Creating Tools for Understanding Systemic Change in Education

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Abstract

The No Child Left Behind Act of 2001 is likely to fuel the need for systemic change in education. I propose to develop a prototype of a Web-based simulation, called SimEd, to help teachers, students, parents, administrators and school boards to: 1) understand the nature of systemic change in education; and 2) know what to look for in terms of consequences of new educational system designs. The basic design methodology will follow processes of effective Web instruction: a handbook for an inquiry-based process. This process is based on user-centered design principles and involves rapid prototyping first on paper and then on computer. Prototypes are rigorously tested with the intended target audiences through usability tests and formative evaluation. Design and development activities are planned for sabbatical between January 1 and May 31, 2005. The prototype will be used as part of subsequent proposals for potential external funding for the resources needed to create a widely disseminated Web simulation.

Purpose and Rationale

Legislation passed by the U.S. Congress and signed by President Bush on January 8, 2002, entitled No Child Left Behind is likely to impact many K-12 schools throughout the United States (NCLB Act, 2001). NCLB requires schools to assess annually student achievement at numerous grade levels. Based on average test scores, schools will be identified as succeeding or failing. Schools that repeatedly fail to meet current state standards for student achievement will be held accountable. Parents will have the opportunity to send their children to different schools, if their present school is not succeeding. However, if as anticipated, many schools are branded as failures, where will parents send their children? There will not be enough room in the successful schools, let alone other logistical problems such as transportation. Failing schools will have real incentive to change. For such change to be successful, it cannot be piecemeal. It must be systemic change (Duffy, Rogerson & Blick, 2000; Caine & Caine, 1997; Senge, Cambron-McCabe, Lucas, Smith, Dutton & Kleiner, 2000).

The Need for Understanding Systemic Change

In the decades following the publication of A Nation at Risk in 1983, considerable effort has been undertaken to improve public schooling. Reform efforts have been typically referred to as site-based management, school restructuring, and educational systems design. Researchers such as Banathy (1991), Reigeluth (1992), Frick (1991), Jenlink, Reigeluth, Carr & Nelson (1996), Caine & Caine (1997), Duffy, et al. (2000) and Senge, et al. (2000) have argued for systemic change in education. 'Systemic change' contrasts with numerous piecemeal reform efforts which have largely failed in twentieth century schooling.

However, the rhetoric of systemic change is not likely in itself to make any real differences in schooling. Such rhetoric has been around for some time. Understanding of educational systems change is needed for intelligent action.

Changing educational systems, if unguided by adequate theory of educational systems change, will be haphazard at best. The consequences of mistakes can adversely affect the very lives of students, teachers, administrators and their communities. Without an adequate theory of educational systems change, we will continue to reform education largely by trial-and-error. It is no wonder that educational practitioners often
Understand system change is not a simple matter. People will need to learn new thinking patterns. Hart (1992) has noted that the vast majority of individual belief patterns do not contain dynamic cycles. Cognitive maps of belief structures tend to be linear with few, if any, feedback loops. Hart indicated that exceptions occurred with those people in professions which taught them to think in dynamic cycles (e.g., ecologists, systems engineers).

Senge (1992) has provided insight into business organizations by identification of 10 patterns of dynamic cycles (process archetypes). These patterns are not easily described or understood through static print and diagrams. Senge and his colleagues have developed role-playing activities and computer simulations such as the well-known Beer Game in order to help business people understand these patterns of dynamic relationships – most of which run counter to individual intuitions about how systems such as business organizations grow and change.

Similarly, Alexander, et al. (1977) have provided insight into design of spaces for living, including regions for cities, towns and agriculture and the buildings and transportation systems needed. They have identified a pattern language, consisting of 253 archetypical patterns. This, too, is an example of systemic thinking that is not easily learned.

**How Can Educators Learn to Think Systemically?**

While several process models exist for going about systemic change in education (Jenlink, et al., 1996), Banathy (1991), and Duffy, et al. (2000), my own observations have led me to conclude that most people get stuck in the process when attempting to envision a new educational system. Most process models call for various levels of participation by teachers, students, parents, school administrators, and school boards.

- First, it is often difficult for many of these individuals to “think outside the box.” The only kind of educational system they know is what they have experienced themselves. Thus, their proposed solutions are in reality piecemeal in nature – despite the rhetoric of systemic change.
- Second, if they are able to “think outside the box,” it is extremely difficult for them to anticipate the practical consequences of their decisions and to plan intelligently – because they do not understand systems theory and have no basis for prediction, as argued above. Thus, their plans appear to be “pie in the sky” – and could even be destructive and ultimately lead to much worse education than that at present.

**Goal of this Sabbatical Proposal**

I propose to create learning tools to help teachers, students, parents, administrators and school boards to address the above two issues: 1) to understand the nature of systemic change in education; and 2) know what to look for in terms of consequences of new educational system designs.

Moreover, I plan to provide these learning tools through the World Wide Web at Indiana University. Thus, they will become widely available. The success of recent Web products I have created or co-created lead me to believe that the Web can be an extremely effective way to reach a large number of people -- Understanding Plagiarism at Indiana University (quiz and tutorial at: [http://education.indiana.edu/~frick/plagiarism/](http://education.indiana.edu/~frick/plagiarism/)) and the Diffusion Simulation Game (at [http://www.indiana.edu/~istdemo/dsg/login.phtml](http://www.indiana.edu/~istdemo/dsg/login.phtml)). Indeed, this in itself is a different kind of educational model and system – teaching people all over the world from Indiana University through the Web. Web usage statistics indicate over 500,000 hits on my personal Web site during the past 20 months ([http://www-reports.iu.edu/tedfrick/trend.html](http://www-reports.iu.edu/tedfrick/trend.html)) and [the Plagiarism Quiz](http://www-reports.iu.edu/tedfrick/trend.html#Rep9) getting more hits than anything else ([http://www-reports.iu.edu/tedfrick/trend.html](http://www-reports.iu.edu/tedfrick/trend.html)). The Plagiarism Tutorial at
Why do I need a sabbatical to carry out this proposal?

The answer is simple: I began working on this problem in 1995 with a doctoral seminar (Understanding Systemic Change in Education – see http://education.indiana.edu/~frick/r695fric.html. I have come to realize that what I need is an extended period of time where I can develop some prototypes of learning tools for understanding systemic change in education – time that is not disrupted by day-to-day demands of teaching, dissertation advising, service demands, and my duties as School of Education Web Director. I am on a 12-month appointment, 50 percent in IST and 50 percent as Web Director.

It is difficult for others to even understand what I want to do – imagine for example attempting to describe the experience of playing SimCity to someone who had never seen such a product. I believe that it is necessary to develop a prototype of these educational systems learning tools in order to subsequently convince potential funding agencies to award grant money to complete the development. What I need is an extended period of uninterrupted time for this creative endeavor.

Expected Products of the Sabbatical

I expect to develop a prototype simulation for designing educational systems that will run on the Web. I am calling this simulation, SimEd. I envision this simulation to be something like SimCity, except that it will allow teachers, administrators, parents, students and school board members to design educational systems, not cities. As they design different variations of educational systems, they will see how a given design succeeds or fails over time. That is, they will be able to experience temporally the consequences of their design decisions, and they will be able to adjust their designs as their educational systems evolve. Thus, SimEd is expected to be a set of visioning tools.

As an analogy, architects have created computer tools that allow them to create virtual buildings. These tools are very useful to envision what a particular design will be like, how it does or does not meet client needs, and to modify designs before committing to actual construction. Clients are able to virtually “walk” through such buildings before they are built, in contrast to looking at miniature models constructed out of balsa wood.

SimEd will help make more concrete some rather abstract and difficult-to-understand educational systems properties. But these properties are not those of physical buildings or cities. Rather, they will be based on the SIGGS Theory Model (http://education.indiana.edu/~frick/siggs.html). The SIGGS Web site is merely descriptive of these educational systems properties. It does not allow people to experience them in a way such as SimCity provides an experience of designing a city and observing the long-term consequences.

I envision SimEd to use systems theory as a basis for the rules that drive the simulation through a period of compressed time. In particular, I propose to adapt the educational systems theory proposed by Maccia and Maccia (1966). See http://education.indiana.edu/~frick/edutheo.html.

Will SimEd validly predict what will happen in reality?

The answer to this question is uncertain. The behavior of complex systems is very difficult to predict – a phenomenon that Wolfram (2002) explains in A New Kind of Science. Nonetheless, systems modeling tools such as SimEd can help teachers, administrators, parents, students and school board members better understand systemic change processes. It will give them new concepts to think with, such as system
filtration, spillage, complexity growth, and compatibility between a system and a system. And it will help them know what to look for as a design is implemented and tweaked.

Will SimEd be able to run on the Web?

I expect SimEd to use a combination of Web technologies. The computer interface will run on a user’s Web browser using a plug-in for Flash MX. Flash MX will allow animation, drag-and-drop interaction, and playing of “movies” that are controlled by ActionScript, a Flash programming language. The Flash interface will interact with Web server programs written in PHP, a widely used programming language for Web applications. PHP scripts in turn will store system states and user data in XML files on the server. This strategy will allow SimEd to run on virtually any Web server and with any computer Web browser with the Flash plug-in installed (a free and fast download from Macromedia). The Diffusion Simulation Game that I co-developed with IST students in 2002 is written in PHP and uses XML data storage (at http://www.indiana.edu/~istdemo/dsg/login.phtml). It does not use Flash MX, as MX was not available at the time. However, to get an idea of how these technologies can interact, see a drag-and-drop activity with feedback at: http://mentor.ucs.indiana.edu/~r641011/flashdemo/dragdrop.html. Indeed, I used my R641 class in spring 2003 as a proof of concept that these technologies can work together successfully. See: http://www.indiana.edu/~tedfrick/r641/.

Thus, I expect SimEd to consist of Flash MX modules, PHP scripts, and XML data files that work together to produce the learning experience for the target audiences.

Do I currently have all the necessary skills and resources to develop SimEd?

No, but my sabbatical will allow me the time to learn advanced ActionScript and PHP coding techniques. I plan to do this by using books and self-tutorials that are available.

It will also allow me the time to work with expert consultants such as:

- Sivasailam Thiagarajan (Design Your Own Games and Activities, 2003) for ideas and strategies in designing SimEd.
- professor Michael Molenda at Indiana University (who co-designed the non-computer version of the Diffusion Simulation Game),
- professors Charles Reigeluth at Indiana University and Kyle Peck at Penn State University (who have been involved with systemic change efforts in K-12 school systems), and
- professors David Wiley and David Merrill at Utah State University (who have designed learning objects and computer simulations).

Will My Sabbatical Enhance My Effectiveness at Indiana University?

- What I expect to learn in designing and developing SimEd will allow me to offer more advanced curriculum to IU students who are interested in learning how to create games and simulations that run on the Web. I see immediate payoff for courses such as R641, Instructional Development and Production Process II. I expect that I will be able to teach advanced Flash ActionScript and more advanced PHP with XML.
- The SimEd prototype I expect to develop will help me to secure external funding to create a more elaborate and complete product.
- The advanced Flash ActionScript and PHP will help me to implement some of these features on the School of Education Website, where appropriate. In particular, I expect to be in a better position to design a new generation of EdWeb tools that we currently use in-house to manage approximately 6,000 web pages whose content is stored as XML data. See http://education.indiana.edu/how.ppt for an overview of the current EdWeb tools.
Is the project well grounded in theory, previous scholarly work, or professional advances?

I began working with systems theory in the early 1970s. The SIGGS theory model was a foundation for a research methodology I developed, called Analysis of Patterns in Time (APT). I used APT in turn to develop techniques of computer-adaptive testing that do not rely on item response theory but discrete student assessment categories such as mastery and nonmastery (EXSPRT and EXSPRT-I). In the early 1990s, I turned to designing information and instructional systems that would run on the Web. I have been interested in improving education and education systems for my entire professional career. I want to develop SimEd because I hope to make a difference in education throughout the world. The Web is a medium that now makes this possible. For more information about me and my past research and development activities, see my faculty Web site at: http://education.indiana.edu/~frick.

Does this project address an important problem or need?

I believe so. The No Child Left Behind legislation is likely to create a great deal of stress on our current systems of education in the U.S. SimEd is expected to be a learning tool that will help people see educational possibilities – to help them envision a better future for education, which in turn should create a better society and quality of life.

Sabbatical Plan

I expect to follow the design process that professor Elizabeth Boling and I have been testing and improving over the past two years. We call this process: Effective Web Instruction.

Figure 1. Overview of the design process for Effective Web Instruction
This process is elaborated in detail in our book in progress at:
http://www.indiana.edu/~pedagogy/preview/ewi/index.html  (requires IU network ID and password) and consists of 6 chapters with multiple sections in each:

Table of Contents.  *Effective Web Instruction:  Handbook for an Inquiry-Based Process*

1 ... Getting started  
2 ... Conducting the analysis  
3 ... Preparing for testing a prototype  
4 ... Testing a prototype  
5 ... Building a web prototype  
6 ... Assessing and maintaining the site

This process has been used successfully on a number of projects with graduate student teams in the past two years in R641 and R547, including:

- **Diffusion Simulation Game** (requires IU network ID and password): Based on the original board game developed by Professor Michael Molenda, you play the role of a change agent in a hypothetical school. Your objective is to persuade as many of the staff members as possible to adopt a particular innovation.  
  Team members: Rui Huang, Kyong-Jee Kim, Barbara Ludwig
- **How to Recognize Plagiarism**: A Web tutorial for use by IST students and others, which includes cases, examples, recognition practice and a mastery test.  
  Team members: Meltem Albayrak-Karahan, Joseph Defazio, Noriko Matsumura
- **Learn the Arabic Alphabet**: letter recognition by position in Arabic words. Team members: Richard Dabrowski, Taylor Halverson, Heidi Withoff  
- **PHP Basics for R547**: beginning programming in PHP in the IU computing environment. Team members: Sanser Bulu, Young Joon Chang, Polly Rastogi
- **Quest Atlantis Training**: instruction for 9-12 year old children in using virtual world communications tools within Quest Atlantis. Team members: Min-Joung Kim, Ming Ma, Pil-Won On.
- **RecNet Purchase Request System**: staff training on making purchase requests with IU's software system. Team members: Mi Kyung Jun, Bosung Kim, Kyungeun Maeng, Eunjung Oh
- **Virtually IST**: a simulated tour of what it is like in one of our core courses in Instructional Systems Technology. Team members: Ju-Yu Chang, Yu Feng, Paul Robertson, Tyler Sparks

More information on these projects is available in the IST Showcase at:  

A variation of this process has also been used for designing effective informational Websites, including:

- **IU Bloomington Web information architecture** (see http://www.education.indiana.edu/ist/faculty/iuwebrep.html)  
- **School of Education Website** (see http://www.education.indiana.edu/how.html)  
- **The City of Bloomington Government Website** (see prototype at http://www.indiana.edu/~educr641/ and http://www.city.bloomington.in.us/design.html).

**Anticipated Timeline for Sabbatical Proposal**

**January, 2005**

- Identify instructional goals for *SimEd*.  
- Conduct context and learner analysis for *SimEd*.  
- Consult with simulation and game design experts.  
- Consult with systems design experts.  
- Create pre- and post-assessment measures, observation instrument and reactionnaire.
• Recruit design volunteers (from IST graduate students and others).

February, 2005
• Review the SIGGS theory model and educational theory.
• Create a paper prototype (and game rules).
• Conduct usability tests and formative evaluation of paper prototype of SimEd.
• Analyze results and revise prototype.
• Conduct additional usability tests and formative evaluation as needed.

March - April, 2005
• Learn advanced ActionScript and PHP.
• Create computer prototype in Flash MX, PHP and XML.

May, 2005
• Conduct usability tests and formative evaluation of computer prototype of SimEd.
• Analyze results and revise computer prototype.
• Conduct additional usability tests and formative evaluation as needed.
• Write summary report of design, development and testing efforts with SimEd.

Notes on Timeline, Resources and Plan

I realize that this timeline is ambitious if I try to do this project all by myself. What I hope to do is recruit some talented IST students to work with me on this project. They would receive credit for a practicum or unpaid internship. I also intend to approach Thiagi, a long-time acquaintance and gaming/simulation expert who works as an independent consultant in Bloomington. I would hope to receive some creative input from Thiagi, and possibly he would be interested in participating in a subsequently funded project to further develop the SimEd prototype (as the quid pro quo). I would seek similar advice from professors Michael Molenda, Robert Appelman, and Thom Gillespie at Indiana University, who have experience and interest in designing simulations and games. I also expect to get some advice and ideas from leading experts in systems thinking in education including professors Charles Reigeluth at Indiana University and Kyle Peck at Penn State University. I also will seek advice of professors David Merrill and David Wiley at Utah State University on design of learning objects and educational simulations. For those people outside of Bloomington, I expect to do most correspondence through telephone conferencing and possibly NetMeeting.

Rapid prototyping on paper is a very efficient way to quickly try out instructional designs. How can one conduct usability tests and formative evaluation of a paper prototype of an interactive computer simulation? Although it is a little cumbersome, we can have someone play the role of the computer in order to dynamically construct what the learner will see and interact with (such as a quasi-board game with pieces). We have done this before with interactive designs. While there are some limitations, such rapid prototypes and evaluation in paper format are highly beneficial in answering some big design questions and also questions about strategies for enhancing the learning effectiveness of the product.

I intend to use the computing resources at Indiana University for Web publishing and PHP scripting that runs on IU Web servers. I have three computer systems in a wired and wireless LAN at home with broadband connection to the Internet and with the necessary software for designing paper and computer prototypes. I intend to do most of the design work at home, and conduct most meetings at my home office. For specialized needs such as any video editing, copying, telephone conferencing, and possible video conferencing, I will use facilities in the IUB School of Education. I do not plan to do any traveling on my sabbatical except as needed for professional development (e.g., some advanced workshops on Flash MX or PHP that may be available in the mid-West).

We will most likely conduct usability tests of computer prototypes in the IST usability lab (paper prototypes can be tested in any convenient location for the users).
Summary

The No Child Left Behind Act of 2001 is likely to fuel the need for systemic change in education. I propose to develop a prototype of a Web-based simulation, called SimEd, to help teachers, students, parents, administrators and school boards to: 1) understand the nature of systemic change in education; and 2) know what to look for in terms of consequences of new educational system designs. The basic design methodology will follow processes of effective Web instruction: a handbook for an inquiry-based process. This process is based on user-centered design principles and involves rapid prototyping first on paper and then on computer. Prototypes are rigorously tested with the intended target audiences through usability tests and formative evaluation. Design and development activities are planned for sabbatical between January 1 and May 31, 2005. The prototype will be used as part of subsequent proposals for potential external funding for the resources needed to create a widely disseminated Web simulation.

References


