

Mobilizing Design Research to Extend the Global Power of Digital Media in Education: The MacArthur Commission's Global Classroom Project on Sustainable Development and the Millennium Village Simulation

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Abstract—What follows is a description of the Columbia Center for New Media Teaching and Learning and its design research work process. The following two sections describe two projects with global significance. The first is a simulation of the economy of a village to support Jeffrey Sachs' Columbia College Challenges of Sustainable Development course. The second is the design and execution of a global classroom course with twelve participating universities from five continents and the focus on the practical practices of sustainable development. Both projects will be completed by February 1, 2008, and ready for conference demonstration at that time. The last section reflects on future possibilities for extensions and enhancements.

Index Terms—environmental sustainability, instructional design, simulation, distance learning

I. THE COLUMBIA CENTER FOR NEW MEDIA TEACHING AND LEARNING AND THE DESIGN RESEARCH PROCESS: MAKING EDUCATIONAL CHALLENGES INTELLIGIBLE AND PEDAGOGICALLY ACTIONABLE

The Columbia Center for New Media Teaching and Learning (CCNMTL) was founded in 1999 as a response to the recommendations of a university-wide faculty and administration committee charged to examine the state of digital technology on the campus. The committee's primary recommendation was to create a service organization whose mission would be to support faculty in their use of digital technologies within the University's matriculated degree programs. The Center works to provide faculty with a broad range of new media services, including: workshops, forums, and individual consultations, as well as ongoing and sustaining support in the development of more advanced projects. In partnership with faculty as content experts, the Center is committed to advancing the purposeful use of new media and digital technologies in the educational programs of Columbia University.

Since 1999, CCNMTL's original staff of three has grown to 40. In its short history, it has provided service to over 3,000 faculty with projects ranging from simple course management support to over 200 larger projects. CCNMTL employs a number of professional web

designers, programmers, and video experts but the core team of Educational Technologists is the frontline for engaging and working with faculty in project conceptualization and execution. The Center, funded in large part through the University's operating budget, has received over \$5 million dollars in grants and \$10 million in gifts.

The notion of design experiments, or a design perspective in educational research, means shifting the focus of research from the laboratory to the classroom. The traditional gap between theory and practice was understood by researchers as the problem of a de-contextualized notion of how learning occurs in real schools, and how teachers foster it. This move from one setting to another implied the development of new ways of conceptualizing and addressing research problems in education [1]. Some of these problems were still framed as advancing what was known about students learning process. But these problems were also related to an agenda of educational innovation and change. More recently, the notion of design began to be utilized as a very appropriate heuristic to describe what it takes to develop technologies that support different teaching and learning activities. Edelson [2] explains that within a design research approach, development and research merge into a process of iterative cycles of design, implementation, and assessment. The notion of design, then, is more than a methodological perspective in educational research. It is also an epistemological frame for producing knowledge about teaching and learning. By addressing the research enterprise as a design effort, one assumes that knowledge gets articulated through a series of provisional understandings, through a refinement of appreciations, and through making the whole process public to others. This is actually one of the main methodological tenets of a design approach in educational research, namely the need for a systematic documentation of the overall design process. This demand for rich, comprehensive documentation is related to two main purposes: analysis and communication.

A. Analysis

One of the most salient features of the design approach is that it allows researchers not only to focus on analyzing the outcomes of a designed educational experience, but also on analyzing its very design processes. The process of designing an educational learning environment is full of pedagogical decisions. A design research framework attempts to capture and articulate this set of decisions and the way they play out in the actual educational experience of students and instructors [2]. Documents provide records

that represent all these decisions and articulate a framework for research and assessment.

B. Communication

In order for design experiments to contribute to the advancement of knowledge about teaching and learning, researchers have to communicate and share their experiences to make them public and available for the study of other researchers and practitioners. A rich documentation of the experience provides this community of colleagues with better opportunities to understand and represent the nature of the activities and processes that took place [3].

This approach to thinking about the production of knowledge about teaching has some important implications for understanding how pedagogical reflections can take place through the design of educational technology projects.

Firstly, identifying challenges or problematic areas in one's own teaching, and thinking about how technology could help address them, invites instructors to make explicit their pedagogical content knowledge [4]. Shulman defines this concept as the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction. Secondly, the pedagogical reflection required to undertake design experiences entails collaboration. It is assumed that different professionals provide different expertise and points-of-view to the design and understanding of the experience [5].

In August 2002, the Columbia Center for New Media Teaching and Learning began to develop a design research framework that would accommodate the needs of its daily services and design practices¹. The Design Research process for developing classroom innovations begins by partnering with faculty members to discuss their teaching practices. This conversation unfolds in a series of discussions around the following stages.

1. **Initial Understanding of Curriculum:** What are the content, purposes, and activities involved in this course?
2. **Challenges and Opportunities:** What challenges or obstacles have faculty and students faced in the course? What new resources, teaching techniques, learning opportunities, and communication strategies would improve the educational process? What possibilities for the construction of new learning spaces begin to come into view, learning spaces impossible before the advent of digital technologies?
3. **Design Hypothesis:** What digital technologies would provide the best solutions to these challenges? What learning experiences will technology enable that had not been possible

before? How will students and instructors work within the redesigned learning environment? What principles and activities will best utilize these technologies to address the identified challenges?

4. **Design of Educational Experience:** How will these digital and pedagogical solutions be designed? These decisions determine the content, activities, and interactions that make up the learning environment.
5. **Educational Experience:** What facilities, orientation and/or training will be required to initiate the educational experience? Faculty, with CCNMTL support, implement the project within the course and closely monitor its use.
6. **Evaluation and Discussion of Findings:** What worked? What didn't? Together with our faculty partners, we evaluate the educational intervention, as well as our design process, and assess our hypotheses. We articulate recommendations for improving the project. The continuous documentation throughout the process enables this discussion and evaluation.

The following is a visualization of the process:

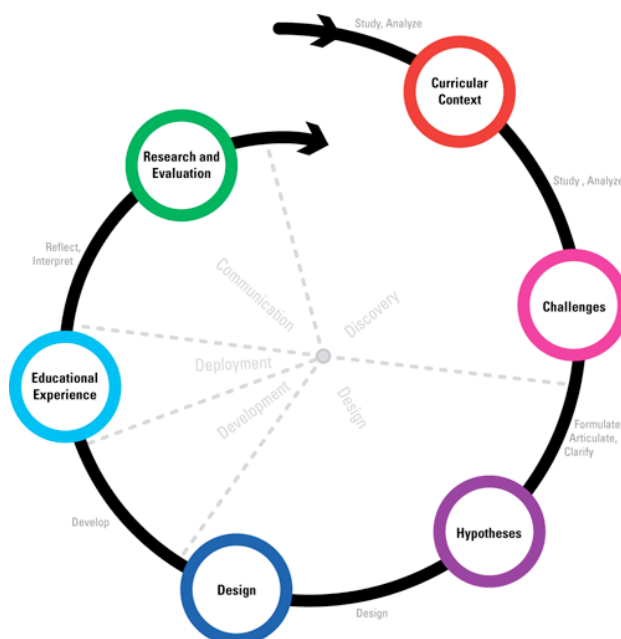


Figure 1. The CCNMTL Design Research Spiral (for a larger version of all figures in this paper, see <http://ccnmtl.columbia.edu/draft/imcl2008/>)

The primary notion that the cycle (Figure 1) represents is symbolized by the screw-like quality of the image intending to indicate the recursive character of the process. The end is the beginning of a new gyre of the process now informed by the assessment of the 1.0 version of the project. The following two sections are examples of the process in action.

II. THE MILLENNIUM VILLAGE SIMULATION: DEVELOPING A CAPACITY FOR JUDGMENT OUT OF DISCRETE DISCIPLINARY UNDERSTANDINGS

A. Initial Understanding of the Curriculum

Dr. Jeffrey Sachs, Director of the Earth Institute and global leader on issues in sustainable development, teaches an introductory undergraduate course in sustainable development. His leadership in the development of the United Nations Millennium Development Goals [6] is the result of his extended efforts to demonstrate that extreme poverty is an understandable and solvable problem. As an economist, Dr. Sachs relies heavily on mathematical models that describe the functioning variables that determine the economic success or failure of a poverty-stricken village. Although capable of mastering the “geometry” of the models, students often have difficulty drawing the connection between the economic models and real-world situations. Another way of putting it is that they can do the procedural work of solving math problems based on the models, but they struggle to apply the solution to a more descriptive narrative-based problem that demonstrates a more integrated understanding of all the influences affecting sustainable development. Since study in this field is not intended to stop at the point of mastery of the theoretical dimensions of the roots and mechanisms of poverty, it is important that students develop the capacity for applying their knowledge, or exercising a form of judgment when confronted with problems that are closer in concrete description to the way that problems will confront them in the real world.

B. Challenges and Opportunities

It might seem from the initial description that case studies would be an appropriate strategy to employ in the course. However, real world case studies (with all their irregularities) can obscure the economic basics that the students are asked to learn. The challenge and opportunity here was to create something new that would make it easier for students to connect their study with its real-world implications. In order to accomplish this, it was necessary to better understand the relationship among the manifold disciplines involved in the Millennium Villages Project from which many of the basic economic understandings were derived, with the goal that students would deepen their understanding of the interdisciplinary nature of Sustainable Development theory and practice. Table 1 shows a basic schematic of the curricular units and their corresponding disciplines.

In classic pedagogical theory, the goal was to scaffold their understanding by providing a bridge between their computational understanding of each factor and the more complex reality of when they function together in the life stream of a village. The general agreement of the design

research group was that it was necessary to create a middle space for study that embodied the reliable models but did so in a progressively more complex and embodied manner.

Curricular Module	Academic Discipline
Subsistence Optimization	Agriculture, Health Studies, Biology, Ecology, Climatology
Poverty Trap	Agriculture, Economics, Health Studies, Microfinance
Deforestation/Fishery Crisis, Logistic Growth	Economics, Ecology
SIR Disease Model	Population Studies, Epidemiology, Climatology

Table 1. Curriculum Units and Disciplines in Sustainable Development Course

C. Design Hypothesis

These challenges pointed to a hypothesis from which we derived the design of the sustainable development simulation: If, in a simulated environment, students are able to explore the impact of changes in one discrete domain of the total village reality at a time, watching it as one would an atom moving and affecting the motion and direction of other atoms, then students will begin to develop the necessary judgment that will allow them to predict outcomes by virtue of their understanding of how discrete economic factors function in a complex and dynamic situation. They will also, by the introduction of a certain randomness related to weather, climate or health, comprehend more fully the difference between models of reality and the sometimes disorderly character of reality itself.

This initial hypothesis emphasizes the importance of the simulation as an environment fostering inquiry and experimentation rather than more straightforward didactics. Both the successes and failures of students become, effectively, teachable moments through which students have the opportunity to reflect both on the problem at hand and its appropriate analysis as well as meta-cognitive issues related to their own development capacities. Given the fact that the simulation is not hermetic but intended as an occasion for discourse, the development of the educational plan, the methodological approach to its use, becomes a significant dimension of the project development related less to technology and more to curricular and pedagogical context.

D. Design of the Educational Experience

Based on the foregoing, it was decided that the simulation would be introduced to students as a complete system from the outset. Throughout the semester, students will be exposed progressively to modules through the curriculum, extending their understanding of the components of the system in an incremental fashion.

The following diagram (Figure 2) is a model of the causal connections between the different elements and conditions that affect individual survival in the Millennium Village Simulation:

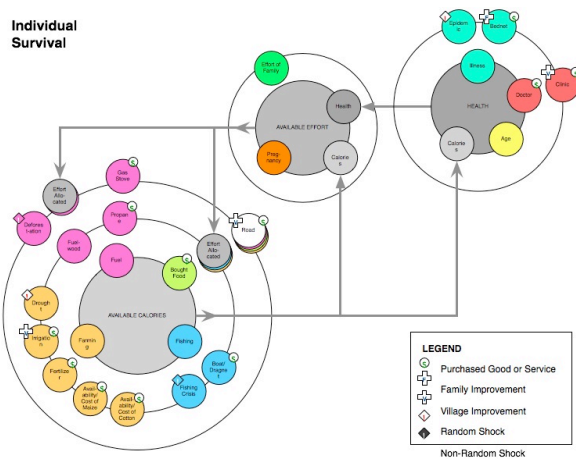


Figure 2. Millennium Village Simulation Model

Notice how the model not only represents the interaction of controllable factors but also allows for the effect of certain random events. The three circular configurations represent the three key clusters of concern for survival: the first (left) is calories translatable into human energy and possible activity, the second cluster (upper right) relates to health and the third (middle) represents available effort, the effective result of health and calories. Secondly, there are many conditions that inflect each of the main clusters. For example, health is dependent on the presence of disease or the age of the inhabitants.

Moving from this abstract vision of the relationship of the active factors of the simulation to the actual sequence of student activities, the design team decided that the starting place for a student was as a family of two. The choice of the familio-centric view was selected on the basis of the belief that it was important for students to get the perspective from the ground up, that is, from the empathic position of a couple trying to survive with the capacity to make all the same choices available to a real family. Putting students into the position where they are reminded that the issue is sheer physical survival will be an important emotional anchor for them when the class discussion becomes more abstract. The following introductory screen (Figure 3) emphasizes this approach by laying out the possibilities for decision-making for the student regarding food, fuel, agriculture, and education, the actual rules of engagement, and the ways that they can see how they are doing:

Instructions:

Keep your family alive

You begin the simulation with a family of two. You may try to expand your family, through birth, or make it smaller, through migration to the city. Your experience ends when the last member of your family either dies or migrates.

Make choices to improve family and village life

Family Actions | **Village Actions**

The simulation is separated into "turns," each lasting a single growing season, or six months. During each turn, you may make choices about your family's health, education, food, fuel, effort, and possessions. You may make similar choices on behalf of the village as a whole, many of which will affect your family directly.

Apply Choices | End Turn

During each turn, choices marked with a may be applied immediately, using the "Apply Choices" button, allowing you to instantly enjoy certain improvements. Other choices, such as crops you've planted, will not have any impact until the end of your turn, when final calculations are made.

Accept what luck throws at you

At the end of each turn, you will receive a "Seasonal Report" of your progress. This report will bring together and calculate the results of all new choices you made, but it will also incorporate weather, epidemics, market pricing and other conditional fluctuations. At some point, you may also be offered assistance from various NGO's.

Learn from your mistakes

Map View | History | Graphs | Equations

You can use history, graphs and other tools to learn the ins and outs of life in a real African Village. As you play more and more, your chances of surviving this harsh environment -- and seeing your life improve dramatically -- will greatly improve.

Figure 3. Simulation Instructions

The following screen shot (Figure 4) represents the actual interface of the simulation:

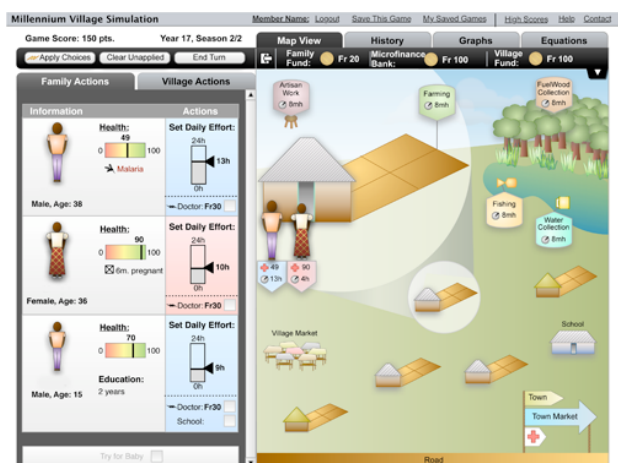


Figure 4. Simulation Visual Interface

Each turn will give the student additional understanding and will increase both the students' ability to succeed within the confines of the simulation, and their capacity to comprehend the exact economic and other

disciplinary models driving it. This concept of a progressive understanding that allows for a deepening of appreciation for the interdisciplinary nature of the problems of sustainable development is key to the design.

It was also decided that the simulation would have an interactive graphical area allowing for visual feedback on student actions as well as a space for graphs and equations that trace the mathematics that underlie the activities in the visual field. Students will make decisions on both a family level and the larger village level (to a lesser extent), thus taking on the dual role of village participant and social planner. These two perspectives will help them grasp how economic, climatological and epidemiological changes affect individual families as well as the communities in which they live. As students grow more familiar with the system as a whole through repeated play-throughs (play-through means completing the arc of the simulation) and progressive exposure to the underlying concepts through readings and lectures, they will become better able to deal with and plan for crises (such as epidemics, droughts and resource stock failures) and, grow in their understanding of the necessity of all the related factors if the given poverty trap is to be overcome. This is the heart of the interdisciplinary character of the enterprise and the Jeffrey Sachs approach to addressing the problem of poverty in the third world [7].

As already indicated, complementing the development of the simulation itself will be a scheduled series of challenges for students to perform within it, coordinated with Dr. Sachs's lectures. To reinforce the importance of using the simulation properly, a teachers guide for teaching assistants that emphasizes strategies related to problem-based and case study pedagogy will be developed to accompany the simulation.

The simulation itself will be run for the first time in a real course in the Spring 2008 semester, at which time we will complete the Educational Experience and Evaluation and Communications parts of the Design Research cycle.

III. THE GLOBAL CLASSROOM PROJECT: UNITING GLOBAL LEARNING WITH A GLOBAL PLATFORM

A. *Initial Understanding of the Curriculum*

As a basic introduction to and a practical illustration of the work of the MacArthur Foundation Commission on Sustainable Development, members have proposed a model curriculum, an interactive global course entitled "Integrated Approaches to Sustainable Development Practice." Scheduled to launch in February 2008, the Global Classroom will provide an opportunity for students from universities around the world to participate in an interactive, on-line learning program. Commission members, as international experts in the field of sustainable development, will provide students with a diverse curriculum focused on core issues of sustainable development.

Twelve universities will be hosting classes of students, composed of 15-20 students and led by an experienced professor and development practitioner. One

class per week, students will listen to a one-hour video lecture. Remaining time will be divided between discussions, local investigations, and practical case-studies.

This semester-long course aims to provide students with a general introduction of the basic core competencies and practical skills required of a "generalist" development practitioner. Using a combination of delivery methods, the investigation of course topics will be grounded in a practical, multi-disciplinary approach that will focus on the inter-relationship between the following core fields of development practice:

- Agriculture and Nutrition
- Public Health
- Environment and Climate Science
- Technology and Engineering
- Economics
- Policy, Anthropology and Social Studies
- Management

Effective practice and management skills will be stressed throughout each course topic.

Joining Columbia University in the Global Classroom project are institutions of higher learning on five continents: The Energy and Resources Institute (India), Georgetown University (USA), Institute of Development Studies, Sussex (UK), Lee Kuan Yew School of Public Policy, National University of Singapore (Singapore), Mekelle University (Ethiopia), Sciences Po (France), Tsinghua University (China), Universidad Internacional del Ecuador (Ecuador), University of International Business and Economics (China), University of Ibadan (Nigeria), and the University of Malaya (Malaysia).

B. *Challenges and Opportunities*

The challenges related purely to subject matter are as follows: to provide students with functional knowledge of the core technical skills required to solve professional problems within the field of sustainable development; to construct new understandings of the work of sustainable development through a demonstrated awareness of cross-cultural, multi-disciplinary, multinational dimensions of the field; to have students demonstrate functional knowledge through the analysis and diagnosis of real-world problems; and to enable students to determine an appropriate course of action when faced with a complex development challenge.

An equally challenging part of the course relates to the fact that the course is being offered as a common experience on five continents in twelve different universities. The challenge is to balance the desire to see a common global educational culture take shape focused on the issues of sustainable development, with awareness that local difference can be extreme in the way that it drives priorities. The larger opportunity is to take a step

in defining the parameters of what the global learning environments of the future will be.

C. Design Hypothesis

If the design of the course is able to balance the technology-facilitated distance and globally cooperative dimensions of the learning experience with focused local activities and instruction, student will receive the necessary knowledge drawn from the range of necessary disciplines, develop problem-solving skills by addressing problems of sustainability in their local areas, while, at the same time developing an awareness of the global character of the problems and issues, and the necessity for collaboration and cooperation.

D. Design of the Educational Experience

The course design turns around the following agreed upon features:

- each university/research organization participant will sponsor a class of approximately 20 participants drawn from their local setting
- each MacArthur Commission on Sustainable Development commissioner will offer a single lecture on a specific topic accompanied by the necessary background materials that introduce the relevant issues, and a number of activities that will demonstrate critical understanding and functional knowledge of the topic
- the aforementioned problem sets (activities) will stress the tension between the need for creative local solutions versus the need for scalable models for addressing global problems
- students will be required to write and share short essays describing a related experience of theirs with the global group
- students will be required to write a Human Poverty report comprised of both a local and global investigation that tries to better knit together the course community.

To accomplish these goals technically a mixture of media and tools for delivery of content and collaboration, including synchronous and asynchronous communication, collaborative workspaces, video streaming, and scalable course management (accommodating low bandwidth and firewalled participants) is required. The following is a more detailed outline of the course requirements:

Introductory Essay

Students will contribute short essays either describing a specific experience they have had while working in development and what they learned from it, or responding to key readings in the development literature. Essays will be 3-4 pages (double-spaced) in length, and students will be asked to post them to a shared website

within the first month of the course. Submissions will be organized and inter-linked into a wiki environment for the Global Classroom.

Human Poverty Report: Local and Global Investigations

Working in small groups, students will complete a local investigation culminating in a poverty reduction proposal for a specific place, as well as a global investigation culminating in policy recommendations for a country. Students will be assigned to different teams for the local and global investigations to increase the number of participants they collaborate with during the course. Students will also evaluate proposals and recommendations submitted by their peers at partner universities.

Part I. Local Investigation and Poverty Reduction Proposal

For the local investigation, each team will focus on a particular sector – e.g. agriculture, energy, health, infrastructure, nutrition, water – and its relationship to development and poverty within their local environment, or a nearby site. Teams will conduct field visits, interviews, and collect data as part of their investigation. In some cases, field research may be supplemented with review of reports, articles, data, and maps available online. The project will culminate in the preparation of a proposal for a new poverty reduction project. The proposal will include a description of local conditions and ongoing development work in the region; identification of challenges, strengths and opportunities for change (e.g. environmental factors, local governance, policies, etc.); and a detailed description of the proposed project (including objectives, expected time-line, etc.). Project proposals (~5-6 pages including background information) will be linked to an interactive global map, and students will review a proposal from a partner university, and submit comments.

Part II. Global Investigation and Policy Recommendations

For the global investigation, teams will first select a country from a different hemisphere than their own. Students will again focus on a particular sector, but will now consider the interaction between the sector (e.g. agriculture, energy, health, infrastructure, nutrition, water), development, and poverty at the national scale. Working in small groups, each group will prepare a policy brief providing historical, political, geographical and/or environmental context for poverty in their country and a set of specific policy recommendations on how best to reduce poverty through improvement in the sector they are working on. Students will be expected to refer to reports and articles, data available through websites (e.g. WDI), and/or maps. Policy briefs (~5-6 pages including background information) will be linked to the interactive

global map, and students will again review a partner group's brief.

Figure 5 represents a early visualization of the project during the discovery part of the process that has survived scrutiny and approximates our effort to balance the focused local work with the global sharing and community building.

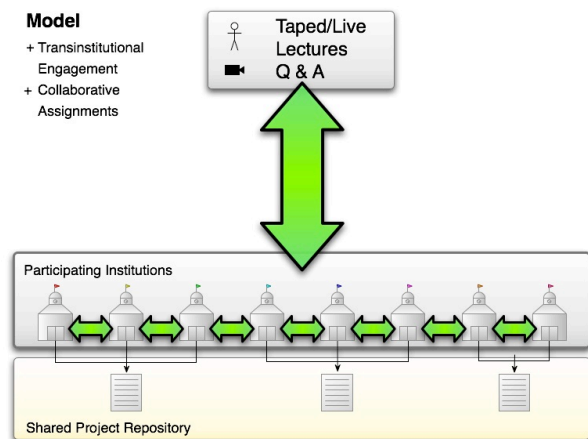


Figure 5. Global Classroom Model

Assessments may be based on the evaluation of problem-solving exercises, written exercises, discussions, group presentations, and self-evaluations. Students will be engaged in on-line discussions and will have opportunities to work in collaboration with students in the participating universities.

The course itself will be run for the first time in the Spring 2008 semester, at which time we will complete the Educational Experience and Evaluation and Communications parts of the Design Research cycle.

IV. CONCLUSIONS

Classic double-blind randomized trial research is an important part of the human knowledge enterprise and its eventual long term practical impact is unquestionable. The state of the world, however, demands an equally aggressive effort, particularly in this sphere of educational practice related to health, poverty and sustainability to produce more immediate results measurable by their observable effects. Design Research as practiced at CCNMTL allows for a reflective process that produces real educational interventions that can be immediately assessed and then modified based on that assessment. The Global Classroom and the Millennium Village Simulation projects position educators to actively

address the issues of surviving poverty and practicing sustainable development and, as such, are active examples of CCNMTL's Design Research process.

ACKNOWLEDGMENT

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F. Moretti and L. Pinto, "What we have learned and how have we learned it? Example of Best Practices of a New Media Services and Development Center in Higher Education," in *Online-Padagogik: Referenzmodelle und Praxisbeispiele*, vol 3, Burkhard Lehmann and Egon Bloh Eds. Schneider Verlag Hohengehren, Baltmannsweiler, 2005.

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Manuscript received 15 November 2007.

Published as submitted by the authors