Paradigm Shifts in Designed Instruction:

From Behaviorism to Cognitivism to Constructivism

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Introduction

Designed instruction has moved through a series of development phases since its reliance on the early behaviorist work of Skinner and Pressey and their followers. The move from instructional theory emphasis on the environmental to emphasis on the internal has been accompanied by similar changes in three technologies: instructional design methodology, the physical technology with which the instruction is implemented or mediated, and the programming mechanism(s) used to develop the instructional software conveying the subject content. The purpose of this article is to chart the development of designed instruction in relation to these factors and to look beyond, to the possibility of further changes. Such changes are of such a dramatic nature that they can be considered paradigm shifts. A relationship exists between instructional theory and its dependent technologies, and it is suggested that implementation of designed instruction, grounded in theory, is limited by the available technology paradigms.

This article examines the history, characteristics, and value of designed instruction, grounded in behaviorist, cognitive science, and constructivist theory. The article attempts to connect the theories to the prevailing technology paradigms.

Behaviorism

Bullock (1982) identifies the basic assumptions of the behaviorist: *objectivism*, where the key to analyzing human behavior lies in the observation of external events; *environmentalism*, in which the environment is the significant factor in determining human behavior; and *reinforcement*, where the consequences of our actions affect subsequent behavior.

Lamos (1984) describes the beginnings of the instructional design movement as centering around B. F. Skinner and programmed instruction (PI). Programmed instruction was behaviorally based and was characterized as having three stages: analysis, design, and evaluation. The stages map to the general scientific approach (hypothesis generation, experimental design, and hypothesis testing). The analysis of requirements constructed as behavioral objectives with criterion-referenced tests as a means of assessing performance—lead to concentration on the required *performance* and the elimination of peripheral knowledge acquisition.

Reinforcement and the concepts that are developed from reinforcement—stimulus control, chaining, shaping, competing and enhancing repertoires, and interpersonal and intrapersonal behaviors--are central to behaviorism. A simplistic early view of knowledge-of-results feedback as being reinforcement gave way to a more complex notion that while learning increases the likelihood of the emergence of target behaviors, the primary reinforcers are considered to be learner generated ("intrinsic") and that external feedback ("extrinsic") is most effective as either correctional or motivational feedback (Bullock, 1982). Behaviorists now consider that the potential for behavioral change is heavily influenced by the current behavior of the learner and the way in which that behavior either competes with or enhances the development of new behaviors.

Feedback as reinforcement has been subjected to some criticism, as research has emerged demonstrating that under certain circumstances, delayed feedback is more effective than immediate feedback. Students, it appears, spend more time studying feedback if it is delayed than if it is provided immediately after difficult material has been presented. The issue of who maintains control of feedback is also important. Student control of feedback can lead to students not interacting with the material, if they can obtain the feedback without doing so. The feedback then lacks value.

The first technology-based instructional programs derived from behaviorally oriented programmed instruction, which was task-based and developed stimulus-response chains of behavior, which were shaped toward a desired terminal or final behavior. Experimental research concluded that, while feedback (reinforcement) is an effective tool, the quality of feedback is dependent

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upon the quality of information that it imparts to the learner; which, in turn, is a function of the diagnostic ability of the program. Feedback mechanisms which only provide a bare-bones indication of correct or incorrect response perform relatively poorly.

Jelden (1984) discusses two mechanisms for achieving stimulus control: *behavior modelling*, which can be job-relevant and achieves successive approximations to the desired behavior, and *algorithms and other job aids*, which provide procedural cues. He then identifies a set of procedures for implementing a behaviorally based instructional unit which allows a degree of learner control. He describes the system as "a computer-based, multimedia, computer-managed instructional approach which emphasizes self-paced individualized learning" (p. 2). He identifies four major components of the system:

(1) a *student information* module, which performs learner characteristic and capability assessment;
(2) an *instructional analysis* module to analyze and order the instructional content;
(3) a *learning activity* module, which identifies the support mechanisms and media required, and suggests a learning sequence for each student; and
(4) a *system evaluation* module, which performs a statistical analysis of the effectiveness of the overall system.

Jelden summarizes his approach by providing a procedure to aid in the development or revision of instructional materials.

Chase (1985) attempts to address some of the criticisms levelled at the application of behavioral principles to instructional design, identifying two major negative reactions to behaviorism. First, technological developments have not been utilized effectively by behaviorists, in particular, the use of computers and interactive media; as a result, few realistic educational applications have been developed. Second, and perhaps more damaging, the application of behaviorist principles leads to a reductionist and fragmented program, which concentrates on low-level skills at the expense of "complex, conceptual behavior" (p. 65). Golub (1983) criticizes the use of microcomputers in schools and at home as automated page turners, which leave the learner as an almost passive bystander, required only to press the RETURN key. Although the criticism is often directed at the behaviorist foundation of such software, he notes that the criticism should be of poorly developed software rather than the underlying theoretical approach.

To combat these criticisms, Chase offers an approach to instructional design which includes the use of authoring systems and the strict application of behaviorist principles. He cites Scandura (1981), who suggested that the courseware developer requires three skills: content expertise, computer expertise, and design expertise. The confluence of all three skills is rare, so the courseware author might have to collaborate with a subject matter expert or a computer expert. Chase identifies a series of practical questions that the prospective author might reasonably ask of himself/herself, including hardware/software compatibility and an assessment of the utility of the authoring system. An approach to instructional analysis follows, which includes specification of the goals, objectives, and tasks; the development of a continuum of tasks from elementary to conceptual relationships; and analysis of the content. He provides a checklist for conducting a content analysis. The final element in the development process concerns evaluation. Evaluation should comprise the assessment of the learners' entering skills, the changes that occur as a result of the instruction, and the calibration of the collected data. Again, a checklist of steps is provided.

Behaviorist attributes are found in most technology-based instructional applications in the learning of small chunks of material related to a single skill and the use of reinforcement through reward. Golub (1983) suggests that behaviorally based instruction seems most useful for clearly delineated content where the branching is constrained and learner responses are categorized as right or wrong.

Numerous studies have been conducted demonstrating the effectiveness of behaviorally-based instructional software in general, and on the utility of feedback in particular. McGowan and Clark (1985), citing Snow (1977) and Snow and Lohman (1984), identify a relationship between the underlying theoretical rationale of computer-based instruction and the effectiveness of that instruction at different learner-ability levels. There is evidence to suggest that lower-ability learners perform better in well-structured, behaviorally oriented instructional environments, whereas higher-ability learners perform better in less-structured environments. They argue against learner-controlled support, as higher-ability students have tended, despite their abilities, to select high-support mechanisms, and lower-ability learners have tended to select low-support mechanisms. Poppen and Poppen (1988), evaluating six widely-used computer-based instruction (CBI) applications, noted that many of the characteristics of a behavioral approach were missing, including lack of assessment of the target population and its capabilities, lack of intermittent reinforcement, lack of prompting or fading, and little evaluation based on student-response data: They conclude that even the "best" software is not very good from a theoretical view, and they urge designers to more closely follow a theoretical framework.

Behaviorist learner principles were first applied to instruction using relatively low-level physical technology, employing relatively simple "programming" principles.. The introduction of electronic rather than electromechanical devices was a technological enhancement. The programming paradigm requires the use of sequencing and iteration. In some ways this parallels the behaviorist design view. The input and output components are of importance, but the internal processing is underdeveloped. Information is presented in "frames" and the responses elicited from the learner are evaluated and used to generate some form of feedback.

Cognitivism

Although Skinner effectively applied Pressey's physical technology to a behaviorist approach, Pressey "in addition to providing the necessary technology implement, anticipated ... the present cognitive perspective and its importance for the instructional technology of the present and the future—the computer" (Lamos, 1984, p. 169).

Hartley (1985) charts the development of the cognitive approach from the initial conception of short- and long-term memory (Hebb, 1949) through the notions of automatic and controlled processing to our current understanding of the cognitive structure model. Tennyson (1992) provides a model of the cognitive system which relates the main areas of cognition (sensory receptors, executive control, working memory, and long-term memory) to their purposes and instructional needs. Long-term memory, for example, holds the knowledge base, which comprises content, skills, and strategies. Tennyson suggests that the model gives rise to a "dynamic, interactive system that assumes constant integration of the various components" (p. 36).

As the behaviorist ground gave way in the past two to three decades, the need to encompass individual differences emerged and brought with it an increased complexity in the technology required. Programmed instruction was forced "toward the handling of the complexity of individual differences" but the "technology of programmed texts and of electromechanical 'teaching machines' proved to be the limiting factor to the instructional accommodation of such individual differences" (Lamos, p. 171).

The analysis phase of PI now had to accommodate the evaluation of individual learner requirements and capabilities, among them cognitive styles and the ability to apply cognitive strategies. Some mechanism for determining the task in terms of cognitive analysis rather than procedural decomposition had to be developed. Central to the notion of cognitive analysis is a model of the internal workings of the mind, the identification of functional components to handle information filtering, storage in short-term memory, semantic encoding for storage in long-term memory, and retrieval when required.

Lamos suggests that there had been a progressive shift from the behavioral to the cognitive, which "has been matched by a corresponding shift in the research and implementation of instructional technology supporting individualized instruction" (p. 169) Robinson (1979) takes this notion of increased complexity one stage further, and theorizes that complexity in the learners' actions has to be matched by a similar level of complexity in the instructor's actions. The instructor employs constraining mechanisms to match the level of complexity appropriately to obtain a form of equilibrium. "One form of constraint is to reduce variety by such means, for example, as ignoring individual differences in a set of learners. The other form of constraint is to reduce variety by absorbing it. It is in this latter form of constraint that the technology becomes important" (p. 173). Lamos distinguished between computer-managed instruction (CMI), which provides a mechanism for evaluating individual aptitudes so that individualized instruction can be applied, and computer-assisted instruction (CAI), the use of computer technology to instruct a learner on a one-to-one basis with interaction, and giving the appearance of being able to make intelligent judgments based on learner interaction as the primary features.

The first attempts at technology-based instruction in the form of CAI betrayed a PI foundation with a linear "frame based" approach, followed by the use of branching mechanisms to anticipate different responses. These approaches, however, lacked the sophistication required to truly compensate for learner differences. Lamos suggests that we are currently in a transition state toward a more complex CAI paradigm, which is exemplified in experimental mechanisms such as Brown's SOPHIE, based on Pask's "conversational theory." Lamos concludes that increasing the complexity of the technology to accommodate individual differerences moves us closer to Pressey's conception of the purpose of his original teaching machine.

Orey (1991) identifies problems that designers of computer-based instruction have experienced in implementing cognitive theory into instruction. While developments in describing the processes and structures of cognition have made significant progress through the work of Merrill (1983, 1990), Hannafin and Reiber (1989), Salomon (1983), and others, the problem of integrating cognitive theory into the design of computer-based instruction remains. The instructional design models available do not currently support cognitively based activities. The ability to capture more data than just the learner response is crucial to the cognitive model. Understanding of the preferred style of the learner and data concerning the predictability of behavior can provide valuable information in manipulating the knowledge base. Hartley (1985) proposes that the use of an intelligent tutoring model as a paradigm can overcome such integration problems. Orey (1991) distinguishes between current computer-based design methods and an intelligent tutoring mechanism, citing Wenger (1987), who states that "intelligent tutoring systems encode knowledge, while computer-based instruction encodes instructional decisions based on knowledge" (p. 3).

The intelligent tutoring model comprises four components:

(1) an *interface*, which is the means by which the system interacts with the learner;
(2) the *expert* module, typically a database of correct responses with which the learner responses are compared;
(3) a *learner* module, which is a "representation of the errors or misconceptions" that typically occur when a learner is presented with new content; and
(4) a *pedagogical* module, which evaluates what is known about the learner and the learner responses and makes decisions about how information is to be presented to the learner.

The learner may not only be learning the content but also how to manipulate the programmed environment. Ease of use and interface consistency are of significance in that they can allow a greater degree of concentration on the content, if well designed. The interaction style can also influence learning. Appropriate style in relation to the preferred learning style of the learner should be a goal. Orey discusses the use of metaphor, such as a windows environment and the mapping of a physical device such as a mouse, to application interaction. "The goal of instruction from a cognitive perspective, then, should be to replicate the knowledge structures and processes of the expert in the mind of the learner" (Orey, p. 6, citing Wildman and Burton, 1981).

Although a number of pedagogical models have been used in different systems, most systems only implement a single pedagogical model. Three general groups of models emerge, those that monitor activity in a problem-solving domain, those that use dialogue between learner and system, and those that use guided discovery. Orey advocates the use of multiple pedagogical strategies and tactics within the same application.

He concludes that some of the characteristics of intelligent tutoring devices are present in CBI that has been designed from a cognitive perspective and that, rather than there being a dichotomy between CBI and intelligent tutoring devices, there appears to be some continuum "anchored at one end by traditional computer-based instruction developed from an instructional systems design perspective (such as that found in many training settings) and at the other end by the 'ideal' intelligent tutoring system" (Orey, p. 10).

Hartley (1985) examines the likely value of artificial intelligence as a modelling device for more intelligent CAI. He notes three main problems that arise from the use of computers in the classroom: the unevenness of the quality of instructional software, the difficulties involved in integrating CAI into conventional classroom teaching, and the difficulty of developing software given current tools. Although there has been some interest in the development of programming tools for the learner (e.g., Logo) there is little documented evidence of the use of the tools in the classroom or of the effect of such tools on cognitive processes.

Current behaviorally oriented and cognitively oriented applications contain relatively little knowledge about the learning topic. Hartley suggests that this needs to be remedied, that the programs must contain an extensive knowledge base, somewhat like expert systems such as MYCIN. The learner's knowledge must be represented in the form of rules and mal-rules representing learner misconceptions. Expressing misconceptions in the form of rules not only provides guidance as to what must be corrected, but also offers a mechanism for correcting them. It has been shown (Newell and Simon, 1972) that learners are not erratic in their responses but consistently apply mal-rules to problems.

Behaviorism Versus Cognitivism

Skinner (1985) criticizes the claims of cognitive scientists in the use of computer simulations of mental models and the implication that behavior is internally initiated. He argues that the cognitive scientists have misused the metaphor of storage and retrieval, replaced experimentation and evaluation with descriptions of experiments and assessment of expectations, and have raised feelings and mental states to the status of *causes* of behavior.

The construction of the notion of "meaningful structures" is also criticized. Cognitivists assume a structure without necessarily any experimental validation. Skinner argues that the behavioral view of perception causing a response explains behavior as well as the cognitivists' abstraction of structure, and suggests that the identification of the internal mechanism is more likely to occur within neurology than cognitive science.

The third area of criticism concerns the learning of rules. When an organism learns a rule, the cognitivist concludes that the organism *knows* the rule. Skinner suggests that there is no evidence to suggest that the organism necessarily knows anything and, with repeated practice and the development of automaticity, the rule becomes unnecessary anyway.

Bourne (1990) examines the development of CAI in library instruction, beginning with a caution that "CAI should not be a gratuitous 'techtronic' exercise but a superior way of learning" (p. 160). She characterizes cognitive theory in contrast to behaviorist theory as "less reductionist, more holistic, and concerned with the developing mind and its organizing cognitive structure" (p. 162). She comments on the usage of hypertext mechanisms, where webs of connections exist between frames, rather than a linear progression between frames. Hypertext and hypermedia have been shown to be effective, although she cites authors commenting on the dangers of the learner becoming overwhelmed as the complexity of the linkage between frames becomes more complex. Navigation through the hyper system becomes problematic, and the *purpose* becomes lost in the process.

Summary In summary, the early attempts to develop cognitively oriented designed instruction used a technological tool set inappropriate for the task. Only later did the programming and instructional design technology allow for the development of useful tools. The increasing complexity of the task resulting from the need to account for individual differences has necessitated increased hardware sophistication. The interface must be intuitive, almost forcing a graphical user interface. The complexity of the software has resulted in the need for mass storage and increased hardware speed and capacity.

The programming paradigm needed to change. The use of modularity and functional decomposition represented a means of reducing the complexity of software development. Even so, that development required the greater application of development resources, particularly time and programming expertise. Of particular interest is the idea that the programming paradigm mirrors learning theory, with additional emphasis on the need to structure and partition internally to make sense of the external.

The paradigm shift, then, has involved more than a tendency toward acceptance of the cognitive view. The development of cognitively oriented computer-based learning, for example, relies on a level of hardware previously unavailable; implementation mechanisms such as intelligent tutoring, hypertext, hypermedia, and expert systems; and a design mechanism that emphasizes content structure.

Constructivism

Jonassen (1991) distinguishes between the assumptions in objectivism (both behaviorism and cognitivism) and constructivism. The objectivist sees reality as external to the knower with the mind acting as a processor of input from reality. Meaning is derived from the structure of reality, with the mind processing symbolic representations of reality. The constructivist, on the other hand, sees reality as determined by *the experiences of the knower*. The move from behaviorism through cognitivism to constructivism represents shifts in emphasis away from an external view to an internal view. To the behaviorist, the internal processing is of no interest; to the cognitivist, the internal processing is only of importance to the extent to which it explains how external reality is understood. In contrast, the constructivist views the mind as a builder of symbols—the tools used to represent the knower's reality. External phenomena are meaningless except as the mind perceives them. Von Glasersfeld (1977) argues that the objectivist view is based on two illogical premises: "that what we learn is a replica of some independent, well-structured world and that this independent ontological reality determines our experiences" (p. 34). Constructivists view reality as personally constructed, and state that personal experiences determine reality, and not the other way round.

Chomsky's (1973) review of Skinner's *Verbal Learning* (1957) began the revolution in thinking that was the beginning of the transition to cognitive learning theory. The first real use of learning technology was applied behaviorally. With the application of systems theory, instructional design accommodated cognitive psychology somewhat. Jonassen (1990) argues that the accommodation is theoretical rather than practical. The reason, Jonassen suggests, is that instructional systems theory is an "objectivist epistemology" (p. 32), holding that knowledge is based somehow in reality and that reality is what the learners learn. In a cognitive frame, what is learned has to be based upon external, observable actions; therefore, the behaviorist view actually is always going to be significant in theory, despite the cognitivist's stated disdain for behaviorism. How ironic!

For the constructivist, learning is problem solving based on personal discovery, and the learner is intrinsically motivated. The learner needs a responsive environment in which consideration has been given to the learner's individual style as an "active, self-regulating, reflective learner" (Seels, 1989, p. 14). Designing instruction that accommodates individual motivations and goals represents a problem for current instructional design theory. Jonassen (1991) notes that the instructional goals and objectives would have to be negotiated rather than set, with no one best way of sequencing instruction. The goal of instructional systems theory would then concern itself more with developing "mental construction 'toolkits' embedded in relevant learning environments that facilitate knowledge construction by learners" (p. 12), rather than specific instructional strategies.

[redacted]. The design tools in current use are founded on an objectivist view. Constructivists would argue that there is no such thing as content-independent knowledge or skill; yet the design mechanism are supposed to be domain-independent. Current forms of presentation and learning environments may well be suboptimal if learners are not converging to a single objective. Jonassen (1990) argues for the use of cognitive and constructive 'mindtools' such as databases, hypermedia, and expert systems. Sawyer (1992) envisions a virtual computer where the computer represents an access point to global resources for education. Alternative forms of evaluation must be designed to account for multiple goals. As a result, evaluation would be less founded upon criterion-referenced tests. Gill, Dick, Reiser, and Zahner (1992) propose a model for evaluating educational software which includes both objective and subjective components. If this can be developed for educational software, then a parallel approach might also be used for performance evaluation. Changing the learning environment to incorporate a constructivist view adds complexity. Robinson's (1979) notion of using technology to absorb that complexity becomes more significant as other forms of managing complexity become overloaded.

The technology on the desktop is not the major hardware issue of importance in supporting the implementation of a constructivist approach. While the hardware has to be powerful enough to support large and complex software, it is becoming increasingly clear that replicating resources locally is not feasible from a cost viewpoint. In consequence, providing access to remote resources is of vital importance. Those resources might not be only hardware and software but also instructional resources, evaluation resources, and communication with other learners.

One key goal is making access to those resources seamless and transparent to the user. Sawyer (1992) goes some way to identifying the major issues and places networking in the center of the arena. Although he does not explicitly make the point, adherence to *standards*, both programming and communication, is an important ingredient of his argument.

The development of instructional software is also undergoing a shift in emphasis. The basic building blocks used to construct a program are relatively well established. Although new approaches such as object oriented analysis and design allow for easier development, the building process, especially in such areas as user interface, has been semi-automated, and it is the analysis design aspects of software development that pose the greatest challenges.

There is a much stronger emphasis on applications that allow exploration, such as database management systems and expert systems, where the learner can interactively query the database; simulations where a model reality is explored; and 'virtual reality,' an extension of the simulation idea which allows the user to physically interact with the application. Once again we see the programming paradigm running in parallel with the theoretical framework.

The issue is no longer simply whether the software can manage the complexity required, but does it fit and can it work with other software and across a complex computer network? Sawyer, for example, notes that "As a general principle it will make more and more sense over time to put the computing element of a personal computer close to its source of data, and use the network to deliver the [rest] to the user. This is potentially the next paradigm of personal computing" (p. 14). When the applications require very powerful processing capabilities, it may make more sense to place just the user interface close to the user and utilize the network to deliver both data and processing resources. The network infrastructure is developing, indeed is viewed as a significant political and economic issue by some, and the basic mechanisms required to distribute applications across that network, e.g., HP/Apollo's "Network Computing System," are already in place.

Conclusion

There is evidence in the shift from behaviorism to cognitivism in designed instruction that the theory had to be accompanied by adequate physical technology, a change in the instructional design methodology, and appropriate programming tools to implement the new theory. It is becoming increasingly clear that a second paradigm shift is occurring; indeed Jonassen (1990) might consider it a *fait accompli*. Certainly the theory and the physical and programming mechanisms exist, even if they are not properly in place. The instructional design mechanism appears to be lacking, and there needs to be a greater effort in addressing that issue.

The first shift changed the way in which designed learning took place. The second shift may well have a more dramatic effect. It represents not just a change in approach but a significant *expansion of the dimensions of the learning setting*, where the limits are expressed in terms of the desires and goals of the learner and not the designs (whether behavioral or cognitive) of the instructor. □

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Technology News

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Digital was named project consultant in 1992 to develop plans with the Department of Education for a $420 million educational technology system. The $10 million award enables Digital to develop and implement the master plan.

The Kentucky Education Technology System (KETS) is part of Kentucky's school reform program. KETS will create an infrastructure for instructional and administrative computing in all schools and a communications network to link students, teachers, and administrators state-wide.

"Our education technology program will dramatically alter the way education is delivered and supported in Kentucky. We will not simply apply technology to existing processes, but will use it to transform teaching, learning, and management," said Thomas C. Boysen, Commissioner of Education.

Digital was selected as consultant because of its networking expertise, adherence to open (non-proprietary) systems, and "vision for the effective use of technology in support of school reform."

The KETS master plan calls for distributed networked systems that place computing, communications, and management of resources in the hands of school districts. Unlike many systems, Kentucky's will combine instructional delivery and administrative computing into one integrated system for more efficient communication and operations.

KETS will encompass all levels of participation—the home, classroom, school, district, and state—with technology distributed to eight regional centers, 176 school districts, and 1,400 schools. A communications network will create an information highway, giving teachers and students access to "a world of electronic information."

Kentucky's reform initiative began in 1989, when the public school system was declared unconstitutional, mainly because of inequities in funding. In 1990 the legislature enacted the Kentucky Education Reform Act, mandating an overhaul of the education system and giving technology a key role in the effort to create world-class schools.

"The scope and vision of Kentucky's plan is unparalleled," said Deborah Nicholls, Digital's Worldwide Industry Director for Education. "Kentucky will be a model for other states in the use of technology to support education reform. Digital is very excited about its role in this ground-breaking venture."

KETS will ensure equitable access to technology by establishing standards for the level and type of technology in each school and providing financial assistance for schools to acquire it.

State and local districts will share the approximately $350 million in one-time costs required to put the infrastructure in place.

Project Explores Educational Applications of Compact Disc-Interactive. A new business-education partnership is studying the effectiveness of interactive technology as a teaching process and classroom tool.

At the end of the semester, participating faculty will prepare an evaluation of the usefulness and applicability of CD-I for classroom instruction as well as a critique of the content and teaching value of each disc used. Teachers will also be asked to identify specific design features of effective discs and offer suggestions for future software titles.

Participating community colleges are Kirkwood Community College, Cedar Rapids, Iowa; Lane Community College, Eugene, Oregon; Delta College, University Center, Michigan; Sinclair Community College, Dayton, Ohio; Monroe Community College, Rochester, New York; Humber College, Toronto, Canada; and De Anza College, Cupertino, California.