in this paper, provides a general hypothesis that the application of equine partnered experiences (EPE) can help transform the awareness and motivation of individuals and teams so they demonstrate improved decision making, more focused observation and clarity, greater commitment to their life and work, and generally improved relationships with themselves and those around them (Strozzi, 2004). Another outcome of the work is the reconnection to nature and animals and the growing awareness of the importance of interacting with animals, particularly horses (Hesler-Key, 2001).

This paper discusses differences in leadership training with horses and examines such areas as equine coaching, team building, leadership awareness, and cross-cultural applications. The reader will learn why horses are effective living biofeedback beings and how the metaphor

of their social systems and herd dynamics is relevant to creating effective and coherent leaders (Coates, 2008; Kahonov 2003). Short cases are included to emphasize training applications and outcomes. Also included is a brief introduction of a quantitative research project that the author has under way to support the assertion of the benefits of human-animal-nature interaction. Using heart rate variability as a marker, the researchers are measuring the existence and strength of the human-animal bond.

The material presented took place over a two-year period in which the author included leadership development in her course curricula as well as in her training and consulting offerings. Various cases are used to demonstrate how equine partnered experiences generated substantial change in learners: something that happened deep within the person and not just in his or her mind. Most executives spend their lives “in their heads”—concentrating, talking, thinking—and move at a rapid pace from one event and opportunity to another (Tolle, 2005). The work with horses in a natural setting is designed to encourage people to slow down, tune in, pay attention, stay in the present, make changes for the better now and not later, have an experience that incorporates both mind and body as a synchronized effort, and experience a way of learning that facilitates change that sticks and that positively influences individuals and the organizations they work in.

The author has been teaching leadership and organizational development for more than 20 years. For the past 10 years, she has also been working with horses, particularly wild horses, gentling them and preparing them to work with and live in partnership with humans. The experiences gained in years of teaching and consulting and then years of training horses led the author to this emerging field of equine facilitated learning. This paper is only a beginning discussion of the work and research taking place in this area, and it is hoped that the work will be welcomed in the management arena as something that will become more mainstream and not considered as trendy or esoteric. The work has potential implications for changing people at their heart level (Rector, 2005)—change that can make a difference in who leads our organizations now and in the future and how these people make decisions for the benefit of their organizations and society as a whole.

### **The Difference Between Dominating or Facilitating Leadership**

*“Leadership isn’t about making people do things”*

Toby (name changed), a computer software engineer and manager of several project teams at a high tech company, showed up for the Saturday session on Leadership with Horses thinking he already understood and had a sense of his leadership style. However, his experiences that day shifted his perspective. When it came his turn to lead a horse through the obstacle course, he had to slow down and check in with Rocket, the horse, instead of “dragging” it along. He learned what it meant to pay attention to the goal (the obstacle course) and to pay attention to his team member (the horse). His first time through the obstacle course did not go as he had hoped. He got angry when the horse dropped its head and started to eat, so Toby began to tug hard on the line to move forward. Then the horse refused to move across a bridge, and that brought more frustration. Finally, Toby stopped, took several deep breaths, and began to pay attention to the energy between himself and the horse. It was an obvious and clear shift from his wanting to accomplish an agenda that the horse had no part in to a focus on how to engage in a partnership to achieve a goal. At that moment, Rocket looked up, took a step alongside Toby, and began

moving in step with him, almost as if they were dancing. The horse responded to Toby's clear focused leadership with energy and enthusiasm.

Toby commented in a journal entry,

It's one thing to have a horse like you, however it is another thing to have a horse want to follow you around with no lead lines attached. You can't be a leader just by telling someone you are a leader. You have to prove it . . . you have to be it. Before, if I was the leader and you didn't do what I wanted, I would get angry. I may give up on you or just do it myself. Now I have a new perspective on leading others which is more effective and energizing as well. I learned how my energy and presence impacted how others (the horses) perceived me and that became a significant learning experience which has shifted how I manage and lead my team.

Toby reported in a conversation the following week that he had immediately been able to apply his newly discovered realization to his project team and found that the work week went smoother. He added that the work was also more fun and less frustrating. He also indicated that the team became more productive when he was less angry and more present to assist his employees.

The lead horse in a herd is responsible for the safety and survival of the herd (Grandin & Johnson, 2005). Imagine working in an organization where each day the leaders show up and work entirely for the safety and survival of the people and the organization. Each day they earn their positions of leadership. And that leadership is maintained only through continuous attention to the environment, knowledge of how to find and lead others successfully through complex environments, the ability to make quick decisions that could mean life or death to the organization, and operation from an energetic connection that is able to mobilize organizational actions immediately, often requiring little if any on-the-spot explanation or manipulation. Horses operate in this manner, and much can be applied to human learning systems from their behavior. If the leaders are not able to maintain this flow of safety, awareness, or social integration capability, then members of the herd, or organization, lose trust, feel unsafe, and experience an imbalance. In this situation it is possible that another mindful and aware leader will quickly move into the leadership position, taking over the territory—a phenomenon that is common in herds and is critical for the survival of the herd. This example is applicable to leadership training for individuals, who can learn to recognize their own presence and command within their organizations so they can sustain a positive leadership role.

### **Keeping People Safe as a Leadership Metaphor**

Horse herds tend to demonstrate three leadership styles that mirror what many of us experience everyday in organizations. First, there are true leaders who lead for the sake of the herd, taking care of their employees and paying attention to the workings of the internal and external environment. Second, there are dominant bullies, pushing others around and looking like they are in control. Others avoid them, which may be perceived as leadership by an onlooker. Finally, there are those who go along with things in a submissively—considered passive leadership behavior. The true lead horse serves as the responsible leader—leading for the protection and survival of the herd. If the lead horse is not constantly aware of the environment and providing

constant communication exchange, predators may kill it or members of the herd. All members of the herd who want to be safe and cared for make sure they know where their lead horse is at all times. The dominant horse tries to be a leader, pushing and moving others around successfully, but it is never given leadership status because it is considered a bully and not looking out for the safety of all. Others may comply temporarily, but they do not look to a dominant horse as their true leader. The passive horse goes along with the leader and willingly takes orders and participates within the herd hierarchy, which is important when the lead horse gives the signal to leave quickly or to indicate that danger is nearby. Most participants in the leadership training programs identify with wanting to lead for the survival of their employees and the organization. Observing and engaging in the training programs helps build that ability.

### **The Difference Between Equine Partnered Experiences and Other Outdoor Adventure Training**

Some people compare the leadership with horses programs to outdoor survival programs, ropes courses, river rafting trips or other outdoor adventures (Graham, 2007). However, unlike these other experiential programs, the equine partnered experiences go beyond overcoming fears in a period of stress to a deeper level of connection, engagement, and heartfelt learning. The activities require true communication and engagement with another being at a level that does not often present itself in traditional training environments (Rosak, Gomes, & Kanner 1995). It is not about overcoming fear or building self-confidence. It is about recognizing the moment of an energetic connection with another being and what that moment really means for lasting and effective relationships. The experience of connecting strongly to a horse has been profound for participants. They often inquire about certain horses a year or two after their interaction. They also retell a particular lesson they learned about themselves in the presence of a horse and how the experience has stuck with them. The changes and realizations are persistent and offer participants reflective insights that resonate for days, weeks, months, and even a few years.

#### **A Lesson on How Others Reflect Your Energy Presence**

During one of the sessions at the ranch, Melissa said that she had difficulty in getting others to truly understand her. She mentioned some situations with her parents as well as her co-workers and her fiancé. Melissa managed a busy retail store and was participating in an organizational behavior class. As part of the leadership segment of the class, the author inserted the leadership with horses workshop into the curriculum. One of the first activities was for participants to mutually choose a horse to work with through awareness of the exchange of energetic connection and understanding between themselves and the horse. Often, one horse might end up with two to three people out of a group of 10 to 15. On this day, Melissa found herself the only person sensing a connection with Rusty. Rusty is a very personal horse and usually ends up with several people who are drawn to work with him. It was unusual this time that it was just Melissa.

She later stated in her journal,

I never felt so “mirrored” in terms of another animal and myself in my life. I felt like he was trying to reach out to me but for some reason I didn’t let him all the way in because it

was overwhelming to me and I didn't quite know what to do. I think that he definitely sensed that with me. He sensed my power and confidence a few times and I really did feel the energy between him and me when I had him moving—then there were times when I felt lost in the process and weak and that was when I knew I lost Rusty and his reliance on me as his leader. It's crazy to me how we can overlook so many minor details within our lives that plague and excite us on an ongoing basis, but then in a moment or through mere seconds with a horse, you can have all the clarity in the world as to what plagues or excites you, as they look within your soul and you to theirs. All I have to say is “wow!” I am truly speechless as to the immense freedom this study has brought to my life. It is a feeling like no other than I have ever known.

Melissa later told the author that the connection with Rusty and the realizations she experienced led her to arrange for a meeting with her parents to talk about some things that had pulled them apart. She also said that she was trying out a different management approach at work and was getting along better with her employees. She also found that she was reducing her alcohol consumption because she wanted to feel more present. She came out for several private sessions with Rusty after the class was over to engage in equine partnered coaching.

### **How Does This Type of Educational Development Work?**

Equine partnered experiences (EPE), equine facilitated learning (EFL), equine guided education (EGE), equine assisted activities (EAA), and equine facilitated psychotherapy (EFP) are gaining increasing recognition in the field of personal growth and leadership development (Halberg, 2008). Horses are included as partners, considered as emotional sentient beings, in the venture and awareness for facilitating leadership change and learning. Because horses do not have a frontal cortex (Grandin & Johnson, 2005), they are not capable of separating their feelings from their behavior. In fact, they are primarily emotional beings and respond to the stimuli produced by emotional energy, which begins in the heart (McCarty, 2006). Horses do not approach relationships with any agendas, judgments, or preconceived thoughts of how the relationship “should” be. In addition, they are not familiar with concepts such as sacred cows in organizations; they don't care what gender, race, sexual orientation, economic status, positions you hold or any other social indicators of status or equity. This makes them ideal in providing honest and clear feedback to those who communicate with them. This process has also been effective at restoring a sense of relationship with nature and natural life cycles—a state that has been considered an important element to the development of the emotional self (Goleman, 2006).

Incorporating participants in a partnered approach with a trained facilitator and willing horses is proving to be a useful and dynamic approach for creating lasting and meaningful leadership changes. It is important to the integrity and outcome that a competent horse person, a competent human relations facilitator, and a horse that has been trained for this work are considered when participating in these types of programs. The potential for transference and counter-transference can occur within the training environment, and it is critical that the horse and the human not be harmed and always be kept safe mentally, emotionally, and spiritually, as well as physically (Rector, 2005).

## **Why Do Horses Make the Difference?**

You may ask, why horses, why is this method different, does it work, and will the learning stick or be sustainable? First, it is different because when a human comes face to face with a horse, the horse can only work within the boundaries of the present moment and offer a communication environment grounded in honesty and truth. Horses are not capable of lying and thus make excellent partners in the leadership transformation process (Dorrance, 1999). Because they are prey animals, horses are masters at reading body language and nonverbal communication. They respond instantly to the true energetic field of the human. The training programs work because the activities with the horses are designed to allow participants to experience the alignment or misalignment of the energetic moment in the present and make changes immediately. The program is not presented in a way that requires participants to do homework or engage in a thinking activity in some future moment to understand what happened. When work is done with the horses, it is delightfully—or painfully—obvious how effective a person or team is at leading for the safety of others and the performance of the organization.

## **Cross-Cultural Training with Horse Partnerships**

The author taught a course in cross-cultural management for ten years. Her evaluations and continuous contact with students would be enough for some to consider her efforts to be successful. However, it was not until she brought her cross-cultural management class to a ranch for a day of leadership training that she realized how significant the horses were in virtually eliminating boundaries of difference and allowing for a state of complete appreciation, care, and support of others, no matter who they were or where they were from (Trompenaars, 1994). One particular class consisted of approximately 20 students who originated from such diverse countries as Kenya, Brazil, Turkey, China, Taiwan, Thailand, Peru, Germany, Sweden, Russia, Tunisia, Mexico, Italy, Egypt, and the USA. The students were asked to participate in several leadership exercises with the horses as a part of a day on leadership and culture.

It was immediately apparent to the students that the horses didn't care what nationality they were or what languages they spoke. They only cared how the students presented themselves energetically: Did the students stand before them in heartfelt appreciation and ready to be effective leaders? The horses just wanted to know whether the students had good hearts and were good leaders. Many students commented that they had never experienced anything like this in the United States—that they had always had to adapt to the American situations or scenarios presented in classroom discussions. Some of the participants shed a few tears of joy at the connection they realized with another being and how good it made them feel. They also stated that they felt an intense desire to care for the horse and to be a good leader and aware person.

One Kenyan student, who was destined to return to his home country and become chief of his local tribe, changed his whole demeanor to the class and could not stay away from Shiloh, a big black mustang adopted from the Bureau of Land Management and gentled by the author. The two of them made a powerful connection. The student proclaimed a great deal of appreciation for Shiloh's "blackness" and his strength and power as a wild horse (he was gentle now).

The walls between all the cultures came tumbling down that day. The debriefing after the exercise was as raw and exposed as any activity the professor had ever conducted. Many tears

were shared among the students as their hearts opened to the horses and to each other. Journals were submitted proclaiming that the “horse experience” was the most profound in all their education in any of their countries. It was the first time they had experienced themselves and others with no cultural boundaries and had interacted with one another from “the heart.” Two sets of parents sent the professor messages from China asking what she had done with their children that had given them so much courage and confidence to continue their studies in the U.S. in such a determined manner. All she could respond was that it was gift from the interaction with the horses. She had just set up the experience for the students. and they took from it what was important to them.

### **Energetic Awareness in MBA Students**

The author included a horses-and-coherent-leadership segment in her leadership and management of change class in the MBA curriculum. During a preliminary activity to prepare the students for going to the ranch, she worked on their awareness of their energetic fields and how they influenced one another with their presence (Lipton, 2005). One student from Turkey, Hakan (name changed), had been particularly aggressive during the practice activities, and the professor suggested that he not attend the horse session if he was going to engage in such aggressive behavior around her horses. He did attend the session, but as a much calmer person. He had had such a strong reaction to the feedback about his energy that he made a tremendous shift toward becoming a gentler, more approachable person. This did not go unnoticed with the horses, who willingly engaged in activities with him, and it was apparent from their behavior that mutual appreciation had occurred between them. In his journal and in subsequent discussions with the professor, Hakan noted that he later changed from a stressful and unfulfilling job to a challenging and engaging organization and job environment. He also broke up a relationship that had proven dysfunctional for several months. He became more serious about his studies and changed from the aggressive, angry presence he initially exhibited into someone who was quite pleasant to be around. It almost seemed too fast of a change. The student attributed his renewal to his experience with the horses and realized he could do things a different way. The author relayed the results to colleagues from the clinical psychology department, who noted that those kinds of changes would normally take months or years, not just a few weeks, and they were supportive of the results, confirming that the training with horses was successful for initiating change.

### **How Does EPE Help Us Understand Organizational Systems?**

As previously stated, horses live in herds and are prey animals. Thus, they depend on their ability to “read” the intention of other animals for their survival. They depend on their ability to relay, or what we often hear as the term “mirror,” this information nonverbally to others in the herd in order to maximize herd survival. They have a keen ability to sense emotional energy of those around them and respond in a synchronous manner. These instincts allow the horse to be an ideal partner in working with humans to help rediscover the ability to sense the environment and communicate whether there is a “threat” to themselves and others. It is this ability to discover the energetic field of human interaction that makes this type of work so relevant to good

communication and organizational effectiveness (Kaye-Gehrke, 2006). Horses expect humans to be congruent and coherent while interacting with them. They are quick and instinctual in sensing the emotional field, which helps encourage people to learn how to develop trust, to operate with integrity and fairness, to be clear in communication and intention, and to accept how things go without criticism and judgment. These lessons, which horses so generously and patiently teach us, can be solidified at the neurocellular level and be helpful in improving people's relationship with themselves and others (Church, 2007).

### **Working From the Heart—Not Just the Head**

Lisa (name changed) is a single mother who experienced a difficult divorce. She was a doctoral student in organizational psychology and participated in an experimental doctoral class the author led, called Chaos to Coherence. Part of the class included group and individual coaching sessions (Goldsmith & Lyons, 2006) with the horses. When Lisa arrived at the ranch, she said that she felt tired and sad. One activity involved grooming horses. Oftentimes participants claim that during grooming they shift into a higher level of energetic connection with the horses and themselves. The next activity, called gestalt with horses, involved Lisa being in an arena with the horse. There was no specific agenda except to listen and be with the horse. The facilitator is always nearby to insure a safe working environment for both the horse and the human. Lisa had a powerful response to the gestalt activity. These were her words about the experience:

This experience has truly changed my life. I am a very skeptical person by nature and I am not easily swayed from my personal beliefs. However, the horse coaching experience has changed my personal beliefs about energy and connections between people and animals. It also allowed me to break away at a wall I have built around myself for some time. I really found myself trying to “think” Rusty over to me, which, of course, yielded no results. When Rusty did come over to me I really felt this warmth between us. I really noticed a difference when I was “in my head” and when I wasn’t. The horses responded so much to me when I was experiencing emotion in my heart. I spend a lot of time in my head and it took a lot of focus to remain in my heart. This experience taught me that I can be “big” and energized and powerful and still be liked and effective. It also taught me that the wall I built was truly pushing people (and animals) away from me and almost unsure of how to approach me. (At one point, Rusty, came halfway down the arena and stopped as if to say, “Do you want me around or not?”) I couldn’t imagine trying to be a leader with people afraid of how to approach me. I also learned that I am so much more effective when I am “in my heart” as far as connections go. The day at the ranch was the most time I have spent in my heart in years. I left feeling so much better and more myself.

Often, you will hear that horses tend to be mirrors for human emotions and are able to allow people to understand themselves and make changes in the present. In reality, horses actually assist in demonstrating the consequences of emotion driven behavior, without the support of verbal communication. If a horse does not trust your intentions, it will not be as responsive to your leadership. Horses’ survival depends on the emotional clarity of the herd leader to keep them safe (Strozzi, 2004). For example, if we work with a horse when we feel

angry, frustrated or depressed, the horse does not necessarily become angry, frustrated or depressed. However, it responds to the emotions. Humans may experience the same emotional response but they have been socialized to censor a visible response. When humans “fake” happiness, confidence, or support, it only serves to deny or misread the congruence of how others may actually feel or want to react to the emotional energy presence. Lisa learned this when she had her coaching experience with Rusty. He did not know what to do when she sent confusing messages about her leadership, making him feel unsafe. Horses do not want to be with the being who is making them feel unsafe—in natural environments they could get killed in such circumstances—so their instincts prevail when a human sends confusing messages to them.

The social pressures of our society have taught humans this learned “fake” behavior. And, as the top predators in the food chain we have not had any incentive to rewire this “dishonest” behavior. When a horse senses a human’s frustration, anger, or confusion, it may do one of three things: (1) try to leave the situation by running away, (2) freeze and not be responsive to any requests or interactions from the human source of the confusion, or (3) become aggressive toward the source or others nearby.

This is not unlike situations found in most organizational environments today. The energy of the emotion is something horses sense and respond to quickly. If they do not sense you as a congruent leader, they will not look to you for leadership or safety. Observing ourselves in relationship with horses and becoming aware of their reaction to our emotional energy becomes a learning opportunity for making changes in how we authentically manage our emotions and our ability to lead in relation to self and others (McCormick & McCormick, 1997).

### **Energetically Leading an Effective Team**

During one of the author’s corporate programs, the organization had requested team-building activities with the horses. To help the group understand energetic connection, participants were asked to form a large circle and stand at least 5 to 10 feet away from one another. One of the team leaders came into the center of the circle to direct the exercise, which was to ask a horse to move from person to person around the circle in one direction, then to turn and go back the other way. The team was not allowed to touch the horse, move it, or get it upset.

They were sure this would be a simple activity. After all, they had already worked with this horse and thought he liked them. They started out very confident, appointing the organization's president as the team leader. The horse, Storm, started in the circle with the team and appeared engaged with the group. Then, as the group became more competitive and interrupted the team leader’s directions by yelling at each other, Storm started acting worried. One person thought the horse liked him so much that he could lead the horse from person to person himself. He proclaimed himself the savior of the activity. When this happened, the leader quit her role. Storm stopped and wouldn't move with the self-appointed individual. To get Storm moving, many of the team members started waving hands. This caused the energy level to escalate so much that the horse ran off to the other side of the arena. It became apparent to the team that the energetic connection was being sacrificed for the sake of trying to get the task done. They initially blamed the horse and thought Storm was not cooperating with their directions. However, the horse *was* doing what they wanted it to do, since it was responding to their energetic communication of franticness, blame, and frustration (Mills, 2005).

The debriefing was powerful when participants indicated that this is exactly how they

conducted their teamwork back at the office. It was a sobering experience for them. A few weeks later they asked if they could go to the ranch and do the activity again. This time they were calmer; they focused on the energy and how the horse was responding. They were more successful this time. They told the author how much they had been working on recognizing and being aware of the energetic connection of how they had all worked together. The president of the company told the author that, “energy” wasn't something they had paid attention to. After the horses and teamwork sessions, it had become more “visible” and apparent to them. Back at the office they started a new behavior of recognizing and monitoring each other’s energy levels and indicating to one another whether it was contributing to more or less motivation to cooperate. They stated that this process had created a significant culture change in their organization. As indicated, the next time they came for a session, the effort and outcome was more successful.

The company president commented:

If a human approaches the horse with an agenda and goal and not from a position of openness and awareness then it is unlikely that results will be attained or fulfilling. However, when the human tunes in to the energetic field of others and responds appropriately then more often than not it leads to successful communication and leadership.

### **Quantitative Research Supporting the Benefits of Horse-Human Interaction**

The author found little quantitative evidence to support all the anecdotal writing claiming the benefits of horses and humans working together. She recently began a research project to quantitatively measure the emotional bond between horses and humans (Kaye Gehrke, 2007). Using heart rate variability as a marker, a team of researchers is setting out to measure the emotional connection between horses and humans (Mistral, 2007). The horse’s heart is four to five times larger than the human heart and capable of sensing a magnetic field much stronger than ours (Becker, 2004; McCraty, 2006). The initial results are supporting the hypothesis that when humans are in emotional states of presence, horse and human begin showing similar rhythms. The research is currently undergoing further rigor, yet, it does provide some initial support to the suggestion that it “feels good” when humans experience heartfelt energetic connections between themselves and a horse. It is a beginning to demonstrate quantitatively what this paper has qualitatively suggested: that this type of leadership development can be stress reducing and contribute to more authentic and effective leadership.

### **Conclusion**

Little published research exists regarding this emerging field of training and coaching in partnership with horses (Kaye Gehrke, 2008). Most of the literature is directed at psychotherapeutic interventions, which are much different than the work described in this paper. Horses are powerful archetypes and evoke intense emotions among training participants. However, in leadership training the facilitators do not engage in psychological analysis. The guidance is based on principles about working in the present moment and becoming aware of the

impact of one's energy on another being—in this case a horse—who provides honest feedback. Horses prove to be effective living biofeedback beings! Unlike other training programs in which a participant may need to go away to work on things learned about themselves, horses allow people to make immediate and lasting changes. This aligns with the emerging neuropathway research suggesting that present moment experiences can lead to permanent cognitive and emotional changes (Church, 2007).

As natural horsemanship trainers have known for a long time, horses are not judgmental (Rashid, 2005). If individuals are angry, fearful, or unaware of their impact on others, they can learn, with the help of horses, to master tools or resources to change their neurological and energetic state. When this happens horses immediately respond to the human change in a positive manner, without “judging that the human was different a few minutes ago or last week.” This ability to make a positive change and rewire or anchor a more positive emotional state as the event occurs is the primary reason this work with horses is so powerful for helping to improve individual leadership ability and group or organizational effectiveness (Hunt, 1987). Plus, it is fun and memorable. Horses enjoy the companionship of humans and respond with love and appreciation to honesty, sincerity, and care. They will try to please a human who offers positive, consistent, heartfelt leadership. Offering leadership training with horses that involves carefully designed activities, well-trained horses, an open working environment, and a team of skilled and educated facilitators supports the hypothesis that horses can serve as honest biofeedback beings for improving leadership and relationships in organizations.

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# Projects and Grant Reports



# Teaching Mathematical Reasoning in Science, Engineering, and Technology

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## Abstract

Teaching mathematical reasoning is a challenge for most result-oriented teachers. In general, many strategies can be employed, including problem-based learning, technology-based learning, game-based learning, community-based learning, work-based learning, inquiry-based learning, project-based learning, team-based learning, web-based learning and participatory learning. However, none of these strategies may address the central problem of mistakes made with inappropriate application of intuition in mathematical problem solving. This paper emphasizes an agile method of teaching rapid reconciliation of intuition and controlled mathematical reasoning to engineering students in order to overcome inappropriate use of the intuitive mode of cognitive function. This emphasis is based on an extensive review of existing research and an emerging understanding of interactions between intuition and the controlled mode of cognitive function.

## Key Words

Intuition, agile teaching, access, metacognitive strategies, algebraic thinking

## Introduction

Daniel Kahneman, in his 2002 Nobel Prize lecture, distinguished “two generic modes of cognitive function: an intuitive mode in which judgments and decisions are made automatically and rapidly, and a controlled mode, which is deliberate and slower” (Kahneman, 2002). Kahneman and other researchers have collected experimental results showing that judgments and decisions made in intuitive mode are frequently erroneous (Alter, Openheimer, Epley, & Eyre, 2007; Evans, 2003; Kahneman & Frederick 2002). In his Nobel Prize lecture, Kahneman mentioned several experiments including the following:

A bat and a ball cost \$1.10 in total. The bat costs \$1 more than the ball. How much does the ball cost?

What is remarkable is that almost everyone has an initial tendency to answer “10 cents” because “the sum \$1.10 separates naturally into \$1 and 10 cents” (Kahneman, 2002). It was found that 50% of Princeton students and 56% of students at the University of Michigan gave the wrong answer. The correct answer is “5 cents” which is reached through the controlled mode (the bat costs \$1.05, which is a dollar more than the 5-cent ball). However, intuitive thoughts come to mind spontaneously like percepts, whereas controlled thoughts do not come effortlessly. Those who gave the correct answer after overcoming their initial tendency have likely utilized the controlled mode of cognitive function in a deliberate way.

Intuitive thoughts are not useless. For example, intuitive judgments about love, affection, and family matters are usually good. However, in engineering, science and technology, students should be able to use mathematical reasoning correctly. “Recent test results show that U.S. 10th-graders ranked just 17th in science among peers from 30 nations, while in math they placed in

the bottom five” (Wallis, 2008). Within the United States there are a number of other variations including urban and suburban. Many teaching strategies that have been tried show important improvements in student learning in different settings (Borman, 2005). However, significant nationwide improvements have not been achieved despite these isolated demonstrations of success.

It is not credible that culture, nationality, race, ethnicity, or religion would have anything to do with mathematical reasoning. Religious, ethnic, and socioeconomic groups may show intuitive differences but must agree with mathematical reasoning such as

$$3x = 18$$

therefore  $x = 6$

We would all agree with this reasoning despite any differences in religion, culture, or political philosophy. Analyses of the serious problems we face today need to be carefully formulated mathematically. The trade deficit, credit crunch, mortgage meltdown, and high cost of oil imports are examples of problems that need to be analyzed mathematically so that remedies can be worked out without any biases. People’s immediate answers to these problems come from intuition. However, use of intuition to solve such problems may give misleading answers. Making correct decisions based on mathematical reasoning should be an ideal goal (Mingus & Grassl, 1998). How do we ensure that we arrive at the correct answers for such problems? Two important considerations are required to address this question: accessibility of thoughts and metacognitive strategies.

The first major consideration is what Kahneman (2002) calls “the relative accessibility” of different thoughts. If someone does not know how to solve linear equations, then problem solving with linear equations is inaccessible to that person. A more interesting case is when one knows how to solve linear equations but does not have sufficient practice in problem solving with linear equations; intuition may often play a dominant role in the thoughts of such a person. Accessibility is the relative ease with which particular mental contents come to mind (Higgins, 1996). Some research indicates that intuitive errors are less likely to be corrected when people are under cognitive load or respond quickly (Bless & Schwarz, 1999; Chaiken, 1980; Petty & Cacioppo, 1986). Other research shows that intuitive errors are more likely to be corrected when people are accountable for their judgments (Tetlock & Lerner, 1999). A major goal of engineering instruction is to strengthen the mathematical foundations of engineering students. Algebraic thinking should be promoted in engineering problem-solving environments (Kriegler, 2008). This paper describes ongoing efforts to increase accessibility of mathematical reasoning by applying a variety of teaching strategies to a number of engineering disciplines.

The second consideration is finding metacognitive strategies for activating mathematical reasoning to overcome the influence of intuition; this is, of course, related to the first consideration. The nature of the interaction between intuition and mathematical reasoning is not fully understood (Chaiken & Trope, 1999; Segalowitz, 2007). However, recent research suggests that metacognitive difficulty activates analytic reasoning and overcomes intuitive errors (Alter et al., 2007). In the above mentioned research, difficulty and disfluency are introduced in an information processing phase in order to activate analytic reasoning. Neuroscientific evidence suggests that disfluency triggers the anterior cingulate cortex (Boksman et al., 2005), a cue that activates the prefrontal cortex responsible for deliberative and effortful thought (Botvinick, Braver, Carter, Barch, & Cohen, 2001; Lieberman, Gaunt, Gilbert, & Trope, 2002).

Metacognitive strategies are widely applied in self-regulated learning (Winne & Perry, 2000). An agile teaching method is designed to help students utilize metacognitive strategies for activating mathematical reasoning in a variety of engineering problem-solving contexts (Arakawa, & Yukita, 2006; Chun, 2004).

In general, many strategies can be used in teaching math to engineering students, including problem-based learning (Barell, 2007; Duch, 2008; Kaminski, Sloutsky, & Heckler, 2008; Savin-Baden, 2003), technology-based learning (Trondsen, 1998), game-based learning (Prensky, 2004; Van, 2008), community-based learning (Owens & Wang, 2008), work-based learning (Bailey 2003; Cunningham, Dawes & Bennett, 2004), inquiry-based learning (Eick & Reed, 2002; Educational Broadcasting Corporation, 2008), project-based learning (Helic, Maurer, & Scerbakov, 2004; The George Lucas Educational Foundation, 2008), team-based learning (Michaelsen, Kniht & Fink, 2008), web-based Learning (Lee & Baylor 2006; O'Neil & Perez 2006), and participatory learning (Barab, Hay, Barnett, & Squire, 2001). There is no conflict between these strategies and agile teaching; an agile method can combine with any of the strategies for effective teaching.

A third consideration for this paper is to define the major issues involved and to set the stage for conducting experiments for measuring the effects of agile teaching on learning mathematical reasoning. An understanding of interactions between the two systems is essential for designing such experiments (Bodenhausen, Macrae, & Sherman, 1999).

### **Access to Mathematical Reasoning**

Access to mathematical reasoning is usually achieved through education and training. The acquisition of skills in reasoning “selectively increases the accessibility of useful responses and of productive ways to organize information” (Kahneman, 2002). In the absence of such skills, there is no possibility of access to mathematical reasoning. Engineering students must acquire mathematical skills to demonstrate problem solving with access to analytic reasoning. Mathematical knowledge is highly structured; one needs to study algebra before calculus. Accessibility is a continuum and “some effortful operations demand more effort than others” (Kahneman, 2002). With this understanding, various courses of study in engineering, science, and technology are designed for adequate skill acquisition and subsequent practice in problem solving.

The pedagogical teaching of mental and mathematical skills to engineering students follows this model well. The beginning undergraduate frequently relies excessively on the intuition mode of thought. Through systematic, slow, deliberate, effortful teaching, judgmental skills are cultivated, options are evaluated and analytic capacity is developed. Students are amazed that focused work is required and that it does not come immediately. A variety of mathematical approaches have contributed to providing evidence for Kahneman’s proposition. Some examples are listed here with corresponding course numbers from the BS in Information Technology Management (ITM) program:

- Use of *gedankenexperiment* or thought experiments that Einstein made so famous, (Aspect, Grangier, & Roger, 1982) ITM470, ITM475
- Learning powers of ten notations. ITM320, ITM470, ITM475
- Learning dimensional analysis. ITM420, ITM470, ITM475

- Learning orders of magnitude estimation. ITM440, ITM470
- Witnessing the power and “mathematical soundness” of Abelian Group theory to relational database normalization. TM470, ITM475
- Virtual configurations. ITM320, ITM440, ITM470, ITM475

These have been applied to various courses in the BS in ITM program beginning with ITM320, Information Technology Management, and advancing through ITM475, Information Security Technologies. In a precourse quiz, students in ITM440, Database Principles, identified only a 27% level of knowledge of relational databases and no normalization capability. Following the completion of the course, 86% of the students felt they had developed the necessary skills to normalize a relational database. “Sound mathematics” in the form of Abelian Group operations produces consistently accurate results in SQL database operations. Furthermore, a union (recombination) of all SQL data subsets will return the original set of data.

The varied learning styles of students must also be recognized and accommodated to optimize the acquisition of mathematical skills in engineering courses. We recognize that there are variations in listings of learning styles starting with some well-known styles (Gardner, 1983). Continued effort and assessment are being made to evaluate the degree to which Kahneman’s proposition holds where skills are developed for quick access in reasoning mode.

### **Metacognitive Strategies**

Cognition about cognition is metacognition. Metacognitive strategies are processes that one uses to monitor and control one’s cognitive activities for ensuring that a goal, such as correct problem solving, is achieved (Brown, 1987). These processes help to regulate and oversee cognitive functions. Recent research demonstrates that metacognitive strategies are effective in reducing errors in problem-solving tasks requiring analytic reasoning (Alter et al., 2007). This research demonstrated that a metacognitive strategy gives a cue that the task is difficult or that one’s intuitive response is likely to be wrong, thereby activating more analytic processing.

Following this research one can predict that students who learn to use metacognitive strategy will be able to overcome their intuitive mistakes by utilizing mathematical reasoning, provided that they have access to mathematical reasoning. Our teaching strategy therefore combines two related goals: (1) to increase students’ access to mathematical reasoning, and (2) to enable students to use metacognitive strategies to their advantage. In our math classes students not only acquire math knowledge and skills but also learn how to use metacognitive strategies in problem solving. Since mathematical reasoning is effortful, analytic, and deliberate, metacognitive strategies are beneficial to the students.

Some general metacognitive strategies applicable to all students include self-observation, self-judgment, and self-reaction. With these strategies students learn how to observe their own cognitive processes, assess their own progress, and take corrective steps when needed. Under self-observation students may ask themselves questions such as “What have I learned in the preceding class? Can I apply De Morgan’s laws of distribution?” Metacognitive strategies have potentials for significantly improving learning mathematical reasoning. These strategies are designed to overcome errors in the intuitive mode of reasoning.

The stage is set for collecting data on the effectiveness of these strategies. At this time, anecdotal evidence of student performance has been utilized for adjusting our teaching strategies

to make further improvements. We have adopted the agile teaching methodology that allows us to combine multiple strategies in multimodel, multicultural learning environments (Dey et al., 2007).

We have gone well beyond anecdotal evidence in our use of Tablet Personal Computers in certain engineering classes. We received a two-year Technology for Teaching—Higher Education Grant from Hewlett-Packard Corporation in 2007. In a number of classes, we have integrated use of Tablet PCs in the hands of every student, with interactive exercises integrated into the flow of the class to help students acquire mathematical reasoning skills associated with complex information structures. In this approach, a mathematical concept is first introduced to the class. Students are challenged with a problem that involves mathematical reasoning to solve immediately in class. Each student is required to develop an answer on his or her Tablet PC and submit it through a wireless connection to the instructor. The instructor has the choice of receiving these submissions on an anonymous basis or with each student's submission identified by name. Anonymous submissions are useful to help students overcome fear of submitting a wrong answer. The instructor can choose certain answers to discuss with the whole class, to illustrate common errors in logic, or to show a particularly clever approach to solving a problem.

This approach introduces a high degree of agility into the teaching process. If the students are taking longer than anticipated to come up with their answers, the instructor may conclude that students do not understand the concept very well and go over the reasoning process with the whole class. If certain students are having problems, the instructor may choose to work with them individually or put them with another student who understands the process and can help the individual having a problem. Use of Tablet PCs with appropriate software adds a great deal of agility to the teaching process.

### **How the Teaching Process Works**

The following example illustrates how the teaching process works. One component of WCM 605—Information Privacy and Security in Wireless Systems teaches students how to generate “strong” passwords for user authentication (Yan, Blackwell, Anderson, & Grat, 2004). Students are also taught seven principles of generating strong passwords, as shown in Table 1. They are then taught a mechanism for generating strong passwords that involves complex mathematical reasoning. They start by thinking up a phrase that is relatively easy to remember and then extracting a password from that phrase by taking the first letter of some words and turning other words into numbers or special characters. For example, a password generation phrase might be “My three favorite months are March (3), June (6) and December (12).” The extracted password could be “M3fmrM3J6&D12.” This thirteen-character password is very difficult to guess or break. It complies with Rules 1–4. Because the phrase is easy to remember, it is easy for a user to comply with rules 6 and 7: “Don’t write it down” and “Don’t tell anyone.” And users are more willing to comply with Rule 5, “Change the password regularly,” when they can generate good passwords using this approach. Research has shown that passwords generated from mnemonic phrases are at least as strong as long random passwords that are computer-generated, but that is beyond the scope of this paper.

This mechanism for generating passwords was taught to WCM 605 classes in January, July, and October of 2007 by simply presenting the concept in class and leaving it up to students to experiment with it on their own. In the January 2008 and July 2008 WCM 605 classes,

students were required to generate a passphrase on their Tablet PC in class, then extract a password from it and submit both the passphrase and the password to the instructor, as discussed above. To help those who got it wrong, several of the anonymously submitted passphrases and passwords were discussed.

Table 1  
Principles of Strong Passwords

1. Use characters other than just A-Z.
2. Choose long passwords.
3. Avoid names or words in any dictionary.
4. Choose an unlikely password.
5. Change the password regularly.
6. Don't write it down.
7. Don't tell anyone else.

We assessed the impact of these real-time, in-class exercises through midterm and final exam questions. One of the exam questions for all WCM 605 classes required students to generate a passphrase, extract a password from it, then discuss how it satisfied the requirements for strong passwords. Exam scores on this question improved from 22% correct answers for the October 2007 class to 88% correct in January 2008 and 95% correct for the July 2008 class.

The use of Tablet PCs with interactive software in class introduced a metacognitive strategy that forced students to use or apply concepts almost immediately after the concepts were taught. As a result, their skill in employing the new concepts was made much more accessible to them. We tested this hypothesis more broadly with a number of other questions dealing with concepts such as expressing a digital string as a polynomial; encrypting and decrypting a short message using substitutions and transpositions; using a complex structure known as a Vigenère tableau in encryption and decryption; and using cipher block chaining for encryption. Results from specific exam questions in the October 2007 class showed that these were all difficult skills for students to acquire. January and July 2008 results of the same questions (with details of the questions suitably altered to prevent cheating), showed dramatic improvement.

Table 2 shows that on the average, the number of students answering the questions correctly improved from an average of 18% correct answers on these five questions in October 2007 exams to a weighted average of 81% correct answers on the combined results of January 2008 and July 2008 exams, when the students were first given real-time, in-class exercises to help them learn the concept to a sufficient depth to make the skill accessible. In addition, the overall weighted average of grades on the combined results of the January 2008 and July 2008 midterm exams improved by nearly 7.6% from 77.2% to 85.27%. These results are based on a combined enrollment in the two classes of 37 students.

Table 2  
Improvement in Mathematical Reasoning

	% of Students Answering Correctly	% of Students Answering Correctly	% of Students Answering Correctly	Weighted Average Improvement
Description of Question	Oct-07	Jan-08	Jul-08	Change
Eselbrücke	22%	88%	95%	70%
Use Vigenère Tableau	11%	81%	89%	74%
Polynomial Representation	33%	75%	95%	53%
Encrypt Short Message	11%	69%	88%	68%
Cipher Block Chaining	11%	50%	40%	33%
Average	18%	73%	81%	60%
Number of Students	9	16	21	
Avg Grade overall	77.18%	84.10%	85.27%	7.58%

Table 2 uses October 2007 as a base with only 9 students. Ideally, we would like to have had a larger number of students in the base. However, these results are so encouraging that we have not been willing to penalize students by running a class without using the Tablet PCs, solely to increase the size of the base sample. Unfortunately data from a July 2007 WCM 605 class was not collected in sufficient detail to analyze individual questions. However, the average grade of the mid-term exam, taken by ten students, in July 2007, was 80.3%. The use of the Tablet PC approach to teaching the most difficult concepts was undertaken because of the recognition of difficulties encountered by students in both the July and October classes in absorbing these concepts.

The data in Table 2 show some variation of results across the particular questions studied. For example, the ability to encrypt a simple message by hand improved from 69% correct in the January 2008 class to 88% in July, while the ability to write a binary number as a polynomial expression declined from 50% in the January 2008 class to 40% in the July 2008 class. Only 11% of the students answered these questions correctly in the base October 2007 class.

Teaching of simple encryption by substitution followed a similar pattern to that discussed above for password generation. Students were taught the basic building blocks of encryption: substitution and transposition. They were given an exercise in class to encrypt the text, “I ENJOY THE SAN DIEGO ZOO” with a substitution algorithm of the form  $c_i = E(p_i) = p_i + n$ , where  $p_i$  is the  $i^{\text{th}}$  letter of the plaintext (the text to be encrypted), and  $E(p_i)$  is the encrypted value of the  $i^{\text{th}}$  letter of the ciphertext  $c_i$ . Students were instructed to use  $n=5$  for the exercise. The correct result of the encryption is “N JSOTD YMJ XFS INJLT ETT.”

It usually takes students no more than five minutes to do the encryption in class and submit it wirelessly to the instructor. Errors are easy to spot and common errors can be corrected quickly by the instructor. Students are also taught that 50% of all English text is one of the six letters A, E, I, N, O, or T and to use that information, along with common words like “the” and

double letters like “oo” as a starting point for decrypting text that has been encrypted using a substitution algorithm. They are then given a decryption problem in their exam.

In the January 2008 class, the students were given an exam question that required them to decrypt a short message and find the value of the size of the shift - n. The specific problem and answer were:

*The following ciphertext has been derived from a simple substitution cipher of the form  $C_i = P_i + N$ . Find the value of N that decrypts the ciphertext, decrypt it, and write the plaintext below. (The numbers and letters below the ciphertext are there to make your task easier).*

*YMJ BFYJW NS YMJ UTTQ NX AJWD HTTQ*

*A B C D E F G H I J K L M N O P Q R S T U V W X Y Z  
1 2 3 4 5 6 7 8 9 10 1 2 3 4 5 6 7 8 9 20 1 2 3 4 5 6*

*Answer: “**THE WATER IN THE POOL IS VERY COOL**”,  $N = 5$*

Of the January 2008 students 69% were successful in decrypting the message. The phrase to be decrypted is varied with each exam, to prevent students in one class from passing the answer to students in later classes. The plaintext result of the problem given to the July 2008 class was “**LOOPS IN LOOPS ARE COMMON IN CODE.**” As shown in Table 2, 88% of the students were successful in decrypting the ciphertext in July 2008.

To date we have taught the following four courses in the MSWC program using Tablet PCs: WCM 601—Digital Wireless Fundamentals, WCM 604—Wireless Coding and Modulation, WCM 605—Wireless Systems Security, and WCM 610—Next Generation Wireless Systems. A newly developed course, WCM 612—Wireless Economics Topics, is currently being taught with Tablet PCs, using similar techniques.

Following receipt of approval of the instrument by the National University Institutional Review Board, students in the April 2008 WCM 604 course and the July 2008 WCM 605 course were invited to complete surveys about their use of Tablet PCs in class. Results of the nine questions will be discussed more fully when we have collected data from more classes, but two survey questions are particularly relevant to this paper. Students were asked to score their agreement/disagreement with the following two statements on a five-point Likert scale:

A. “Classes taught with a Tablet PC keep me more engaged in learning than classes taught with desktop or laptop computers for students. ”

and

B. “Use of Tablet PCs by students enabled me to learn new concepts better/faster because I was able to understand the way other students reasoned about a problem.”

The average score from the April 2008 WCM 601 class was 4.4 for statement A and 4.2 for statement B. The average score from the July 2008 WCM 605 class was 4.18 for A and 4.09 for

B. We believe this supports our contention that this teaching technique makes material more accessible to the reasoning needed to learn complex mathematical concepts. We look forward to collecting the same data from more courses to better support this contention.

### **Concluding Remarks: Setting the Stage for Experimental Studies**

As we learn more about learning, we understand its scientific aspects based on the recent contributions from neuroscience, psychology and cognitive science (Bransford, Brown, & Cocking, 1999). The emerging notion of interactions between intuition and mathematical reasoning is important for teaching environments. It is possible that in certain problem-solving approaches, people use random guessing; that is, they use neither intuition nor mathematical reasoning. Thus, questions can be raised about the validity of the classical dual process theory for unrestricted problem-solving circumstances. However, the focus of this paper has been narrow in the sense that it has tried to find strategies for avoiding mistakes of intuitive mode without addressing mistakes of other possible modes of cognitive function. Teaching strategies have been suggested for increasing students' access to controlled mathematical reasoning. Teachers need to perform their teaching with sufficient agility in order to adjust their strategies to learner's goals, styles and preferences.

With deeper understanding of the issues, we are now better prepared for conducting our experimental studies on the effectiveness of our agile teaching methodology. A special strategy we will be investigating will introduce the use of games in teaching certain engineering subjects through a project titled, Virtual Apprenticeship Through Mobile Gaming: Facilitating STEM Learning Through Game Design. One of our major goals in this work is to change students' focus from learning theory to learning practical application of theory through simulation games—i.e. to acquire the skills to apply the theory. We will expose students to real-world challenges that they will soon face in their careers by extending their learning through the introduction of simulation games in virtual environments. Through simulation gaming, we will provide an environment of problem-based learning that promotes constructive competition among students. These games will simulate real-world organizational dynamics and improve retention of complex concepts. This process will involve mapping fundamental theories of engineering to rules and procedures expressed through game play. Effectively, the students will design and build the games and then play them. We intend to use this approach, for example, to teach wireless communications network design and to introduce competition among groups of students, working together to design the “best” network.

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