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THE UNIVERSITY OF TEXAS AT AUSTIN

Title: **A Guiding Vision for Fluid Learning: The Future of Education and Training**

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Abstract:

Position paper by the Digital Media Collaboratory (DMC) of the IC² Institute at The University of Texas at Austin. The authors envision learning systems as a ubiquitous public utility and propose an architecture to accomplish it. The paper includes a description of DMC research activities in 2003.

Keywords: IC² Institute; education; educational games; e-learning

[D]igital [M]edia [C]ollaboratory

A Guiding Vision for Fluid Learning: The Future of Education and Training

DMC Agenda

Digital Media Research & Development
Advance research and applications in the areas of game theory and design, distributed computing, simulation, artificial intelligence, response algorithms, cognitive and social sciences, and telecommunications.

Digital Media Workforce Development
Develop workshops, professional curricula, undergraduate and advanced degree programs for entrepreneurs and practitioners of Digital Media business.

Digital Media Opportunity & Participation
Create open, accessible venues/labs where industry professionals, researchers, faculty students, hobbyists, and others can experiment with digital media design and development.

Digital Media Games for Education
Experiment with and model the educational efficacy of digital games for learning through applied research and demonstration projects.

Our Vision

The Digital Media Collaboratory envisions a future where learning opportunities abound and interconnect with the multiple sectors of daily living: home, school, work, civic and leisure. Like other ubiquitous public utilities, turning on learning will be as easy as flipping a switch, dialing a knob, twisting a faucet. Learning content will be available when needed, where needed, in what form or however much needed, and for whom needed. From solo learning quests to fulfillment of group missions, learning supports will enable access to mentors and to communities of practices, to knowledge management and decision tools, and to performance evaluation and skills assessments.

Introduction

The exponential explosion of human knowledge and rapid technological advancements are shifting long-held paradigms about learning. In this era of knowledge creation and technology innovation, public education cannot respond effectively to the accelerated pace of societal change. K-12 education might sufficiently prepare an individual for their first job or next program of study; but, even post-secondary degrees are not sufficient to maintain opportunity within the global marketplace. Competitive advantage relies on readiness.

A new way of learning is required: authentic, accessible, accelerated skills acquisition. The same principles that revolutionized late-20th century business practices must be

applied to 21st century learning practices: speed, adaptability, agility, flexibility, efficiency and effectiveness.
The futurist Alvin Toffler said, "The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn and relearn."

The time has come for learning solutions that are flexible and responsive to both the skills demands of the modern labor market as well as to the family responsibilities and work schedules of the modern labor force. Accelerated skills acquisition, multiple pathways into and through the education and training pipeline, and rapid transitions from learning to using skills are required.

To meet the challenges of the 21st century, we must implement learning systems that can:

- rapidly respond to changing technologies and economies;
- compress training times;
- support and accelerate performance;
- narrow the gaps of disadvantaged citizens.

Historical Perspective

According to Dr. George Kozmetsky, founder of the IC^2 Institute at the University of Texas at Austin, in the 21st century education and training will be differentiated as follows:

- education is knowledge an individual must convert to value; whereas,
- training is knowledge with immediate market value.

Dr. Kozmetsky points to the failings of our current education system as instituted by his favorite president, Thomas Jefferson. Jefferson envisioned the U.S. public education system as the fountainhead of democracy. The purpose of public schools was to create civil and capable citizens. For democracy to succeed, the participation of an educated and efficacious public is required… by the people, for the people.

Public education serves mainly as a democratizing institution by providing basic knowledge and skills to all people. Thereafter, it is up to each person to use this foundation to actualize individual ambitions in the open market of opportunity.

Founded during an agricultural era, the U.S. public education system continued to function fairly well during the industrial era. But in the era of knowledge creation and technology innovation, public education cannot respond effectively to the accelerated pace of societal change for all people. Learning must become a lifelong endeavor.

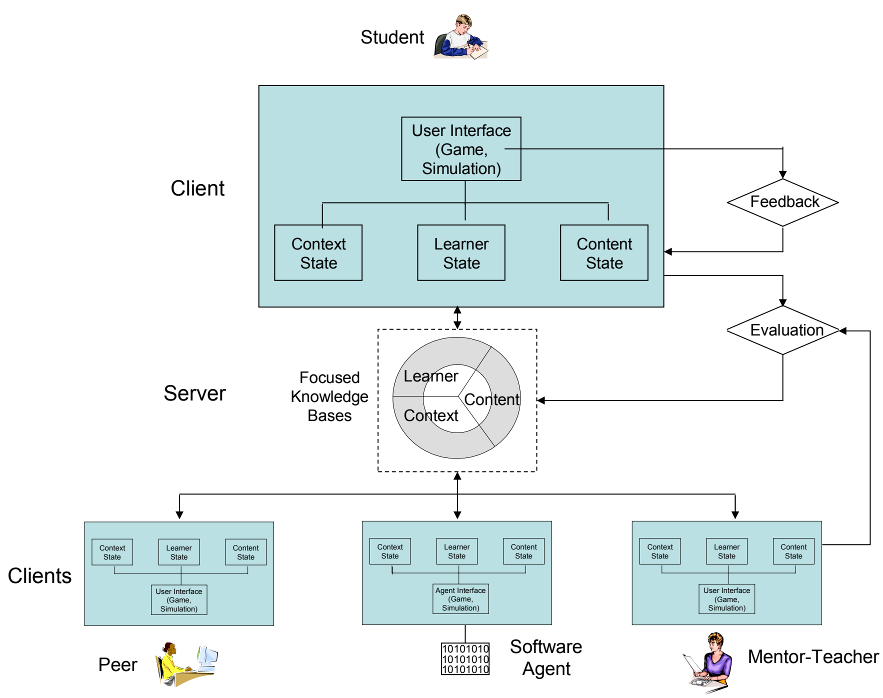
Future learning technologies must meet demand for increasingly interdisciplinary knowledge requirements, lifelong migratory work patterns and evolving skill sets by providing dynamic interfaces to ‘intelligent’ datastores and immersive content delivery systems. Information technologies, digital entertainment innovations and cognitive sciences are the research drivers to this future.

Fluid Lifelong Learning

Fluid Lifelong Learning is a concept that fulfills the envisioned future of education and training. It is an online learning system that empowers people to access learning content in a path and by means that suits the individual learner. It is not bound by location or time constraints. It consists of immersive interactive game environments and simulations that couple learning technologies and pedagogies, integrated measurement and evaluation, constructive experimentation and instant feedback. The system combines the best parts of interactive features and feedback with an adaptive content management system that tailors delivery and individualized experience. Simulation technology enables students to experiment within learning environments in ways not currently available on a large scale. The system also connects learners and mentor/teachers in this online learning environment in situations that promote understanding through shared experience and communication, and where users collaborate in engaging, mediated activities.

The envisioned Fluid Learning System will blend distributed networks for compounded computational processing and interconnected databases, dynamic modeling that incorporates real-time information, software agents (artificial intelligence), and adaptive assessment features that present personalized and optimized content for learning and for supporting decision-making.

Figure 1. Fluid Learning Environment Architecture



A fluid lifelong learning environment is illustrated above. Students, their peers, their mentors/teachers and intelligent software agents are all connected to the system and to each other wherever and whenever necessary. The system is made up of *user interfaces*, *clients* and *servers*. Architectures may be client-server or peer-to-peer. Access devices may be mobile or locality-based.

A student's interactions with the system and with other people are in the form of simulations and games that are customized to fit the needs of the student and personalized to fit the learning style of the student. This customization and personalization is enabled by a set of *focused knowledge bases* on servers that form a virtual repository of knowledge about the *learner*, the *content* to be learned and the *context* in which the content is to be learned.

- *Learner* knowledge includes the student's learning style, skills and competencies mastered and job experience throughout the lifetime of the student.
- *Content* knowledge is in the form of learning objects that can be dynamically aggregated into unique learning experiences based on the knowledge of the learner and of the context.
- *Context* knowledge includes mappings between skills and types of tasks, mappings between skills and learning objects, and mappings between skills and communities of practice.

As illustrated in Figure 1, the student interacts with the system through an immersive interactive interface that is based on simulation and game technology. The user interface provides feedback by monitoring the student's interactions with the system such as progress through learning pathways and correctly completed tasks.

The feedback is received by the *client* in the figure which maintains localized information about the learner, the content and the context. The client periodically updates the server with selected portions of this information to enable sharing of the state information with peers, mentors/teachers and software agents. Furthermore, the client receives periodic updates from the server of information that has been changed by other clients. The client also has software that evaluates the learning progress of the student and updates the server with this evaluation information.

Peers and mentors/teachers interact with a user interface and clients that are equivalent to the environment provided to the student. This enables peers and mentors/teachers to participate as collaborative partners in simulations and games. Software agents interact with an *agent interface* that is equivalent to a user interface in that it monitors and adjusts student learning situations for optimal performance.

The implementation of a fluid learning system presents a variety of challenges in terms of technological, social and cultural, and pedagogical considerations: from diffusion of innovations, to federal and philanthropic investments, to wide scale adoption of new pedagogical standards.

Technological Considerations

The technological advents of the 20th century are too astounding to enumerate. But just to consider telecommunications, in less than a century we traveled an innovation timeline that includes mass adoption of telephony, radio, television, Internet, and wireless handheld computing. In 1901 Marconi transmitted the first trans-Atlantic radio message; in 1991 Tim Berners-Lee posted the first code for the World Wide Web.

Technological innovations of the early 21st century will yield more ubiquitous communications and computing through portable, integrated, interactive, context-sensitive and palm-sized devices. What of 10 years from now? 20 years? 50 years? How will our lives be transformed? How will we ever learn all we need to know?

Transformative learning environments will require technological advancements in:

Intelligent Tutoring: Advances are needed in intelligent tutoring research that provide generic algorithms and frameworks that can be used in building domain specific tutoring systems. Expert models, student models and instructor models for intelligent tutoring must be easier to construct and must effectively draw from knowledge in existing knowledge bases.

Simulations for Learning: Authoring tools for developing simulations for learning must be improved so that simulations can be easily constructed by domain experts. The resulting simulations must be driven by knowledge representations that enable a more accurate and less brittle portrayal of real world situations.

Games for Learning: Further investigation of the application of game techniques and technologies to the learning process is needed. Massive multiplayer games provide an immersive interactive environment that can motivate learners and enhance learning if properly applied.

Enhanced Collaboration: Enhanced software tools are needed to support collaboration among students, their peers and their mentor-teachers. Formal collaboration must be supported to enable simple and effective group authoring of learning experiences. Ad hoc collaboration must be supported to enable a student to find and to interact with members of domain specific communities of practice.

E-Learning Infrastructure: Technology breakthroughs must be integrated with the evolving e-learning infrastructure. This may require modifications and enhancements to existing and proposed e-learning standards, such as the SCORM specification developed by the Advanced Distributed Learning (ADL) Initiative. Technological innovations also must be integrated with existing Learning Management Systems (LMS) and Learning Content Management Systems (LCMS).

Scalable Architectures: Salable architectures such as peer-to-peer and grid computing must become part of the general computing infrastructure to support the intense, sporadic style computing capability needed for customization and personalization of learning experiences.

To construct a total system for fluid learning, as envisioned herein, many components and subcomponents must be researched, built, and evaluated. Huge ontologies of information must be built into knowledge bases. Reams of algorithmic response code must be programmed. User interfaces must become more intuitive while the technology itself becomes more transparent. Simulation and game "engines" must be put into the hands of the ordinary person. Schools and businesses and governments and civic organizations must adopt high-speed networking platforms and the devices that connect their people to it and to each other.

Sociological & Cultural Considerations

The envisioned future of interconnected communities of practice, peer supports and mentor-teacher facilitations must bridge impediments that include technology adoption, accessibility, usability factors, localization and customization, cross-cultural communications and language translations, time/place differentials, and institutional cooperation.

In the U.S., public schools and community training centers are extremely under-funded. To radically transform education and training, we also must radically transform our policy priorities.

Perhaps more than any other constraint, perceptions of high costs combined with quick obsolescence stunt diffusion of technology. Consumer purchasing patterns, public funding policies, and the social value proposition of information and instructional technologies must change.

Likewise, the design considerations and usability factors of the technologies and the instructional experiences enabled by them must change to accommodate sociological and cultural requirements. Easier, more universal/standardized human-computer interfaces, dynamic translation of different languages and content sensitivity to culturally-variant norms/expectations must be engineered into a fluid learning system.

Just as convenience and ease-of-use are built into all practical daily appliances – from telephones to televisions, motor vehicles to microwave ovens – the usability of learning technologies must be de facto as well.

Social networks are vital to the success of a fluid learning system which must provide opportunities for learners to connect with educational and social institutions that support learning opportunities across individuals' life spans ("K to Gray").

The need is for technologies to mitigate learning problems, facilitate global exchange of ideas and culture, enhance learning experiences, and do so more effectively and efficiently than we are currently able. And to this end, our social institutions must determine to fund and to adopt, to risk and to innovate for a better future of learning and human performance enhancements.

The Report of the Web-Based Education Commission to the President and the Congress of the United States, *The Power of the Internet for Learning: Moving from Promise to Practice*, surmised:

> "Based on our findings of our work, the Commission believes a national mobilization is necessary. One that evokes a response similar in scope to other great American opportunities – or crises: Sputnik and the race to the moon; bringing electricity and phone service to all corners of the nation; finding a cure for polio." (Executive summary, page iii.)

Pedagogical Considerations

Today more is known about both the human physical capabilities/capacities and human characteristics of learning than ever before. Cognitive science has revealed the basic processes of knowledge acquisition, storage and retrieval as well as the significant factors to engage and motivate learning.

Important cognitive learning theories such as constructivist theory (sometimes called situated learning) and social learning theory must be applied to technology-enabled learning environments. And, research into the effects and efficacy of technology-enabled learning environments must be conducted to extend our ability to create truly effective learning systems.

In a study conducted on the use of a blended learning environment that combined computer-based simulations and individual/group-based learning activities to impart employability skills – both abilities and attitudes – among adults with low-basic skills, several key factors to learning success were identified:

- Simulation provides an engaging and effective learning environment where essential skills can be practiced in context of use. Rather than learning via an absorption process of educational materials, this learn-by-doing model provides a facsimile "job tryout" or realistic job preview that imparts skills through participation with tasks, daily procedures and processes that also included the routine sights, sounds, and culture of the work setting.

- Incorporating a realistic narrative or storyline within the instruction created compelling and motivating scenarios that told the story of "what work requires." Decision points – branching problem-solving decision trees viewed through hypermedia presentations– revealed natural consequences to action with cause-effect learning opportunities embedded. Storytelling is a powerful instructional tradition and learning by trial-and-error is the most fundamental mechanism of human learning.

- By blending instructional delivery methods – computer based tasks, group-based projects, workbooks and individualized personal planning – learners gain a deeper

> understanding of skills and concepts. Within a community of practice that included peer mentors and instructor facilitation along with varied problem-interactions with the performance objectives, learners quickly move from knowing to applying skills in real-world settings. (see The EnterTech Project: Changing Learning & Lives, in Adobe PDF).

To revolutionize training and education, we must likewise revolutionize our pedagogical approach.

Out-dated modes of stand-and-deliver lectures in overcrowded classrooms, rote memorizations of static data, disengaging multiple-choice tests, and standardized curriculums of one-size fits all, must be replaced with engaging and interactive experiences that prepare students for 21st century lifelong learning.

We need real and virtual learning laboratories, with students experimenting with information and constructing knowledge with each other and with experts, with authentic skills assessments and reflection on problem-solving capabilities, and with enrichment and remediation curricula that involve all of us and each of us as equally capable of learning success. A fluid learning system enables such a transformation.

About the IC^2 Institute

Founded by Dr. George Kozmetsky 25 years ago, the **IC^2 Institute** is an organized research unit of UT-Austin. As an international, multi-disciplinary "think-and-do-tank," the Institute links technology, entrepreneurship and education to foster sustainable social and economic development around the world by considering unstructured problems, developing multidisciplinary think teams, and relating theory with practice. Core programs of the Institute include entrepreneurial education, business incubation, and technology-based, regional and multi-national economic development initiatives.

E-Learning & Training Labs (ELT Labs) is a collaboratory ("laboratory without walls") that brings together transdisciplinary teams from academia, business, and government to synthesize 21st century learning issues with 21st century solutions. Understanding the connectedness of workforce development to economic development, ELT Labs recognizes that education and training must become lifelong endeavors.

The **Digital Media Collaboratory (DMC)** is an initiative to facilitate coordinated, inter-departmental research and development in digital and interactive media.

With emphasis on the trisect of learning sciences, interactive and digital arts, and computer technologies, the DMC offers practicum experiences for faculty and graduate students to work with a wide cohort of people advanced in their disciplines for breakthrough transdisciplinary projects that provide significant new directions in the applications of their specialized areas. Through the establishment of "communities of practice," the DMC enables scholars to combine their areas of specialization with other academic and professional sensibilities through project-based, cross-college teams.

The DMC aims to enhance individual learning and societal outcomes by engaging in transdisciplinary, applied research that intersects human-computer communications and converging information technologies. The primary goal of the DMC is to research, to develop, to implement and to study the impact and influence of new interactive technologies and digital content that enhance human performance and improve the social good.

> *from* National Science Foundation's **Converging Technologies to Improve Human Performance: Nanotechnology, Biotechnology, Information Technology, and Cognitive Science**
>
> In the future, everyone will need to learn new skills and fundamental knowledge throughout life, often in fields connected to mathematics, engineering, and the sciences. Thus we will need new kinds of curricula, such as interactive virtual reality simulations run over the Internet that will allow a student anywhere to experience the metabolic processes that take place within a living cell, as if seeingthem from a nanoscale perspective. New, dynamic ways to represent mathematical logic could be developed based on a correct understanding of how the human mind processes concepts like quantity and implication, allowing more people to learn mathematics more quickly, thoroughly, and insightfully. The social interaction resulting from multiuser video games can be harnessed as a strong learning motivator, if they are designed for the user's demographic and cultural background and can infuse the learning with mystery, action, and drama. The goal would be to revolutionize science, mathematics, and engineering education through experiences that are emotionally exciting, substantively realistic, and based on accurate cognitive science knowledge about how and why people learn.

UT-Austin is home to some of the finest programs in the world in Radio-Television-Film Production, in Music and in Theater Arts, in Computer Science, and in Business. The combined know-how and prestige of these programs represent a tremendous potential for innovation.

Twentieth-century scholarship was marked by revolutionary advancements in the disciplines of science, most especially the understanding of quantum, biomolecular and computer sciences; 21st century scholarship will represent the integration of the disciplines.[1]

The Society for Design and Process Science defines transdisciplinary education and research as follows:

"A transdisciplinary education program is built around a core of design, process, systems integration, and metrics. The core is then surrounded by knowledge and skill "tools" selected from various disciplines. The learning environment offers instructor facilitated team projects and discussions. Transdisciplinary educational and research processes are technology driven, project-oriented."[2]

DMC can be the catalyst for transdisciplinary academics that assimilate and synthesize knowledge across disciplines and thereby create new knowledge and solve problems. UT-Austin is poised to harness its resources for unparalleled synergies to lead the next 20 years of innovation in digital, interactive media.

In addition, Austin, Texas ranks third in the nation in number of interactive entertainment studios. Combined with its vibrant music and arts scene and film industry, the Austin digital, interactive media industry is a prime economic sector.

The DMC will leverage and stimulate the indigenous qualities of Austin. DMC can be a partner to the region's development of interactive media by creating academic and industry collaborations that accelerate applied research, invigorate innovation, that stimulate industry growth, and that cultivate and connect the region's creative sectors.

Research Initiatives at the DMC

Games for Learning: The popular appeal, arts and science of PC and console games for entertainment is being transformed into games for learning at the DMC. From massive multiplayer game environments to complex response algorithms that generate dynamic interactive experiences, the game industry's tools and techniques are applied to create engaging and adaptive training content.

Focused Knowledge Bases: A focused knowledge base (FKB) is defined as a knowledge base that is tailored to support a specific *mission*- a stated organizational objective for bringing about desired change. Like other knowledge bases (KBs), the FKB contains an ontology—a hierarchy of classes—along with instances of domain knowledge in the ontology. However an FKB extends the traditional KB in an important way: it includes a separate representation that captures the processes and functions of the domain considered as a *system*.

Simulation-based Decision Tools: Simulated decision scenarios driven by focused knowledge bases can generate powerful problem-solving tools from which users can discern cause-effect among complex, multi-domains, and multi-sectored problems. From regional planning to supply-chain improvements, the simulated case studies utilize real-time data and a feedback loop between system and learner that provides dynamic investigative and informative pathways to decision making.

Game Design Lexicon: Contemporary designers and producers in the video game industry express frustration with their lack of communication across ordinary organizational boundaries. The lack of a common lexicon, or vocabulary, inhibits and constrains communication between software firms developing games, and between game designers and the consumers. Furthermore, addressing needs in the game research community to provide definitions and shared understanding of an evolving medium, the project will combine critical theories with practical naming of common conventions in design and production.

Valuation Matrices for Learning/Educational Content in Popular Games: This project researches the potential for commercially situated computer games to demonstrate educational utility, both in elements of the product's "gameplay" and in the more "contextually-based" content that a particular game exhibits. Evaluation matrices to pinpoint learning content, presented formally or informally, within popular console and PC-based entertainment games are being created and applied to top-selling game titles.

Artificial Intelligence: Artificial Intelligence is a misnomer in videogames. NPCs (Non-Player Characters) and scripted feedback loops follow algorithms that are optimized to use as little processor bandwidth as possible for real-time gameplay. Future games require the research and development of more dynamic and sophisticated computer interaction systems to achieve truly engaging, immersive experiences.

Empreendedor Digital (Digital Entrepreneur): A micro-enterprise entrepreneurial education program will use a blended learning environment that includes e-learning and simulation. The Institute for Brazilian Productivity and Quality (IBQP) is the project manager for this ambitious curriculum to provide basic business skills to self-employment for people living in poverty. Instruction will be produced in Portuguese, Spanish and English. DMC is taking the lead on technical considerations and design of a virtual "enterprise city" that combines multiplayer game format with realistic simulations of business transactions.

Career Connect Project: Youth need access to career information that informs and inspires, and to experiences that prepare them for the world of work and adulthood. The Career Connect Project provides experiential job previews that combine engaging, high-quality and interactive simulated work environments with meaningful occupational information. The system includes database features that allow students to associate interests to multiple career pathways.

The EnterTech Project: The originating project for DMC, the 45-hour EnterTech program is Web-based workforce training program that simulates "on-the-job" experiences and rapidly imparts employability skills. The blended learning environment includes decision-making scenarios with virtual coworkers, classroom group-based projects, print-based materials, individualized planning, and the facilitation and mentoring of a classroom-based instructor.

Conclusion

Rapid technological innovations and knowledge creation makes imperative the need for anytime, anyplace learning opportunities to support human performance. The global hypercompetitive marketplace is intolerant to the slow pace of traditional educational institutions. Just as 21st century business relies on integrated, real-time systems to support enterprise resource performance, like capabilities must be applied to human resource performance.

Our founder, Dr. George Kozmetsky, often quoted within this whitepaper, also says, "In the knowledge economy, your business can grow only as fast as you can train your employees, train your customers, and train your customers' customers."

Based in currently accepted economic models, we believe too that learning and training are a regional function because economies are regionally based. This leads us to a fluid learning model of connected resources engaged in cooperative learning activities. These activities connect learners to the social and cultural capital within their geographical region and beyond.

As such, the DMC aims to fulfill this vision through incremental and iterative research and development projects to build the fluid learning system. The requirements of such a system demand the research and development of numerous subcomponents and their integration. We will apply these initiatives locally and globally through the IC^2 Institute's international network of research fellows and corporate partners. We will partner with other research institutions to study the efficacy and impacts of the projects.

We believe fluid learning systems are vital to economic development, wealth creation and shared prosperity at home and abroad.