Journal of Instructional Science and Technology

http://www.usq.edu.au/electpub/e-jist/homepage.htm
ISSN: 1324-0781

Published by the
Distance Education Centre
University of Southern
Queensland
Australia 4350
Tel: +61 7 4631 2215
Fax: +61 7 4631 2868

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Volume 3 No. 2, March 2000

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Editorial

Welcome to Volume 3 (Issue 2) of the *Electronic Journal of Instructional Science and Technology*. This is our first Issue of the journal for year 2000 so it is somewhat special in that sense. There are 4 papers in this Issue and we hope you will find something of interest in all or some of them.

The first paper in this Issue by **Gregory MacKinnon** (*Integrated Interactive Science Software: A New Role for Teachers*) describes a model for teachers to create their own software, based on their particular curricular outcomes. The author claims that the implementation of this model could have profound implications for the classroom processes in that it has the potential to promote a truly facilitative role for the teacher.

Virginia Kupritz's paper, with its very recognizable title (*The medium is the message: Implications for teaching in cyberspace*), attempts to shed some light on the functional relationship between information, context and meaning in learning environments.

There are two papers in this Issue by **Sharon Gander**. The first paper (*Development of a Corporate Learning Game*) is a case study on the development of a learning game for adults in a corporate environment. This paper provides a window on one educational game's development process within the corporate education/training environment.

Sharon's second paper (*Does Learning Occur through Gaming?*) explores if Cerner Corporation's computer-based game, *HNAM DataQuest: The Millennium Architecture Knowledge Adventure* taught the concepts that it was intended to teach. This report of CVU's results with computer-based gaming offers some support for the use of games designed expressly to teach specific knowledge.

So enjoy, and as usual we welcome your comments and thoughts on any of the issues raised in this Issue of the eJIST. Please address all such correspondence to the Executive Editors.

Som Naidu & Olugbemiro Jegede

Integrated Interactive Science Software: A New Role for Teachers

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Abstract

This paper offers a model for teachers to create their own software based on their regional curricular outcomes. The implementation of this model has profound implications for the classroom structure and promotes a truly facilitative role for the teacher.

Computer Technology in the Science Classroom

Recently I polled 500 teachers of science (grades 7–12) to ask them how they used computer software in their classrooms. The most popular innovation (79%) was the advent of the computer probe. These so-called CBL (computer-based laboratories) and MBL (microcomputer-based laboratories) are quickly gaining in popularity because they allow science teachers to promote higher-order thinking (Kurubacak, 1998) in ways that teachers could never access before. Students can gather data very quickly using temperature, motion, pH and pressure probes and thus spend the majority of their time critically considering their findings. Teachers have developed innovative activities that utilize ‘retro-analysis’. In these exercises, students are supplied with graphs and asked to generate them using experiments with the probes. This represents a very different way of thinking for children and early indications (Berger et al, 1994) are that many children are learning more effectively in these settings.

This article is less about recognised technological successes in science classrooms, and more about the potential of computers for promoting a facilitator role for teachers in the coming millennia. In this same survey teachers complained repeatedly that they spend a lot of money on pieces of software that have singular utility in certain aspects in their curriculum. Applications that are great for that one class of the year, but software that really misses the mark in ever other respect. This ‘poor value’ for the limited technology dollar, arose because most software just didn’t fit the teacher’s curriculum outcomes. How can teachers respond to this?

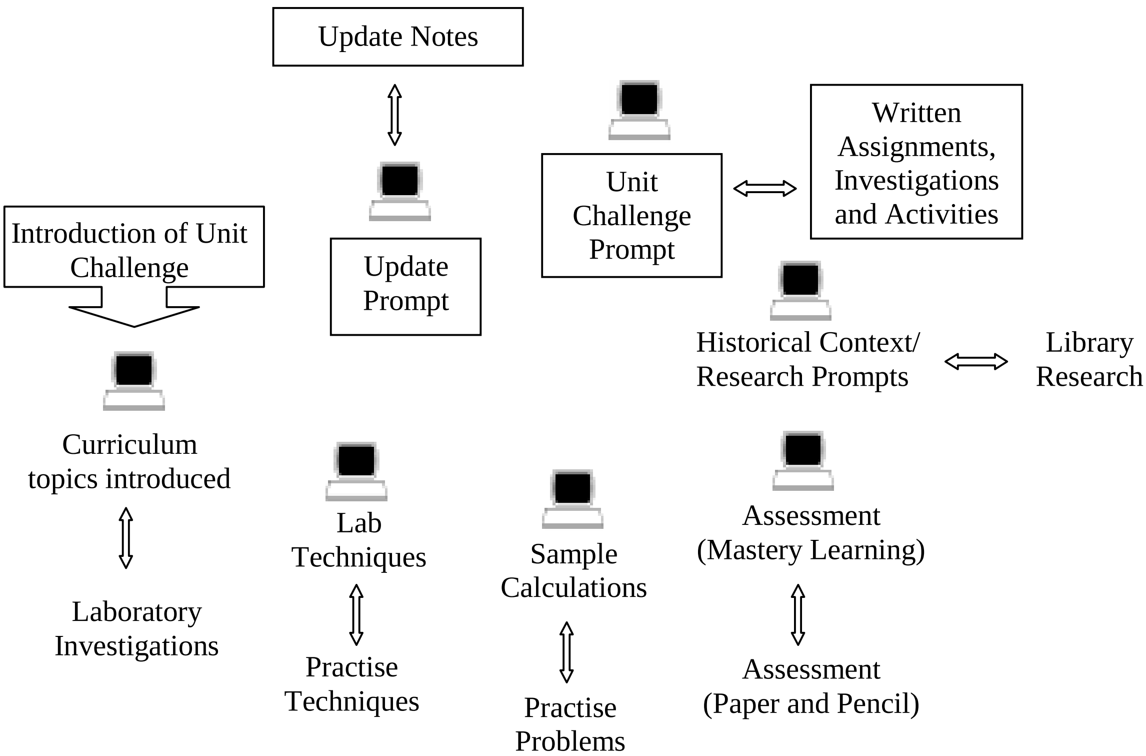
Opportunities

More than ever before, teachers have access to simple software tools that allow them to design software for their classrooms either on their own or in school software teams. Advances in user-friendly multimedia and a corresponding drop in the cost of these tools has made such approaches accessible for all teachers. Perhaps the most critical progress has been made in the area of creating ‘non-linear environments’. In these software settings, students are able to use such things as buttons and hypertext to access a wide variety of media. Simple software development is no longer the exclusive realm of so-called 'early-adopters' of computers. Thanks to products like Powerpoint and Hyperstudio teachers can begin to formulate truly 'integrated' software. These multimedia tools are relatively inexpensive and have become increasingly more powerful but not at the cost of making them 'user-unfriendly'. They still maintain very simple user interfaces with comfortable learning curves. Those teachers who want more flexibility may consider more powerful tools such as Authorware or Toolbook. Though these are more expensive products they remain fairly simple to use at the entry level.

A Learning Model

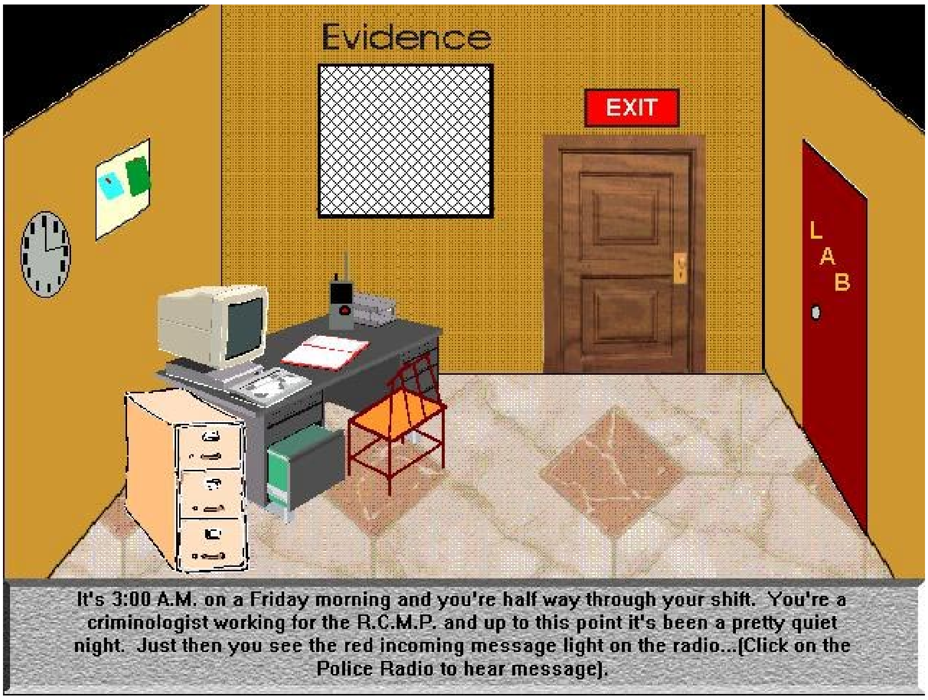
What does it mean to create interactive and integrated software? Interactive simply means students are entering data into the computer as it prompts them for information. This information can be anything from numerical data for calculations to multiple choice questions to test content knowledge. In our research, 'integrated' means developing software that directs students through the content in their specific curriculum. Our learning model for such integration is shown in Figure 1. At the onset of the unit, students are given a problem that draws on the process skills and content knowledge which will be developed throughout the unit. This we call the unit challenge and it is usually given to students in paper copy at the beginning of the study. Students then progress through the learning cycle periodically reflecting back (at the prompt of the computer) to the unit challenge as they construct new meanings throughout.

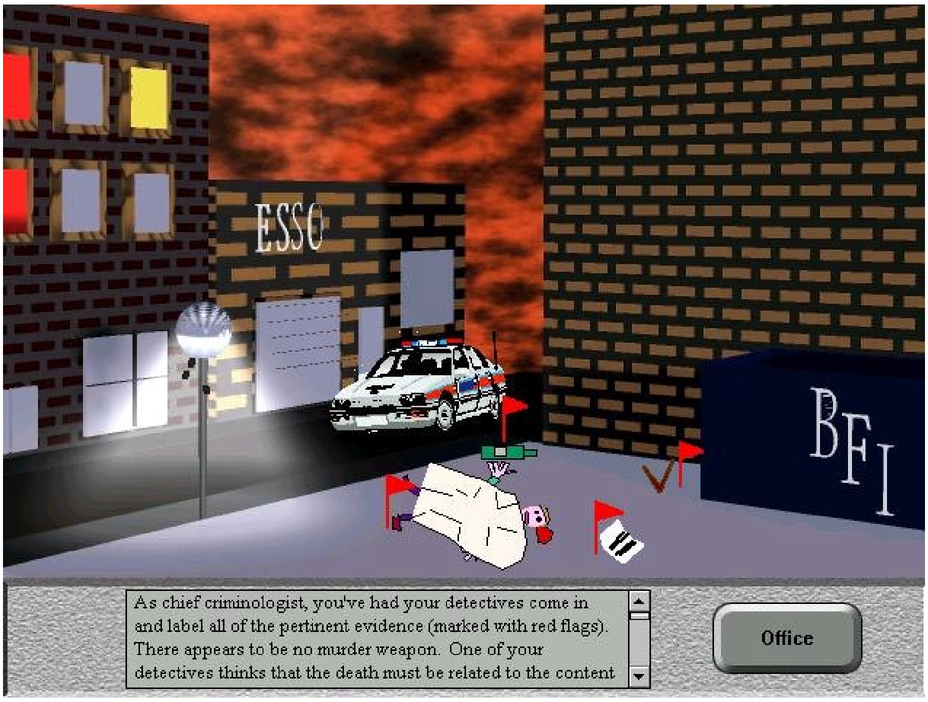
Figure 1: A Model for Integrating Computers into Curriculum



The computer serves a number of functions in this model none of which represents a stand-alone approach. This important aspect of the model addresses the lack of computer resources in many classrooms (Dockterman, 1997). Students can enter the unit learning cycle at a variety of nodes and thus two or three computers in a classroom can be quite sufficient to direct the learning of several groups of students. The computer then acts as a director of classroom learning activities. As can been seen in Figure 2-4 below, the software introduces the unit with a simple ‘omni–directional’ hypertext menu or graphic interface with selectable hot spots.

Figure 2: Software Developed for a Science Plus Unit on Solutions





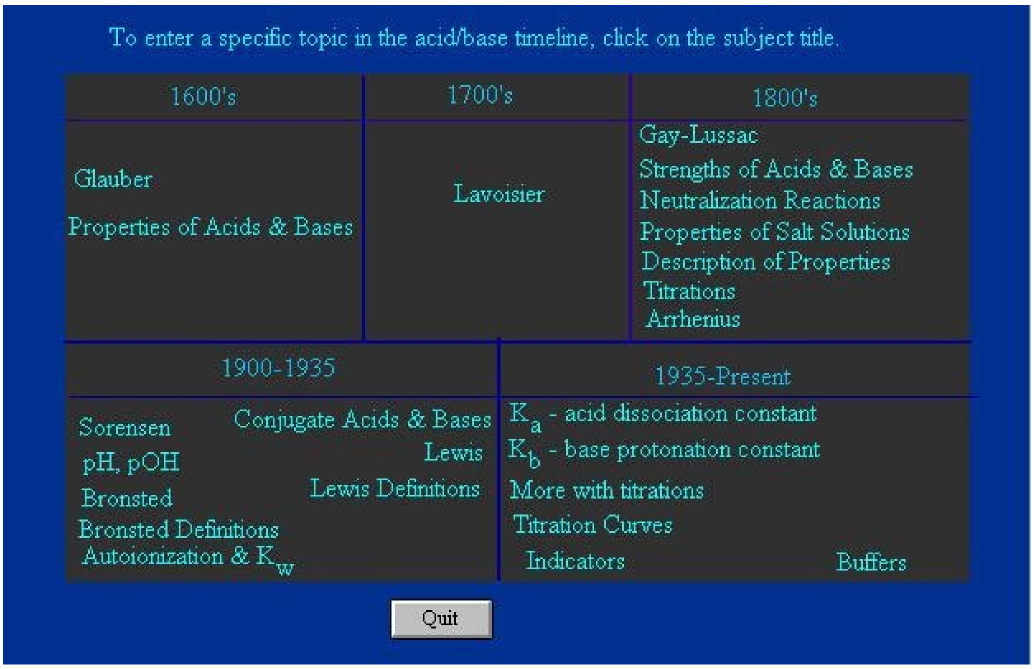
Samples of Interactive, Intergrative Teacher–Generated Software

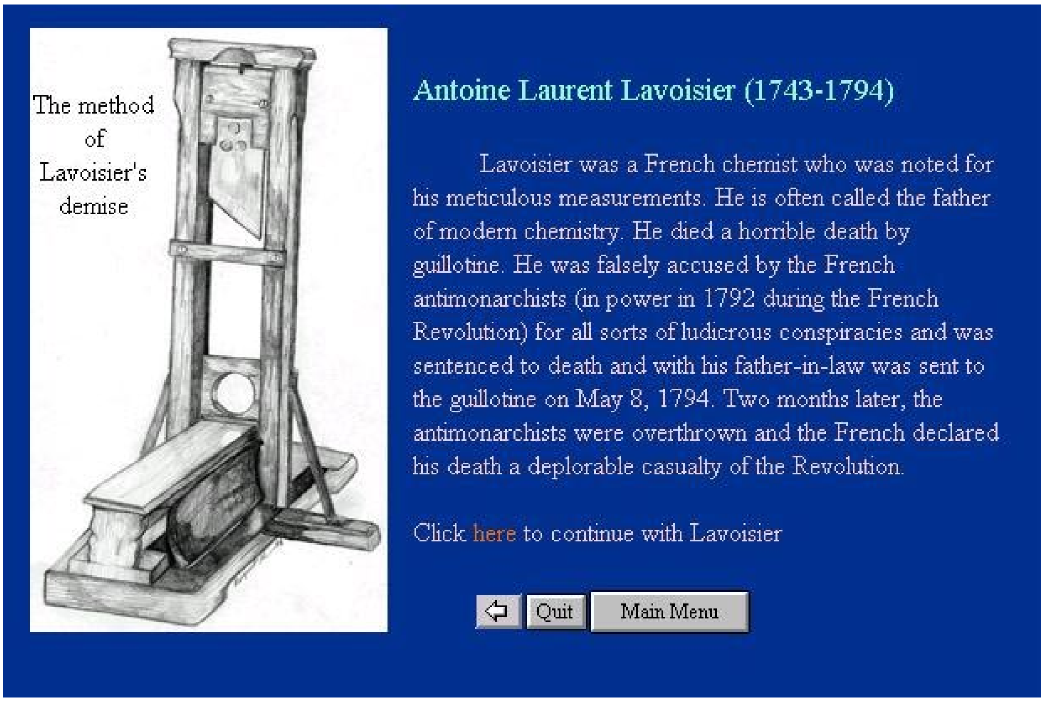
In the solutions software (Figure 2) students are presented with an interface that gives them access to a variety of activities through two interfaces. Their overall challenge is to determine who committed a crime. The computer serves as a database while students, through a series of solution-related activities (chromatography, suspensions etc.) narrow the suspect list to determine the culprit. In the office they can visit the crime scene for evidence, go to the lab to examine the evidence, enter data into the computer and open the filing cabinet to examine personal files on the criminals. At the crime scene each piece of evidence is flagged and here students begin their research by clicking the data they wish to follow up on. Students in a single classroom can be working simultaneously on different parts of the unit through this interface.

The software shown in Figure 3 was created for a six-week Grade 12 unit on acid-base chemistry. The overall unit challenge for the students was to solve a complex authentic problem of acidification of lakes in their region. As research groups they were to submit a proposal for environmental cleanup for the system. As they mastered various aspects of the unit content they would gradually build up the resources to respond to this challenge. This type of situated learning (Carr et al, 1998) has the potential to teach students to be better solvers of ill-structured problems (Spiro et al, 1992).

The timeline interface in this software helps to contextualise (McFadden, 1991) the development of acid-base theory. Though the menuing system allows access to all aspects of the unit at any time, students have preferred (MacKinnon & Forsythe, 1999) to address content in a linear sequence. In preparing software, teachers will find that some topics by nature are additive and thus student entry at different nodes of the learning cycle (Figure 1) is less practical. Because developing historical context of science helps students to situate their learning (MacKinnon, 1996) we have purposefully included (Figure 3) historical vignettes in this software.

Figure 3:Software Developed for a Grade 12 Chemistry Unit on Acids and Bases

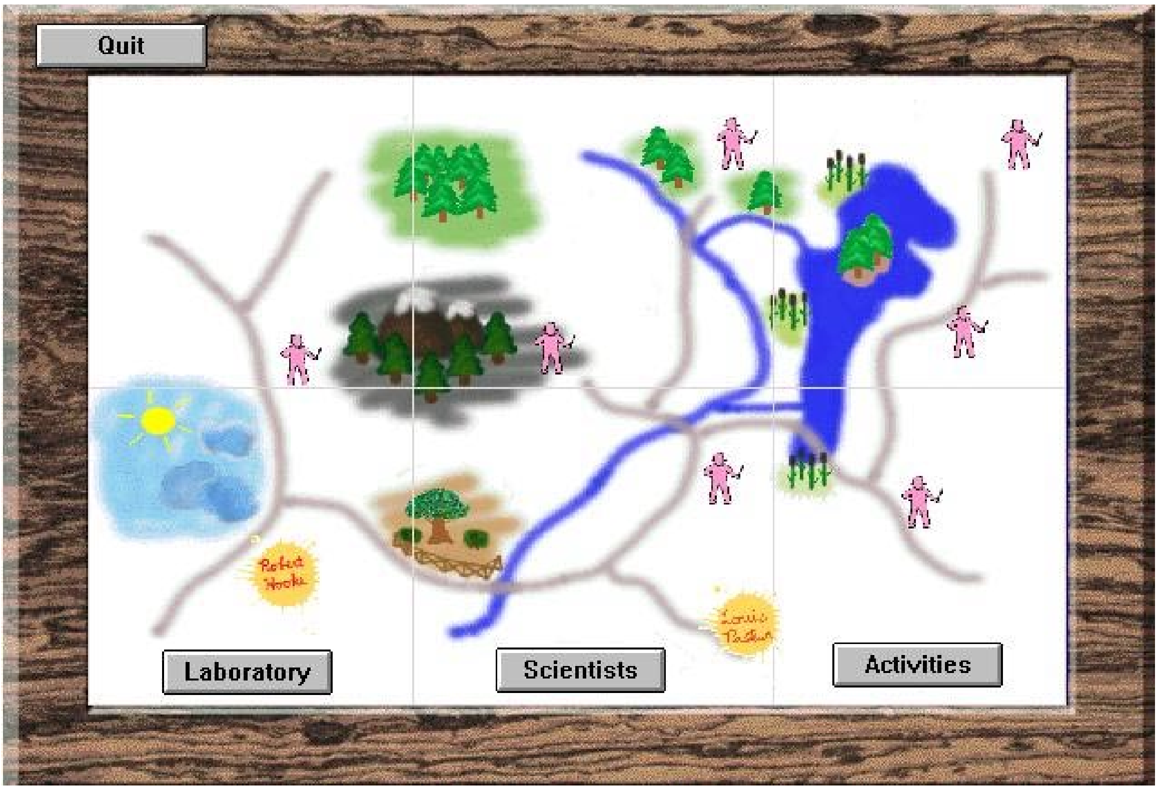




The software example shown in Figure 4 is unique in several ways. The content being developed is the science of the cell and the program could be used at a variety of grade levels. This large project has multiple components and is part of an initiative (Fasano & Brown, 1992) to adapt secondary school curriculum materials for use in inclusive classrooms. From the map interface (Figure 4) students take a historical journey that follows the science of the cell. Each quadrant accesses different scientists (Hooke, Mendel, Fleming, etc.) and their corresponding experiments. The student entering the program is mentored through a series of investigations at and away from the computer. Non-productive experiments and program paths have been included with corresponding positive reinforcement in an effort to emulate real science. In our program, the experiments of Mendel (Figure 4) are a particularly good example of how multimedia can be used to simulate cross-pollination experiments. Throughout these exercises students develop higher-order thinking skills as they analyse data and formulate concepts en-route to meaningful understandings.

This project has been particularly insightful for the authors in terms of teacher led software development. The quadrant approach was promoted because of the inherent flexibility it allowed to add compartmentalised content regarding the cell at a later date. We found that it was far more productive to have a teacher team work on a single component of this project rather than assign individuals to each of the quadrants (i.e. one person working on Hooke, one person on Mendel etc.). Secondly it should be noted that creating software for students of special needs is a unique challenge. In considering each and every student-computer interaction we diversified the interface. To mention a few, this was accomplished by use of larger buttons, text and screens, scrolling text combined with recorded and voice-read text, simplified data input schemes, readily repeated audio and video clips and printable screens.

Figure 4: Software Developed for the Cell and the Experiments of Mendel



Implications for Teachers

In our software designs, the computer may; introduce historical content, pose numerical problems, animate or simulate complicated processes, show video clips of demonstrations, send students away to perform laboratory investigations or library research or perhaps do classroom activities and assignments. Integrating computers into the curriculum in this way ensures a very active classroom setting. The organisational framework helps students to regulate their own learning (Shin, 1998) and work at their own pace. In our classroom observations, we have found that this maintains high motivation and on-task behaviours. In a recent pilot study of this model (MacKinnon & Forsythe, 1999), students were seen to utilise the teacher in very different ways. The co-operative group would field most trivial questions amongst themselves. Students used the computer screen as a teaching aid to explain concepts to the their peers. Generally, questions directed to the teacher were for clarification of instructions or more frequently, to re-explain a difficult concept. Overall students felt that the random access of the teacher for help was improved greatly as a result of this model. These systems have many benefits that parallel ‘centres approaches’ made popular in the elementary classroom. Intrinsic to this setting is considerable preparation as the teacher offers up all aspects of the unit on the first day! Subsequently the teacher is not preoccupied with the delivery of knowledge but moreover the engagement of that knowledge with students.

There has been an abundance of research (Berger et al, 1994) on the impacts of computers in science classrooms. Pedagogically-sound models that move beyond the techno-romantic era in considering the realities of limited resources in real classrooms, are most likely to emerge as useful technologies. Through teacher teamwork, classroom settings can be created that make efficient use of the available technology while ensuring specific curriculum outcomes are met.

References

Berger, C.F., Lu, C.R., Belzer, S.J. & Voss, B.E. (1994). *Research on the Uses of Technology in Science Education.* In D. Gabel (Ed.), Handbook of Research on Science Teaching and Learning, (pp. 466–490). New York, NY: MacMillan Publishing.

Carr, A.A., Jonassen, D.H., Litzinger, M.E. & Marra, R. M. (1998). *Good Ideas to Foment Educational Revolution: The Role of Systemic Change in Advancing Situated Learning, Constructivism and Feminist Pedagogy*. Educational Technology, 5–15.

Dockterman, D.A. (1997). *Great Teaching in the One Computer Classroom.* Watertown, MA: Tom Snyder Productions.

Fasano, J. & Brown, M. (1992). *Facilitating Inclusive Secondary Classrooms Through Curriculum Adaptation*. Exceptionality Education Canada, 2(1), 155–179.

Kurubacak, G. (1998). *Critical Thinking and Educational Computer Applications*. Annual Proceedings of the Society for Information Technology. (From Teacher Education, 1264–1267)

McFadden, C. (1991). *Towards an STS School Curriculum*. Science Education, 75(4), 457–469.

MacKinnon, G. & Forsythe, T. (1999). *Pilot Study in Progress*.

MacKinnon, G. (1996). *Biographical Science*. The Science Teacher, 63(2), 43–45.

Shin, M. (1998). *Promoting Student's Self-regulation Ability: Guidelines for Instructional Design*. Educational Technology, 38(1), 38–44.

Spiro, R.J., Feltovich, P.J., Jacobsen, M.J., & Coulson, R.L. (1992). *Cognitive flexibility, constructivism & hypertext: Random access instruction for advanced knowledge acquisition in ill-structured domains*. In T. Duffy & D. Jonassen (Eds.), Constructivism and the Technology of Instruction. Hillsdale, NJ: Erlbaum.

Electronic Journal of Instructional Science and Technology (E-Jist)
Volume 3 Number 2 Feb 2000

The Medium is the Message: Implications for Teaching in Cyberspace

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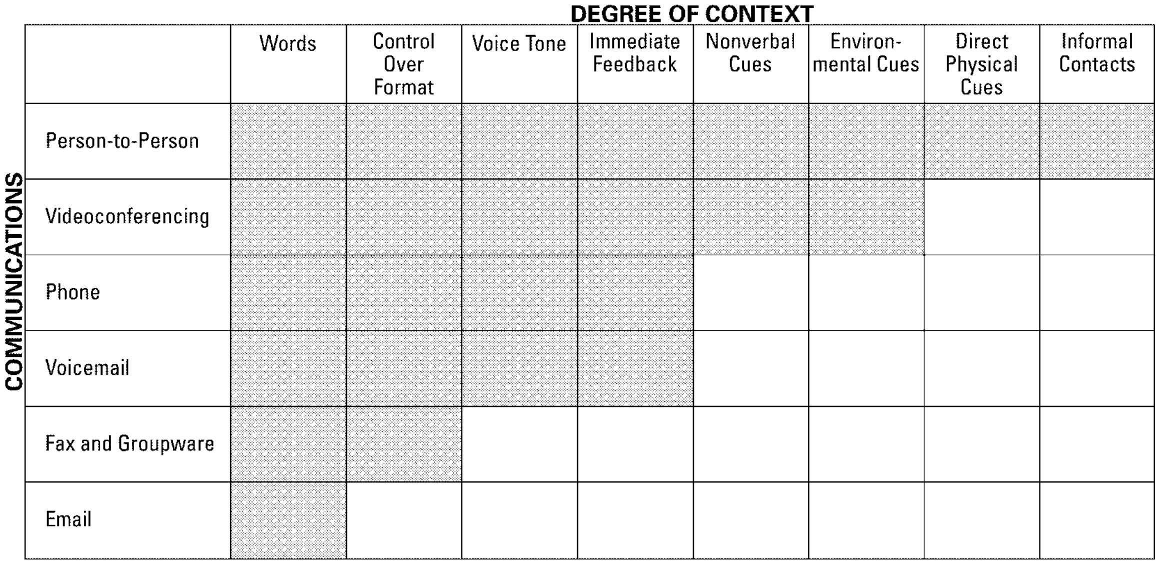
My journey of learning how to use innovative technologies to build online learning environments began with a summer workshop. The workshop prompted me to search for answers to questions about the dialectic between pedagogy and information technologies. In my search for answers, a red flag appeared regarding the role of context to communicate meaning through online instruction. Review of the literature and discussions with fellow adult educators lead me to believe that the full implications of this subtle yet powerful tool to communicate meaning are not readily understood. Gundling (1999) describes context as the 'core intercultural issue when using communication technologies' (p. 30). Over three decades ago the renowned anthropologist, Dr. Edward Hall, coined the term 'contexting' to describe the perceptual and cognitive process of recognizing, giving significance to and incorporating contextual cues in order to interpret the meaning of a situation (Hall, 1983; see also 1966, 1977). Hall argues that information, context and meaning are bound together in a balanced, functional relationship. This paper attempts to provide some basic insight into this relationship.

The Medium is the Message

People communicate through a variety of contextual mediums. This requires that we analyse the amount of contextual information needed to communicate meaning and select the appropriate instructional method that supports this contextual level. Table 1 illustrates the amount of contextual information afforded by different communication modes and identifies contextual mediums for communicating meaning: words, control over format, voice tone, immediate feedback, nonverbal cues (e.g. facial expressions and gestures), environmental cues (both social and physical), direct physical exchange (e.g., a handshake), and informal contact (e.g., incidental meeting in the hallway). Contextual mediums provide information about the learning environment at the conscious and subconscious level. These contextual mediums are cues that facilitate meaning so that the uses of the language can be understood (both verbal and nonverbal) along with the particular situation and circumstances (Hall, 1966, 1983; see also Heath, 1983; Schein, 1992; Weaver, 1986). The learning environment fails to communicate if the learner does not decode these cues.

Table A: The context of various communications by E. Gundling (1999), cited in How to Communicate Globally, Training and Development, p. 30.



While I do not necessarily agree with how Table 1 represents different communication technologies in their entirety, I believe the table illustrates the many contextual mediums we use to communicate meaning. Person-to-person communication through in-classroom instruction provides the instructor and student with the highest degree of context for learning. Online instruction provides a very low contextual form of communication, which is why it cannot replace the person-to-person classroom environment. This is not to say that high context forms of communication are always better; rather, it is essential to select the communication mode most appropriate for the learning situation.

Misleading assertions about the role of context for learning frequently appear in arguments that online resources offer a greater contextual environment for learning than the in-classroom experience (see for example Gillespie, 1998; Kearsley & Shneiderman, 1998; Petraglia, 1998). These generalizations confuse the contextual role of information resources (e.g., the Internet and the World Wide Web) with the contextual level of instruction needed to communicate meaning. The question is not just the real world context that students have ready access to, but also, in what social and physical context is learning being delivered? Online communication is through the computer, which lacks the context of a person-to-person classroom experience. The vast amount of information offered online and the ease by which technology brings real world information into our classrooms are mind-boggling. Nevertheless, the contextual role of these information resources should not be confused with the contextual level of instruction needed to communicate meaning.

My workshop class discussed the power of contextual mediums to support or impede instruction. One of my classmates gave an example of technology problems with context to communicate meaning in an online course. She explained that two cyberspace student teams participated in a project, one team located in the Netherlands and one team located in the United States. Both teams communicated extensively through e-mail during project development. When the teams were asked, at completion, how often they talked to each other during the project, both teams responded that they never talked to each other during the project, but often had wanted to ‘pick up the phone and just talk to each other.’ Findings by

Crook and Webster (1999) provide further insight into communication experiences with e-mail. Their study revealed that contextual properties of e-mail poorly match practices of interaction for undergraduate learners.

Another classmate described to us a course he teaches on images of Jesus–complex, value-laden and evocative. Students are exposed to new ways of thinking about their values, which can be explosive. The instructor needs all the contextual mediums at his disposal to communicate meaning and provide a steady hand as students explore their values. This classmate reflected upon those times in his course that a hush comes over the classroom as students experience the 'ah-ha' of recognition when affective learning occurs. The instructor recognized that his subject matter requires a high contextual level of instruction to communicate the meaning of subjective knowledge—knowledge that is not absolute and is value-laden (see Rescher, 1977). Technology is better suited as a compliment to in-classroom instruction for his course.

The Efficacy of Technology to Communicate Meaning

Technology does not make communication necessarily more efficient, even across international borders. Gundling (1999) argues that technology tools can be counterproductive in cross-cultural business environments. For example, an American firm installed videoconferencing facilities in its Thailand subsidiary. The firm believed that the new facilities would enable communication with other sites worldwide and would increase productivity of the Thai employees by eliminating the need for unnecessary travel to another location for meetings. The American firm soon discovered that the local managers were conducting the videoconference for the firm's benefit and still travelling to the other location to have face-to-face meetings afterwards. The Thai managers explained that they wanted to be able to meet in person to gauge the reaction of others. Electronic delivery can approximate but not duplicate face-to-face interaction even when supported by two-way audio and video (see Wiesner, 1998).

The need for face-to-face interaction to communicate also can depend upon the particular situation and needs of the individual or group. Levi, cited in Smith & McCoy (1999), examined American worker perceptions of virtual offices, asking whether the physical space was relevant any longer. Findings determined that preferences for different communication modes used for receiving important organizational information reflected different group beliefs about management. Groups that trusted management wanted their information via e-mail or written. Groups that did not trust management preferred face-to-face interaction. Levi concluded that 'creative and collaborative work can be supported by communication technologies, but the physical environment also is needed for building social relationships, providing training and support, and dealing with communication problems' (p. 12). This finding emphasizes the need to understand the role of context to communicate meaning in all learning environments. The process of instructional design requires careful attention to the power and subtleties of contextual mediums to communicate meaning.

Some Final Thoughts

My workshop experience left me with the feeling that I had left the hard ground and had entered a swampy terrain searching for answers with no absolutes and no fixed realities about the appropriateness of new technologies for all learning situations. Information technology is changing so rapidly that we are behind in developing pedagogy to guide our experiences with technology. Gaver (1996) astutely points out that ‘new technologies seldom simply support old working practices with additional efficiency or flexibility. Instead they tend to undermine existing practices and to demand new ones’ (p. 112).

The growing army of competitors from public, virtual and commercial institutions are not bound by our pedagogy or traditions. As stewards of learning, we need to be asking the right questions, the difficult questions. I believe that one question we must not overlook is how meaning is communicated through online instruction. As teachers, we struggle with the same practical issues of how to ration our time to learn the new technologies, adopt new approaches to teaching and learning, keep up with all that is required of us in scholarship and service, and somehow make a difference in students’ lives and learning. Yet we need to preserve the essence of our valued traditions and still change. We owe this to our students and to ourselves who must live and learn in an electronic world.

References

Crook, C. & Webster, D.S. (1999). *Designing for Informal Undergraduate Computer Mediated Communication*.
URL: <http://www.cti.ac.uk/ publ/actlea/al7pdf/crook.pdf>.

Gaver, W. (1996). *Situating Action III: Affordances for Interaction: The Social is Material for Design*. Ecological Psychology, 8, 111–130.

Gillespie, F. (1998). *Instructional Design for the New Technologies*. In the Impact of Technology on faculty development, life, and work. New directions for teaching and learning no. 76. K.H. Gillespie (Ed.), pp. 39–52. San Francisco: Jossey-Bass.

Gundling, E. (1999). *How to Communicate Globally*. Training and Development, (June), 28–31.

Hall, E. T. (1966). *The Hidden Dimension.* New York: Doubleday.

Hall, E.T. (1977). *Beyond Culture*. New York: Doubleday.

Hall, E.T. (1983). *The Dance of Life: The Other dimension of time*. New York: Doubleday.

Heath, S.B. (1983). *Ways with Words: Language, Life, and Work in Communities and Classrooms*. New York: The Press Syndicate of the University of Cambridge.

Kearsley, G. & Schneiderman, B. (1998). Engagement theory: A framework for technology-based teaching and learning, *Educational Technology Research and Development,46* (3), 20–23.

Petraglia, J. (1998). The real world on a short leash: The (mis)application of contructivism to the design of educational technology. *Educational Technology Research and Development,* 46, (3), 53–65.

Rescher, N. (1977). *Methodological Pragmatism: A Systems-theorectic Approach to the Theory of Knowledge*. New York: New York University Press.

Schein, E.H. (1992). *Corporate Culture and Leadership*. San Francisco: Jossey-Bass, Inc.

Smith, P. & McCoy, J. (1999). Imaginative thinking needed: Where's the power of workplace design? *Design Research News, 3*,12.

Weaver, (1986). Understanding and coping with cross-cultural adjustment stress. In R.M. Paige (Ed.) *Cross-cultural Orientation: New Conceptualizations and Applications*. Lanham, MD: University Press of America.

Wiesner, P. (1998). Web delivery of training and education for industry: Some thoughts.

Educational Technology & Society, *1*(1), 30–31.
URL: <http://ifets.ieee.org/periodical/issues.html>.

Case Study: Development of a Corporate Learning Game

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Abstract

This paper provides a case study perspective on the development of a learning game for adults in a corporate environment. The game, Cerner Corporation's *HNAM DataQuest: The Millennium Architecture Knowledge Adventure*, teaches Cerner's specific information systems architecture to associates. The process of creating a game for educational rather than entertainment purposes is not well documented. This paper provides a window on one educational game's development process within the corporate education/training environment.

Educational game design and development projects like this one have different hurdles to manage than do entertainment games. Creating educational games within a corporate environment adds other challenges. Therefore, other corporate game development project managers may find this window on one educational game's project useful.

Background

In 1998, Cerner Virtual University, (CVU), developed a computer-based learning game to teach core processes and knowledge of Cerner's three-tiered client/server architecture and relational database. The resulting product, *HNAM DataQuest: The Millennium Architecture Knowledge Adventure (a.k.a. HNAM DataQuest)*, was an experimental venture for CVU. At the same time, CVU was creating more traditional CBTs using standard project management methodologies. In many ways the game development project was a "skunk-works" type project.

Project Overview

The Vision

The vision was to develop a learning game for adults on the topic of Cerner's architecture. The game needed to be engaging and fun while educational. That is, players not only needed to learn Cerner's architecture, they were to have fun learning.

The Challenges

There were three major challenges in developing this game:

(a) Cerner's architecture was thoroughly defined at a deep technical level and not at all documented at the intermediate level needed for content in the game. This meant that extensive translation was needed to move that knowledge from deep technical language and abstract knowledge stored in experts heads into the concrete language needed by those not familiar with the technology.

(b) Cerner Virtual University's game development team was staffed with individuals who were committed to the concept of educational gaming but who had previously created a computer-based learning game.

(c) The project was staffed as a skunk-works with most of the project's team members participating in multiple other projects as well as this one.

Project Champion

One of the first steps, as with any project, was to get one or more executive level champions for the project. The primary champion was Cerner's Vice President of Learning, Dr. Robert Campbell, E.D., who had the original vision of game on this topic for several years before it came into being. He not only provided the vision; he financed and staffed the game development team and guided educational decisions. In addition, he provided invaluable feedback embedded in an abiding commitment to the concept of a learning game throughout its development.

The second champion, Steve Oden, was a senior manager in engineering who provided subject matter experts as resources and whose commitment to the concept created a demand within the organization. He understood the game format and its value in creating learning for the intended audience. He provided a long-term stability throughout many changes and effectively represented potential audience. In addition, he often translated the deep technical knowledge into lay-language, which is more accessible to novices and more effective in gaming. His commitment to this learning product and to the skunk-works type project management process ensured that the needs of the audience were continually bonded into the game's content and processes while game development continued over an atypically long time period. These were invaluable assets throughout the design and development process.

The Game Project Team

Cerner Virtual University (CVU) started the project with a team of three – a multi-media programmer, an internal project manager/instructional designer and a multimedia/instructional design consultant. The multi-media programmer was the only full-time member of the team throughout the life of the project. The internal project manager/instructional designer was assigned half time to the project (and half time to several other projects). The consultant was also part-time.

There were five key subject matter experts. Subject matter experts had extensive workloads outside of this project. Their time commitment was less than two hours once a month. Due to work demands, it was not possible to bring together all subject matter experts in one room. Nor was it possible to meet with any one person on successive days or even weeks. This ‘hit or miss’ relationship with these key actors impacted the project management process significantly. The knowledge needed had to be captured from them and translated into more concrete language. Their limited availability added several challenges for the project team. As a result, they mostly worked through the project manger/instructional designer and seldom participated in design discussions with the rest of the development team. However, their long standing patience and willingness to keep working on the project made it possible to complete the project.

As the project progressed and deliverables demonstrated that the concept could become reality, three more part-time specialists were added: a graphic artist/illustrator, part-time multi-media architect and a part-time writer. Like the rest of the team, each of these new team members was only partially assigned to this project while working on other major projects. The game development project eventually had six people working on it even though only one of them was assigned to the project full-time. However, each team member brought strong major personal commitments to the idea of gaming as a learning method. Without their commitments the game would not exist, as other key projects would simply have moved in and taken over their time. They deserve considerable applause for their commitment and dedication.

As may be expected under the circumstances, significant overtime was needed by all team members in order to make the game a reality. Even then, the project's deliverables were pushed back many times. In part this was due to the part-time nature of the team. Some of this was also due to the skunk-works nature of the project as well as the lack of experience the team had in developing gaming and equally to the low availability of subject matter experts. Timelines reported here are the actual timelines not the projected ones.

Educational Needs Assessment

Before starting the project, the project manager/instructional designer spent significant time developing contacts and subject matter experts. The project officially started only after it was determined that the content while available, was not clearly documented but mostly stored in subject matter experts' heads and that this was in fact the content needed by others throughout the organization.

The actual Needs Assessment was very primitive. The project manager/instructional designer asked individuals in assorted roles throughout the organization to ‘describe the architecture’ or ‘explain the architecture.’ Roles of individuals interviewed include programmers, instructional designers, managers, product specialists, certification analysts, sales people. Their answers were either a negative response (I can't) or a pat-answer that they could not elucidate further. **The need was very basic – to create a memorable and describable version architecture.**

Deliverables

Few deliverables actually met their projected timeline. Accuracy of time estimates continues to be a challenge for this team. Timelines reported here are the actual timelines not the projected ones.

However, unlike other kinds of projects at Cerner Virtual University, this game had no previous precedent within the organization and was kept relatively obscure within Cerner Virtual University during its development stages. In many ways it was a ’skunk-works’ type project. Therefore, sponsors were willing to reset timelines and continued to encourage refining and improving this product.

Project Process and Deliverables

Phase I: Development of the First Game

1. Content gathering and determination of whether there was a game – November 97–February 98

   - This project had been started at least twice previously. The difficulty in gathering information with sufficient breadth and depth had hindered previous development efforts. Previous efforts had included definitions of high-level concepts and high-level organizational visions of the abstract architecture. These had not provided sufficient breadth or variety to allow for a game format. Uncovering the process/flow of the conversation finally opened the design process providing sufficient breadth and depth for this format.

2. Instructional Design and Engineering/Functional Designs–completed March 98

   - Needs assessment and design documents were somewhat cursory. The need was clear and basic – new Cerner associates needed to understand Cerner's architecture and be able to articulate it. The available documentation did not clearly describe the architecture in lay language for the non-technical associates who are often the interface with clients. Describing and teaching Cerner's three-tiered client/server architecture and relational database became the key need.
   - The design documentation provided the basic educational descriptions of needs, outcomes, goals and objective and only very rudimentary descriptions of the projected game and game play. Textbooks on game development helped some but did not provide the experience to know what needed to be document and what did not. Therefore, the functional technical designs evolved through skunk-works style proof-of-concept and prototyping.

3. Determining Game Format–completed March 98.

   - The project sponsors recommended creating a drag and drop game similar to the children's game, The Incredible Machine, for at least one portion of the content. The team reviewed The Incredible Machine and considered several other options including quest-style adventure games. In the end, a combination of both a drag and drop game and a quest-style adventure game format were merged to create one game with several levels of play.
   - Defining the intended format allowed actual game development to begin. The actual decision was more ‘hunch’ and ‘faith’ and ‘vision’ than fact-based as there is little research on use of different game formats for educational purposes.

4. Paper-based prototype (or Proof of Concept)–completed April 98.

   - A paper-based prototype and usability test was used to define and test game playability – rules, images, some textual content, and some action. A side benefit of this methodology was that it allowed Cerner Virtual University to be more confident that the end product would be both appropriate and useful. This confidence would be important during the coming months of development and revision.

- The key to the paper-based prototype was the involvement of an illustrator who created graphics that were both fun and informative. The paper-based prototype was a large white-board sized playing area on a magnetized surface. Each paper game piece could be moved around the playing area as though one were dragging and dropping it on a computer screen: it provided the look and feel of a drag-and-drop interface. Game pieces were small graphics (2–3 inches square) printed on a colour printer with small magnets attached. On the back of each game piece was additional support material in the form of textual messages about the role and function of the game pieces.
- During paper-based play, players were asked to think out loud in order to help the testers understand the player's unique perspectives and issues. Playing the game during the paper-based prototype phase involved picking up game pieces and placing them on the playing surface where they ‘stuck’. If a player needed help, they could pretend to press the HELP button to receive additional hints. HELP was free-form discussion used to find out what kinds of questions people had about playing the game as well as what kinds of answers helped players move forward with the play.
- When the players were ready to run the game, they simulated pressing a run button and one of the testers played the role of computer moving graphical game pieces. If the game pieces were not correctly organized, the computer role-player would provide an error message explaining only that this was the wrong game piece for that location. Game players then had to correct that error and press run again to find out whether there were additional errors. It was clear even in the paper-based testing stage that with every error players learned more about architecture. It was also clear that most players had fun with this format.
- Some players worked hard to get the ‘right’ answer the first time and were very frustrated when they made any error; they became visibly more tense at each feedback. Others played the game by trial-and-error. They would make a reasonable guess about which piece to place next, press run and learn from the next error message – they became visibly more concentrated and relaxed with each feedback.
- Using a paper-based prototype was both an effective test of the game play and a learning experience for the game developers. In addition, there were several side benefits of the paper-based prototype. Having a paper-based prototype allowed us to:

  (a) Show progress at a stage of development, which is otherwise extremely abstract.

  (b) Test our ideas with subject matter experts, sponsors and a small group of volunteers without significant investment in the concept of a game as a learning tool.

  (c) Generate enthusiasm and additional commitment for the project.

  (d) Show subject matter experts where additional content needed to be developed.

  (e) Define how the computer should interact with players.

  (f) Define how different learning styles/approaches would need or want to use support materials and hints.

5. Computer-based prototype–June 98

- Once a paper-based prototype was available work began on a computer-based prototype. As the computer-based prototype emerged it became clear that the chosen development language/tool would significantly influence the resulting game. There was a hot debate around this issue. We changed languages mid-stream several times in order to find one that would provide quick development and a pool of programmers who could work with the language.
- We tried Java, VisualBasic and ToolBook. Each had advantages and disadvantages. Eventually, the multi-media programmers settled on ToolBook as the tool of choice. Once chosen, the team revisited game rules and imagery issues. Key issues of debate were:

  (a) Did the images provide both tacit and explicit clues to support their function within the game's architecture? (Was it better to use images specific to computer hardware and software such as CDs and system towers or to use metaphorical images such those chosen around transporting the message? Was it necessary to follow a theme or could players handle working with unrelated images?)

  (b) How many times would a player be required to play each level? Would ‘fun’ be enough to draw people back to play it over and over?

  (c) How could we measure learning? Was it possible to get the ‘right’ answer without learning anything?

  (d) How much text was needed? When and where was it needed? How obvious did the text need to be the player (e.g., should it appear automatically or require a mouse click, etc.)?

  (e) Did we need to provide text explaining how to play or simply allow users to discover the rules of play as well as the educational content built into the game pieces and their relationships?

  (f) How technical did the language need to be? Could we move non-technical players into understanding and comfort using technical terms without defining and using those terms?

  (g) How easy or difficult should it be to get to supporting documentation such as a glossary, explanations of the technical process, etc.? How many steps might make it too difficult for the player to get supporting information? What automatic presentation of supporting information would be obnoxious to players?

- The ‘play’ that was tested in the prototype was not exactly how the game could be played in a computer version. Many discussions ensued as each element of play was hashed out and as each image was evaluated and justified or changed.
- In addition, as game play changed imagery changed. For example, at one point the game pieces for one level of the game were assigned ‘in’ and ‘out’ areas on the left and right of each game piece respectively. Over time, these areas moved up or down the game pieces due to programming issues or changes in the definition of how to play the game. In turn, as the design of the game pieces changed the rules of play changed. It

was an iterative change process fraught with strong emotion as everyone had their own perspective of what the players would need.

- In addition, there were many ideas that seemed reasonable in the paper-based format or document stages but were difficult to re-create in programming. The challenge here was to determine what concepts, interactions, educational theories, content, user interface requirements, and programming language/tools limitations were at stake and find ways to balance them and retain or improve the engaging, fun nature of the game while teaching certain content. For example, one portion of the play had a background of many lakes connected by rivers where the lakes represented data tables and rivers represented relationships between tables based on keys. This playing area was actually nine times larger than the visible playing area on screen. Considerations included how to make a canoe (the person 'fishing' for data) manoeuvre the rivers. The team considered issues like the use of a world map and close-up maps, how to provide an overview so that the player would know which lakes (tables) they might need and where currently outside their visible play areas, etc. It worked well in the paper-based prototype. However, computer prototyping demonstrated the severe limitation of this model on-screen. After much reworking, the resulting play area fit within one play area window, had a hydroplane fly to any lake on a double click, and provided detailed information about lakes on (single click) menus available for each lake.

6. Final game: Beta version – October 98

- Creating the final product meant coordinating images with action and text. Much of the text-based content development was from 'scratch', as it needed to be in lay language not technical language. Of course, this new content had to be validated by subject matter experts, revised, revalidated, etc. Since subject matter experts were difficult to reach, had competing demands on their time and, when available, found the translation of their technical expertise into lay language difficult, it meant that instructional designers wrote the first draft – and the second and third drafts until they got the translation correct. Then textual content was often revised and revalidated at least once more, as available space was not sufficient for the original content. As the project neared completion, the multimedia writer took over fine-tuning and finalizing the text to be sure that it both fun and understandable.

- During this stage, interface imagery changed almost daily as button designs, button placement, text placement, themes, borders, colors, and game piece images and relationships between game pieces and interface changed and changed again. At every iteration images, text and action were continually tested against usability.

- With strong owners of imagery, text, and action pitted against each other and against the usability and education theorists, this stage was fraught with tension. However, it was also filled with zest and enthusiasm for the emerging product. At each iteration, it was clear that the resulting game got better and better.

- As a team we also came to agreements over time on key theories which we felt needed to be consistently handled the same way throughout the game. The battle cry became, 'Is it fun? Will they come back and play it again and again?' We had finally decided that we could overcome the issues inherent in the massive, complex and difficult content if we could get players to come back and play the game at least three times.

- Usability and content testing continued throughout this phase. However, subject matter experts, learning specialists and sponsors were the major audience along with few new technical associates who had also participated in earlier alpha testing.
- However, finalizing the game did not end the development.

7. Testing–November/December 98

- Once the beta version was available, it became imperative to test both usability and learning. We wanted to know from the intended end-user audience whether or not the game (a) taught them what they needed to know, (b) was playable without classroom-based/instructor support and (c) was fun.
- In addition, since the game is a form of orchestrated immersion and since orchestrated immersion often overwhelms learners, it became important to define players learning and emotional states during play.
- Orchestrated immersion learning provides such massive content to learn and multiple paths through which to learn that most learners shift from modes they use in more traditional learning to deeper learning modes. However, a few individuals will ‘downshift’ during the early stages of orchestrated immersions. They freeze. If they have appropriate intervention, they can turn around the anxiety, fear and frustration and begin to learn. However, in a CD-based game, there may be no one available to intervene. This downshift and freeze may result in these individuals simply quitting and never returning. We needed to know what caused the downshifts, when and where in the game play.
- We had provided a semi-active agent who was intended act as coach and to prevent the downshift. However, the rules for this agent were limited. In addition, the programming necessary for its active (or rather semi-active) status had it behaving in a nearly passive mode. That is, the active agent popped up with some fairly generic text comments appearing in a small window and providing some coaching hints. There are three problems with the agent, which will need to be resolved in future productions:

  (a) The text for coaching was not robust.

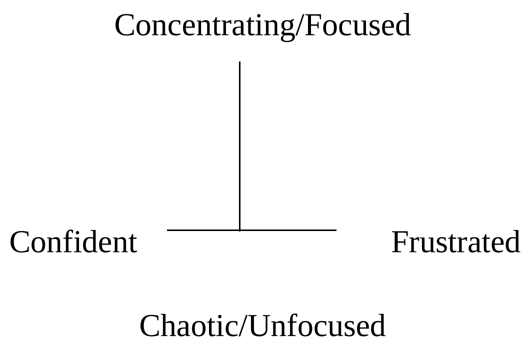
  (b) The rules activating the agent are limited in scope.

  (c) The agent does not intervene as much as it appears temporarily in a small window.

  (d) The agent's behavior is mouse-sensitive – if the player is moving their mouse when the agent appears, it immediate disappears. This means that some players never see the agent.

- In order to find out how to make the active agent more effective in the orchestrated immersion-game format, we needed to find out what individuals did during play which would indicate that they were experiencing downshift or that they potentially heading for a downshift.
- The test process included a pre/post test and observation of players. In order to observer fifteen to twenty players, we needed to mobilize a team of observers. Observer training was provided.

- Our test audiences were new associates still in their first two weeks with Cerner. Observations were done in one large room with many players to one observer.
- Observers reported observed learning states and usability factors at five-minute intervals. Players self-reported their own learning state at twenty-minute intervals. Learning state was reported on a grid whose X axis was emotional state and Y axis was attention behaviors. The X axis ranged from frustration to confidence. The Y-axis ranged from chaotic/unfocused behavior to concentrating/ focused behavior.
- Learning State Observation Grid



- Results were mixed. Observers were inconsistent in their observations. Few observers managed to report 12 data points per player. However, some useful information did appear. Players seem to fluctuate learning states on 15–20 minute intervals and as they changed levels of play. The majority (80%) of players started out each level feeling somewhat to highly confident and somewhat to highly concentrating and focused. They became frustrated and more chaotic during the next 5–10 minutes. Most were able to turn that chaos and frustration around. A small percentage (15%) remained in that state of frustration – they got stuck in a downshift and could not get out.

8. Refined game based on test results: Full-release version – January 99

   - Usability observation results identified areas for quick changes that could be made between a beta release and a full-release. These changes included a new strategy for a tutorial, fixing some bugs, providing the active agent with a few more hints, modifying the action slightly in the hopes of preventing downshift and frustration at one key point and fine-tuning some of the architecture for improved performance.
   - The first full-release version was provided to users in March of 1999. It is still being tested. Changes are planned for the next version.
   - Over 350 individuals are using the beta-release version of HNAM DataQuest with more about 700 more individuals waiting semi-patiently for the full-release to come through the CD product house's production cycle.

Phase II: What is next?

Complicating Factors

Many factors increased the inherent difficulty of the task. The innovativeness of the product is only the outward sign of many innovations in project management, development processes and teamwork. Everything from team resourcing to availability of subject matter experts to previous experience with gaming to choice of development language added complexity to this project. In addition to the traditional project management challenges, this project experienced some unusual challenges in deciding on the development language and in deciding on uses of imagery and text.

Development Language(s)

The choice of development languages also created challenges. The full-time multimedia programmer started with Java, which was a new language for him and for which he had no in-house support system. Eventually, the project moved to Visual Basic where the project consultant had expertise. In order to move to Visual Basic, the multimedia programmer learned a second new language. Development still was not as flexible as desired. Eventually the team moved to ToolBook where prototyping went faster and in-house expertise was available from a multimedia architect. However, this meant that the multimedia programmer learned a third language in order to move to ToolBook.

Imagery

Imagery was always a hotly contested topic. Everyone has their own way of perceiving reality and nothing was more controversial than the graphics of the game. The team acquired an illustrator who saved the day by producing fun images at an unbelievable speed. The game would not have had quite the same impact with clipart graphics.

Interface issues often ended-up in graphical redesign. Graphics were changing right up to the final days before full-release.

Text

Words move the tacit knowledge of imagery and game action back into the realm of explicit knowledge. Text was the under-valued aspect of educational gaming. Since there is little research available on the design aspects of education gaming, the team under estimated the value and importance of the text both for content and for game-playing guidance. The fun, precise and clear lay language describing each of the game piece and the matching fun, lay language videos were as vital to the overall impact of the game as was the game action.

Hints and tutorial were a hotly contested issue throughout the game design. Eventually we provided a combination of hints including suggestions of functions that should be found in the next game piece. The tutorial was re-written between beta release and the first full release.

Support information was of less interest even though it is necessary for some learners whose learning styles prefer text-based factual documentation. It had to be available even though the majority of game players may never find it much less read it. Support information included a glossary, FAQs, overviews of each level of play and access to video segments.

Phase II of the Project–What's next for the game development team

The beta-release and first full release of *HNAM DataQuest* have three levels of play embedded in three scenarios. In other words, the play is fairly limited. Additional levels of play need to be developed. A process for generating content and images has been drafted. The team needs to test that process. In addition, a scenario generation engine has been built which should increase the speed at which scenarios and levels of play can be built. In fact, instructional designers and technical writers can now do the majority of the work in designing scenarios. Programming will still be needed to integrate all the elements as well as to improve the quality of play. Programmers will be focusing on improving responsiveness, making the active agent more effective, building an external reference tool that allows content to be found outside of gaming, and building development engines to allow other instructional designers to develop more games in this format.

Summary

The *HNAM DataQuest* project was experimental in both its use of gaming for an educational methodology and its use of resources. The *HNAM DataQuest* game project required nearly one and a half years to complete due to constraints of part-time team members, limited access to subject matter experts, and team members who were new to computer-based game development.

Gaming as a learning delivery tool is not fully accepted as an adult education methodology, which contributed to the experimental nature to the project. However, the project was completed within a skunk-works type environment that allowed for experimentation and adjustments of timelines. Through the process of developing the game, team members learned a significant amount about the application of learning theories and their own personal learning experiences to a new methodology.

The *HNAM DataQuest* game is providing learning opportunities for nearly fifteen hundred Cerner associates. Testing proved that associates could develop the mental model needed to articulate Cerner's three-tiered client/server architecture and relational database.

Educational games can be effective learning tools. As their acceptance grows, project management methodologies can be fine-tuned and standardized. At this time education game projects in corporate education are the exception rather than the rule. Therefore, the structures and processes needed to work an educational game design project are often hit-and-miss. The *HNAM DataQuest* team used traditional project tracking tools and invented many communication tools. However, in the spirit of innovation and entrepreneurship, technical design documentation never did get created. Decisions about content, use of text, use of imagery, and use of development language were team decisions and, as with team decisions in inexperienced teams, took longer to finalize than they may have with a more experienced team.

As many corporations develop learning games for adults where the content and game methodology are complex enough to require complex project management methodology, educational game project managers and project teams will need to develop specific methodology for game projects. Specific methodology that includes design tools, technical documentation of functionality, and clarification decision processes will decrease the time required for game development.

References

Caine, R. M. and Caine, G. (1994). *Making Connections: Teaching and the Human Brain*. Alexandria, VA: Innovative Learning Publications, Addison-Wessely Publishing Company.

Dempsey, J.V., Lucassen, B. A., Haynes, L.L. and Casey, M.S., (1996). *Instructional Applications of Computer Games*, paper presented at 1996 annual meeting of the American Educational Research Associate, (ERIC Document Reproduction Service No. ED #394500.)

Dombrower, E. (1988). *Dombrower's Art of Interactive Entertainment Design*. City, State: Publishing company.

McMullen, D. (1987). Drills vs. Games - Any Differences? A Pilot Study. (ERIC Document Reproduction Service No. ED #335355.)

Merrill, M. D. (1999). Article Name. [On-Line] Available: http://www.coe.usu.edu/it/id2

Wolfe, J. (1997). The effectiveness of business games in strategic management course work. *Simulation and Gaming Journal*, v28 (4) p360-76.

Does Learning Occur through Gaming?

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Abstract

Cerner Corporation's Cerner Virtual University (CVU) created a computer-based game, *HNAM DataQuest*: The Millennium Architecture Knowledge Adventure, to teach technical information systems concepts. This game was designed to match knowledge required with instructional and game design strategies chosen. CVU needed to determine whether or not the game taught the concepts intended was determined through pre/post testing. Therefore, if the game was properly designed, then an increase in delta of post-test minus pre-test scores would indicate the extent of new knowledge acquired by the learner-players. While not a broad-base scientific study, this report of CVU's results with computer-based gaming provides support for the use of games designed expressly to teach specific knowledge. The change in post-test minus pre-test scores indicates that only game playing could have produced ratios of this magnitude.

Introduction

This introductory section provides an overview on the development of Cerner Corporation's learning game, a review of the literature and the questions posed by the development of this product.

Development Background

In 1998, Cerner Virtual University, (CVU), developed a computer-based learning game to teach core processes and knowledge of Cerner's three-tiered client/server architecture and relational database. The resulting product, *HNAM DataQuest:* The Millennium Architecture Knowledge Adventure (a.k.a. *HNAM DataQuest*), was an experimental venture for CVU. As CVU worked through the development of this game, one of the reoccurring concerns was whether or not adult learners could actually acquire new knowledge through this medium. Therefore, a testing plan was developed and the results, based on the delta of post-test minus pre-test scores, were analysed.

Literature Review

A review of the educational literature provided limited data on whether or not learning occurs during gaming even though many educators firmly believe in and back gaming as an effective educational methodology. McMullen (1987) provided the only available data demonstrating that games were more effective than drill and practice CBT. However, his work was done with sixth-graders and not with adults. Dempsey and colleagues (1996) reviewed 100 games and found little substantive research on how to use computer games for educational purposes. Furthermore, Demsey proposed that games were designed to be entertaining rather than educational and that, consequently, learning was incidental. Wolf (1997) found only one case study existed that controlled learning outcomes produced by a business game (1975). Merrill (1999) indicated that the research is insufficient to prove that learning does in fact occur during gaming.

Therefore, a pre- and post-evaluation was needed to determine whether or not Cerner Corporation's target audience had in fact acquired the new and essential knowledge presented in the HNAM DataQuest. During beta testing for this product, CVU used a simple pre/post test and observation procedure as one element of its usability review. This testing was aimed at resolving whether or not gaming can be an effective learning strategy for adults learning highly technical content.

Questions Posed

CVU needed to determine whether or not the *experimental HNAM DataQuest* game was an effective learning tool and to what degree and where it was and was not effective. Likewise, CVU wanted to know whether *HNAM DataQuest* taught the concepts it purported to teach. The questions that needed answers were:

1. Do computer-based games teach adults?

2. Does *HNAM DataQuest* teach the Cerner-specific information systems concepts it purports to teach?

3. Can learning occur through a computer-based game whose format matches the learning content desired?

4. Is 'length (in minutes) of play' a factor that influences, whether or not, learning occurs?

Methods

This section describes the intended user audience, education design basis, and game strategy related to instructional design strategy. The final sub-section defines the match of audience, design and game strategy to the testing procedures.

Audience

This section reviews the match between the intended and tested learner-player audiences using three factors (roles, computer experience, and Cerner experience). Other factors were not specifically measured but may have influenced learning; these factors are identified. Overall the tested audience did match the intended user audience.

(a) Intended Audience.

The intended audience for the game was ‘anyone at Cerner who worked with Cerner's HNAM Millennium products’. The targeted range of role titles identified included:

(1) Application Developer;
(2) Application Specialist (a technical implementation consultant);
(3) Learning Analysts.
(4) Project Architect.
(5) Project Executive.
(6) Project Manager.
(7) Sales Consultant.
(8) Systems Analyst/Systems Engineer.
(9) Technical Writer.
(10)Tested Audience Roles.

Twenty-nine (29) individuals were tested. The test audience included the following roles and the number (#) of tested individuals in each role:

(a) Account Manager (2),
(b) Application Developer (2),
(c) Application Specialist (3),
(d) Call Centre Support Specialist (2),
(e) Certification Analyst (2),
(f) Functional Architect (1),
(g) Learning Analyst (1),
(h) Learning Coach (1),
(i) Multimedia Writer (1),
(j) Role not identified (2),
(k) On-line help Developer (2),
(l) Project Architect (5),
(m) Sr. Manager (1),
(n) Sr. Marketing Communications Specialist (1),
(o) Systems Analyst (2), and
(p) Technology Technical Consultant (1).

This tested audience included the needed roles and, in fact, represented a broader audience than required.

(b) Audience experience level.

The test-audience included both new associates with no Cerner experience and experienced Cerner associates as described in the Table A. The newest Cerner’s associates start employment at Cerner with a range of computer skills from no-previous computer experience to highly experienced information systems management backgrounds. Those who had information systems backgrounds would have general information systems knowledge and not specifics about Cerner’s architecture. Current Cerner associates should have experience both with computers and with Cerner’s specific information system. Therefore, in background experience with Cerner’s products and/or with general information systems experience the individuals tested adequately represented the typical Cerner audience – both experienced and newly hired.

The experience level of the 90 minutes-of-play group (Table A) was sufficiently different from other groups to impact their pre-test scores. This group started with more Cerner experience, more computer experience and more database experience than the other groups. Therefore, this group was expected to start with higher pre-test scores and show less change overall.

The test groups were arbitrarily assigned based on the date when individuals participated in testing. The first group tested were internal associates who had been with Cerner a number of years. Subsequent groups were new-hires, who had been with Cerner for only a few weeks even though some of them had worked with Cerner's products in previous occupations. All were volunteers willing to take from other work to assist in testing a product. Some of the new associates had information systems experience and others did not. All together, the test audience adequately matched the intended Cerner audience. (See Table A).

Table A: Average Audience Experience Levels by Length-of-play Groups and Composite-of-all-play Group

	90 minutes	60 minutes	30 minutes	Composite of all play
Number of Individuals	7	20	3	30
Years w/ Cerner	1.44	0.00	0.00	0.34
Computer experience	4.71	0.00	3.67	3.33
Database experience	2.57	0.00	1.67	2.13
Cerner products experience	1.71	0.00	1.00	1.03

(c) Tested audience gender balance.

The test audience was a random audience not selected for gender. However, it did contain both male and female learners in all length-of-play groups. There was a reasonable balance of men and women in each group in approximately the ratio that would be experienced throughout Cerner. However, gender was not a controlling factor, was not tracked, and has not been reported as a factor of results.

(d) Tested Audience Age Balance:

The test audience was a random audience not selected for age. Participants ranged in age from young college-graduates (approximately 21 years) to those over fifty years old. The mix of ages in each group was approximately the same balance as would be found throughout Cerner. However, age was not a control factor taken into account in the design of testing, was not tracked, and, therefore, has not been reported.

(e) Tested Audience Learning Styles/Thinking Preferences:

The test audience was a random, self-selecting audience not selected for specific learning styles or thinking preferences. Since this was not a variable for which the testing controlled, and since the audience appears to have matched Cerner's typical associate audience, it was assumed that a wide range of learning styles and thinking preferences were represented. Some learner-players found gaming as a learning format easy, intuitive, and enjoyable while others found it difficult and less informative that other modes of presentation. These personal responses to the game format indicate that differences in preferred learning and thinking modes affect learners. However, the impact of match (or non-match) between preferred learning/thinking modes and learning was not a control factor taken into account in the design of testing, was not tracked, and, therefore, has not been reported.

(f) Match between tested and intended audiences:

The test audience effectively represented the intended market audience within Cerner in terms of roles, length of service within Cerner. Even though gender, age and experience in the information systems industry were not factors for which the study was controlled they were not noticeably out of alignment with Cerner's audience.

The Educational Design Basis

This section discusses the selected instructional design strategies intended to enhance and highlight the desired outcomes.

(a) Basic Design Principles

Key learning principles used by the HNAM DataQuest design team included: a] goal-based learning events with rich learning environments motivate learners to explore and facilitate learners discovery of underlying concepts and principles for themselves (Caine and Caine) (Shrank), (b) PEAs (process, entity, and attributes) provide motivating and memorable content (Merrill), (c) Just-in-time (JIT) learning support to create a rich environment controlled by the learner, and (d) experience (including mistakes) provides the basis for learning (Gagne, Briggs, & Wager.)

(b) Applying goal-based learning events

The game's learning environment was a resource rich situated learning environment similar to goal-based scenarios. Light-hearted, fun visuals and sound were added to increase the inherent motivation of problem-solving for goal. The rich environment provided many ways to solve the inherent problem and discover the underlying architecture's structure. Synthesis and review opportunities moved the tacit knowledge discovered in play into the explicit realm and reinforced learning.

(c) Applying Process, Entities, and Attributes (PEAs)

The 'play' of the game was based on two central Cerner process which together dramatized Cerner's three-tiered client/server architecture as it accesses its relational database. Conflict and motivational tension of play were created through the use of entities as game pieces. Each entity had: a] a unique light-hearted, fun, metaphorical image which became its game piece, b] distinct relationships to other entities, and c] unique attributes that must be understood to successfully play the game and build the correct relationships and processes.

Key processes were reflected in the connected path (between game pieces) on the playing area. The action of animated cartoons moving between entities reinforced relationships by dramatizing each entities input, output and relationship to other entities as they moved between game pieces. Depending on the state of the game the cartoon-reinforcement varied. When two game pieces had been connected correctly: a] the name of each entity appeared on-screen above the entity as it was touched by an animated cartoon, b] the entity/ game piece animated, c] an animated cartoon was generated as output, and d] that output-cartoon moved to the next entity/game piece as its input. However, where a given entity was incorrectly ordered, play stopped and error feedback appeared. The informational text in the error feedback reinforced the relationships and output of previously successfully encountered entity/game piece and provided hints and additional information about entities that might use the most recent successful output as their input. Error feedback did not provide a 'right answer' but encouraged continued exploration of relationships and attributes.

Attributes could be discovered many ways: through observation of the animation of game pieces, through use of the error feedback as previously described, or through use an attribute menu was available on each game piece. For each game piece the following attributes were available on the attribute menu:

(a) Who am I?
(b) Where do I live?
(c) What do I do?
(d) What is my input?
(e) What is my internal process?
(f) What is my output? and
(g) To whom do I relate?

Attributes described the essential functions of a given entity and its relationships to other entities.

(d Rich JIT Learning Support:

Just-in-time learning support was provided in order to strengthen learning and support a wide variety of learner-players' preferred learning and thinking modes. Learning support tools provided: a] Rules of road explaining how to play and what constituted 'winning', b] Tutorial on how to move and connect pieces, c] Hints (both automatic hints and hints-upon-user-request were available), d] Supporting documents describing Cerner-specific processes, events, and interactions, e] A summary video synthesis at the end of each round of play, and f] FAQ (Frequently Asked Questions) documents providing information about game play as well as information about Cerner processes and entities.

(e) Experience (including mistakes) provides the basis for learning**:**

Traditional adult education theory states that experience – active involvement – in learning is more valuable for adult learners than are more passive learning interventions (e.g. listening to a lecture). HNAM DataQuest was an active learning intervention, which provided a fun way for learner players to develop and test their understanding of Cerner's HNAM architecture. Mistakes provided opportunities to delve into the content at a deeper level. Successes were reinforced with light repetition, synthesis, metaphorical images and opportunities to go to deeper and complex levels of understanding. Each round of game-play was another experience and another learning opportunity.

Game Strategy Related to Instruction Design Strategy

This section discusses the chosen game design strategies and their relationship to instructional design. Game strategies considered included: 'twitch' play, 'strategic' play, and the use of violence.

(a) Twitch Play vs. Strategic Play:

The design team defined 'Twitch' play as the video-like game strategy where speed and eye-hand coordination were key learner-player actions. Learner-players were scored on how fast they could accomplish the given task with the fewest errors. Building and organizing servers and databases were not deemed to be speed tasks or eye-hand coordination tasks. Twitch speed did not match the content or purpose embedded in PEAs. Therefore, 'twitch' video-like gaming was deemed an inappropriate strategy -- one that did not support the instructional design.

'Strategic' play was defined as gaming formats that focused on discovery of relationships and on uncovering the consequences when incorrect relationships are played. Organizing servers and selecting data fields from relational data has strategic relationships which learners needed to uncover. The relationships and consequences inherent in a strategy game format did match the PEA design and desired content. Therefore, a strategic game format was chosen.

(b) Violence in Play:

The design team considered the use of violence (killing off aliens or monsters or shooting down planes) to imply removing something from the play and equated that to destruction or loss of that entity. It was deemed inappropriate to imply that loss of information, servers, data or information services would be acceptable in an information system. Therefore, violence was not used in the design of *HNAM DataQuest*.

Testing Procedures

This section provides an overview of the test design, the testing procedures and describes how these were matched to the instructional design. The test design is less than scientific due to the nature and timing of the usability review in which it was embedded.

The specific pre- and post-tests and test-scoring procedures were designed to match the core knowledge outcomes required and to ensure that the *HNAM DataQuest* game was the only learning intervention that could have created the change in test scores. Three groups of test participants played *HNAM DataQuest* for different lengths of time. These three length-of-play groups provided the resulting data on the difference that length of play (in minutes) made in the amount of learning occurring through playing HNAM DataQuest.

Match of Game Design to Core Knowledge Outcomes:

The instructional design and game play format of *HNAM DataQuest* were specifically and intentionally selected in order to match the intended learning points and outcomes. Thus, learner-players were tested to determine whether or not they had learned the intended knowledge of processes, entities and their attributes. It was expected that *HNAM DataQuest* learner-players would show a positive change (delta) for their post-test scores minus their pre-test scores.

Testing Process:

A simple pre/post test was used to test change in knowledge. The test contained five multiple-choice questions and three short essays. The questions and their responses were the same on the both the pre- and post-tests. However, the sequence of questions and the order of each question's responses were re-ordered in the two tests to encourage test takers to think about their answers and to minimize rote memorization of questions and answers. The five multiple-choice questions were specifically focused on outcome knowledge needed. Each of the multiple-choice questions was designed to include at least one wrong answer, one answer that novices commonly use, at least one industry-standard answer that individuals trained in computer science would choose as well as the Cerner-specific answer that was preferred. Ratings on each answer indicated degree of preference for that response with 10 points being the preferred Cerner-specific response. The three essay questions were typical of questions that Cerner associates might be asked by a client about key technical concepts taught in the game; such as Cerner's three-tiered/client server architecture, the interaction between tables and keys in the relational data base, and the purpose and use of servers.

Length-of-Play Groups:

Testing done in groups where each group's length-of-play varied: 90, 60 and 30 minutes of play. There were slight variations in group's membership. Group membership was determined by the date on which the game was played and participants self-selected. This resulted in groups with uneven experience and backgrounds.

The 90 minutes-of-play group was composed of individuals who worked in an isolated testing station with no other players around them. In each case, one beta-test observer monitored both the test-taking and the game-playing. After completing the pre-test, these individuals used approximately 90 minutes to complete all three scenarios of the game. They were given the post-test immediately after completing their play. In total, this experience was a two-hour commitment to an intense process. Learner-players appeared mentally drained and exhausted at the end of this process.

Other learner-players tested and played the game while working in a classroom group situation with other learner-players around them. Each worked independently; they did not interact with each other. An observer monitored each person's test-taking and game-playing. Each person was given a pre-test, given time to play and then asked to complete the post-test. A sub-segment of this group was asked to take the post-test at 30 minutes-of-play and was then allowed to continue playing. This sub-group was not tested at 60 minutes-of-play. All other learner-players worked for one hour and were given the post-test after one-hour regardless of how far they had progressed within the game. This 60 minutes-of-play group was the largest number of individuals tested.

Scoring Procedures

Test scores were tabulated using a simple spreadsheet and differences (delta) between pre- and post-test scores on each question were determined as follows. Preferred answers were specific to Cerner's information systems, while other answer were less preferred even though correct within the information systems industry generally. Some answers were not at all acceptable. Therefore, the multiple choice questions received 10, 5, or 0 points for the correct, industry accepted, or all other responses, respectively.

Essay question answers were evaluated for accuracy, clarity, and brevity. Rambling answers were considered to show a lack of understanding and an inability to effectively describe to a client the point of the question. Therefore, an answer could have been technically accurate and may not have received full points. Points given were: 10, for clear, accurate and concise answers; 8 for technically correct but wandering answers; 5 for correct on at least half of the concept, 3 for partial answers less than half correct and 0 for every other answer.

The results were analysed both on a one-tailed regression analysis by the time spent and finally by delta, change in response to specific questions related to which elements of the game had been completed during their play.

Testing Controls

Testing was not controlled for:

(a) Gender differences.
(b) Age differences.
(c) Learning style/ thinking preference.
(d) Impact of violence (or lack thereof).
(e) Choice of playing format — strategy versus twitch.

Testing was controlled for content that matched instructional design (PEAs) and for length of play. Testing was controlled for length-of-game-play, where length-of-game-play was the only learning intervention available between pre- and post-tests.

Results

This section reports the test data as it is related to each of the following four questions:

1. Do computer-based games teach adults?
2. Does HNAM DataQuest teach the Cerner-specific information systems concepts it purports to teach?
3. Can learning occur through a computer-based game whose format matches the learning content desired?
4. Is 'length (in minutes) of play' a factor that influences, or not, whether learning occurs?

Do Computer Games Teach Adults?

This section considers whether or not learning occurred across all groups of learner-players tested regardless of length of play. Test results are reported in Tables B (pre-test), C (post-test) and D (Delta Mean and Significance).

Table B: Table B: Pre-Test Range, Median, Mode, Mean and Deviation For Each of Three Length-of-Play Groups and the Composite-Of-All Play Groups

	90 minutes	60 minutes	30 minutes	Composite of all play
Pre-test Minimum Score	15.00	0.00	14.00	0.00
Pre-test Maximum Score	70.00	56.00	40.00	70.00
Pre-test Median	55.00	22.50	35.00	30.00
Pre-test Mode	#N/A	0.00	#N/A	0.00
Pre-test Mean Score	48.29	23.60	29.67	29.97
Pre-Test Mean Percentage	60%	30%	37%	37%
Pre-Test Standard Deviation	19.12	18.20	13.80	20.37

Table C: Table C: Post-Test Range, Median, Mode, Mean and Deviation For Each of Three Length-of-Play Groups and the Composite-Of-All Play Group

	90 minutes	60 minutes	30 minutes	Composite of all play
Post-test Minimum Score	35.00	15.00	25.00	15.00
Post -test Maximum Score	75.00	60.00	35.00	75.00
Post -test Median	70.00	40.00	33.00	40.50
Post -test Mode	#N/A	48.00	#N/A	30.00
Post -test Mean Score	62.86	38.10	31.00	43.27
Post -Test Mean Percentage	79%	48%	39%	54%
Post -Test Standard Deviation	14.14	12.00	5.29	16.14

Table D: Table D: Significance of Change for Each of Three Length-of-Play Groups and the Composite-Of-All-Play Group

	90 minutes	60 minutes	30 minutes	Composite of all play
Delta in Minimum Score	20.00	15.00	6.00	15.00
Delta in Maximum Score	5.00	4.00	1.00	5.00
Delta in Median	15.00	17.50	4.00	11.00
Delta in Mode	#N/A	48.00	#N/A	35.00
Delta in Mean	14.57	14.50	3.67	13.43
Delta in Mean Percentage Correct	18%	18%	5%	17%
Delta in Standard Deviation	(4.98)	(6.21)	(2.35)	(3.91)
Significance	<.01	<.01	>.05	<.01

As seen in the comparison of Tables B, C and D, the mean change delta of post-test minus pre-test scores for each length-of-play group and for the composite-of-all-play group indicated that learning did occur regardless of length of play. That is, the scores on the post-test questions increased an average of 13.43 points or 17% for most individuals regardless of how long they spent playing the game. Learning was directly related to the *HNAM DataQuest* game intervention as is indicated by a significance of <.01 for all groups. This positive delta indicates that learning of new concepts or refining of industry-standard concepts to fit the Cerner-specific model did occur.

The smallest deltas were shown for the 30 minutes-of-play group, which had completed only one round of play. The size of this group (three participants) made it difficult to arrive at any valid conclusions. With a significance greater than 05 (>.05) for the 30 minutes-of-play group, learning probably was directly related to game intervention even though the significance of this change can not be validated from this test-group. Other indicators of learning include specific responses to questions which learner-players had touch during play versus those they not touched (see Question 2 and Table E.)

The deltas and significance of changes (<.01) shown on Table D were strong for both the 60 minutes-of-play and 90 minutes-of-play groups. Learning was definitely happening in these two groups and, since the only intervention was the game, learning was related to *HNAM DataQuest*.

All together changes in test responses indicated that learner-players gained knowledge through playing HNAM DataQuest. Learning was happening generally across groups even in the 30 minutes-of-play group where change was the weakest. 2. Does *HNAM DataQuest* teach the Cerner-specific information systems concepts it purports to teach?

This section considers whether or not learning occurred for Cerner’s specific information systems concepts. Test results reported in Table E provides mean change in responses for each of the eight (8) questions tested.

Overall the delta for most questions was positive and the mean overall change in scores averages a 13.43 point increase or 17% change per test. Change appeared to be occurring across all length-of-play groups for all questions. In particular, questions demonstrating change were those for which the majority of leaner-players had come into contact with their concepts during play. That is, the 30 minute-length-of-play group had not yet experienced the request server and may not have experienced the relational database while most or all members of the other two groups had experienced these concepts at 60 or 90 minutes-of-play.

Table E: Table E: Pre- to Post-Test Mean Change (Delta) In Scores By Topic/ Question for Each of Three Length-of-Time In Play Groups and Composite of All Play Group

	90 minutes	60 minutes	30 minutes	Composite of All play
3-tiered Client/Server architecture	2.86	5.00	1.33	4.13
Conversation	(1.43)	1.00	(1.67)	0.17
Relational database	2.86	1.25	0.67	1.57
Functions of a request server (a specific Cerner server)	0.71	3.20	(0.67)	2.23
General functions of servers as a class	0.00	(0.50)	1.33	(0.20)
Describe conversation	2.57	2.30	1.00	2.23
Describe tables and keys	4.00	1.10	0.00	1.67
Describe Purpose of servers	3.00	1.15	1.67	1.63
Mean Change In Pre-Post Test Scores	14.57	14.50	3.67	13.43
Overall Increased % Correct	18%	18%	5%	17%

Deltas did decrease for some questions. A decreased delta could have been indicative of ‘unlearning’—the change that occurs when one discovers that their current model is incorrect and they are groping towards an improved model but have not yet discovered it. This was most likely to be happening for individuals with some industry standard knowledge who discovered that Cerner's specific model differs a little from theirs.

In the version of *HNAM DataQuest* tested by learner-players (the beta version), players were required to build the conversation three times–once for every round of play. They complained that this was tedious and frustrating. This may have been a factor in the small delta all three groups received for the multiple-choice question on the conversation. The decreased delta for this question may also have been indicative of a poorly designed question. Regardless of fluctuations on the multiple-choice question, learner-players steadily improved their essay responses for the conversation as length-in-play increased (1.00, 2.30 and 2.57 respectively). Therefore, individuals in all three length-of-play groups became more capable of explaining the conversation clearly and precisely as they played this game longer. Learner-players' increased their ability to describe Cerner's implementation of the conversation as they spent more time playing *HNAM DataQuest*.

Also, mean scores improved with increased length-of-play for the relational database factual recall question–0.67, 1.25, and 2.85 for 30, 60, and 90 minutes of play respectively. They also improved for the relational database essay question. Learning was happening on the relational database questions.

Mean change in responses to server questions, both multiple choice and essay questions, were more variable. Knowledge of servers was the last concept introduced in the final round of play. Therefore, this variability in deltas may have been indicative of the stage in which players were when they were tested – exhaustion, concentration, and/or unlearning. The variability here may have been indicative of the need for additional rounds of play or, for the 30 and 60 minutes-of-play groups, it may mean that some portion of the learner-players had not yet reached the more advanced level of play which introduced the concept. At 60 minutes-of-play some players had completed all three rounds with exhilaration while others were just finishing their second round, were experiencing stress, and had not yet delved into servers. This variability of stages may have been reflected in the test scores for this concept.

In addition, groups that played longer increased the mean number correct for all three essay questions and not just for the key concept of the level that they had most recently played. In other words, they demonstrated the ability to remember and reuse concepts learned in the first round of play even at later stages of play. Overall change in responses to specific questions appeared to be directly related to the segments of play that each learner-player had experienced. Therefore, *HNAM DataQuest* taught the concepts that it purported to teach.

Can Learning Occur Through a Computer-based Game Whose Format Matches the Learning Content Desired?

This section considers whether it is possible to create a learning game that teaches specific content delivered in the game format, which has been designed to specifically teach instructional outcomes. This is a review of the match between design intentions and results.

HNAM DataQuest's chosen game format (strategic game play with consequences for failure) and chosen instructional design strategies intentionally matched the desired knowledge outcomes relative to Cerner's information system. The pre- and post-tests were designed to test both factual recall knowledge through multiple-choice questions and application of broad understanding through essay questions about Cerner's specific information system knowledge (the learning outcomes). Testing was controlled such that only game play could have been the learning intervention causing change in responses on the pre- and post-test. Differences between pre- and post-test scores indicated that learning did occur.

Therefore, *HNAM DataQuest* provided the learning intended. If this game could be designed to teach specific skills and knowledge then other games can also be designed to teach content-specific skills and knowledge. Therefore, learning can occur through computer-based games whose game format and instructional strategies match the outcomes desired.

Is 'length (In Minutes) of Play' a Factor That Influences, Whether or not Learning Occurs?

This section considers whether or not length (in minutes) of play increases or decreases the amount of learning (the delta) that occurs through game play. Since length-of-play and date of play were the only variable between all three groups and since game-play was controlled and measured by pre-post testing and observation, any difference between groups would indicate whether length-of-play effected learning or not.

Players in the 30 minutes-of-play group were tested after playing one scenario or round of HNAM DataQuest. The first round of play for all learner-players was essentially the concept of Cerner's three-tiered client/server architecture as it uses servers in the conversation between the user's data request and the database in providing the requested data. On Table E, the 30 minutes-of-play group showed some improvement in both factual knowledge and essay responses of the Cerner's three-tiered client/server architecture and an increased understanding of servers. However, the change was not strong.

In the 60 minutes-of-play group, there were changes indicative of learning occurring in all conceptual areas that individual learner-players had touched. Results were somewhat mixed as both learning and unlearning appear to be still occurring. In addition, at 60 minutes of play some individuals had not yet touched the more detailed information about server functions and had only played the database portion of the game once while other had completed all three rounds. However, change did appear both in the factual recall on multiple-choice questions and in application of broad-based knowledge through the essay questions. Overall, changes were more than two times larger than found in the 30 minutes-of-play group.

In the 90 minutes-of-play group, all players had completed all three scenarios or rounds of play. After completing three scenarios, learner-players showed a stronger and deeper understanding of the architecture as shown increased delta indicative of stronger Cerner-specific responses on the essay questions. Responses to essay questions were much stronger in this group indicating an increased confidence in their ability to explain Cerner's specific information systems concepts.

For the 90 minutes-of-play group, there was still some confusion in some areas. As previously discussed these variations may have been attributable to many causes including

(a) exhaustion after 90 minutes of intense play;
(b) unlearning, and
(c) frustration with a design flaw requiring learner-players to rebuild one aspect of the game three times (once for each round of play).

Subsequent releases modified the design flaw.

Overall, the deltas for changes in minimum score, maximum score, median, mean score, mean percentage correct, and standard deviation all improved as time-in-play increased. Each increased dramatically between 30 and 60 minutes-of-play and then levelled off slightly between 60 and 90 minutes-of-play. The slight levelling may be due to several factors:

(a) The experience level of the 90 minute of play group was higher and their pre-test scores were higher than other groups were, which would indicate that the 90 minutes-of-play group may have been fine-tuning knowledge rather than developing new knowledge as the 60 minutes-of-play group with its less experienced associate base would have needed to, or
(b) The exhaustion factor for the 90 minutes-of-play group, or
(c) Frustration due to the design flaw previously mentioned, and/or
(d) the possibility that 60 minutes of game play is an 'ideal' length for learning from gaming.

As indicted on Table D, the significance of the change in scores increased as time in play increased. This significant change related to length-of-play indicated that length-of-play impacts the amount of learning acquired through game-play. The longer a learner-player played *HNAM DataQuest* the stronger their learning was.

Further Study Needed:

This section considers future studies needed to strengthen the body of knowledge around game playing as an instructional methodology. Suggestions are provided for re-creating these findings in more scientific studies and for studying factors not controlled in this study.

As indicated, literature about scientific studies and research on learning through game-play are limited even though educational practitioners value game-play as an effective methodology. Some studies focused on children as learners. Other studies were literature reviews. Still others used marketed games and self-reporting without controlling for or measuring changes in specific knowledge for each game.

This study controlled for change in knowledge over three different lengths-of-play for an audience of adult learners who demographically reflected the intended audience within one company, Cerner Corporation. The game design was intentionally created to deliver specific knowledge of Cerner's unique information system concepts. Testing was controlled to ensure that the game intervention was the only learning intervention that could have caused the change. In addition, length-of-play was controlled in order to determine whether knowledge increased with increased length of play.

Recreating these conditions with a different audience and/or different game in scientifically controlled situations would provide needed reinforcement that gaming can truly create learning. Without additional studies that provide similar controls and more rigorous audience controls, the results of this study are merely suggestive that learning does occur.

Additional testing needs to occur for game playing where such tests control for other factors such as gender, age, difference in learning and thinking modes, and use of violence in play. It would also be valuable to study different types of game formats ('twitch' versus 'strategy') where those formats match the intended learning points as closely as HNAM DataQuest's design matched its intended outcomes.

In addition, the difference between 60 and 90 minutes-of-play were not as large as those between 30 and 60 minutes-of-play. Therefore, it would be useful to determine whether there is an 'ideal' length of play that garners the greatest learning.

References

McMullen, D. (1987). *Drills vs. Games - Any Differences*? A Pilot Study. ERIC #ED335355.

Dempsey, J.V., Lucassen, B. A., Haynes, L.L. and Casey, M.S., (1996). *Instructional Applications of Computer Games*, paper presented at 1996 annual meeting of the American Educational Research Associate, ERIC #394500.

Wolfe, J. (1997). *The Effectiveness of Business Games in Strategic Management Course Work.* Simulation and Gaming Journal, v28 (4): p360-76, Dec. 1997.

Merrill, M. David, (1999). *What Motivates the MTV Generation*? Some comments on motivation, http://www.coe.usu.edu/it/id2.

Caine, R. M. and Caine, G. (1004). *Making Connections: Teaching and the Human Brain*, Alexandria, VA: ASCD. 1994. 0201490889

Merrill, M. David. Instructional Transaction Theory (ITT): *Instructional Design Based on Knowledge Objects, Instructional-Design Theories and Models: A New Paradigm of Instructional Theory*. Mahwah, NJ: Lawrence Erlbaum Associates and http://www.coe.usu.edu/it/id2.

Gagne, R., Briggs, L. Wager, W. (1992). Principles of Instructional Design (4th Ed.). Fort Worth, EX: HBJ College Publishers.