Institute for Learning Technologies
Teachers College, Columbia University
New York, NY 10027

New Laboratory for Teaching and Learning
The Dalton School
New York, NY 10128

The Cumulative Curriculum:

Multi-media and the Making of a New Educational System

A Project Description

Spring 1991

EXECUTIVE SUMMARY

The Institute for Learning Technologies at Teachers College and the New Laboratory for Teaching and Learning at the Dalton School propose to collaborate with IBM Watson Research Labs in a basic development program designed to achieve systemic innovation in education through the use of advanced information technologies. This group will aim to design, implement, and perfect a technology-intensive educational system. A range of key questions will guide this comprehensive effort to develop a new system for education based on the intensive use of information technology.

- How should educators structure activity in space and time to fulfill the pedagogical possibilities of computer-based education? What kind of place and schedule should a new system be given?
- What motivational energies should a technology-intensive system activate in students to drive and sustain their inquiry and development?

- How should educators organize and present the substance of our culture through interactive, multi-media systems so that the young will acquire the fullest, most valuable education?
- What will make the work of teaching in the new system interesting, challenging, and attractive to highly talented professionals?
- What civic ideals and aspirations will lead the public to allot a technology-intensive educational system the resources needed to implement it?

We intend to work to develop practical answers to such questions. We believe that a curriculum based, not on print media, but on interactive, multi-media electronic systems, will have distinctive cultural and educational properties. Most significantly, learning and study with these resources will be cumulative, not sequential. The new system will conduce to cooperative learning in contrast to the reliance on competitive learning in the current system. The new technologies will balance verbalization with more effective use of visualization in the acquisition of information and ideas. If effected, such a cumulative multi-media curriculum will transform practice into a new educational system.

Here are operational goals that we want to achieve through the Cumulative Multi-media Curriculum Project.

- **Environment.** Design the physical and temporal layout for work with the cumulative, multi-media curriculum and build versions of it for use at The Dalton School and associated public school field-test sites, starting with the 1993-94 school years. Evaluate, refine, and expand the designs for 1994-95 and 1995-96 to accommodate successively larger cohorts of students. At the conclusion of this effort, we should have practical experience in organizing educational time and space for work with the new system. Deliverables: a book of designs; two prototype designs built and tested; an evaluation report based on experience with these. (1991-1996)
- **Motivation/Assessment.** Establish liaison with the multi-media project at P.S. 92 to explore patterns of engagement that work with students. Begin to develop ways of evaluating the performance of students working with a cumulative, non-sequential, curriculum and of giving students and teachers feedback useful in individual and group learning situations. Extend these explorations with the groups at Dalton and the Lab Schools. At the conclusion of these explorations, we should have grounded knowledge about the patterns of motivation that will work with students using a cumulative multi-media curriculum and practical experience in assessing and guiding their work with these resources. Deliverables: curriculum materials and study tools with appropriate

motivational strategies and assessment resources built into them. (1991-1996)

- **Knowledge**. Prototype a comprehensive, multi-media curriculum, sufficiently full in content for students in the 4th through 9th grade age-brackets to acquire a cumulative educational experience lasting three years. At the conclusion of this effort, we should have a sound implementation of a new curriculum, one ready for further development and evaluation at all levels of education. Deliverables: a cumulative multi-media curriculum and a practical integration of multi-media technologies that will allow teachers and students to use the curriculum with ease. (1991-1996)

- **Profession**. Organize a demonstration-design seminar for teachers from diverse settings to explore the pedagogy of the cumulative multi-media curriculum. Use the pedagogical framework developed in these seminars to prepare cohorts of ten teachers for 1993-94, 1994-95, and 1995-96 to work with the prototypes and students at Dalton and the Lab Schools. At the conclusion of these activities, we should have a group of 30 teachers with working experience of the new system and a network of interested schools and teachers through which we can further develop educational principles pertinent to a cumulative curriculum. Deliverables: materials suitable for training teachers to work with the new curriculum. (1991-1996)

- **Policy**. Plan and carry out a set of specific studies of policy problems associated with the cumulative curriculum. To extend preliminary experiments with a cumulative multi-media curriculum into a full-fledged educational system, numerous issues will need clarification. As we become aware of these, we will try to address them systematically. At the conclusion of this effort, we should have reflective reports on selected issues that have impressed us in the course of exploratory work as problems to be considered in preparing for larger-scale implementation. Deliverables: a half dozen or so studies, suitable for public dissemination, of policy issues raised by the Cumulative Multi-media Curriculum. (1991-1996)

This project will be in, and of, and for, New York City. The ethos of the City -- its problems, resources, and institutions -- will provide the settings and stimulus for the work of the project. Participants in the project at the outset will include:

- The Institute for Learning Technologies at Teachers College, Columbia University;
- The New Laboratory for Teaching and Learning at the Dalton School, and through the New Laboratory, the NYC Mayor's Public-Private Schools Partnership;
- The Cooper Union Research Foundation at the Cooper Union for the Advancement of Science and Art;

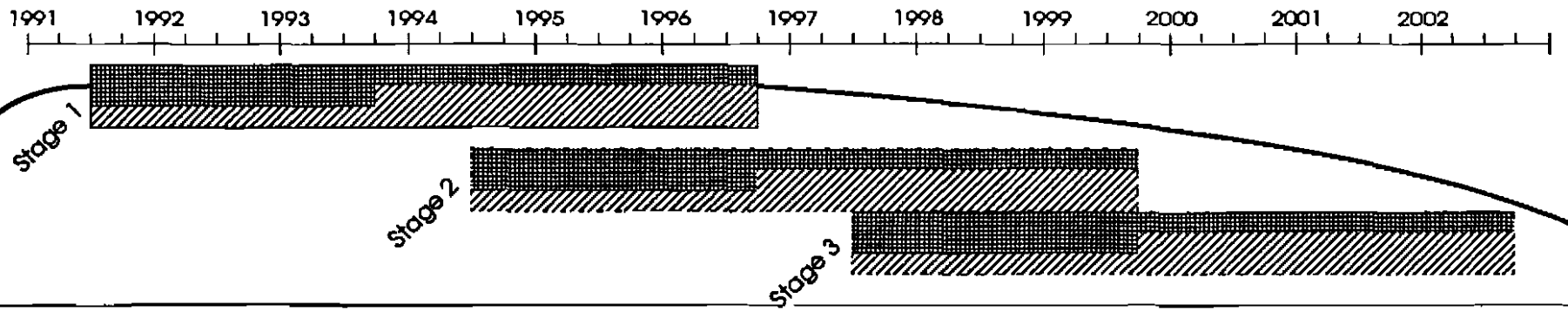
- Selected field-test sites in New York City's District 2, 5, and 10;
- Kids at the Wheel, a multi-media expressive learning project at P.S. 92, sponsored by IBM Research;
- The Center for American Culture Studies at Columbia University; and
- Program developers using cultural resources such as the Museum of Broadcasting, the Smithsonian Institution, the New York Public Library, the New York Historical Society, and the Metropolitan Museum.

We seek funding of approximately one million dollars annually, over five years, to support our effort to initiate a Cumulative Multi-media Curriculum as the basis for developing a new, more effective educational system.

Educators need to pursue a demanding vision. They need to develop powerful tools, energized by a large market. Education can be changed, profoundly for the better. But it cannot be changed with little efforts, backed by small resources, promising marginal results. Energized with new tools, education can become a material force bettering the human condition. Through this project, we aim to joint with IBM and others in a concerted effort to extend the limits of education and culture.

The Cumulative Curriculum: a three-stage design and development effort

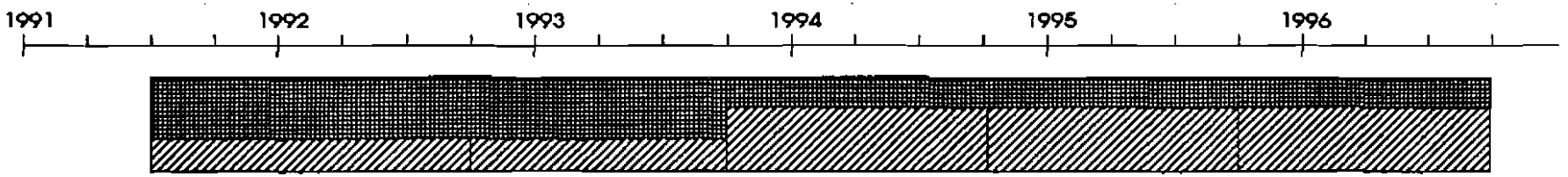
Purpose: To develop a Cumulative Curriculum and to test its effectiveness for children ages 6 through 18.
Stages: Differentiated by distinctive hardware-software platforms.



Current Proposal: Stage One of the Cumulative Curriculum

Objective: To provide proof of concept for the Cumulative Curriculum by building a prototype and field testing it with children ages 8 through 13 (grades 3-5 and grades 6-8).

Strategy: **Build** the prototype and **do** the field test **Build** **Do**



Build the prototype

1) Configure and validate the prototype platform.
2) Assemble the prototype curriculum: intellectual content.
3) Assemble the prototype curriculum: media of expression.
4) Develop curriculum applications.
5) Develop assessment applications.

Do the classrom field tests

6) Prepare field test sites.
7) Train teachers in the philosophy and practice of the cumulative curriculum.
8) Conduct the field test classes.
9) Evaluate and document the field test results.

LETTERS OF TRANSMITTAL

The following letters indicate support for the project by the key institutions involved:

Teachers College, Columbia University

The Cooper Union for the Advancement of Science and Art

The Dalton School

The New York City Mayor's Public-Private Schools Partnership

New York City Community School District Two

TEACHERS COLLEGE
COLUMBIA UNIVERSITY
NEW YORK, N. Y. 10027

OFFICE OF THE PRESIDENT

September 6, 1990

To Whom It May Concern:

I am delighted to encourage and support this extension of the relationship between IBM and Teachers College through the Cumulative Curriculum project. The project is most ambitious, and Teachers College, as the nation's largest, most comprehensive graduate school of education, is, I believe, the appropriate initiator of it. Our faculty has the depth and range of interest to support the project in all essential areas--environmental design, motivation and assessment, curriculum development, professional development, and educational policy studies.

For the past decade, I have put a great deal of personal effort into fostering and assessing the efforts of business leaders to become effective participants in the improvement of American education. From that experience, I am convinced that success in this ambition will require extensive efforts like the one proposed here. Education will need alliances with business leaders and public officials at every level to succeed in creating new visions, developing new tools, and improving practice and performance in the nation's schools.

For these reasons, I see the project proposed here as propitious for all. Innovation entails risks, and we are eager to join with IBM in taking the risks inherent in the Cumulative Curriculum project. The risks are worthwhile, we stand a good chance of success, and the benefits can be immense.

Sincerely yours,

P. Michael Timpane

PMT:ntg

The Cooper Union for the Advancement of Science and Art, established in 1859,
is a private institution of higher learning where all students receive full-tuition scholarships.
Peter Cooper's legacy supports degree-granting programs in Art, Architecture and Engineering.
The historic Great Hall is home to public forums, cultural events, and other community activities.
The Cooper Union is located at Cooper Square, New York, New York 10003.
The phone number is (area code 212) 353 4240.

Office of the President

September 7, 1990

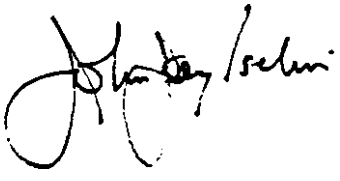
To Whom It May Concern:

For many years -- as president of WNET/Thirteen and now as president of The Cooper Union -- I have sought to make new communications resources serve as more effective educators of the public. The cumulative curriculum project is one of the most promising I've seen and I am eager to participate.

Cooper Union can help in several significant ways, among them:

- Through our Design and Typography Center, which can bring top professional screen and graphic design to the project;
- Through our Center for Learning, which will be using installations like those projected to provide wider access to the humanities and science curricula and extensive visual study resources,
- Through our Architectural School, which can help frame and evaluate the competition for the design of a new educational environment; and
- Through the Engineering School, which brings a wealth of faculty and student talent to the task of software and systems integration that the project will entail.

The pedagogical and philosophical approaches of the project coincide with those that Cooper Union espouses and has pioneered and we would be, therefore, honored to participate in its realization.



THE DALTON SCHOOL
108 EAST 89TH STREET
NEW YORK, N.Y. 10128-1599
722-5160

GARDNER P. DUNNAN
HEADMASTER

September 7, 1990

To Whom It May Concern:

It gives me great pleasure to write on behalf of the Cumulative Curriculum Project Proposal. It is not only appealing and to be praised for its challenging intellectual content but it is exemplary in its orchestration of diverse institutions - Public and Private School and University, Profit and Non-Profit - in the interest of a common civic end. The proposal suggests a revolutionary redefinition of the roles of teachers and learners and the settings in which they interact, and such models of collaborative sponsorship demonstrate the kinds of new relationships that will be necessary if we are to successfully serve the children of urban America. It is proposals just such as these that we in the Mayor's Partnership and at Dalton, as members of a complex and troubled educational community, seek to promote as models of the type of cooperation necessary to surmount the many obstacles before us.

Both Drs. McClintock and Moretti are well known to me and, were I to have selected two people to lead such an effort, it would have indeed been them. They have my complete confidence and full support in launching what might become one of the breakthrough educational experiments of our day.

I am at your disposal. If you should require further information, please feel free to call me.

Sincerely,

Gardner P. Dunnan

Gardner P. Dunnan, Headmaster
The Dalton School;Co-Chairman
of the Advisory Board of the
Mayor's Partnership for Public
and Private Schools;President,
New York State Association of
Independent Schools

ANTHONY J. ALVARADO
SUPERINTENDENT

COMMUNITY SCHOOL DISTRICT TWO
330 WEST 18th STREET
NEW YORK, NEW YORK 10011
(212) 337-8700

September 5, 1990

To Whom It May Concern:

It gives me great pleasure to endorse the proposals submitted by Drs. McClintock and Moretti, called The Cumulative Curriculum. District Two has had a long standing association with the New Laboratory at Dalton and the Mayor's Partnership for Public and Private Schools. Dr. Moretti, the Director of the New Laboratory, and Dr. Dunnan, the Chairman of the Advisory Board of the Mayor's Partnership, have been staunch friends and aggressive contributors to the well-being of the children of our District. I look forward to the opportunity to pursue this breathtaking proposal with them and their estimable colleague, Dr. McClintock.

We are eager to begin the planning and construction of the prototype mentioned in the grant. We anticipate that our new Laboratory Schools, which now encompass Kindergarten through ninth grade, will be an ideal setting for doing so. We are ready to proceed at the moment of approval. We are, of course, aware that the first two years of the proposal are devoted to curriculum and environmental design as well as teacher training. We are also ready to devote the energies of our district resources to those ends.

If I can be of further assistance during the process of your considerations, please do not hesitate to call me.

Sincerely,

Anthony J. Alvarado
Community Superintendent

AA:tg

CONTENTS

1 A PERSPECTIVE ON THE TASK

Let's look ahead. In the twenty-second century, how might an historian of education sum up the major changes in pedagogical practice over the sweep of time? Imagine that we could commission a leading authority to report on the view backwards from that future time. This might be her executive summary.

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Through most of history, education was a loose system of apprenticeship and indentured service in households, the main location of productive activity. Those who wanted their children to become learned employed tutors to help them out. A few schools existed within specialized institutions, such as cathedral priories and monasteries, but these were not like the schools that eventually proliferated, for students were not divided into classes or grouped according to age.

Around 1500 a.d., a major pedagogical transition began as printing with moveable type made an unprecedented era of educational development possible. But the transition was not a quick and simple change: to bring it off, innovators had to develop a complex of different, yet interrelated, educational strategies that together eventually made mass schooling for all a practical reality. Key steps in this process involved:

- *developing a characteristic place, a set of classrooms where children could be grouped by age, with the classes organized together into a school; and creating a standard unit of time, the fixed instructional period, which would allow for planned scheduling of the academic day and year and for organizing subject-matter into a sequence of measured lessons;*
- *discovering how to manipulate motivational energies, essentially engendering a many-sided competition at memorization and mimicking normative examples, displayed through diverse recitations and examinations;*
- *implementing a suitable presentation of the materials of the culture through specially designed textbooks and related resources, a presentation that stoked the competition and fit well within the educational time and place of the school classroom and schedule;*

- *instituting means of preparing adequately trained teachers who could manage the system and make it work; and*
- *developing public polices, centering on material progress, social improvement, and political cohesion, that moved parents and the public to devote sufficient resources to sustain the educative effort.*

These developments were difficult because they had to come in parallel, as they were tightly interrelated. The transition required the integration of complex factors into a functional system: the design of educational space and time; a chosen pattern of educational motivation; pedagogical materials suitable for use in such places with such motivations; teachers adept at using such tools and strategies; and arguments demonstrating that the substantial costs of it all were worthwhile -- all were simultaneously essential to the historic transition to mass schooling.

Sixteenth-century educational reformers worked out solutions to these five, interrelated matters. For five hundred years, educators perfected, expanded, and developed the basic components of the educational system introduced early in the era of print, in due course creating modern systems of universal, compulsory schooling. The degree of elaboration and penetration of the system into society changed, and the specifics justifying the effort evolved to stay synchronized with cultural transformations. The main features remained stable, however. The design of the classroom and the organization of the school day, the motivational strategies employed, the scope and sequence of textbooks, the definition of good teaching practice, and the rationales for public support remained very stable. The reason for the underlying stability was rather simple: throughout it all, the character and limitations of printed textbooks remained substantially fixed, the keystone of the system.

We who inhabit the electronic ethos of the twenty-second century must remember that early in the twenty-first century, the function of printed materials changed rapidly, becoming restricted to their current role of verifying and guaranteeing standard data sets. Before then, physically printed materials had a much more central intellectual function. For five hundred years, books were the unmatched resources for making the ideas and knowledge of the culture available to students, and so long as this role was unquestioned, educators paid little attention to how the characteristics of books shaped the whole instructional enterprise.

But during the last half of the twentieth century, diverse innovations in communication and computation occurred, displacing books from their privileged cultural position and creating our current, electronic means of access to cultural achievements.

From our vantage point, we can clearly see that the microcomputer and all its attendant peripherals, that quickly matured into powerful multimedia systems, created a significant historical dilemma for educators at the end of the twentieth century. How were they to make use of these new resources in education? To what degree did the existing educational system comprise permanent, necessary arrangements? Were classrooms for twenty-five children, of similar age and talent, overseen by a single teacher, learning set subjects that had been divided into lessons, competing for grades and recognition, the way that education should be organized indefinitely into the future? To what degree were these arrangements historically relative accidents, sensible in one communication context but perhaps vestigial survivals with distorted function in a new context? In planning computer-based educational efforts, what were educators to take as givens that would remain stable, before and after the introduction of powerful information technologies?

At first, this question was not clear to educators. Early users of computers in education simply assumed that most features of the given system would remain stable, only getting better through judicious use of the new technology -- with a good deal of divergence, we might add, over what "better" might mean. We will not here rehearse all the details of these divergences. There was an initial wave of enthusiasm, and a strong undertow of skepticism, and lots of ingenious, but encapsulated, efforts to incorporate computers into the educational system. Through such efforts to introduce computers into late-twentieth-century schooling, educators became increasingly aware that the then-existing practice was a complex technical system highly adapted over centuries to making use of books as the prime medium of cultural exchange. Encapsulated innovations repeatedly engendered inflated expectations and produced disappointment and disdain.

Unfortunately, the old system had spawned a huge establishment of educational research, which functioned to optimize techniques and programs within the given system. Almost all its methods for measuring results were system-specific, assuming that existing divisions of subject matter were appropriate domains for testing, standard grade-levels were fit bases for norming results, and verbalized information was the prime indicator of learning. The bias of such research helped to protect the existing arrangements from systemic changes.

To organize education to exploit the possibilities of electronic media of cultural exchange, potentially far more powerful and flexible than the printed media, educators had to rethink the system as a whole, to take

none of it as a given that would necessarily persist, unchanged, from before to after the introduction of computers. Further to assess a new system, relative to the old, they had to develop a whole new type of educational research, one that did not presume in its standards of testing and measurement, that structural accidents of the old system were educational necessities of timeless applicability. The full, fundamental re-examination of educational options, and the methods for assessing them, began in the 1990's. It initiated the second historic transition in educational practice.

Looking back from the twenty-second century, the results of this re-examination are clear. Educators began to explore new solutions to all aspects of the existing system of schooling. They stopped applying computers to the educational strategies that had been developed in the early era of print. Instead, they started to search for educational strategies that seemed sensible in an era of digital information technologies.

- *At the end of the twentieth century, educational innovators scrapped well-worn assumptions about the physical location of education, keeping the school, largely for reasons of socialization, but discarding the traditional classroom, opening it physically to make many different groupings possible, from the very small to the very large. Likewise, they discarded assumptions about the periodization of school work -- the school day and the school year. Instead, they adopted very flexible scheduling strategies, which were among the many possibilities the new technologies facilitated.*
- *Educators harnessed a much broader mix of motivational energies than had been possible with print-based schooling. As sustained work by small groups became more feasible, cooperative learning became even more important than traditional competitive learning. With that development, the educational system began to function less exclusively as a sorting mechanism and more effectively as a means to engender social integration and interpersonal solidarity.*
- *Simultaneously, curriculum reformers profoundly changed the organization of ideas and knowledge, reversing the tendency to break the whole up into discrete domains of subject matter. With the old system, there had been a separate text for each subject and each grade -- the experience of study had been compartmentalized and sequential, with minimal access in any particular grade to the materials used in prior or coming years. The new organization substituted one, comprehensive and integrated organization of ideas and knowledge for the sequence of graded texts, with a variety of navigators, appropriate to different ages and interests, to help the student. The result was most important: the experience of moving through the curriculum ceased to be one of a sequential*

study of subjects, grade by grade, and became much more one of a cumulative mastering of the cultural landscape.

Also with respect to the organization of ideas and knowledge, innovators made the cues for accessing ideas on demand broader, more flexible, and more effective. In the era of print, keywords and a substantial acquisition of verbal knowledge mediated access to stored ideas and information. Even to find a picture, or later a film, one had to be able to read one or another sort of verbal listing. The new technologies greatly extended the power of multiple representation in the culture, and multiple representation had its most significant effect, not on how people received ideas, but on how they found them and activated them and then apprehended them. Pictures, icons, sounds, and gestures came to rival written expressions as means of accessing ideas. With that change, the resources routinely usable in the curriculum blossomed -- pictures, films, performances, recitations, diagrams, graphs, animations, simulations, maps lost their merely "illustrative" character and gained apodictic, declarative, propositional power. We can now sum up all these changes: in our electronic culture visualization enhances the verbalization that characterized the print culture.

» *Concomitantly, educators also altered significantly the character of the work that teachers experienced thanks to the same features of the computer-based curriculum that made the learning of students cumulative. In the old system, teaching had been a highly repetitive profession, with few challenges to sustained self-development in it, for the material in the syllabus and in the text, year after year, had remained static. But the integrated, multi-faceted computer-based curriculum comprised an inexhaustible resource that teachers could continue to explore with verve throughout their careers. As a result, in the twenty-first century, the profession gained significantly in stature.*

» *Soon, leaders in the profession and the public even developed important new policy justifications for the emerging computer-based system. Formerly, the public had typically supported classroom-based education because they had perceived it to be a needed means to some extrinsic end -- religious salvation, political power, economic security. To be sure, the new computer-based system continued to be a useful means to such goals. But in addition, education became, in the eyes of most people, an end worth pursuing in itself. A strange split had long existed between entertainment -- held to be fun and amusing, but idle and small-minded -- and education -- considered to be work and laborious, but constructive and enlarging. With the new educational system, this split quickly disappeared. The consequence has been fun-*

damental: in the twenty-second century, most people generally rank educational opportunity, in preference to social security, national defense, or material progress, as the key benefit of civilization.

These developments took shape in the decades preceding and following the year 2000. Educators gave up trying to introduce new technologies into the established system and they thought out an alternative system, which ineluctably displaced the old one. Since then, of course, the new system has evolved steadily, more and more thoroughly displacing the vestiges of the print-based educational system. The results have been liberating and profoundly progressive. Democracy, which had been, for the most part, a predominantly political development through the twentieth century, has gained a substantial cultural import. The persistent tendency of print-based education to reproduce and accentuate differences of power, privilege, and wealth has been decisively reversed. The great twentieth-century aspiration, verbalized by John Dewey through ***Democracy and Education****, has become substantively fulfilled, although in an environment of pedagogical practice quite different from any he could then imagine.*

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Perhaps our informant from the future depicts a vision too rosy -- she says nothing about great problems like the greenhouse effect. Nevertheless, her account draws our attention to the need to look at the whole educational system in considering how to introduce information technologies into it. If computers in education are to have substantial effect improving education, they will amount to a systemic innovation, one that changes not only the medium of cultural exchange, but the entire context for working with that medium. We propose a comprehensive, sustained research and development effort, one that aims to understand and facilitate the full complex of changes needed to create a new educational system.

Our effort should concern our informant's five interrelated domains of innovation: environment, motivation, knowledge, teaching, and educational policy. These topics, in the large, set the research and development agenda that we propose to IBM. In what follows, we first interpret more fully what is at stake in each of these five areas. We then describe our operational goals and explain how we plan to pursue them, estimating costs and equipment needs. We close the proposal by indicating why we think these beginnings can lead to a major transformation of the educational system. After these components of the main narrative, we append supporting documents concerning our projected activities, the people and groups who will lead the effort, the pedagogical theories that will inform the work at the start, and an indication of how this project relates to other efforts to use information technologies in education.

2 MAKING A NEW EDUCATIONAL SYSTEM

We aim through our research and development agenda to initiate a new system of education, one different from the system of print-based schooling that has dominated educational effort for the past five centuries. To make such a departure, the five components essential in the construction of the given system need to be redesigned with full awareness of the potentialities of information technologies in mind.

- How should educative activity that makes full use of information technology be organized in space and time? What should its location and schedule be?
- What well-springs of human emotion and activity should it tap for its driving energies?
- How should the works and knowledge of our culture be organized so that presentation of them through advanced information technologies will best support the educative effort?
- How can the activities of those facilitating the educative work of the young be structured to attract highly talented people and provide them with self-renewing and self-developing conditions of work?
- What ideas and policies will best present the possibilities of such a system to the public so that they will allocate to it the resources needed to make it flourish?

These questions that will generate an educational system need to be explored anew. In this proposal, we will expand on each in turn and then consider how to draw them together in an integral educational system, one that may differ significantly from the mass, compulsory schooling so familiar throughout the world.

Educational Design of Learning Environments

Education has a setting. In a print-based culture, the setting is the age-graded classroom where lessons unfold according to the time constraints of the standard instructional period. We seek first, to rethink the organization of educational space and time in light of the possibilities of advanced information technologies. This involves something much more basic than simply inquiring

into the optimum size and configuration for a classroom in which students will use computing equipment.

New technologies can alter the available ways for structuring educational space and time -- they can become resources in the educational design of learning environments. Currently, electronic mail is perhaps the most familiar example of this point, for it significantly alters the temporal frame within which consultations between students and teachers can take place and it may also subtly change the spatial requirements of exchange, diminishing the need for simultaneity in both time and space, as in face-to-face exchange, or even for simultaneity in time alone, as with telephone exchanges. An intensive, many-cycled give-and-take can occur without the parties needing to be synchronous either in time or space. Thus, the physical constraints impeding one-to-one consultation between a teacher and a student can be greatly lowered.

Very soon, however, information technologies may become even more powerful architectural resources, allowing a single space to serve multiple functions and different kinds of groupings by switching attentional foci electronically. Thus imagine a large rectangular space, twice as long as it is wide, suitable without crowding for about a hundred persons. When a very large screen at one end was active and all attended to it, the space would function as a large room for the whole group rather like a small auditorium. Imagine that the long walls were divided into four quarters, with a display screen on one wall in the first and third quarter and on the other in the second and fourth quarter. When those four screens were active, each with different material, the whole space would be divided into four sections, each with, say, twenty-four people. Retractable dividers, designed to provide simple visual and acoustic buffers, could easily strengthen that division. Imagine further that throughout the large room twenty-four well-designed display consoles were placed so that the students, in groups of four, could orient to the consoles when those were active, enabling the space to work well for small cooperative groups. Finally, equip each student with a notebook computer linked to a server by a radio coupling. When the screens of those individual machines were active, rather than those of the consoles or the display walls, each person would be in a somewhat private space within a large room, with each person going off according to his or her curiosity. A schematic, involving a slightly simpler layout, will be found on page 70.

We offer this example, not to assert that it indicates the new design that should prevail, but to illustrate ways in which information technologies may make the definition of new forms of educational space and schedule possible. The existing forms of the age-graded classroom, functioning according to the standard period, do not adapt well to the use of powerful communication media. For instance, many feature films could be moving and illuminating educational tools, but they do not fit well into existing schools: neither is a classroom for twenty-five an optimum viewing space, nor is the 50-minute standard period a good time division within which to use such resources. Alternatives are possible that are currently unexplored.

Multi-media information technologies with powerful networking, tracking, and scheduling capacities can make the very flexible use of space and time possible. We plan to work closely with established and emergent schools that have the opportunity and capacity to experiment with such flexibilities. Our inquiry will proceed according to the basic principle that the new technologies provide resources with which space and time can be organized differently than it can be without those technologies. We are dealing with innovations that invalidate the common sense that held under prior conditions; our task will be to develop a new common sense, suitable for the new conditions. With the old common sense, educational environments were standardized and predictable; with the new, they will be flexible, diverse -- a challenge to the imagination.

Motivational Sources of Education

Think of a fifth-grade classroom. Imagine the class dealing with virtually any subject. The teacher has just provided an explanation of a key point summarized in the text. She asks a question -- some pupils raise their hands and wave eagerly, confidant that they know the answer. Some sit in a studious effort to avoid attracting the teacher's attention, knowing that they do not know and not wanting that fact to be registered in the public knowledge of the teacher or the class. Others seem neither eager nor reluctant, they fidget, raise and lower a hand in ambivalence, thinking they know the answer but not being sure, wanting to earn the teacher's commendation, but fearing that, if wrong, they risk rejection or rebuke. These are the signs of instructional competition at work. From the early grades through the highest levels, the existing system motivates children by engaging them in a competitive effort to shine in recitation and examination, in which each tries to show that he or she has mastered better than others the information sanctioned to be fit for his or her level and to be correct in the view of academic authority. As a result of this reliance on competition, the educational system functions as a powerful sorting mechanism, and when it becomes clear to many that however they may try, they have lost the competition, they drop out.

It is remarkable how thoroughly existing educational systems, around the world, have been adapted to harness competitive motivations. It is very hard to find arrangements in schools that have been designed to encourage children to act from other motivational sources. Undoubtedly the reasons for this reliance are complex, and certainly one among them is the important fact that competition is a very powerful, effective motivator. But there are other powerful motivators, among them cooperation and it is remarkable how few educational arrangements have been designed to motivate children to learn through cooperation. The reason for this imbalance between competition and cooperation may have had much to do with the logistics of working with printed information.

Think of a ninth-grade teacher, preparing a unit on feudalism, lamenting --

> I can't have them do group projects. There just aren't enough worthwhile materials reasonably available to them. New York City has all sorts of resources, but it doesn't really help -- those who would need to go to the

> Cloisters wouldn't be able to get there without all sorts of complications. The school library is good but inadequate and they can't just simply use the high-school annex to the New York Public Library -- we either stay in the school or arrange, all together, to take a trip. How do I get some to the Met, others to the Morgan, and a couple into the stacks at Butler Library? How can projects be done at a high academic level in a routine way?

If it is hard to do group projects at a high academic level in a routine way in New York City, it is far harder, most other places. Sadly, serious information management problems discourage inquiry and cooperative learning, problems that must be solved if these alternatives to competitive learning are to become practical, everyday alternatives in mass education. Competitive motivation arises when a group of students start from an appropriately equivalent basis, usually as measured by age, and each is then asked to master a limited, standardized body of material, with goods -- praise, grades, promotion, and acceptance by the college of choice -- being distributed in proportion to how well, in comparison to others, each performs. From the point of view of information management, this practice is very efficient; it is essential in establishing the comparison that all work with the same body of subject matter. This creates a large market for inexpensive, well-chosen, clearly-presented selections, which textbook publishers compete to provide.

Cooperative learning does not make sense in situations where each student starts with the same content with the goal of mastering more of it than anyone else. Cooperation aims at having participants do different things and then coordinating their accomplishments in a common achievement that exceeds what each would manage alone. In educational situations this puts far greater strain on the information resources available to the cooperating participants. Ideally, for robust cooperative learning, students should face an expansive horizon of questions, armed with extensive resources to pursue their inquiries in many directions to considerable depth. If the questions and resources available are limited, their cooperative effort will not make much sense and different members of the group will find themselves working at cross-purposes with each other, repeating each others' efforts, and vying with one another to do the most with the few resources on which all converge.

For centuries, educational reformers have contended that cooperative learning would be a good thing, and occasional examples of learning by working together to solve real problems keep the ideal alive. It has been very hard, however, to provide the intellectual resources to sustain good cooperative learning in most educational settings. The practice has worked best with the very young, where relatively limited materials will sustain the effort, or at the most elite levels of education where bountiful laboratories and libraries sustain the extensive specialization of inquiry that cooperative learning generates. For the age between these extremes, cooperative learning has been very difficult to implement. What materials will be needed to have twenty fifteen-year-olds do a

two-week unit on feudalism according to the principles of competitive motivation? Each will need a copy of a well-written text and regular attendance to a teacher who can provide supplemental explanations and manage recitations and a test. What materials will be needed to have those students spend two weeks cooperatively exploring the history of feudalism, drawing together at the end a presentation of their results? The range of possibly pertinent materials is nearly limitless and the possible roles a teacher might take in the effort is almost boundless. Consequently, the information logistics of cooperative learning strain the print-based system.

Electronic information management technologies will significantly alter the logistical constraints on cooperative learning. One of the simplest examples of such change involves the problem of movement. Traditionally, inquiry meant that children had to leave the classroom to go to the library or other locations of specialized resources. This usually was not efficient, introducing confusion about who was where and wasting time in excess movement. With inquiry in a well-networked electronic environment, the children can access specialized resources, almost instantaneously, with very little waste of time or effort. Such changes in logistics can have profound effects on the experience of working together. Traditionally a simple decision -- "I'll get this and you get that" -- would draw a cooperating pair apart, often to quite different locations, perhaps with one getting stymied on the way. In an electronic environment of information management, the two can allocate their effort while remaining in close proximity, physically and intellectually, often checking on the implications of what each is finding for the other.

We propose to study how to implement multi-media information resources in an educational environment in order to enhance the available range of educational motivation.

- How should systems be implemented to support cooperative inquiry?
- What groupings relative to different subjects and ages work best?
- How should teachers assess performance in cooperative settings?
- How should curriculum designers organize knowledge and tools of inquiry and expression in order to support learning by the members of study groups?

These, and many similar questions, need serious examination in order to broaden the motivational energies effectively harnessed in a technology-intensive educational system.

Organizing Culture[1] and Knowledge

We speak of the print-based school because printed materials have been the main medium for making culture and knowledge accessible to students. So long as there has been no alternative to this reliance on printed materials, educators have paid close attention to the pedagogical features of one text compared to another, but there has been little attention to the pedagogical character of printed text, per se.

If we inquire into this latter matter, we see that the logistics of working with printed texts have much to do with the sequential character of the existing curriculum. Developmental psychologies delineated the sequences of major stages in the child's growth. But educators should not exaggerate the degree to which curricular sequences, differentiated by year and by subject, have arisen by rationally adapting curriculum and instruction to children's developmental needs. That world history should be a tenth-grade subject and American history a eleventh-grade one, or that biology should precede, or follow, physics or geology has little to do with the developmental characteristics of children. It is largely a conventional solution, one among many, arising from the need to divide the curriculum up into discrete subjects that can be presented in some sequence. The need for sequence is inherent in the constraints of print, not those of psychology. And whether it should be this sequence or that sequence is comparatively an inconsequential question.

What does it mean to move from fifth to sixth grade? A child who does so usually changes teachers and rooms, sometimes even a building, but these are not the essential changes -- the child could move from fifth to sixth grade while staying with the same teacher in the same room. What changes from one grade to the next is the curriculum, and most importantly the set of textbooks the pupils use. Sixth-grade texts differ from fifth-grade texts and so on and as the child progresses through school he or she does not cumulatively carry the texts from prior grades around. Educators have long likened the curriculum or sequence of grades to a ladder or staircase because the sequence of texts are like the sequence of rungs upon the ladder: one climbs from rung to rung, leaving the last one behind. Students in any particular grade find it hard to regain access to the materials studied in prior grades, without somehow going backwards, and

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1 In an educational context, "culture" results from a selection and evaluation of the sum of human acquirements, narrowing the infinite range of possibilities to a finite field, one that nevertheless exceeds the power of acquisition of any individual by a wide margin. The effort to organize culture and knowledge through this project will take place in a context set in part by disagreements between proponents of "cultural literacy," a fairly narrow, canonical selection, and "multicultural" approaches, a broader, inclusive selection. We do not intend to define what we mean by "culture" relative to this polarity as if the positions within it stand above the material limitations of particular implementations of education. Instead, we think the terms of the debate between cultural literacy and multicultural education will be reshaped substantially by the development on a new system of education that uses information technologies with full effect.

they find it even harder to anticipate access to materials slotted for grades higher up. Unable to move easily, back and forth, pupils experience the curriculum as a set of sequential studies. The costs are high. If a pupil did not get one part of the sequence, the omission can be portentous, not because the sequence is the only way things could be reasonably mastered, but because, once missed, the opportunity to make it up may be very hard to regain.

Pupils will have a very different relation to a computer-based curriculum, assuming that the whole body of culture and knowledge relevant in education has been integrated into a comprehensive system, any element of which they can access at any time from any place in the school. With continuous and ubiquitous availability, the sequence of grades would loose much of its meaning and study would be experienced as a cumulative effort.

We propose to investigate how the subject-matter appropriate for a complete and excellent education can best be organized, making no assumptions about the year-by-year sequencing of its presentation. A smart, computer-based curriculum should be able to sustain an infinite number of paths through it, and it should be able to provide each student with clear reports about what he or she has so far covered, regardless of the path and sequence he or she has taken. With such resources, we will ask questions such as these:

- What technological resources will best make all the knowledge, skills, and ideas in the curriculum continuously available to all students at all times?
- If the subjects of the curriculum become more cumulative, will the mix of activities that are useful to students change, and if so, how?
- Will there be a set of essentials, that must be mastered in a mandatory sequence, with the new system, and if so, how will this component of the curriculum relate to less sequential, less mandatory parts?
- What will happen to distinctions between subject-matter areas if all components of the curriculum are accessible to all students at all times?
- What tools of access, orientation, and expression will be needed by students to sustain their work with such a comprehensive curriculum?

Our main task will be to prototype a cumulative multi-media curriculum, one with a comprehensive selection of materials in it all of which will be accessible to all students at all times. We will implement this curriculum in working educational settings and pursue answers to questions like those above through intensive participant observation in these sites. In a nutshell, this set of activities defines our research agenda.

In addition to potentially making the content of the curriculum accessible to children in a much more cumulative way, we should note another, profoundly important structural effect on subject-matter that the new technologies will have. For five centuries, written materials have been the main channels of access to

culturally significant knowledge. This dominance of written communication arose because printed texts developed a level of accessibility radically different from other modes of embodying cultural expression. Access to printed materials could be general, efficient, and enduring. Access to other forms of cultural embodiment was comparatively restricted, troublesome, and transient.

To grasp this point, consider the theater, the drama, and its place in education. Multi-media are not new. Their significance pedagogically has grown of late. One often encounters the text of Shakespeare's *Hamlet* and other great plays as works taught within the curriculum. Productions of one or another play may be significant extracurricular activities in schools, and students may be encouraged to see a professional staging of them, should such performances be accessible in their locale. Nevertheless, the performances, whether student produced or professionally produced, have not been the central educational use of the drama during the era of print because access to the performance has been highly idiosyncratic and temporary, whereas access to the text of the play would be general and enduring. In the era of print, written materials have dominated educational effort from the most elementary to the most advanced levels because these have been the materials to which access has been general, efficient, and enduring.[2] A radical departure is afoot because now electronic information technologies can provide general, efficient, and enduring access to a much broader range of culturally significant materials: recorded performances of the play can be as easily retrieved as its text. The educational consequences of this development will be vast.

Networked, multi-media electronic systems provide general, efficient, and enduring access to cultural works of nearly every form conceivable. In the era of print, written works had a superior cultural usefulness than other resources. People could distribute, store, cite, retrieve, and use printed resources far more effectively than they could work with other forms of cultural expression. Essentially, one has long been able to refer other people to printed materials without knowing the particular physical location of the particular instance of the material that people will consult, for one cites editions -- Plato, *The Republic*, Book IX, 592b -- the numerous instances of which are scattered at many places. Paintings, plays, sculptures, and buildings, in contrast, cannot be referenced in this generalized way -- they exist in unique locations and access to them can require taxing trips, even a pilgrimage. Owing to this superior accessibility, printed materials, usually written materials, have more and more mediated the production and communication of knowledge in modern culture. Let us sum up

[2] Engravings, woodcuts, and other forms of printed images are a partial exception to this assertion, except that accessing them requires one to manipulate the written language, not pictorial images. Thus, to retrieve pictures of Chartres Cathedral, one must use written catalogues and indexes.

this development: in the era of print, *verbalization* increasingly dominated education. [3]

Slowly through the twentieth century, and building rapidly at its end, other modes of exchanging information, ideas, and knowledge between people are gaining cultural power relative to printed text. For centuries, texts have been available "at any place at any time" -- that has been their power. With the rise of the broadcast media, first speech through radio and then the moving image through television gained part of the power of print, becoming available "at any place," provided one tuned in at the right time. The recording industry gave music full accessibility, independent of particular place and time. Video tape is giving the same to the moving image, and very soon, with fully interactive multi-media systems, the superior accessibility of text compared to other forms of expression will completely disappear.[4]

When people speak about interactive, multi-media systems, they are speaking about a process by which the full gamut of human expression will integrate into one complex system, with all components, regardless of form, being generally, efficiently, and enduringly accessible. This integration, enhancing the accessibility of all forms of expression, we will call *visualization*.[5] A powerful trend toward the visualization of education is taking hold. Its historic effect will be to broaden effective participation in the culture greatly.

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3 "Verbalization" here refers not only to the spoken word, but even more essentially to the written word and even conceptualizations communicated through the symbolic notations of mathematics and the like. In its most comprehensive form, the basic proposition of verbalization is that higher-order thinking consists in manipulating symbolic notations.

4 More rigorously, video tape has so far initiated only half the process. The superior accessibility of printed materials has rested on two related, but different, techniques -- title pages and pagination. Title pages allow people in many places at many times to easily gain access to the same work. This can be immensely helpful, but if the work in question is large and complex, it still leaves people with a difficult problem of "getting to the point." Pagination within the edition solves this problem, allowing a reader not only to get to the right work, but also to the right place in the work, with ease. The commercial availability of videotapes allows a community of viewers, dispersed in time and space, easy access to the same film, exactly as a community of readers, dispersed over centuries, have had with important books. The second technique, analogous to pagination, has not generally been reached, however, even though technically it is a trivial task to put searchable timecode on the tape. Videodisc and the full conversion of analog media to digital form are rapidly completing the second stage of retrievability.

5 As we here use "verbalization" to describe far reaching assumptions about the relation between words and symbolic notations to higher-order thinking, so we here use "visualization" expansively to situate reflective thinking in pre-linguistic forms of perception and awareness, which may then be expressed through words and symbolic notations, or through images, sounds and all manner of associations and actions. In this sense, "visualization" is not a mere opposition to verbalization, not a simple alternative to it, but a Hegelian *Aufhebung* of it, the upheaval of it into something else in which the original form remains nevertheless included and preserved. "Visualization" in this extended sense includes "verbalization" as one among a number of different forms of reflective thinking, which all should be integrated into a comprehensive and many-sided culture and education.

We propose to investigate how to facilitate such visualization of education. This requires that we find how to create multi-media presentations and to stock the curriculum with them and to present the whole effectively to students. Such inquiry reaches very deeply into the basic assumptions about teaching and learning and educational common sense. Gone is the finite body of subject matter that should be teachable and that students can be held responsible for learning. The idea that good learning consists in apprehending what has been taught no longer will hold. With multi-faceted curricular resources, which can sustain many valid paths of inquiry within them without any inquirer exhausting all their contents and permutations, one cannot specify precisely what has been taught. Hence, our effort also requires that we develop important new forms of evaluation. Verbalization pervades existing forms of evaluation, which usually test the recall of verbal information and assess students' capacities to express their ideas in writing. With extensive visualization in education, other ways of testing the results will become essential.[6]

In sum, then, with the effort to develop a computer-based system of education, we not only need to explore new ways of organizing culture and knowledge, we need to recognize that we change fundamental assumptions about education by doing so. With the print-based system education has consisted primarily in imparting authoritative selections of material to students who are responsible for learning them. With the electronic system the scale of the authoritative selections of material jumps significantly and the student can no longer be held responsible for simply learning them in full. Instead the student becomes responsible for intelligently exploring them and taking from them a unique but sound and useful sampling. Formal learning thus becomes much closer to experiential learning. The student needs to become a skilled explorer, not a docile learner; the teacher becomes, not the master, but the native guide, like Virgil to Dante, interpreting, elucidating, cautioning, exhorting. We propose to try to uncover and understand such changes by implementing a prototype of

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6 AND Communications, for instance, has produced an interesting demonstration tape for IBM Educational Systems in which James E. Dezell, Jr. shows how students might work with a multimedia unit on Tennyson's "Ulysses." The demonstration provides a good example of what we here call visualization and Mr. Dezell appeals at the end to his audience asking whether, in the eighteen minutes the demonstration took, they haven't learned an unusual amount about Tennyson's poem and all that associates with it. The audience acclaims an affirmative, but one would be hard pressed to devise a rigorous measure of what they learned, and even more, of what individual pupils working independently with the system might learn. What sort of student evaluation would be appropriate at the conclusion of such a unit? Surely not a simple test, multiple choice or otherwise, of the student's recall of information in the unit that the tester deemed essential. That would defeat the central idea of the system, which is that there should be more that is available and worth learning than any single user will master and that many different samples of that totality represent worthwhile engagements with the material. Evaluation of learning with such systems will have to somehow assess the *scope* and *sample* of a student's knowledge relative to the universe of what might be learned. This will not be a simple thing to do.

the new system and attending closely to how it changes patterns of educational activity within it.[7]

Improving the Conditions of Educational Work

Teaching in the print-based system has required skilled professionals. The earliest Protestant theorists of schooling pointed to the importance of well-trained teachers, if the system were to be effective. And the need has been constant since then. Nevertheless, the conditions of educational work within the print-based system have had significant deficiencies. Teaching a set curriculum with set texts tends to be highly repetitive, year to year, and teachers often find their work routinized. They cannot do much beyond the text and after a few times through, the text becomes a familiar locale that ceases to challenge their imaginations.

Allied to routinization is deskilling, which is a kind of routinization that happens, not as a by-product, but as the purposeful result of policy. When work requires higher levels of skill than the average worker may possess, managers have often tried to simplify the job, believing that to be a more efficient solution than improving the skills of the worker. Complex tasks once performed somewhat unpredictably by high-paid skilled artisans were analyzed into component steps that anyone, following instructions, could passably perform. Unskilled workers replaced the artisans with the process tightly managed according to the principles of Frederick Winslow Taylor, and the output became predictable and the production costs minimal. Curriculum developers have sometimes used these techniques to seek a "teacher-proof" curriculum, hoping thereby to better guarantee results and to get by with lower pay for less-skilled teachers. In many industrial areas, such processes have reduced numerous artisans to mere machine-tenders, mindlessly repeating dumb tasks as products wend toward completion along the line.

An industrial system that achieves production efficiencies by steadily lowering the skill requirements in many forms of work over several generations can find itself in trouble should the skill requirements of work suddenly increase. Advanced technologies in the workplace have caused precisely this shift in recent decades. In factory and office, deskilling jobs had made much work diseducative. And educational preparation for work in such jobs put a premium on rote learning and routinized teaching in the "factory school" where students were primarily acculturated through drill and practice to follow instructions with uncomprehending accuracy.

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7 Preliminary thoughts about principles that can suitably guide the construction of such systems are in Appendix B, Section 2, "Toward a Pedagogy for the Cumulative Curriculum," page 167.

Increasingly, high technology reverses the polarity on the skill needs of labor in the industrial and service sectors. Machine-tending jobs, performing a single task according to a prescribed manner in a complex division of labor, are growing scarcer. Process-managing work, controlling a complex system by monitoring information about the condition of its parts, has become more prevalent. In them, a mindless mistake can prove most costly. This shift in polarity carries all the way through the educational enterprise. Learning to learn and critical thinking are fast becoming important educational results, not only for the most successful, but for all who go through the system. In such a situation, the demand arises for more highly skilled, fully engaged teachers. Hence it is becoming socially important, not to simplify instruction so that any teacher, no matter how unskilled, can make it work provided he follows instructions, but to structure it so that the teacher will continually develop his skills, growing more and more adept with more and more experience.[8]

We propose to investigate ways in which a computer-based educational system can be designed to engender continuous growth and development in teachers, to provide them with an intellectual environment that does not become repetitive or static, to equip them with resources with which they can be effective from the start of their careers, while continuing to develop their skills as their experience grows. Above, we surveyed possible changes in how educators motivate students and how they organize culture and learning to provide broader, more engaging access to it. These changes can have profound effects on the work of teaching, changing what teachers do and can be held accountable for, expanding the opportunities for personal growth. As that happens, the profession of teaching may become more attractive to the talented and ambitious, salaries may increase, and the prestige of the teaching profession may rise with the public. Such are the hypotheses that we seek to explore in this sector of our effort.

Strengthening Public Participation in Education

In order to construct a technology-based educational system, the level and structure of expenditures on education must change. Currently, K-12, expenditures on instructional materials per pupil amount to a small fraction of the total per pupil expenditures. Most go instead for salaries of teachers and staff. Here are the estimated average per pupil expenditures and national totals for public elementary and secondary schools for 1987-88.

	Per Pupil	Per Cent	Total
Elementary & secondary schools, total	$3,703	100.0	$149,420,000,000

[8] Twenty years or so ago, teacher-proofing the curriculum was a fashionable topic in the professional education literature. Now teacher-burnout has displaced it as a topic of considerable concern.

Administration	$166	4.5	$6,701,000,000
Salaries of Instructional Staff, total	$2,151	58.1	$86,798,000,000
Other expenditures for instruction	$341	9.2	$13,779,000,000
Operation of Plant	$279	7.5	$11,238,000,000
Maintenance of Plant	$104	2.8	$4,215,000,000
Fixed Charges	$363	9.8	$14,637,000,000
Other School Services	$299	8.1	$12,051,000,000
Capital Outlay	$395		$15,932,000,000
Interest on School Debt	$122		$4,925,000,000
Total enrollment			40,350,000

The line, "Other expenditures for instruction," seems at first to represent a nearly sufficient sum, close to $350 per pupil per year, to have substantial technology outlays for each pupil. The following table provides a breakdown of it, showing far less to be potentially available for investment in technological resources.

	Per Pupil	Per Cent	Total
Other expenditures for instruction	$341	9.2	$13,779,000,000
Clerical assistance to instructors	$84	2.3	$3,372,000,000
Teacher aids & para professionals	$28	0.8	$1,112,000,000
Free textbooks	$26	0.7	$1,056,000,000
School library books	$17	0.5	$677,000,000
Teaching supplies	$49	1.3	$1,994,000,000
Other instructional expenses	$138	3.7	$5,569,000,000

The first two subcategories represent further salary expenses and the last line covers things like travel, graduation ceremonies, and other special aspects of the academic program. If all textbooks, library books, and teaching supplies were devoted to technology in a computer-based system with expenditure patterns otherwise similar to those currently in force, $92 per pupil per year (2.5% of expenditures) would be available for hardware and software per pupil. True, this amount would aggregate nationally into a lot of money, but it would be far from sufficient to provide the technical investment needed per pupil for a fully computer-based educational system.[9]

With a heavy infusion of technology, other educational costs will not decline. Were we to assume that the technology makes it possible to have fewer teachers, a questionable assumption, the level of average salary for teachers would likely rise proportionately, keeping labor-related costs even. To implement a technology-based educational system, total per-pupil expenditures will need to increase significantly with a substantial increase in the expenditures for

[9] These figures are approximations, roughly sound, pending receipt of the official figures for the most recent reporting period. They were generated by applying the 1971-72 proportions for each category to the total expenditure for public elementary and secondary schools for 1987-88.

instructional materials and equipment becoming possible through that increase. Let us guess: a robust computer-based system would require spending about $500 per pupil per year (about 12% of a total $4200) on hardware and software, with other expenditures remaining about as they are. This works out to an increase in total public school expenditures of about 13.5%, an increase sufficiently large to require a compelling public justification before it would be incurred. At that level of expenditure, however, we are postulating an annual American market for educational hardware and software for public elementary and secondary education, alone, of over 20 billion dollars, so it may well be worth exerting the serious effort!

Having to develop powerful justifications for substantial increases in educational expenditures is not a novel challenge. Universal, compulsory school systems evolved as nations found reason to devote increasing percentages of their GNP's to such costly instructional efforts. Over the past five hundred years, the provision of education has *never* become more efficient, providing significantly more output for substantially less input. Rather it has become more *important*, more *valued*, with the public deciding that increased educational results are worth increased costs. In precisely this way, policy justifications for a computer-based educational system will need to convince the public that the increased costs bring benefits that justify the added expenditures. Developing those justifications will be an integral element of efforts to invent the new system. Without them, the only things that will seem realistic from a marketing point-of-view are the creation of specialized adaptations to the existing system that fit within the existing per pupil expenditure patterns. Those might make a few entrepreneurs wealthy, but they will not create a systemic change in education.

To institute a new system of education, educators will need to marshall large arguments of broad public purpose. These are of three general types: arguments of relative national advantage; arguments concerning the achievement of basic civic goals; and arguments that something is a good an end to be sought for its own sake, not merely as means to something else. We propose to investigate the degree to which the development of a new, computer-based system of education can provide grounds for each of these types of arguments.

Relative national advantage. In the late 1950's the pursuit of relative national advantage through education resulted in the National Defense Education Act. Now the quest for military preparedness has given way to the problems of remaining competitive in a global economy. A fully developed computer-based educational system can have three types of significant effect on the over-all competitiveness of the American productive enterprise.

- First, insofar as the computer-based system is substantially more effective than the print-based system, the general level of American preparation for productive effort within a knowledge-based economy will rise.

- Second, insofar as the economy itself is increasingly a computer-based system, a computer-based educational experience would align more effectively with the skills needed in the job market than a print-based experience would, even if the absolute level of attainments through the former were not significantly better than they are through the latter. At least the student would be acculturated to the significant tools needed in the workplace.
- Third, insofar as the organization of work in advanced sectors of the economy places a greater premium on persons' abilities to function cooperatively in groups, a computer-based educational system that substantially extended opportunities for cooperative learning would better prepare students for working together in ways that the economy needed than the competition-prone print-based system would.

We hypothesize that all three of these benefits would develop with a shift to an intensive use of information technologies in education and we will seek to develop and test such hypotheses.

Achieving basic civic goals. Although the agenda of freedom has taken great strides in most recent history, that of equality has been stuck in stasis. Significant portions of the population are addicted, nearly unemployable. Uncounted families cling to survival -- homeless street people hawking *Street News*, begging, and scamming, and groveling through the refuse of the relatively rich for cans and bottles redeemable for a nickle each. Many, prideful on having made it, blame social failure on the failings of those who suffer the failure, and espouse social policies designed primarily to help those already adept at helping themselves. In our willingness to bail out bankers who mismanaged the savings of the middle class while we cut back on programs to serve those most in need, we poorly represent the centuries of humanitarian progressivism that has animated our traditions. The agenda of equality merits substantial civic effort.

Educationally the problems with the agenda of equality appear in the prevalence of drugs, dropping-out, and the difficulty of making schools work in areas of chronic urban and rural poverty. These are big problems and they will require complex solutions. Efforts to deal with these problems by further improving the current system of schooling will not work. Unfortunately, the current system is part of the cycle of causality, not a means of breaking it. Interpreters of the education system tend to be people who have done well within it. They experienced schooling as a happy system for self-development and self-advancement. Interpreters often therefore have difficulty seeing how the experience of the less successful was fundamentally different: for many others, the same system functions as a powerful social sorting mechanism, frustrating their self-development and reinforcing their disempowered status. A computer-based system of education may help break the cycles holding the truly disempowered in thrall in three ways.

First, the way the current system handles subject-matter is invidious. Size limits on textbooks require that a very limited selection of ideas and information be packaged together. The materials chosen become, ipso facto, sanctioned by inclusion in the standard texts and tests. The result will harmonize with the experience of some children and be at odds with that of others; some will find more with which they can identify emotionally, and others less. Interest groups realize that what the selection includes and excludes has import, good and bad, for their interests. However, where the scope and compass of texts is seriously limited, the politics of textbook development and curriculum design has become a contest to exclude whatever particulars may offend an articulate sensibility. Increasingly, such efforts to exclude all possible cultural bias tend simply to render the curriculum pedagogically impotent for all. In contrast, computer-based curricula can be comprehensive and inclusive. The politics of a computer-based system has the possibility of opening the narrow confines of the standard curriculum to genuine multi-cultural possibilities. With the new system, the politics of curricular development will cease to be exclusionary, becoming instead a many-sided effort to ensure that what may empower this or that interest finds its place within the spacious system. We propose to work with diverse racial and ethnic groups to develop multi-cultural curricula through which high levels of disciplinary mastery can be achieved along numerous paths of interest and inspiration.

Second, reliance on printed sources in the current educational system provides a narrow access-path to the power of knowledge. Those who experience the existing system as disabling do not do well with book learning. To be sure, in theory the system offers them vocational tracks, which put greater stress on learning to make productive use of hand and body. But these tracks have a stigma associated with them because everyone knows that in a print-based culture the only real access to knowledge is through verbal facility, and no matter how *manually* skilled one becomes without high levels of verbal knowledge one will be held *mentally* second-rate. Insofar as a computer-based system can complement the verbalization of print media with the visualization of electronic media, multiple access paths for acquiring and manifesting mental excellence will open. This will not do away with distinctions between people with respect to intelligence and intellect, but it can broaden the existing structure of intellectual opportunity. We want to implement a thoroughly technology-based curriculum so that it will make full use of the power of visualization in our culture.

Third, the way the existing system motivates educational effort through pervasive competition creates a sorting mechanism that deprives disempowered groups of their more able members. Those who succeed in the competitive assent often assimilate to the dominant elites. Imagine an educational system that did a better job at fully developing the potentialities of each person while less effectively grouping and sorting the members of age-cohorts according to their performance on a narrow set of mandarin acquirements. Such a system would be a very different response to the Jeffersonian idea that talents distribute randomly through a population. Rather than co-opting those talents to the

service of power and privilege, it would preserve those talents in their random distribution, leavening the whole through a multiplicity of communal excellences. A computer-based educational system that can put a premium on cooperative learning and offer a multi-cultural curriculum with many paths to mastery within it has the possibility of functioning in this more genuinely Jeffersonian manner. We seek to implement a technology-based system of education in order to explore the possibility of such socio-cultural effects.

Education as a good in itself. Soon the ethos of "More" must give way to an ethic of "Enough." As that happens, problems of public purpose will remain, but they will undergo revaluations. In the era of print, the basic justification for the support of education has described schooling to be a useful means to the achievement of publicly sanctioned ends. For the past few centuries, those publicly sanctioned ends have often been variations on "More" -- more power, more wealth, more influence, more adherents, more law and order, more of what-have-you. What good did the print-based system serve as it mobilized competitive energies to distribute broadly a level of literate skills through the population and sorted the young effectively according to the quality of their performance within the system? It served best as a means in the pursuit of "more." Would it serve well in support of an ethic of enough? One might suspect that a system that relied on cooperative learning, that could attract participation in educational self-development, not as a means but as an end itself, providing an enhanced quality of life, bonds with others, shared experiences of personal meaning, would be an education well adapted to the ethic of enough.

A competitive ethos of "more" can take hold among people when they feel they can safely compete for possession of finite, limited goods. Where the competitors become aware that the competition is fundamentally unsafe and unstable they withdraw from the unbridled continuation of it. In the late twentieth century, the age-long competitions for national power, pursued through the pursuit of more population, more armaments, more material output, has become increasingly unsafe and unstable as armaments become too destructive to use, populations too large to feed and nurture, and material output exhausts natural resources and threatens to destabalize world climates and ecologies. Unlike the various forms of power, which are finite and relative, education is not a limited good. More education for one need not mean less for another. Hence, education can be a public purpose, one pursued by each and all, without an inherently limiting competition arising, without one person being pitted against the other. Taken as a means to relative advantage, people have an interest in acquiring learning and withholding it from others. But taken as an end in itself, people have an unbound mutual interest -- the educational attainments of others enriches the educational possibilities that I enjoy. "A learning society" is a society adapted to a world of finite resources. A computer-based educational system is not the only possible basis for a learning society, but insofar as it can supplant competitive educational motivations with cooperative ones, and insofar as it can genuinely broaden educational opportunity by opening multiple channels

to knowledge, it will facilitate the emergence of such a society. We propose to explore how well education can serve, in-itself, as the basic goal of civic life, serving not merely as a means to some other purpose, but as the good animating the common pursuit of the good life.

3 WHAT IS TO BE DONE

We aim to prototype a new system of education, one based on the intensive use of multi-media information technologies as the primary means of access to the cultural content of education. To accomplish this purpose we need to be mindful of its complexity. We cannot simply apply multi-media technologies to existing components of the educational system, designing technology-delivered lessons for the existing curriculum. Likewise, we cannot simply layout the five major components of the task in a sequential order -- first designing a new environment, then developing a new pattern of motivation, with that followed by a comprehensive effort to organize the cultural content of education according to the new principles, proceeding to set up training programs for teachers, and concluding with an impassioned call for public support of the new system. To work well on the tasks we need to proceed with them all, as much as possible in parallel, with an effort to note which define the critical path, the timing determining when the whole can begin to function.

Let us try to situate where things stand in a schematic way. From that baseline we can chart what is to be done. In this, we will use single terms -- Environment, Motivation, Knowledge, Profession, and Policy -- to denote the complex domains discussed above. The current situation confronts us with isolated pieces and parts, each of which has been fashioned without concern for its place in the whole. Educators are gaining experience with the diverse components of a new system, but that is not the same as beginning to put a preliminary version of the new system together.

Summaries of the Current Situation

» **Environment.** Here and there, one can find sophisticated efforts to think out the design of technology-based educational environments. But insofar as designers have built these visions, they have used what we call *transition technology,*[10] a technology that bears little relation to what

[10] Technological innovation usually follows an S-curve, along which change accelerates, ascends, and then tapers off. Many of the specific innovations in the acceleration and ascent phase but not very indicative of what the technology will be like as it levels off into maturity. The standalone microcomputer with a character-based screen and software on a floppy disk is as much an artefact of transition technology as are punchcards, starter cranks, or house-top TV antennas. We will use the term "mature technology," in contrast to transition technology, to describe the technical characteristics of a system after the pace of innovation has slowed.

can and should emerge. Insofar as designers have anticipated a mature technology, they have not really built the designs, not for want of technology, but for want of the intellectual content with which to test the technology realistically.

- **Motivation and Assessment**. Likewise, inquires into the possibility of alternative motivational strategies in education occur, but these generally take place in settings designed for the traditional system, with materials developed for the sequential curriculum, and evaluation procedures devised to suit its ways.

- **Knowledge**. Numerous multi-media educational units exist, created to demonstrate concepts or to fill niches within the print-based curriculum. These units have been developed for diverse specific systems: even if they covered the scope of what the new system needed, they could not all function together. In that sense they are neither sequential nor cumulative and they are, all things considered, still far from covering the full scope of materials requisite for a curriculum. A technology-based curriculum, sufficient to support a cumulative educational experience for a cohort of children from start to finish, does not yet exist.

- **Profession**. Teacher training programs for the use of technology in education have lagged far behind the scope of the task. For the most part these programs introduce teachers to the use of transition technology, which may be useful in raising their consciousness and confidence about the pedagogical potentials of technology. Professional training for work with a mature educational technology has not begun.

- **Policy**. Policy discussions of technology in education have raised expectations and have begun to define the full scope of the task. They are limited, however, because the available examples implement transition technology, which may perform quite differently from the way a mature technology will perform. Further, the modes of evaluation available have been designed to document the relative effectiveness of options within the existing educational system, not to assess alternatives to it.

Project planners, faced with such a complexity of tasks, need to decide where the critical path to their implementation lies. Work can proceed in parallel on several aspects of the problem, and in due course a fruitful interaction between the different aspects can emerge. But one of them will be pivotal, critical, defining how quickly the whole project can move ahead. With respect to the new educational system, the critical sector is that of Knowledge, the reorganization of knowledge for presentation through multi-media systems in ways that differ significantly from the presentation of knowledge through printed materials. Without that, new environments will be visionary, not usable; strategies of motivation will be hypothetical, not actual; reforms of the teaching profession will be utopian, not practicable; and policy rationales will be

unrealistic, not down-to-earth. In order to develop the new system, we need to draw together a full multi-media knowledge-base that can serve as the cultural content of a complete education. Without that we are not coming to grips with the challenge.

Operational Goals of the Project

In order to think out the process for creating this full multi-media knowledge-base, we again need to put established curriculum-development paradigms in abeyance. Essentially we must substitute a cumulative resource for a sequential one. With the sequential curriculum, developers would work grade-by-grade, following, with one or another distinctive variation, the typical and mandated syllabuses for subject and age-group. We are discussing a new system precisely because a comprehensive electronic curriculum will *not* be sequential in the same way that the traditional curriculum is and consequently we *cannot* use the same strategy of design and development. In order to develop a traditional curriculum step-by-step, one can do it a grade at a time. To develop the new curriculum through a series of steps, something different must be tried, namely filling out a sparse matrix.[11]

Think of a painter composing a large canvas. She does not treat the whole as a sequence of component panels, say three rows of four, starting at the lower left and completing the first panel, then moving on to the one to its right and so on until all twelve are executed, one by one. She would, instead, sketch the whole composition, making sure that the essential components of the composition balance and interact effectively. Then she might roughly fill in much of the painting and bring some parts to an early, tentative finish while leaving other parts close to the first sketch. Working here, then there, sometimes making significant alterations in the original conception, she completes the whole work. Such a procedure works, with adjustments, in diverse areas of creation, where people create functional wholes. We call this process one of filling out a sparse matrix, and it is the form of implementation especially appropriate where the elements have not been previously organized into a set sequence.

To get a better sense of how the lack of sequence affects the process of completion, consider a different, but similar, example. Compare how people distribute themselves in a subway car with how they board an airplane when having been assigned sequentially ordered seats. The airline attendants will call the passengers by rows, boarding, in this case, from the back to the front in a way similar to how one implements a traditional curriculum grade-by-grade. The subway car in a more random way, as a sparse matrix, with each new passenger

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[11] We do not suggest here that the way any particular child experiences the multimedia curriculum will be devoid of sequence. The curriculum must sustain many different sequential encounters, and hence it cannot be phased in, step one, step two, step three, according to a cannonical sequence. Here we are discussing the problems of curriculum development, not the characteristics of the pedagogies that should guide its study.

usually seeking to situate himself with the maximum open space between himself and other people. The basic algorithm of maximum face-to-face distance will be further adjusted by factors based on gender, ethnicity, age, class, and comportment, but however modulated the car fills up, not sequentially, but diffusely, with all the space being occupied all the time at variable levels of density. The multimedia electronic curriculum needs to be implemented in this way.[12]

How large should our subway car be, so to speak? What should be the full capacity of the cumulative curriculum? However sparsely filled out at the beginning, its scope should be the full range of knowledge that a highly able undergraduate might be expected to have acquired on having completed his or her general education. We want to emphasize that this college-centered scope is appropriate *for the K-12 curriculum.* We have two main reasons for adopting this scope. First, the existing system already incorporates the content goals of undergraduate education by providing a means by which students can earn "advanced placement" credit. It would not be appropriate to have a lesser scope for the new system. Second, if the new system has a future, it will need to perform more effectively than the old one, by a significant margin. If the existing system allows the gifted few to achieve advanced placement, the new system should engender something approaching that level of performance from the average student. For these reasons, we conclude that the scope of the new curriculum should to be that of good undergraduate general education.[13]

Given this scope, how will the project proceed? What will its specific activities be and how will it be organized? Here are operational goals that we want to achieve, with an indication of the timespan during which we will actively work on them.

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12 A movie theater generally fills also in a random way compared to the sequential boarding of the airplane, with people seeking to situate themselves in the theater with least obstructed views according to one or another preferred perspective. Some want to be up close, others way back; some by an aisle, others in the middle. Even with only a few people in the theater, most of the seating regions will have someone in it, and as the theater fills, the more popular areas will pack dense first, but all the areas will fill out according to the play of preference. The multimedia electronic curriculum should to be implemented in this way, with something in all its parts, but more in some areas, the whole filling in, something here and something there, until all that should be included has been included.

13 Immediately here the question springs forth: how will younger children be *ready* to study such an advanced body of knowledge? We cannot answer this questions, lacking suitable curricular tools to have acquired experience with which to form an answer. We aim through our project to create those tools in order to seek answers to this question. We can observe at his point, however, that the question gains much of its force from our inveterate habit of thinking about the course of study as a sequential one in which the child moves through the succession of grades as a preparation for exposure to the content of undergraduate study. We confuse the way we do things with the way things must be done to the point of loosing sight of the fact that we also do things in other ways. Thus, the child did not learn his mother tongue through sequential study: he was immersed in the milieu where it was spoken and he learned it by exploration and use, with that learning being cumulative for life.

- **Environment.** Design the physical and temporal layout for work with the cumulative, multi-media curriculum and build versions of it for use at The Dalton School and the District 2 Lab Schools, starting with the 1993-94 school years. Evaluate, refine, and expand the designs for 1994-95 and 1995-96 to accommodate successively larger cohorts of students. At the conclusion of this effort, we should have practical experience in organizing educational time and space for work with the new system. Deliverables: a book of designs; two prototype designs built and tested; an evaluation report based on experience with these. (1991-1996)

- **Motivation/Assessment.** Establish liaison with the multi-media project at P.S. 92 to explore patterns of engagement that work with students. Begin to develop ways of evaluating the performance of students working with a cumulative, non-sequential, curriculum and of giving students and teachers feedback useful in individual and group learning situations. Extend these explorations with the groups at Dalton and the Lab Schools. At the conclusion of these explorations, we should have grounded knowledge about the patterns of motivation that will work with students using a cumulative multi-media curriculum and practical experience in assessing and guiding their work with these resources. Deliverables: curriculum materials and study tools with appropriate motivational strategies and assessment resources built into them. (1991-1996)

- **Knowledge.** Prototype a comprehensive, multi-media curriculum, sufficiently full in content for students in the 4th through 9th grade age-brackets to acquire a cumulative educational experience lasting three years. At the conclusion of this effort, we should have a sound implementation of a new curriculum, one ready for further development and evaluation at all levels of education. Deliverables: a cumulative multi-media curriculum and a practical integration of multi-media technologies that will allow teachers and students to use the curriculum with ease. (1991-1996)

- **Profession.** Organize a demonstration-design seminar for teachers from diverse settings to explore the pedagogy of the cumulative multi-media curriculum. Use the pedagogical framework developed in these seminars to prepare cohorts of ten teachers for 1993-94, 1994-95, and 1995-96 to work with the prototypes and students at Dalton and the Lab Schools. At the conclusion of these activities, we should have a group of 30 teachers with working experience of the new system and a network of interested schools and teachers through which we can further develop educational principles pertinent to a cumulative curriculum. Deliverables: materials suitable for training teachers to work with the new curriculum. (1991-1996)

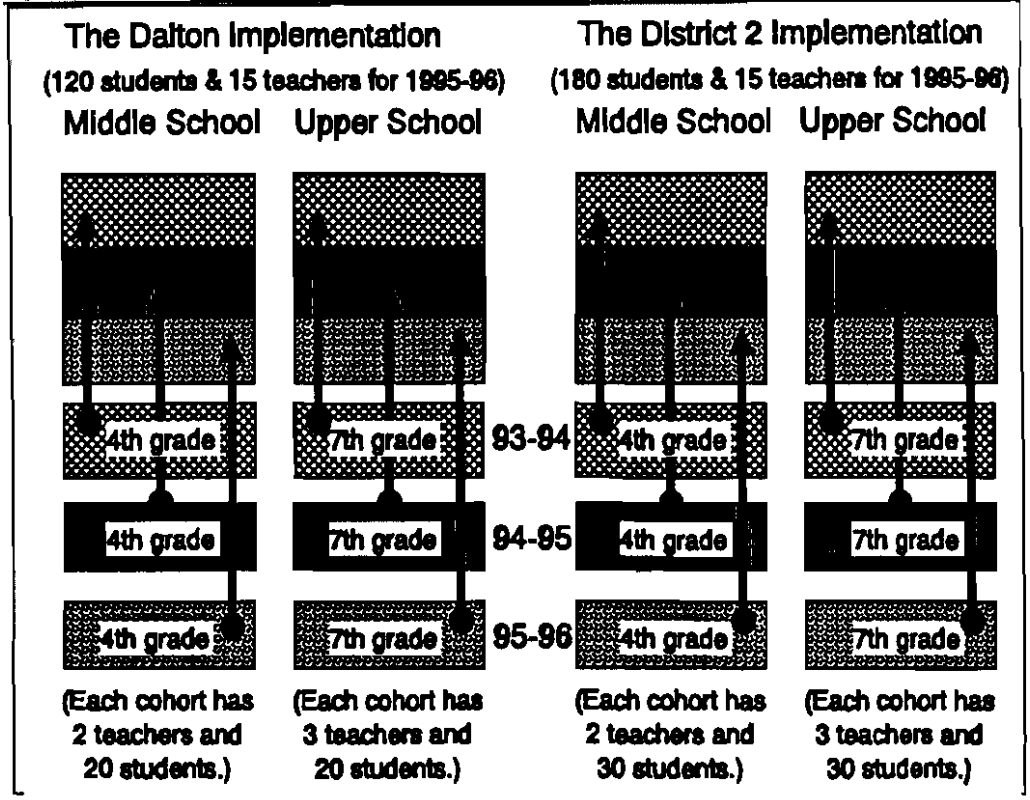
- **Policy.** Plan and carry out a set of specific studies of policy problems associated with the cumulative curriculum. To extend preliminary

experiments with a cumulative multi-media curriculum into a full-fledged educational system, numerous issues will need clarification. As we become aware of these, we will try to address them systematically. At the conclusion of this effort, we should have reflective reports on selected issues that have impressed us in the course of exploratory work as problems to be considered in preparing for larger-scale implementation. Deliverables: a half dozen or so studies, suitable for public dissemination, of policy issues raised by the Cumulative Multi-media Curriculum. (1991-1996)

In each of these areas we have made preliminary, but comprehensive, inventories of activities to be accomplished. Here we provide a summary indication of the work to be carried out in each area.

- **Environment**. We intend to concentrate much of the work on environmental design in the first half of the project. To explain what needs to be done, we begin with some assumptions about very general features of the new educational spaces and organizations, which we need to initiate design but which may be revised as we gain experience. We assume that the year-by-year grade structure will disappear, with the 12 grades replaced by a broader age grouping consisting of four three-year schools -- Lower School (6, 7, and 8 year-olds), Middle School (9, 10, and 11 year-olds), Upper School (12, 13, and 14 year-olds), and High School (15, 16, and 17 year-olds). During this project, we expect to implement two prototypes of the Middle and Upper School, one within the Dalton School and the other within the New York City District 2 Lab Schools. We select these age segments for our first prototypes for reasons that have to do with the constraints of curriculum development and we anticipate at the end of this project to have curriculum materials sufficient for a High School prototype. For this project, however, we will populate our prototypes with progressively larger groups by adding, each year, one class of fourth graders at each location to the Middle School and one class of seventh graders to the Upper School. A schematic is at the bottom of this page.

  At the end of three years there will be 60 students in the Middle School at Dalton, and 60 students in Upper School there. At the Lab Schools, the Middle School and the Upper Schools will have 90 students each. Technology-based curricular materials for each of these groupings will have resources in them adapted to the developmental characteristics of the group. The whole ensemble of materials, however, will be available to any student within any group. Thus, as discussed above, the curriculum will be cumulative in a way fundamentally different from the print-based curriculum.



We will initiate work toward the design of these prototype schools by drawing up a detailed design program for both -- available square footage; structural limitations; ventilation, lighting, and electrical requirements; expected usage patterns; costs constraints; and so on. We then will circulate this program to prospective firms as the basis for a design competition to be completed by the end of September, 1991. We would expect to publish all the submissions and to have the winner converted into detailed plans, with structural renovations completed by June, 1993, so that equipment for the 1993-94 school years could be installed over the summer of 1993. At this point, the work on environmental design would cut back, with attention being concentrated on evaluating the effectiveness of the installed designs and minor adaptations to them being feasible during the summers of 1994 and 1995. The primary opportunity to learn from this first effort to design a new educational environment would come, however, in a follow-on project we would expect to propose for 1995-2000, in which these prototypes would be enlarged and extended into the High School level.

- **Knowledge.** We plan to begin with two intense, parallel efforts to specify the physical system for providing access to the curriculum and to

determine its content. In the first, we will research hardware options, user-interface and system software options, and presentational options. We will then draft system standards and circulate them to knowledgeable people for comment, in the light of which we will revise the standards and adopt them for the project. In the second, we will aim to establish a framework for consistently dealing with issues of subject matter selection and providing a rationale for including and excluding matters, with maintaining presentational coherence across a wide range, with providing effective tools facilitating study and expression, and with adopting strategies of clarification and explanation appropriate for materials included. [See Appendix B, Section 1, "The Stimmir," p. 159, for a discussion of concepts pertinent to the system specification.]

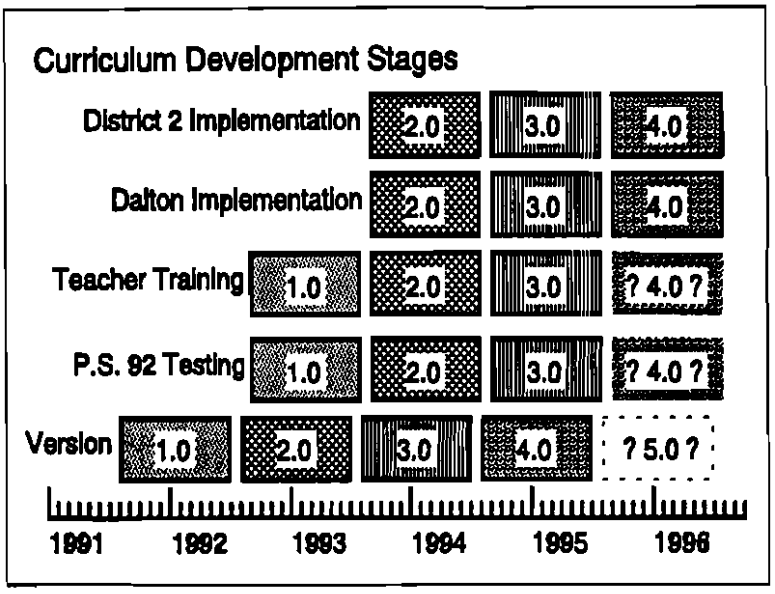
In the late Spring of 1991, we will begin the first of four successive waves of substantive curriculum development effort. These will constitute a major part of the overall project. To begin, we will install development systems at the Institute for Learning Technologies at Teachers College and the Cooper Union Research Foundation at Cooper Union. We will recruit a development team, with a specialist in each of four areas -- math/science, languages and literature, social science, and personal skill development -- and with other associates, as well as undergraduate and graduate students paid hourly, as appropriate. This team will work with the senior project members to select goals for coverage and concentration. Members of the team will work, over the course of each year, from the beginning of July through the following June, to meet those goals for each curricular area and then, during July and August, the whole group will integrate the components into one prototype delivery system.

Our curriculum effort will involve two related but distinct types of activity. One significant component of the curriculum design will use existing video, audio, pictorial, and textual materials. The curriculum development task will require selecting and integrating these materials into a manageable, usable system and developing links among them. The other significant component will entail developing new materials -- also video, audio, pictorial, and textual. The development task here requires not only selecting and integrating, but more significantly producing the materials, and it will therefore be far more costly per unit of material. To hold down costs, wherever possible, we will use existing materials rather than producing new materials. Towards this end, the Project Management Group will seek cooperative arrangements with diverse cultural institutions to gain inexpensive access to useful

collections of material. We will make a special effort to develop ways of using these collections that hold down royalty costs.[14]

Each cycle of curriculum development will provide the resources for training cohorts of teachers at the New Laboratory for Teaching and Learning at the Dalton School, who will staff the prototype installations there and at the District 2 Lab Schools. Thus Version 1.0 of the Comprehensive Multi-media Curriculum should be ready for use in teacher development September 1992; Version 2.0 should be available for use in the next round of teacher development and in the prototype installations starting September 1993; Version 3.0 will serve the same uses in September 1994; and Version 4.0 will provide the curriculum in the prototypes starting September 1995. A schematic representation of these stages appears below.

14 We believe these costs can be kept to a minimum. Too many people think of educational software using an analogy to the textbook. We suggest, instead, that the textbook will be displaced by a well developed implementation of educational technology. Such an implementation will be much more like a school library than a school textbook. We think that a large collection of tapes and digitized materials can be acquired like books in the library and used without further royalties throughout the school as requested by individual students. To make this possible, it will be important that the linking and navigating software store information about materials in idependent databases and not require that the information be uniquely recorded in the material to which it points. Thus, for instance, if our curriculum makes use of a sequence from the *Adams Chronicles* or any other tape by including in it machine instructions and capacities to load, cue, and play the tape, we would not need to acquire rights to the tape, but would rather simply need to have bought a copy of the tape that we hold in the curriculum collection.



We anticipate during 1995-96 to be working on a Version 5.0 that would be well enough filled out in substance to begin prototyping with high school students and anticipate a follow on project through the late 1990's in which our implementations extend from the upper elementary through high school and continually expand in scale.

» **Profession.** We believe diverse teachers should participate in the design and development of the cumulative curriculum. In addition, the prototypes we plan will require ten full-time teachers in 1993-94, twenty in 1994-95, and thirty in 1995-96. We do not want to engage teachers in an unstructured way, vaguely asking them how they think technology in education should be used. Instead, we plan to establish a **demonstration-design** resource for working with teachers systematically. This resource will be located in the New Laboratory for Teaching and Learning where we plan to hold Saturday workshops through each school year with teachers recruited through the Mayor's Public/Private School Partnership. In these workshops, we will demonstrate the current version of the Cumulative Multi-media Curriculum and engage participants in a participatory design process.

We expect to learn three types of things from these demonstration-design workshops. First, they should provide a form of immediate assessment of ideas and implementations. Often one only needs to show a possible implementation to someone knowledgeable to see that

something will not work well. Second, the workshops should provide design stimulation, functioning as a recurring brainstorming opportunity. On seeing one thing, one or another teacher will say, "Gee, if we can do that, why don't we try this?" Such reactions will be invaluable in developing the curricula. Third, they should provide insight into the sort of strategy that we will need to develop in order to implement the Cumulative Multi-media Curriculum on a wide scale. If the system is genuinely new, some aspects of it will prove specially confusing or difficult to manage. From these sessions we should develop insight into what parts of it confuse people are and how to best clarify the system. In addition, ten new teachers will need to be recruited and prepared for each year of full prototyping. The demonstration-design workshops will help us in recruiting and training these teachers.

Throughout the work of curriculum design, throughout the effort at professional development, and throughout attempts to create appropriate strategies of motivation and assessment, we need to search for the pedagogy and educational theory fit for the new system. Whether it rests on educational research or on practical experience, most of what people think and say about education relates to the system built around the sequential curriculum. In order to build a new system, it will be important to develop pedagogical principles appropriate to it. If the project generates new educational ideas, a major mode of self-evaluation, one especially pertinent to the area of Professional Development, will emerge. We start with hypotheses about a pedagogy appropriate for guiding our work. Appendix B, Section 2: "Toward a Pedagogy for the Cumulative Curriculum," p. 167, introduces some of these ideas. A measure of the success of the overall effort will depend on how much, as a result, we can extend, revise, and improve such ideas.

- **Motivation/Assessment.** Motivation and Assessment Design will concern strategies for activating the energies of students, developing the means for assessing their work, and giving them useful feedback and guidance. Our first efforts here will be to design the system to facilitate cooperative learning. Current assessment strategies concentrate on normed tests in which comparisons to the performances of others provides the reference point. Such procedures do not lend themselves well to the assessment of group achievements and they provide little inducement to cooperative inquiry. Further, they do not help a student understand what he or she knows, but rather they provide statistical information on how he or she stands relative to others who also took the test.

  Assessment within the new system should be, as much as possible, criterion-referenced rather than norm-referenced. In criterion-referenced assessment, the matter at issue is not what other students have done,

but whether or not one knows and understands the subject. Criterion testing can provide substantive feedback and help in self-paced, self-directed study. And even criterion-based evaluation will be too restricting in many ways, for in making the test, one must set a clear criterion. Students often need feedback of a sort more subtle than being told "right" or "wrong." Like travelers, who are getting to know a territory, exploring first this village, then that view, going here and there with the excitement of discovery, they need orientation from time to time, a guidebook, maps. It is the sequential context of the traditional curriculum that puts the angst into assessment, tinging it with a threat -- this pupil might not be ready to proceed. In a cumulative context, the most important purposes of assessment will change, becoming perhaps very matter of fact -- this student has been here and done that and she might try this, or that, or some other thing. Developing such assessment procedures will be part of creating the overall curriculum resource, and they are essential components in the full navigational resources the system can provide its students.

We will start by establishing liaison with *Kids at the Wheel*, a related project at P.S. 92, which uses a pedagogy of self-expression through multi-media as a way to engage third and fourth grade students in the process of learning. The importance of navigational assessment is implicit in the very name of this project and it should serve for us as a pre-prototyping site informing the work on Version 1.0 and 2.0 of the Cumulative Multi-media Curriculum. In this situation we will begin to deal with motivational and assessment issues raised when the learning situation is open, and we will begin to see what happens when groups whose members have differing strengths and interests, in the sense of Howard Gardner's "multiple intelligences," interact with it. To what degree, in such situations, should students be given free rein to do what comes naturally and to what degree should each be encouraged to go against his or her grain?

As we move into the full prototyping stage, we will concentrate further on developing assessment strategies appropriate for the mix of motivational strategies used in the curriculum. Currently, most forms of student assessment make sense with competitive motivational strategies and they will not help much. Means will need to be designed to discouraging students from "plateauing," or becoming satisfied with a given level of competence, and from "niching," or encapsulating their effort in one area that comes easily to them. The demonstration-design workshops with teachers will probably prove very important in advancing work on assessment resources. Is the pupil ready to move to the next stage of the sequence? This is the basic question in the context of the sequential curriculum. Our work in the area of motivation and assessment will depend for success on our ability to see clearly that

readiness to move on is no longer the basic question in the context of the cumulative curriculum.

» **Policy.** A variety of issues will arise as we proceed that should trigger systematic policy study. No large-scale system optimizes at its absolute level of potential peak performance. There is a complicated balancing between costs and performance. Nations could improve the performance of their sequential school systems, as they could push the normal speed of air travel beyond the speed of sound, but generally they do not do so, for the added costs, relative to probable benefits, in the end become daunting. Large-scale systemic change is unusual and requires a convergence of many factors in order to come about. Not all feasible systems take hold in practice -- witness the difficulty in introducing the metric system of weights and measurements in the Anglo-Saxon realms. Not all calls, even when broad-based and well-founded, for the significant transformation of practice result in effective solutions -- witness the difficulty solving problems of waste disposal in our society.

Mass schooling using the sequential curriculum is an area that may have been optimized, even though people believe it to be obvious that schools could do much better if only . . . . If only, say, the teacher/pupil ratio could be significantly improved. Would the costs, easily an additional 15% to 40% of current totals, be worthwhile? If only, say, teacher pay were improved to make it competitive with more lucrative professions, attracting more of the best and the brightest into educational careers. Again, would the costs, again easily an additional 15% to 40% of current totals, if not more, be worthwhile? It is not the task of this project to essay answers to these questions. It should be its task, however, to seek to answer similar questions that will arise should the cumulative multi-media curriculum be workable in prototype form.

- ¶ What funding issues would arise and need workable solutions for a prototype to become a system?
- ¶ Would the teaching profession need to change significantly and, if so, how and would those changes be feasible?
- ¶ Would the mix between education as a venue for research and the advance of knowledge and education as the process for disseminating knowledge and skills change and if so, what would be the consequences?
- ¶ If cooperative learning begins to displace competitive learning, how will the needs of practical life to sort skills and to credential competencies be met?

These are the sorts of questions we should have in mind while carrying out the overall project. The overall project will consist of numer-

ous operational choices and these should be made, not only with reference to immediate constraints, but also with respect to a feel for the larger situation. For this reason, we do not plan to set up a separate group charged with conducting policy studies. Rather we intend to have that process take place within the key management group for the project. As the work proceeds, operational issues will arise that will have significant policy implications. For instance, different ways of implementing the database essential for the cumulative multi-media curriculum may have different consequences vis-a-vis intellectual property rights, potentially making a technically convenient implementation very costly in the long run. To decide such operational choices well, with foresight, we should have the issue of rights and royalties under careful study. Throughout the project, we will try to be responsive to such issues and to make our operational choices in full awareness of the broad horizon of relevance.

Project Structures

To achieve our operational goals, we need an effective organizational structure. The key structure will consist in a Project Management Group, composed of senior participants in the project, that will meet quarterly, if not more often, to monitor work in all aspects of the project. Two standing sub-groups will overlap with the Project Management Group -- the Professional Development Group and the Curriculum Design Group. The first of these will combine responsibility for Environmental Design, Motivational Design, and Professional Development. The second will concentrate on Curriculum Design. The two sub-groups will plan and conduct the substantive activities of the project; the Project Management Group will be responsible for the setting of goals, the allocation of resources, and the selection of participants.. Extensive overlapping membership will ensure good communication between the groups -- each group represents a distinct focus of responsibility and concern more than a different hierarchy of offices and personnel. A conceptual map of these project structures appears on page 52. Briefly, here is the composition and purview of each.

» **Project Management Group.** This Group will run the overall project and will include the following:

- ¶ Project Director, Robert McClintock, who will serve as the Manager of Curriculum Design;
- ¶ Project Co-Director, Frank Moretti, who will serve as the Manager of Professional Development;
- ¶ Manager of Environmental Design, to be recruited;
- ¶ Manager of Motivation and Assessment, to be recruited;
- ¶ Project Executive, to be recruited;
- ¶ 2 Policy Studies Associates, to be recruited; and

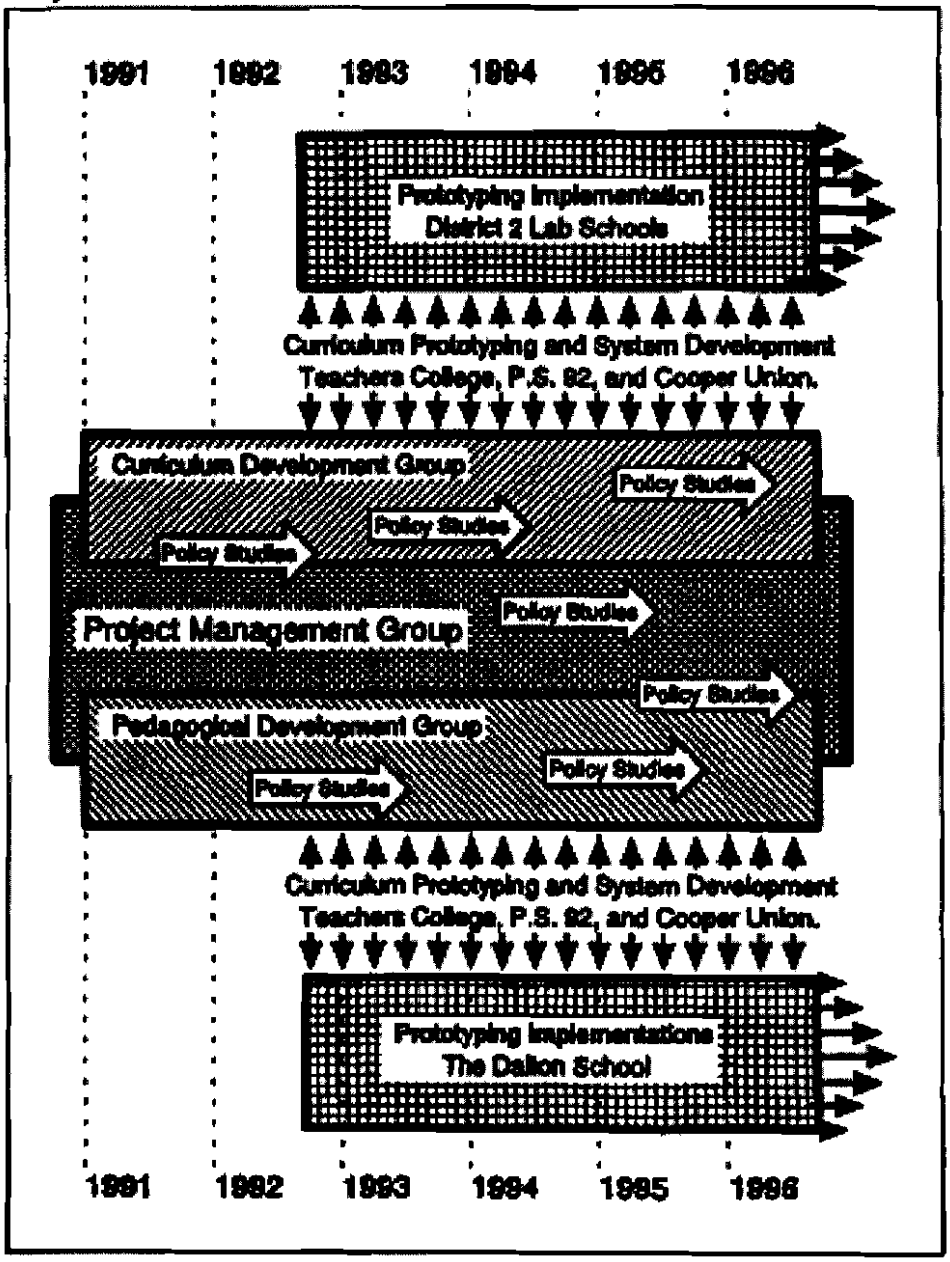
¶ 4 Project Principals to be assigned by IBM Research.

The Project Management Group will meet regularly and collegially discuss all aspects of the project. It will set priorities, allocate resources, and hire project staff and participants. Usually the Group will make decisions by consensus, but where uncertainty or disagreement predominate, it will be the responsibility of the Project Director in consultation with the Co-Director to make decisions and to take action. Policy Studies will be managed directly by the Project Management Group. The other substantive areas will be managed through the two sub-groups.

» **Professional Development Group**. Frank Moretti, Project Co-Director, will chair the Professional Development Group. Its membership will include the Manager of Environmental Design and the two Environmental Design Associates, the Manager of Motivation and Assessment and the Motivation and Assessment Associate, and the two Professional Development Associates. The Project Director and Project Executive will serve ex officio and two of the Project Principals from IBM Research should also participate. This will make a regular membership of twelve. This group will set and monitor the agenda of substantive work in the areas of environment, motivation and assessment, and professional development.

» **Curriculum Design Group**. Robert McClintock, Project Director, will chair the Curriculum Design Group. Its membership will include the System Design Manager, the Math/Science Curriculum Manager, the Social Science Curriculum Manager, the Personal Skill Curriculum Manager, and four Curriculum Design Associates. The Project Co-Director and Project Executive will serve ex officio and two of the Project Principals from IBM Research should also participate. This will make a regular membership of fourteen. This will make a regular membership of twelve. This group will set and monitor the agenda of substantive work on developing the cumulative curriculum.

Project Structures and Activities



Key People

We propose a comprehensive redesign of the educational system and to accomplish this purpose, we need an unusually broad range of participants. We want to set the project up, however, with several strict ground rules concerning the recruitment of participants. Often an extensive roster of participants precedes a project, with the result that funding, when secured, tends to become funding of the participants rather than funding of the project. This weakens the ability to manage the overall project and diffuses effort. We explicitly seek funding for the project, not for a predefined roster of participants. Only two roles, Project Director to Robert McClintock, and Project Co-Director to Frank Moretti, have been assigned to individuals at this point. If funded, the first major activity they will have, as the initial implementors of the project, will be to start recruiting further participants.

What we describe here, and have used in making our budget estimates, is a roster of roles, of capacities, that we will need to fill with creative effect in carrying the project out. In the following paragraphs, we provide an initial inventory of these roles.

Project Management Group. In addition to the roles listed below, the Project Management Group will include the four Project Principals from IBM Research. Although we structurally identify this and the two sub-groups as having differentiated memberships, operationally, memberships may be redefined as appropriate to the tasks at hand.

» **Project Director and Curriculum Design Manager.** Robert McClintock will fill this role. The Project Director will have final decision making responsibility, and when the Project Management Group does not share consensus or is uncertain about the proper course, the Project Director should, after consulting with the Co-Director, make the necessary decisions and take the appropriate actions. In allocating areas of emphasis between the Director and the Co-Director, the Director will accentuate the intellectual, academic concerns of the Project, being the chief spokesperson for the ideas associated with it. The Curriculum Design Manager will be responsible for organizing and managing the process of developing the cumulative curriculum. He will chair the Curriculum Design Group and be responsible for seeing that it functions effectively. McClintock's vita will be found in Appendix A, pages 130 to 135.

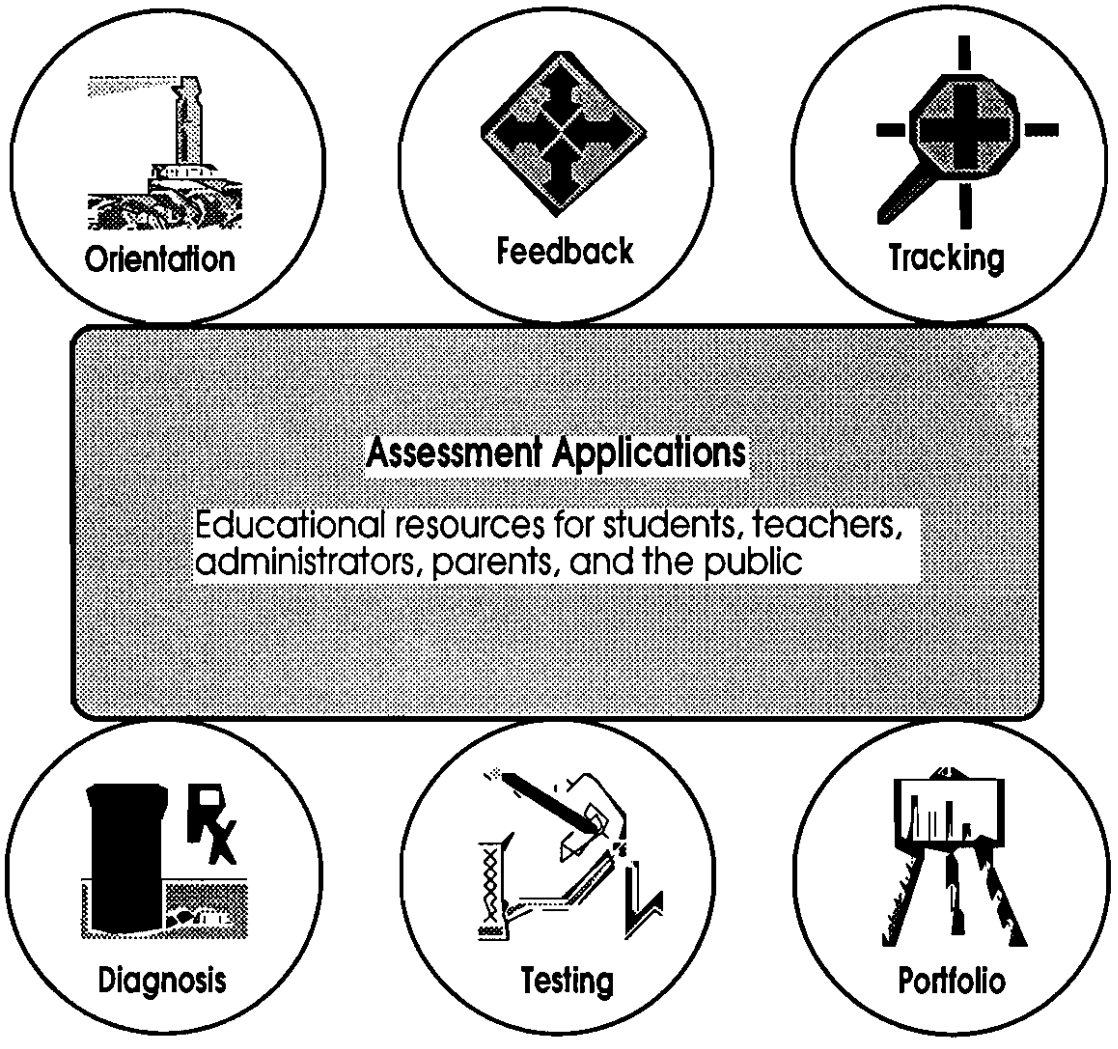
» **Project Co-Director and Professional Development Manager.** Frank Moretti will fill this role. The Project Co-Director will work with the Director on all aspects of the project, advising on issues that cannot be decided by consensus. In allocating areas of emphasis between the

Director and the Co-Director, the Co-Director will accentuate the public involvements with significant power groups -- schools and school boards, teachers and administrators, associations and other relevant groupings. The Professional Development Manager will be responsible for involving teachers and other educators in the design and development work of the Project, for staffing the prototype implementations. He will chair the Professional Development Group and be responsible for seeing that it functions effectively. Moretti's vita will be found in Appendix A, pages 142 to 144.

» **Project Executive Director.** This will be a full-time senior staff position for the project. The person to be recruited should have proven executive capacity in substantial technology-based projects. The person should be quick to grasp the ideas associated with the project and be eager to help bring them to fruition in an executive, not substantive, role. The Executive Director will be responsible for seeing that the operations of the project run smoothly, for tracking budgets and fulfilling institutional requirements, for setting up meetings and following through on decisions and directives, for managing day-to-day operations and for enabling those with substantive responsibilities to concentrate productively on them. The Executive Director should be able to understand the responsibilities of each person in the Project and to work creatively to facilitate their accomplishment of the Project goals. The Project Director and Co-Director should fill the position of Executive Director as soon as possible once the project commences, with the expectation that the person chosen will hold the position for the duration of the project, but with an annual contract, to be renewed year-by-year after a formal performance review with the Director and Co-Director.

- What are the objectives of the project?

Develop the assessment applications



- Make an inventory of the forms of feedback that would be useful.
- Set criteria for choosing assessment applications to develop.
- Select the assessment applications to be developed.
- Design and code the assessment applications and integrate them into the cumulative curriculum prototype.

» **Environmental Design Manager.** This will be a senior project position. The Environmental Design Manager will be a member of the Project Management Group and the Professional Development Group and will be responsible for managing the environmental designs appropriate for the Cumulative Multi-media Curriculum. The person chosen should have a proven capacity to develop and evaluate technology-intensive environments, with an appreciation of pedagogical processes and possess an ability to work both with educators and with children. This position will carry through the whole project, but the support positions associated with it will be greater through the first half of the project.

» **Motivation/Assessment Design Manager.** This will be a senior project position. The Motivation/Assessment Design Manager will be a member of the Project Management Group and the Professional Development Group and will be responsible for developing the motivation strategies and the student assessment resources that should be integral to the Cumulative Multi-media Curriculum. The person chosen should have a clear understanding of the opportunity to depart from the motivation and assessment patterns that seem to be natural, inherent necessities in the sequential, print-based curriculum. Experience with the design of cooperative learning programs and/or criterion-referenced student assessment would be helpful.

» **Policy Study Associate 1.** This will be a junior project position, budgeted as a full-time research assistantship for a doctoral-level graduate student. The person chosen for the position will be recruited to carry out a specific study within a specific period, to be defined by the Project Management Group. The first Policy Study Associate should begin late in the Spring of 1991 and the typical study should take a year to complete.

» **Policy Study Associate 2.** This will be a junior project position. The person chosen for the position will be recruited to carry out a specific study within a specific period, to be defined by the Project Management Group. This second Policy Study Associate should begin in 1992 and the typical study should take a 2/3rd's of a year to complete.

Professional Development Group. In addition to the roles listed below, the Professional Development Group will include the Environmental Design Manager, the Motivation/Assessment Design Manager, the Project Director, the Executive Director, two Project Principals from IBM Research, and the Professional Development Manager, who will chair the group.

» **Environmental Design Associate 1.** This will be a junior project position. The person or persons who staff this position will be recruited to perform specific design and design management functions that will be

set by the Project Management Group and the Environmental Design Manager.

- **Environmental Design Associate 2.** This will be a junior project position. The person or persons who staff this position will be recruited to perform specific design and design management functions that will be set by the Project Management Group and the Environmental Design Manager.
- **Motivation/Assessment Design Associate.** This will be a junior project position.
- **Professional Development Associate 1.** This will be a mid-level project position. The person actually holding the position will probably be a teacher or junior faculty member committing a considerable amount of his or her time to the project. The person recruited to the position will assist the Professional Development Manager in designing and organizing teacher demonstration-design workshops and help run the teacher preparation activities leading up to the implementation of our prototypes.
- **Professional Development Associate 2.** This will be a junior project position.

Curriculum Design Group. In addition to the roles listed below, the Curriculum Design Group will include the Project Co-Director, the Executive Director, two Project Principals from IBM Research, and the Curriculum Design Manager, who will chair the Group.

- **System Development Manager.** This will be a mid-level project position. The System Development Manager will work with the Curriculum Design Manager and the Project Management Group to develop hardware and operating system standards for delivering the Cumulative Multi-media Curriculum and will oversee the installation and use of development and prototyping systems. The person recruited to the role should grasp the educational intents of the whole project and be able to implement local area networks, multi-media development and presentation platforms, and multitasking graphical user interfaces.
- **Math/Science Curriculum Manager.** This will be a mid-level project position. The Math/Science Curriculum Manager will work with the Curriculum Design Manager and the Project Management Group to design and implement the components of the Cumulative Multi-media Curriculum devoted to math and science. The person recruited to the role should have a full, advanced sense of the uses of mathematics and science in contemporary culture and a creative capacity to apply information technologies to making mastery of these subjects accessible to diverse students.
- **Languages/Literature Curriculum Manager.** This will be a mid-level project position. The Languages/Literature Curriculum Manager will

work with the Curriculum Design Manager and the Project Management Group to design and implement the components of the Cumulative Multi-media Curriculum devoted to mastering the tools of spoken and written expression, to crafting a sensibility for traditions of verbal and visual creativity. The person recruited to the role should be responsive to all forms of effective communication, grasping at once the rigor of their basic entailments and the diverse subtleties of their distinctive nuances. He or she should see the new technologies for using word and image, not as a threat to established forms of expression, but as an opportunity to renew, extend, and invigorate them.

- **Social Science Curriculum Manager**. This will be a mid-level project position. The Social Science Curriculum Manager will work with the Curriculum Design Manager and the Project Management Group to design and implement the components of the Cumulative Multi-media Curriculum devoted to clarifying social and economic conditions, historical and cultural traditions, and political and philosophic ideas. The person recruited to the role should understand how to use multicultural resources to help each person form a strong sense of self-worth and identification with inspiring examples of humane aspiration.

- **Personal Skills Curriculum Manager**. This will be a mid-level project position. The Personal Skills Curriculum Manager will work with the Curriculum Design Manager and the Project Management Group to design and implement the components of the Cumulative Multi-media Curriculum devoted to developing the distinctive capacities that mark each individual's skill a coping with the world and realizing his or her potential to contribute to the common weal. The person recruited to the role should have keen appreciation of art and music and should have a good insight into the ways people build up their personal skills.

- **Curriculum Design Associate 1**. This will be a junior project position. The person or persons who staff this position will be recruited to perform specific research and development functions that will be set by the Project Management Group and the Curriculum Design Manager. Through this role, we will commission implementation of particular curriculum components.

- **Curriculum Design Associate 2**. This will be a junior project position. The person or persons who staff this position will be recruited to perform specific research and development functions that will be set by the Project Management Group and the Curriculum Design Manager. Through this role, we will commission implementation of particular curriculum components.

- **Curriculum Design Associate 3**. This will be a junior project position.The person or persons who staff this position will be recruited to perform specific research and development functions that will be set by

the Project Management Group and the Curriculum Design Manager. Through this role, we will commission implementation of particular curriculum components.

» **Curriculum Design Associate 4.** This will be a junior project position. The person or persons who staff this position will be recruited to perform specific research and development functions that will be set by the Project Management Group and the Curriculum Design Manager. Through this role, we will commission implementation of particular curriculum components.

Project Staff.

» **Project Administrator.** This will be a full-time office management position of considerable importance to the success of the project. Unlike the Executive Director, who needs a broad, sympathetic understanding of the project, this position will not require such substantive involvement. Nevertheless, the person recruited to the role should excel in the effective use of office technology, should be able to keep minutes, transcribe dictation accurately and efficiently, use spreadsheets and desktop publishing resources, be resourceful and responsive in handling telephone messages, scheduling of appointments, and generally keeping the flow of information and ideas smooth and easy within the project. As necessary, the person in this role should be adept in directing temporary office help.

» **Project Coordinator -- New Laboratory for Teaching and Learning.** This will fund a portion of the salary of a staff member of NLTL so that he or she can act as Project Coordinator for the activities at that site. In this role, the person will be responsible to the Project Executive Director and will generally be the daily presence of the Executive Director at NLTL.

» **Project Coordinator -- Cooper Union Research Foundation.** This will fund a portion of the salary of a staff member of CURF so that he or she can act as Project Coordinator for the activities at that site. In this role, the person will be responsible to the Project Executive Director and will generally be the daily presence of the Executive Director at CURF.

» **Hourly Employee 1, 2, 3, 4, & 5.** This funds hourly work for approximately 38 weeks per year, 40 hours per week. The position will generally be filled by masters level or undergraduate students to perform roles that the project needs to have done and that will contribute to the student's educational development.

IBM Project Principals. We invite substantive participation by IBM Watson Research Labs and believe that such participation should be an integral component of the project. It would be, of course, up to the managers of IBM Research to decide who to assign to the project and what skills and interests

they should have. However, it would be very helpful if participants had interests such as the following, which would round out the competencies encompassed in the effort.

» **IBM Research Participant 1.** Multi-media authoring and its uses in education -- Don Nix. Dr. Nix has collaborated extensively with the Institute for Learning Technologies, where joint-study projects using *Handy* have been taking place since 1985, and the Dalton School, where a precursor project to Kids at the Wheel took place. The pre-prototyping site, Kids at the Wheel at P.S. 92, is managed by a Teachers College doctoral candidate and the expressive learning ideas essential to that project relate closely to the effort to build a cumulative curriculum that we are proposing.

» **IBM Research Participant 2.** Local area networks and digital video. While these two areas of expertise do not need to go together, they are linked in our project and it would be helpful to have people from IBM Research with expertise in these technologies. We believe that the full educational use of digitized materials, especially multi-media materials, requires that they be accessed from local area networks. Special technical issues arise with such access and we believe the project would gain much from IBM's input in this area.

» **IBM Research Participant 3.** Intelligent tutorials and background diagnostics. We are not so much interested here in a designer of tutorial programs than in someone versed in creating programs that can run in the background and keep track of what a computer user is doing, offering suggestive advice when requested. Assessment and navigational resources required by the cumulative curriculum will require innovative program development of this type. IBM Research can efficiently provide the project help in this area.

» **IBM Research Participant 4.** Imaging and systems interfacing. In developing the overall project needs, we have concentrated on defining the cultural and education capacities that need to be mobilized in order to develop the cumulative curriculum. A participant from IBM Research with strong systems engineering skills would help ensure the effective translation of educational concept into functional system.

Participating Groups

In order to provide settings in which this spectrum of possibilities can be explored without undue constraint, practical educational sites need to be included where current practice is relatively indeterminate and susceptible to significant restructuring. We include several emerging special schools and programs as part of our research and development consortium in order to have such locations where the restructuring of education can be explored.

As we have suggested in the previous section, we invite the substantial and integral collaboration of IBM Research in the over-all effort. We believe it essential to the fullest success of the project. Those who invent the essential structure of an education system that is suited to making full use of information technologies will need to understand the general possibilities of those technologies. But the interaction between the technology and the system will be reciprocal: as the new technologies will not leave the educational system unchanged, so the emerging educational system will not leave the technologies unaffected. Thus, we expect educational ideas to emerge from the work we propose that will carry implications for the design and development of the enabling technical systems. So that the development of those enabling systems can be timely, it is important that IBM Research be a full participant in this process.

» Institute for Learning Technologies, Teachers College, Columbia University, will provide over-all project management, key researchers, and general integration of the effort here proposed. Teachers College has diverse researchers in education, with a significant group specializing in the uses of technology in education. Robert McClintock, director of the Institute for Learning Technologies has a special concern for the design of multi-media curricular resources, particularly in the social studies. Teachers College has a significant record of funding from IBM, having conducted projects with support from IBM University Relations, IBM Academic Information Systems, and IBM Watson Research Labs. Fuller information on Teachers College and the Institute appears in Appendix A below, pages 120 to 130.

» The New Laboratory for Teaching and Learning, the research arm of the Dalton School, will coordinate project efforts at school sites. The Dalton School is a progressive, independent school, based in Manhattan. The New Laboratory, and its Executive Director, Frank Moretti, maintain collaborative relationships with diverse institutions, among them:

  several graduate schools of education such as the New York University School of Education, Health, and Nursing; Teachers College, Columbia University; and the Bank Street College of Education;

  specific public schools, particularly those in New York's District 2, including that district's three new Laboratory Schools and The School of the Future; and

  a more general network of schools throughout the five Boroughs of the City, public and private, through the NYC Mayor's Public-Private School Partnership.

  The New Laboratory houses a spectrum of experiments, many of them technology-based and many carried out in partnership with the above institutions.

In the context of this proposal, the New Laboratory will provide professional and technical support, as well as coordinate the projects' efforts at various school sites throughout New York City. The Dalton School, home of the New Laboratory, has initiated a major architectural renovation, with priority given to redesigning instructional space along the theoretical lines indicated in this proposal. This, coupled with opportunities to instructional spaces and schedules in the Laboratory Schools and The School of the Future, makes these ideal sites for this project. For two years, Robert McClintock and Frank Moretti have been engaged in work planning the Dalton renovations, which are scheduled to begin in January, 1992. More extensive information on the Dalton School and the New Laboratory, and the Mayor's Partnership appears in Appendix A, pages 135 to 141.

» The Laboratory Schools (elementary, middle, and high school) are experimental ventures protected from the trammels of the usual curriculum constraints and free to explore new educational modalities such as those described in this grant proposal. These schools are being phased into existence, under the sponsorship of Mr. Anthony Alvarado, Superintendent of District 2, with the help of Gwyn Solomon, Ken Forman, and Jackie Ancess, all District 2 administrators. The New Laboratory for Teaching and Learning at Dalton has collaborated in developing the vision of these institutions. More detailed information on the Lab Schools appears in Appendix A, page 152.

» The Mayor's Public-Private School Partnership is a network of 50 public and private schools throughout the five Boroughs of New York City, supervised by an advisory board of public and private school educators -- Gardner Dunnan, Amina Abdur-Rahman, Lee Blake, Howard Hadest, Joseph Blaney, Bea Ramirez-Epstein, Rosalie Byard, Sheldon Lindenbaum, and Naomi Hill. The partnership resulted from the collaboration of the former Mayor of New York and the administration of the Dalton School, which provided the actual effort to create the partnership's infrastructure. With continuing sponsorship from the current Mayor, the partnership provides a variegated experimental setting for the exploration of the new curricular possibilities that powerful information technologies create. Through the partnership, the project here proposed can recruit extensive involvement by teachers and educators. More extensive information on the Mayor's Partnership appears in Appendix A, pages 145 to 146.

» The Cooper Union Research Foundation, a design, research, and policy initiative being taken by The Cooper Union for the Advancement of Science and Art, can provide environmental design and visualization resources to the project, as well as technical expertise. Robert McClintock has worked extensively with the president of The Cooper Union, John Jay Iselin, in exploring how multi-media information technologies can

improve access to higher education. The Cooper Union, combining schools of engineering, architecture, and art, offers much needed design resources to the project we propose. More detailed information on the Cooper Union and its Research Foundation appears in Appendix A, pages 147 to 151.

- Kids at the Wheel, an expressive learning project at P.S. 92, will be an excellent pre-prototyping and test site for the project. Unlike the prototype locations, it will not permit the restructuring of the space and time of the school. But it will provide a valuable place to explore motivation and assessment ideas, to use the multi-media curricular database, and to demonstrate the system to others. Most importantly, it will provide a steady dose of realism in that children with unfavorable life chances will be involved. More extensive information on Kids at the Wheel appears in Appendix A, pages 153 to 155.
- Center for American Culture Studies, Columbia University, has had several extensive projects organizing cultural materials for study and research. Such projects have documented different ethnic heritages. They have worked extensively with the history of New York City and bring well-developed contacts with the City's cultural institutions to the project. More comprehensive information on the Center for American Culture Studies appears in Appendix A, pages 156 to 157.
- Resource Providing Institutions: NY Public Library, NY Historical Society, Smithsonian Institution, Museum of Broadcasting, WNET, and so on. New York City is one of the great cultural repositories of the world. To develop the Cumulative Multi-media Curriculum we will need access to diverse collections and will draw on those of the City, as well as ones elsewhere, as needed.

Current Funding Situation

Requested:
5 million for 5 years

Recommended:
2.5 million for 2.5 years

Recommendors:
IBM's Grants for Innovation in Education
IBM Research
IBM Educational Systems

America 2000 proposal:
150 to 200 million for 3-7 Research & Development Centers

Problems:
Recession -- Commitments delayed by IBM
Complexity -- Slow policy formation in IBM

Assessment:
Chances of funding are high, but not sure
Official action between September 1991 and January 1992

Follow-through:
Individual Donors -- Dalton
Related Research Projects -- CTR's ACORN
Major Foundations -- Annenberg, Lilly, etc.
America 2000 Proposal

Evaluation Strategies

Several types of evaluation are built into the project. The first of these, we call "development evaluation." It will take place through the annual cycles of development that we plan, in which each successive stage of development work will be informed by evaluations of how the prior stage works. These developmental evaluations will be made by ourselves and by experienced teachers recruited for the purpose. See the sub-section of "Profession" for a further discussion of the way teachers will contribute to our developmental evaluation, page 46. These cycles of development evaluation will feed back into work on environmental design, motivation and assessment, the curriculum design, and teacher development. Developmental evaluation is probably the most important form of evaluation for this project.

Another form of evaluation that is integral to the project concerns the component, "Motivation/Assessment," which will largely be an effort to develop assessment measures appropriate for students working with a cumulative curriculum, and progress in this area will be essential to enabling formal evaluation of our prototypes to take place. The Motivation/Assessment Manager will need to have highly developed evaluation skills, combined with an eagerness to develop new forms of evaluation that are particularly adapted to students learning through a cumulative curriculum. See the sub-section on "Motivation/Assessment" above, page 47, as well as the discussion of cooperative learning, pages 21 to 23.

A third form of evaluation, staff evaluation, has been built into the management structure of the project. In specifying roles we have stipulated that in all instances, except those of Project Director and Co-Director, commitments should be on a one-year basis with a formal review of performance annually. In setting the functions and schedule of the Project Management Group, we have charged it with conducting systematic quarterly progress reviews in each of the five work areas of the project.

Finally, much of the concluding year of the project, will be devoted to a formal, summative evaluation of all aspects of the effort. Design and development work on Version 4.0 of the Cumulative Multi-media Curriculum will end September 1995 and this proposal does not seek funding for work on Version 5.0. It does include funding for continued effort through the school year 1995-96.

As the project evolves, we will clarify precisely what should be evaluated in these summative efforts. We should define the key questions relative to the generative goal of initiating a new system of education based on a cumulative, non-sequential, curriculum. The prototypes will not yet be a functioning instance of the new system. Only a few students will have had sustained experience learning with the prototypes. An outright comparison of results between the new system and the old will not be possible -- at best that can start happening in a

significant way in the first decade of the 21st century. What can be posed at the culmination of this project are questions like these:

» Is the Cumulative Multi-media Curriculum well enough filled out to start a High School prototype?

» Should a Lower School be tried? Are its curricular needs significantly different?

» What have we learned about the range of useful motivational strategies in education? Do the basic ideas about a cumulative curriculum need to be revised in the light of these findings?

» What assessment measures seem most valuable in the context of the cumulative curriculum? How do students learning in the traditional sequential system perform on these measures?

» What does our experience with the prototype environments suggest by way of further alterations in layout and schedule?

» What problems will teachers have in adapting to the cumulative curriculum? What needs to be done as such an educational effort ceases to be a special one, staffed by volunteers, and becomes a mandatory environment that the teacher must, like it or not, adapt to?

» What learning problems arise with the cumulative curriculum? What sorts of difficulties do different students encounter? What teaching or mentoring strategies need to be developed further to help students over those difficulties?

» Within the context of a cumulative curriculum, are there matters that should be treated sequentially, learned and discarded, as such, like the multiplication tables?

» Does the texture and emotional tonality of education seem different in the context of the cumulative curriculum? Does the balance of initiative between teacher and students change? Do support roles such as school librarian or various counselors alter in significance?

» How do parents react to their children's work with the cumulative curriculum? How can their reactions to novelty -- "this isn't the way I learned in school!" -- be distinguished from reactions that disclose significant aspects about a system using a cumulative curriculum?

» After a prototype comes field testing. Is the cumulative multi-media curriculum ready for that?

Equipment Needs

For several reasons, accurately estimating equipment costs is difficult. The project assumes the availability of a mature multi-media computing environment, when in fact that is still in the process of development. We know neither how

quickly costs will drop with important items to levels that would pertain with full-scale production nor do we know precisely what developmental path certain technical possibilities will take. Further, we can only now guess what equipment we want, for the design and development work, through which we will decide on system specifications and the like, has still to be performed. All the same, we can provide general assumptions about what we will want and what will be available, and from that, we can tentatively itemize resources.

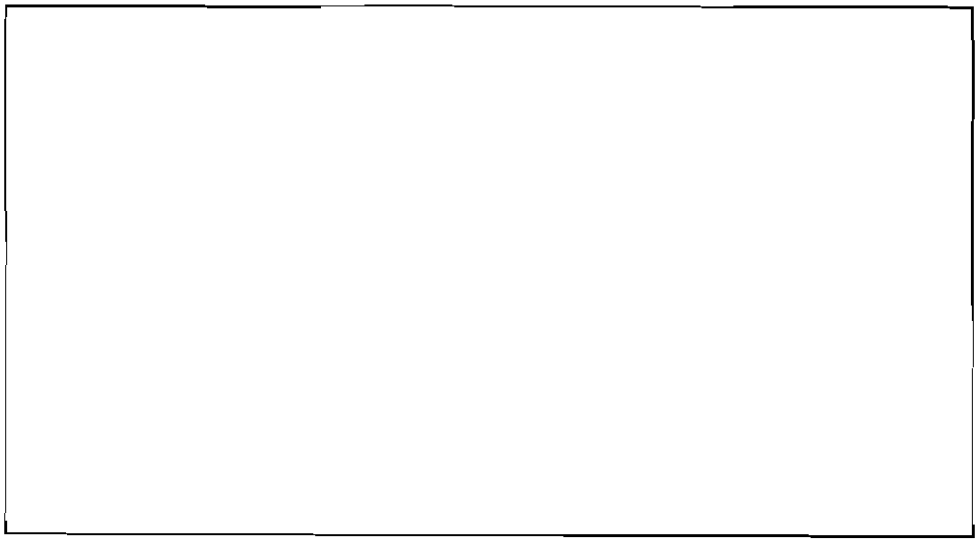
Let us begin with a statement of principle: the educational computing environment should be as functionally powerful as possible and as standard as possible. We are seeking, through this project, to substitute a cumulative curriculum for the sequential curriculum. It would run counter to the idea of the project to introduce a sequentially staged computing environment -- machines of small function for young children and progressively larger function as the children get older and more mature. Pages turn from right to left and lines read from left to right, top to bottom, within English language conventions, whether the reader is five, fifteen, or fifty. The adult user interface, the adult processing power, the adult repertoire of software, should be the interface, power, and repertoire for the child as well. Full-screen graphics take as many MIPs to generate for children as they do for adults; response delays are as distracting to the young as they are to the old. If the adept adult wants a computer at hand at all times, so too will the adept child. Standard, full-functioned technology should be the basis of technology-based education until we have clear evidence that some other norm, lesser or greater, makes better sense.

We specify a standard, full-functioned technology, not with respect to transition technology, but with respect to a mature computing environment. One cannot be sure what that will be. We will cope with this uncertainty in two ways, adopting what we call a "centrist" set of technical choices and moving in an anticipatory relation to the marketplace. We have just voiced the centrist doctrine: educational technology should broadly represent the main technological options in their most functional forms. Education, by its nature, needs to be representative, reflecting in its tools and substance the stuff of the culture. Educational technology needs to be used with special pedagogical intent, but at the same time, it should be acculturating, accustoming the young to the resources of thought and activity that they will be using throughout life. Were an educational technology to consist primarily in esoteric implementations, it would not serve well this acculturating role.

Our second way of coping with the uncertainty over what the mature computing environment will be involves making anticipatory choices relative to the market. We do not seek to be a Media Lab, exploring imaginable educational technologies with no attention to whether they will ever come to market. Equally, we do not seek to function as a training institute, giving hands-on experience with the current repertoire of established products. Rather, we seek to develop the cumulative curriculum in anticipation of the market, using technologies that have been shown feasible and have entered into development for the marketplace.

DV-I, Digital Video-Interactive, is a good example: development systems are available at a market premium with the expectation that a new implementation will become widely available starting in 1993 or so. By remaining centrist and in anticipation of the market, we should be able to develop the cumulative curriculum while moving toward a mature technology environment, remaining uncertain about exactly when the plateau of functionality will be reached, but being relatively secure that we will not have staked our designs on technological assumptions that must be discarded, along with the work and investment premised on them.

With these principles in mind, let us start making a preliminary specification of technology so that we can estimate the equipment needs of the project. We will proceed from two directions, one beginning with the immediate technical environment to be available to the student, the other with the school level system support needed to sustain it. Here is a sketch representing a small-group workstation, four notebook computers, and a video camera. We guess that four is the right size for the small group -- it might prove that two, three, or even five or more is better, but let us assume four for the purposes of estimating equipment. We leave unclear exactly how the notebook computers will connect to the small-group workstations, and those to the school server, although such connections will be necessary. Here are tentative specifications of each component.



» **Small-group workstation.** This should be a PS2/Model 80, running at least a 386 CPU and co-processor at 25 megahertz, with both DV-I compression and decompression capacity (or its equivalent), 8 to 16 meg of RAM, a 300+ megabyte fixed disk, and an 8514 color monitor (or its equivalent). The system should work as a server for the student's

notebook computers, with the capacity for handling up to six at once, preferably with a radio or microwave linkage. The small-group workstation would serve as a multi-media display and editing terminal and as a locus for integrating work that each student performs on his or her notebook computer. It would be the prime focus for their cooperative activities and a channel of exchange between the group and teachers and other groups. Each student would also have his or her disk directories here.

» **Notebook Computers**. Each student should have his or her notebook computer, which should weigh under 5 pounds, and have a 386 CPU, a fine resolution dark on white VGA screen, 8 meg RAM that will not go dead when the notebook is powered down, a full functioned keyboard and a pointer device: mouse, trackball, or equivalent.[15] A LAN interface to the small-group workstation should be easy to connect and disconnect and ample, non-volatile RAM should take the place of disk drives with permanent mass storage being on the small-group workstation and accessible from a variety of locations over the school network. The notebook computers should allow students to be mobile while having easy access to their basic computing resources. Ideally, the notebook should be the one "book" that goes with the student anywhere and everywhere. Design work will need to be done to make the notebooks unobtrusively secure from loss or theft, and if that cannot be done effectively, restrictions on the notebooks' mobility will need to be instituted. Whether or not DV-I decompression chips should be on the notebooks depends largely on the progress of flat screen technology.

» **Video Camcorder**. This should be an 8-millimeter or VHS camcorder normally set adjacent to the small-group workstation monitor, feeding directly into the DV-I compression board so that it can provide a video component to e-mail. Additionally, students should be able to take the camcorder to other locations. The small-group workstation will serve as a digital video editing console and video input for presentations and study sessions should come to the workstation from the camcorder and from the central system repository over the network.

A rather sophisticated central system should support this immediate technical environment for students. A schematic diagram (page 71) represents a school server system surrounding sixteen small-groupworkstations, with three teacher workstations on it, one large video display for the whole group, and two smaller projection video systems for smaller groups. The diagram additionally shows

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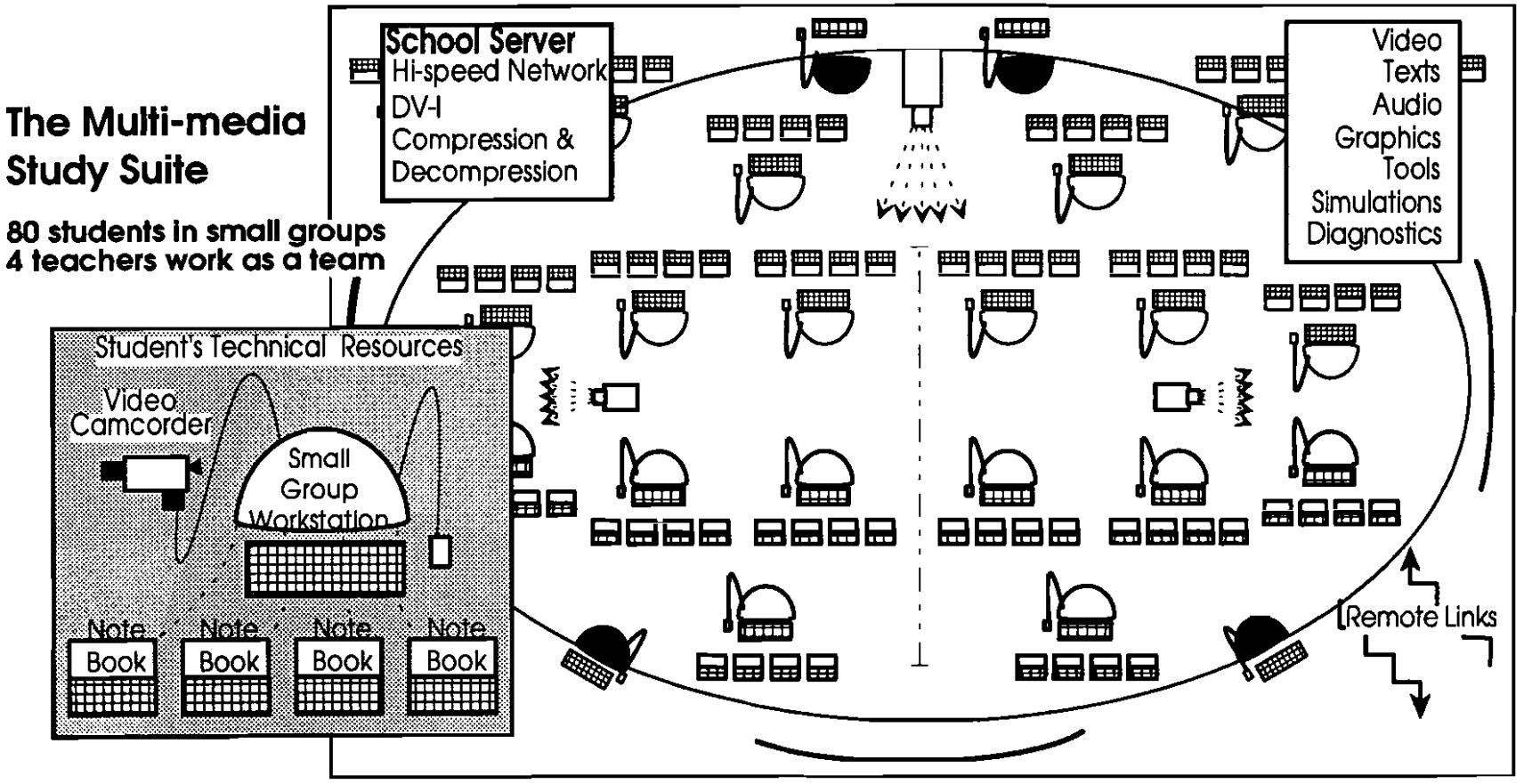
15 If stylus input can be added without interferring with other specifications, it should be added. Stylus input would seem most attractive, however, to people who never learned to type (and won't for some reason do so) and in cultures such as the Japanese where non-alphabetic writing systems are in use. If keyboard and stylus are equally at hand, which will people who know both prefer?

remote links, out and in. The proportional relation -- 4 to a workstation, 64 students as the full group, 32 to the sub-groups, one teacher to twenty some students -- are very approximate, determined more by the constraints of the page on which the diagram appears than by design and planning for real situations. The diagram, however, allows us to define components and their relations. We need a large, interactive video display for the whole group, intermediate interactive displays for sub-groups, teacher workstations with essentially the same functionality as the small-group workstations, a large system server that will store and manage the Cumulative Multi-media Curriculum, and dial-in/dial-out capacities available over the network.

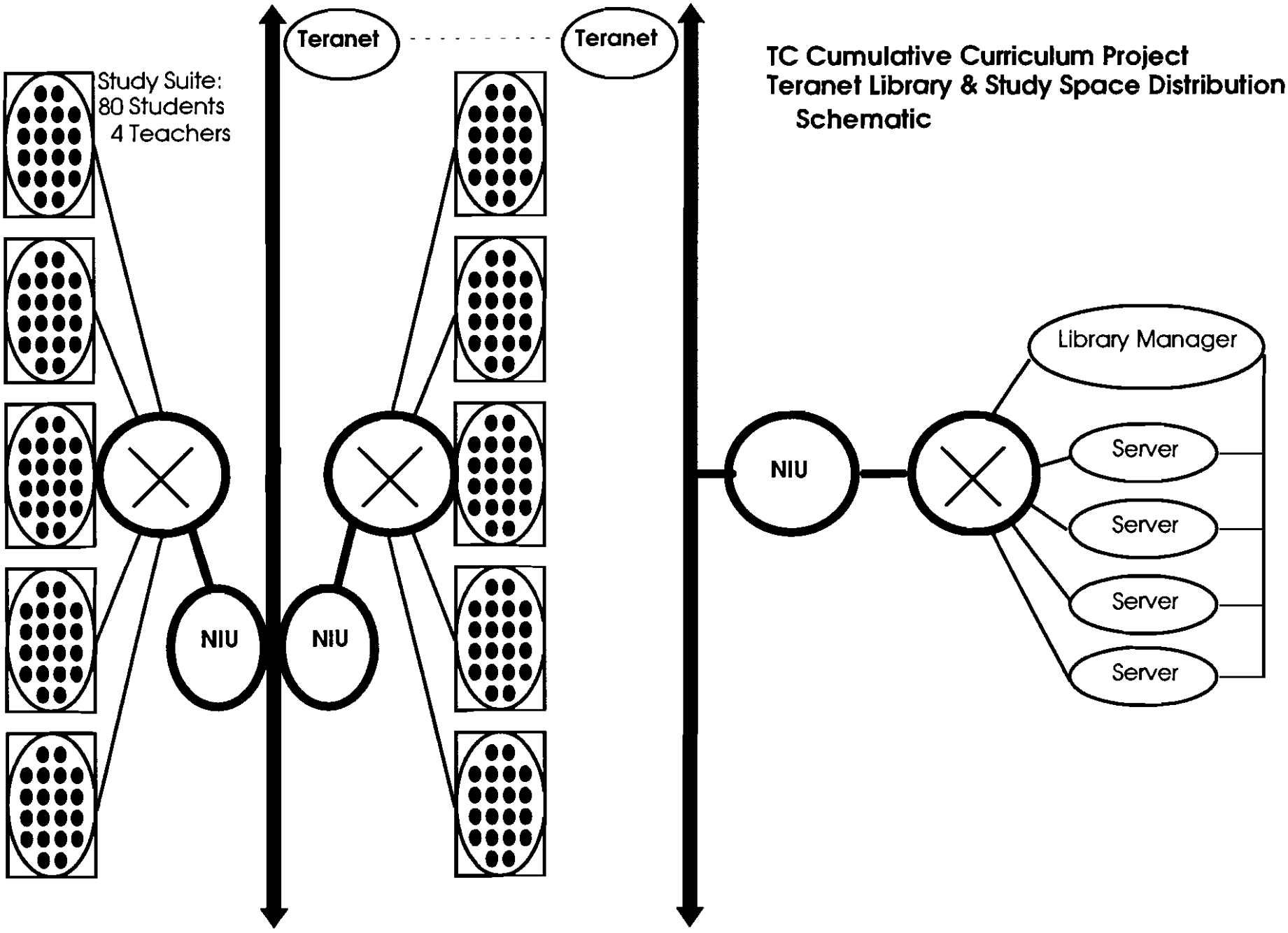
» **Central Server System**. This should be a high-speed, high-capacity server. We want to tailor it to the needs of the Cumulative Multi-media Curriculum, not the other way around. By and large, all the special purpose storage and retrieval peripherals needed to support the curriculum should attach through this server. Through it, we want to manage an extensive video library, stored probably on standard analog tapes, accessible remotely through a jukebox system, with requested material digitized and compressed through DV-I real-time mode and sent over the network to the requesting workstation. Some video material may have been pre-compressed and stored on CD-ROM or on DAT. In addition to a video library, we expect the server to manage a large library of texts and images, much of it on CD-ROMs accessible through a jukebox, and other frequently called parts of the library on high-speed magnetic disks.

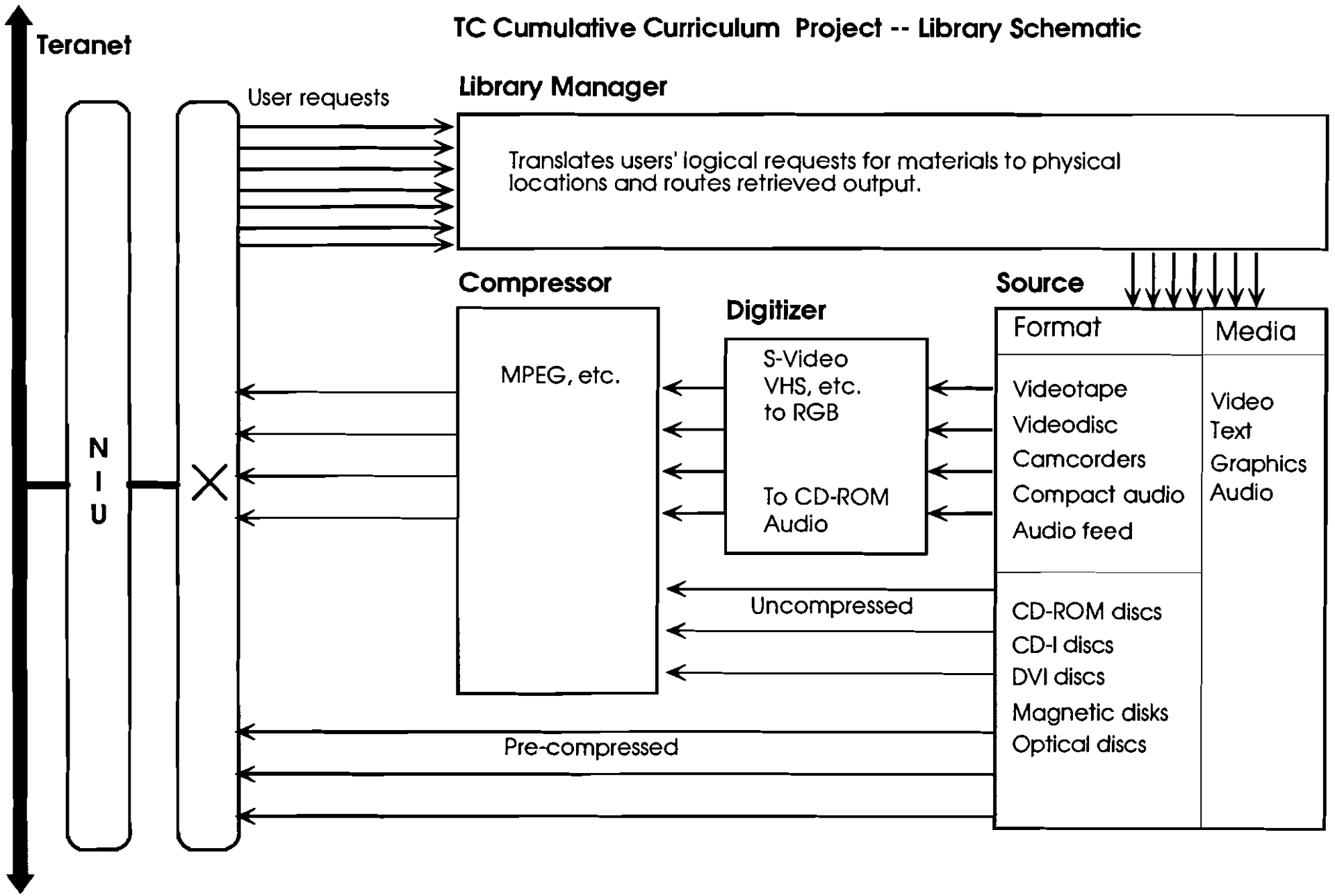
» **Teacher Workstations**. These should have the same functionality as the small-group workstations, including a video camera attached for DV-I based e-mail. In addition, teacher workstations should have the capacity to mirror what is happening on any other workstation on the system and to work in parallel with it. Further, a teacher should be able to manage the flow of information between the system server and other workstations from a teacher workstation, to make sure that specific materials needed to sustain small-group projects and the like are properly disseminated over the system. Finally, each should have a page scanner with OCR software such as OmniPage and a laser pageprinter for output.

How might the educational experience be changed through a full use of information technology?



Significant changes will occur throughout the domains of historical innovation in education.


TC Cumulative Curriculum Project
Teranet Library & Study Space Distribution
Schematic
Teranet
Teranet
Study Suite:
80 Students
4 Teachers
NIU
NIU
NIU
Library Manager
Server
Server
Server
Server


TC Cumulative Curriculum Project -- Library Schematic
Teranet
User requests
Library Manager
Translates users' logical requests for materials to physical locations and routes retrieved output.
Compressor
MPEG, etc.
Digitizer
S-Video
VHS, etc.
to RGB
To CD-ROM
Audio
Source
Format
Media
Videotape
Videodisc
Camcorders
Compact audio
Audio feed
Video
Text
Graphics
Audio
N
I
U
Uncompressed
CD-ROM discs
CD-I discs
DVI discs
Magnetic disks
Optical discs
Pre-compressed

» **Video Displays.** These will be important components of the Cumulative Multi-media Curriculum. Genuine multi-media needs to preserve the power of sustained, sequential presentations such as well-crafted films. These are usually best experienced in groups -- all, some, and many. Projection monitor systems that permit all to be one audience and intermediate groups to cohere as audiences should be under the control of the teacher workstations, with aggregate input -- group polling and the like -- possible from each student's notebook.

» **Remote Links.** Dial-out capacities should provide access to services and information that may be needed on occasion but not as integral components of the Cumulative Multi-media Curriculum. In addition, these will be important for groups within one school to interact with students elsewhere. Dial-in capacities should support homework and e-mail exchanges outside of school hours, and they may be very important in facilitating system support and maintenance. Since the Cumulative Multi-media Curriculum will require a full-screen graphical user interface, which is too information intensive to work well over phone linkages, a sub-set of resources that can be used in character-based formats, will be tagged within the overall curriculum for remote access.

We can now provide an approximate estimate of equipment needs of the project, realizing that these may change as work proceeds. We can identify three different types of systems: development systems, demonstration systems, and delivery systems. We will need two of each -- development systems at Teachers College and at Cooper Union; demonstration systems at the New Laboratory for Teaching and Learning and at P.S. 92, and delivery systems at the prototype sites in the District 2 Lab Schools and the Dalton School. The systems will differ in scale, rather than functionality. The development systems should start up as soon as possible in 1991; the demonstrations should be installed by September 1991; and the delivery systems by September 1993. All the systems should be upgraded yearly throughout the project, and the delivery systems will need to be expanded each year to accommodate new students and teachers.

» **Development Systems.** These should consist of one system server with a small CD-ROM jukebox, two industrial grade tape decks, and two videodisc players; one teacher workstation with video camera; one small-group workstation with video camera; six notebook computers that can be linked to the small-group workstation; and one ceiling mounted projection video system. We expect to develop the system using DOS and *Windows 3.0* as an operating environment until it clearly gives way to an alternative based on OS2 or UNIX. Software should include *Novell 386*, *Word for Windows*, *Excel*, *PageMaker*, *Current*, *ToolBook*, *Guide 3.0*, *Designer 3.0*, *Actor*, *Bridge Development Kit*, *Windows SDK*, Microsoft *C 6.0*, Glockenspiel *C++*, and an authoring language for DV-I. The development locations should also be equipped with a high capacity

scanner such as a Kurzweil, feeding into the server, as well as the page scanner on the teacher workstation. Sometime, probably in 1993, the tape decks would need to be expanded to jukebox systems and the CD-ROM jukeboxes would need to be enlarged. For the sake of budgeting, an increment of the installation cost, say 25%, might be allocated annually to upgrade and expand the systems.

» **Demonstration Systems**. These should be basically the same as the development systems, with some subtractions and some additions. On the minus side, it would require a somewhat more restricted software library and would be without the high capacity scanner. On the plus side, instead of one small-group workstation, it would have four, and instead of six notebook computers it would include sixteen, perhaps twenty. Like the development systems, these would need to be upgraded year by year, although the cost of that relative to the original installation cost would probably be somewhat lower.

» **Delivery Systems**. These would be like the demonstration systems except scaled to the prototype installations. In the first year of prototype operation, 1993-94, these would need 5 teacher stations and 10 to 15 small-group workstations (40 to 60 notebook computers) at each location. The size would double the next year (1994-95), and increase by the same increment the last year of the project (1995-96). Roughly two video projection systems would be needed at each location each year.

4 DESIGNING AN HISTORIC TRANSITION

To fulfill the potential of information technology in education, educators need to invent new solutions in the basic areas that generate an educational system:

- the environmental structuring of pedagogical space and time,
- the motivational energies that drive educational work by pupils and students,
- the curricular and information designs that facilitate accessing and apprehending the contents of our cultures,
- the organization of educational work to make it challenging and sustaining to people of talent, and
- the formulation of policies that will move the public to support educational activity at a high level.

But can these things be accomplished? Why should we believe that we can change the current system, with its vast inertias of scale -- contracts, regulations, procedures, customs, and conventions -- and all its vested interests -- the bureaucracies, unions, associations, clients, and pressure groups -- that thwart smaller-scale reforms? Have we longer-term strategies for converting our prototypes, if they succeed as prototypes, into systemic innovations?

To begin, let us note what would define success for our prototype. We base this project on an implicit premise: traditional schooling with the sequential curriculum has been optimized as an educational technology and now offers few opportunities for significantly improving its performance. Some evidence seems to challenge this premise. For instance, international comparisons of school achievement indicate significant differences in the level of attainments, one nation to the next. So, too, the substantial differences in achievement between schools suggests that if all traditional schools could perform as well as the best among them, a major advance in educational performance might be attained.

Both comparisons, we think, suggests illusory expectations for further perfecting the prevailing system. Neither set of comparisons discriminates persuasively between the school-based determinants of educational achievement and the non-school determinants. Thus the observed differences do not necessarily reflect differences in the quality of schooling, but rather differences in the conditions under which the schooling takes place. American social policy is seriously retrograde in comparison to social policy operative in

most other industrial nations. As a result, the housing, health, nutrition, and welfare of our least advantaged citizens, urban and rural, compares poorly to conditions in other advanced nations. Such disadvantages can account for substantial parts of the differentials in school achievement revealed by international comparisons. Indeed, our low ranking on indicators of school achievement parallels similar low rankings on many other social indicators. Further, differentials across nations, localities, classes, and ethnicities may arise from all sorts of non-school factors -- the way the culture of mass entertainment and consumption catches the attention of the young, how an ethos of boredom, despair, and underachievement spreads within groups and regions. In short, we assert our premise believing that most of the observed differences in school achievement result from non-school determinants: the existing system of schooling is a mature system that cannot perform significantly better than it does as a result of adjustments within it.

Our prototype will be successful if it can serve as the enabling factor for a new system of education that will have a different, more desirable spectrum of achievement associated with it. The prototype will succeed as a prototype if it demonstrates the feasibility of an alternative system, a system based on a cumulative, not sequential, curriculum, one that enables access to culture through an integrated mix of media. Assuming for now that the prototype succeeds as a prototype, have we reason to believe that it can translate into a system?[16] It is easy to imagine a successful prototype that, despite an effort to convert it into an alternative system of education, does not do so. Failed reforms are legion in history. The early twentieth-century movement for progressive education stands as an evident case in point. Progressive prototypes worked well; their conversion into a new system flopped. Why would the Cumulative Multi-media Curriculum be different?

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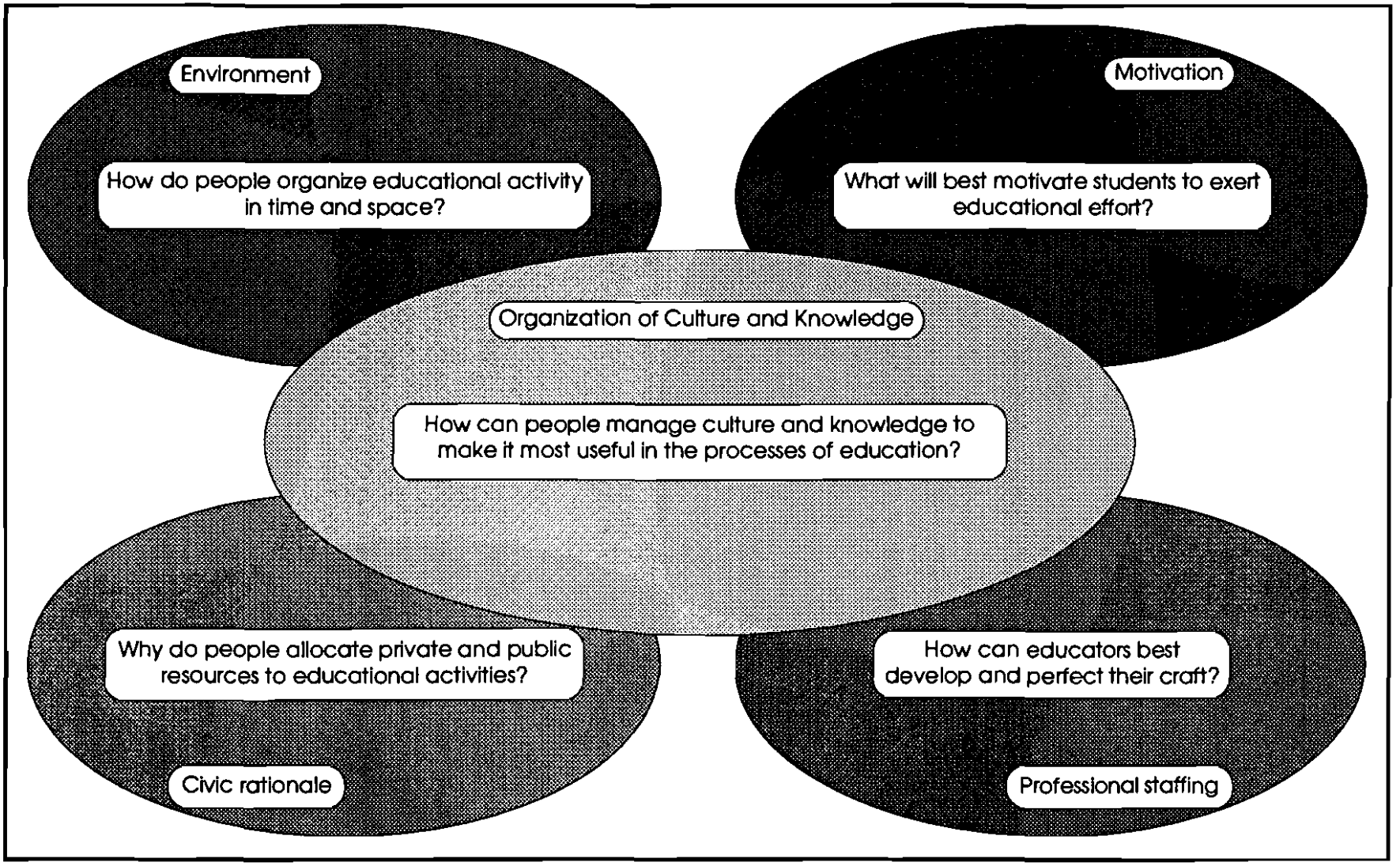
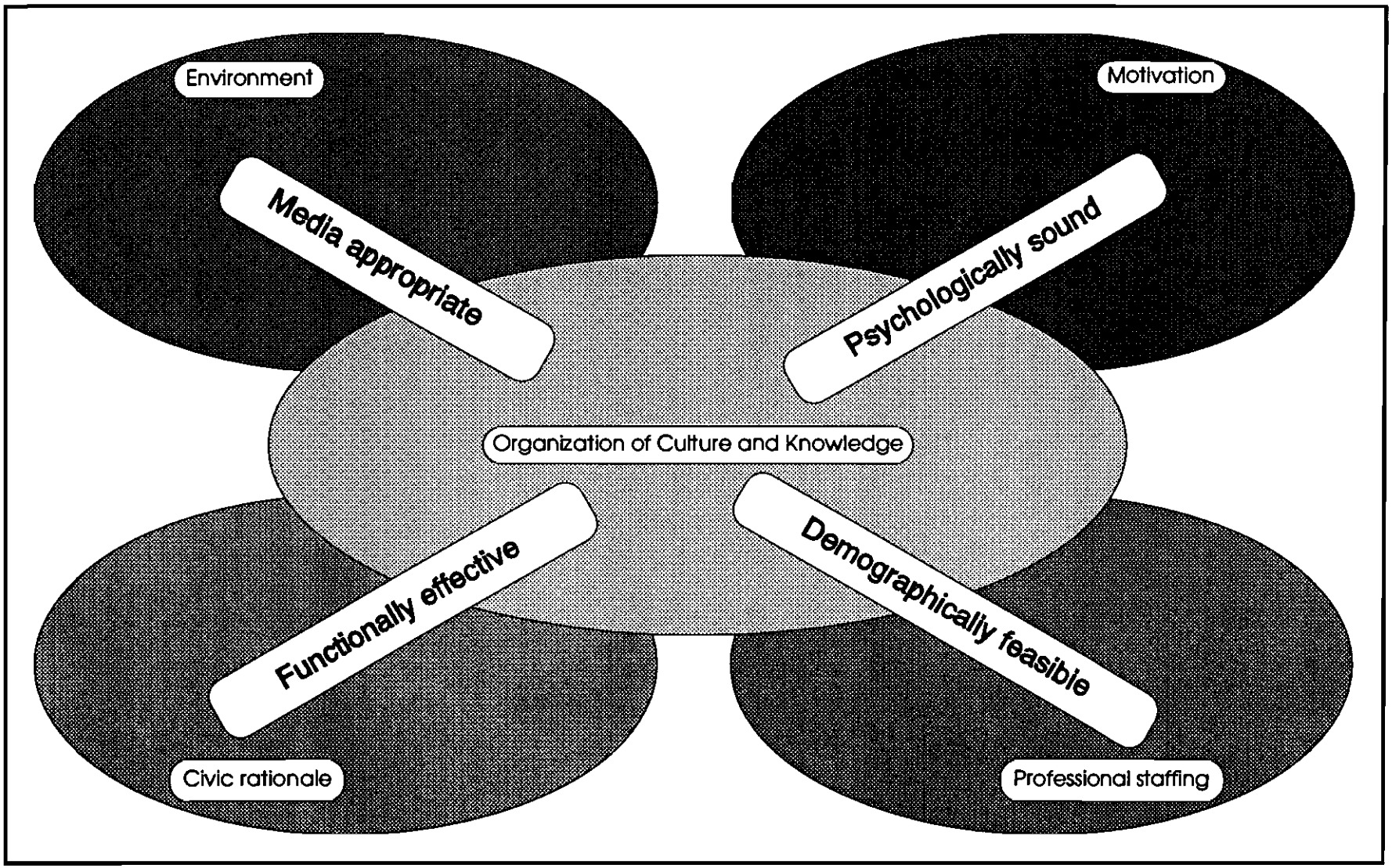
[16] Should the Cumulative Multimedia Curriculum appear to be successful in the sense that it seems to work, a controversy will erupt over what measures would be appropriate for judging whether the spectrum of achievement that would emerge with it would indeed be more desirable than the spectrum diffracted by the existing system. Devising a measure for judging the desirability of its results will not, however, be a key to success or failure in converting the prototype into an alternative system, for people make choices between alternative systems largely on intuitive, not on reasoned, grounds. As the saying goes, "You cannot compare apples and oranges." A rationalized choice of optimal means takes place within a system. The preference for one system rather than another depends on how people form expectations about eventualities that they cannot predict and know firmly.

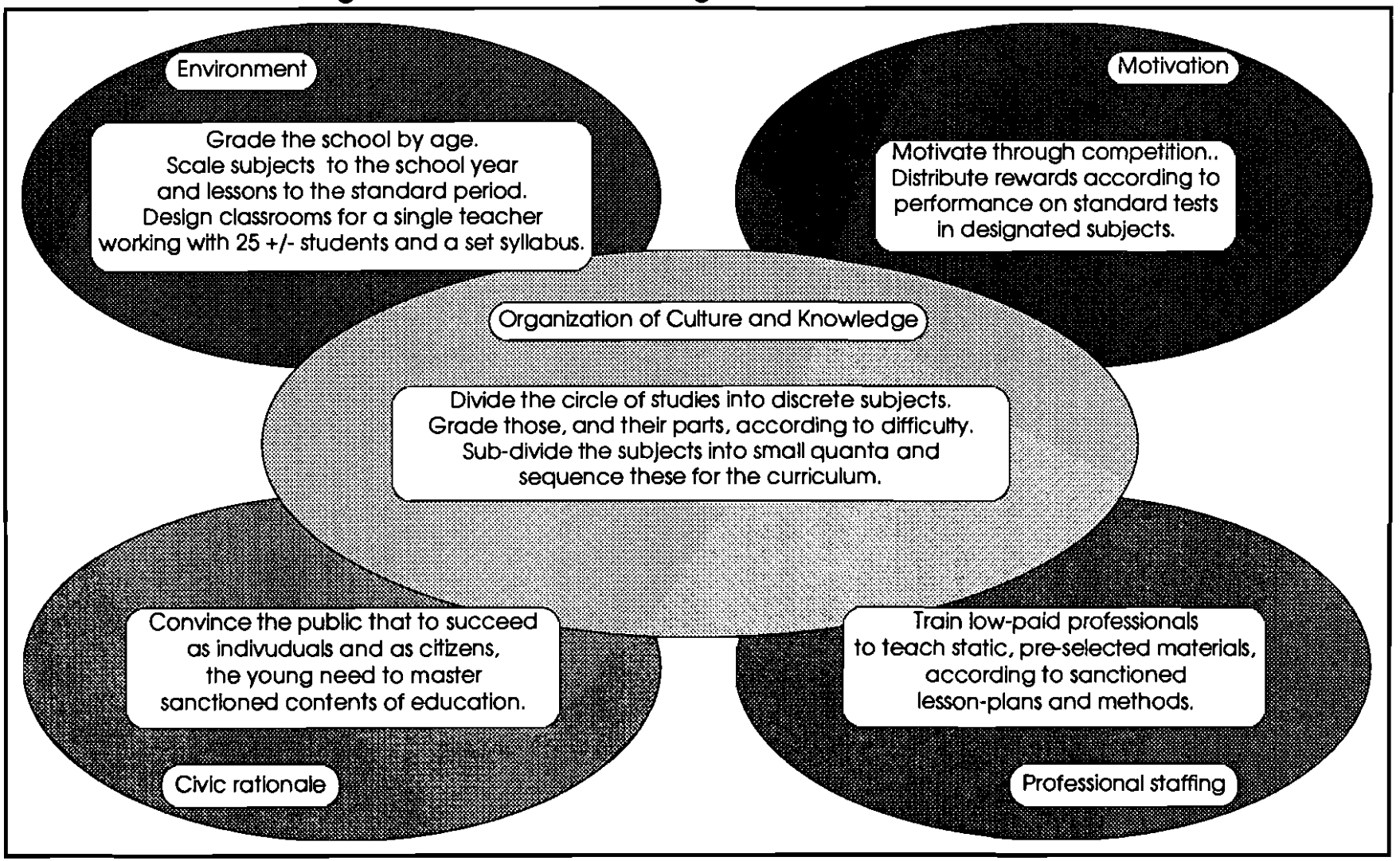
The domains of historical innovation in education



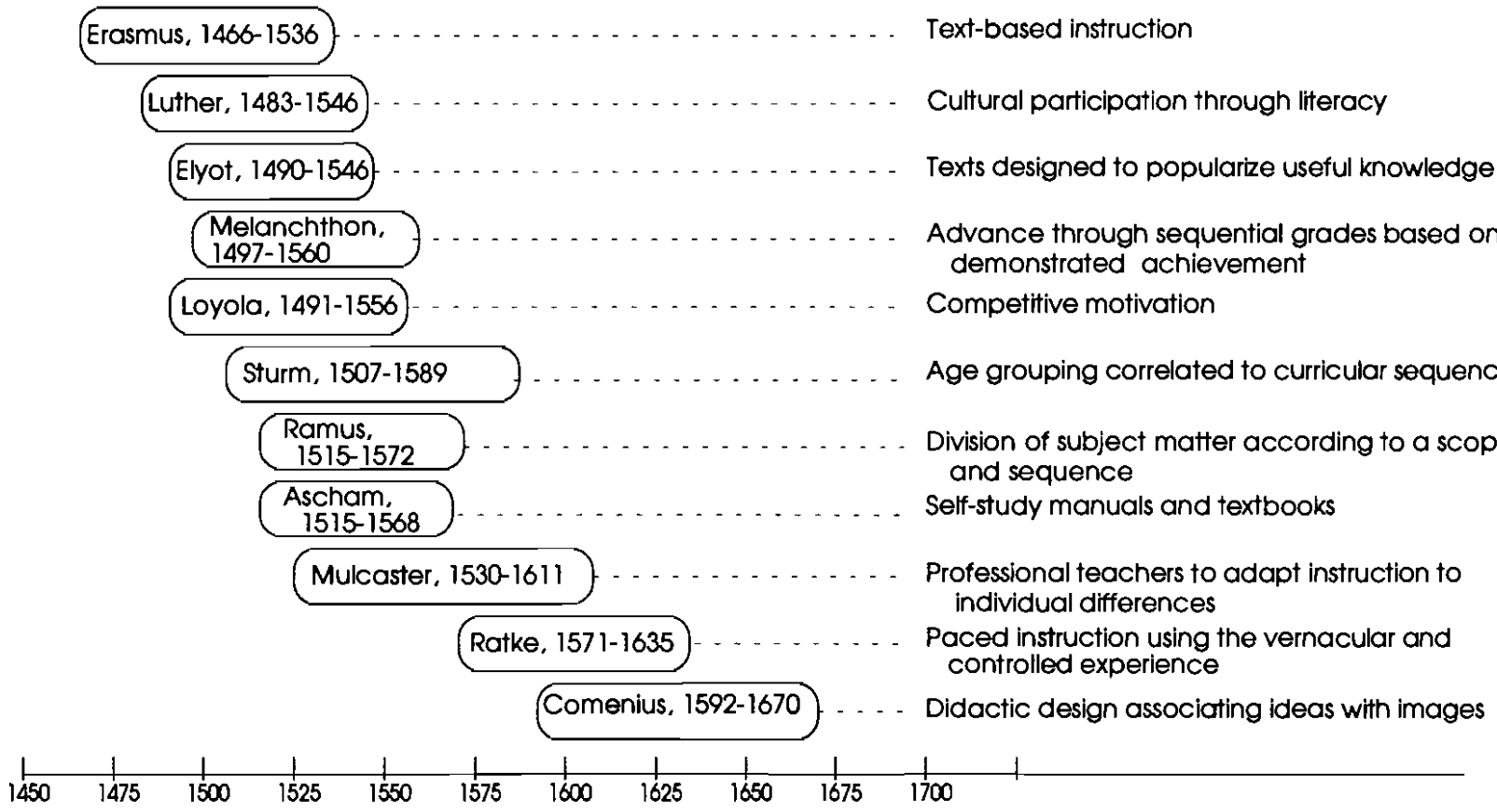
Structural limitations on historical innovation in education



The Historical Grounding of Print-Based Schooling

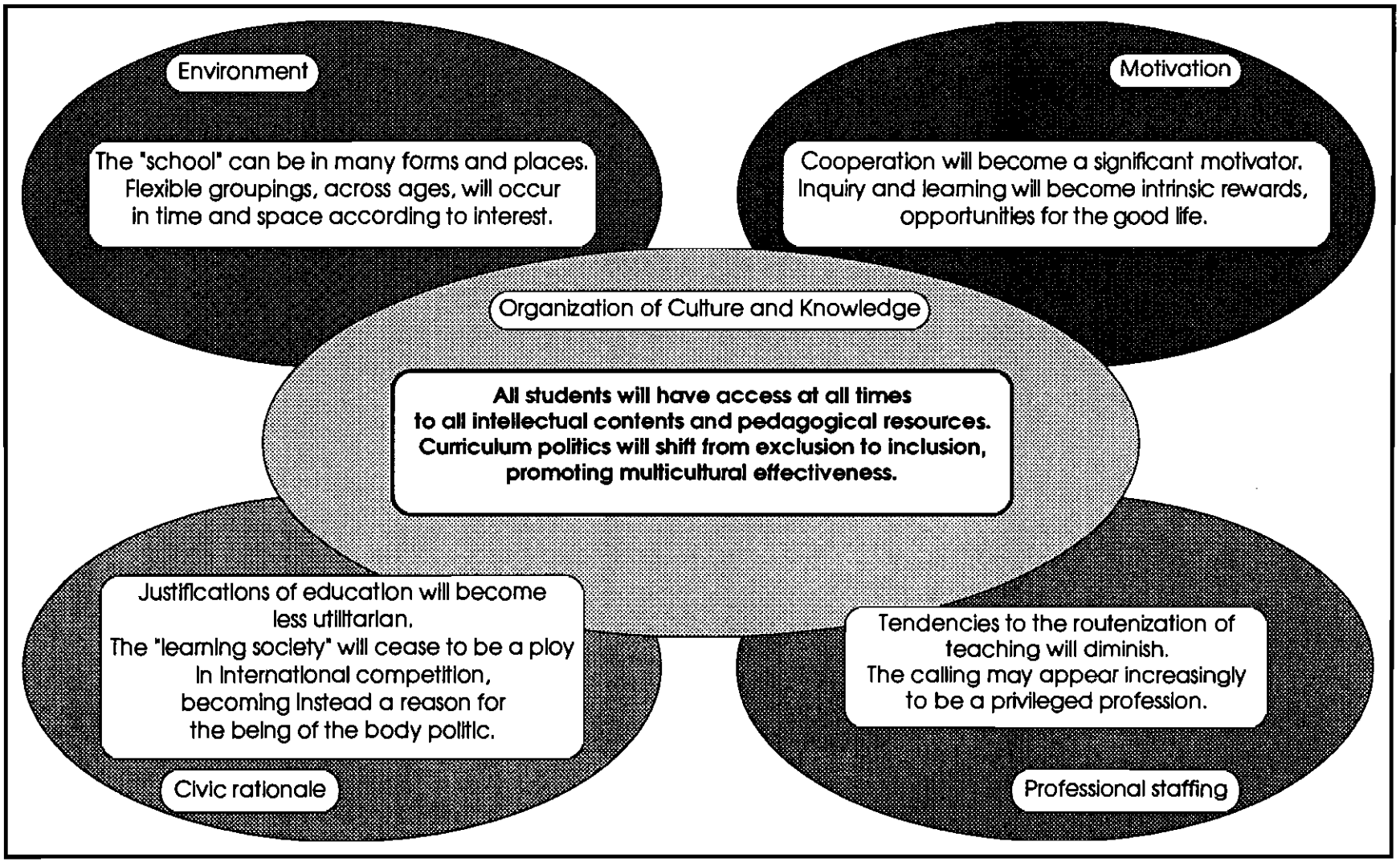


Printing and Early-Modern Educational Reform



Most of the main techniques of schooling were developed between 1500 and 1650, and printing was an essential means by which the reformers implemented their ideas.

The Historical Grounding of the Cumulative Curriculum



To change a system, one must change its material conditions. Many failed educational reforms have been reforms in idea only, changes in method and guiding principles that left in tact the material life of schools. Such failed reforms have been designed to take hold in the given environment. Indeed, people even hailed that characteristic as a sign of the practicality of potential reforms. But ideas that do not affect material life have little historic staying power. The new system of education that we envision will change the daily realities of education; it will change the patterns and structures of educational activity, the locus of study and the tools employed. The new system will transform education by transforming the artifacts of educational activity.[17]

Stop to wonder how a craftsman succeeds in teaching his apprentice or a mother passes her skill in cooking to her child. The pedagogical art is small but sure because the lesson is enforced by the actuality of the activity. The master points to the task and gives a tip when the time is ripe for the apprentice to grasp a new knack. The hammer has a balance and a feel that allows the novice to quickly sense how the tool should be used. Culture, not as things thought and said, but as things made and used, determines what people do and do not know how to do. To change educational ideas and principles one needs to change the tools and conditions of education, otherwise the old ideas and principles will reassert themselves through the weight of doing what is done.[18] The teacher's craft is not independent of her tools, but evident, as with any craft, in the mastery with which she wields them.

Unlike many efforts at change and reform that have centered on educational "method," leaving structures and conditions in tact, we aim to design an alternative material reality, changing the place of education, its schedule, and the tools and resources in daily use. Our prototype, if successful, will show that a different set of material conditions for education are workable, adoptable, and desirable conditions. The first reason for believing that our prototype may indeed metamorphose into a systemic change is its materiality, its substantiality. A second reason arises from a willingness to attend to the realities of power and interest.

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17 One of the most successful innovations in twentieth-century education, standardized testing, exemplifies such materiality. The tests were a new physical tool, administered in places and times set apart for them, scored with new technologies. The material reality of standardized testing is crucial to the way it has so quickly and so widely taken hold, the way it has generated the resources to support its further development and extension, the way it commands attention, forcing schools to teach to the tests and arbitrating success and failure throughout the system.

The late Dr. Ben D. Wood, whose generosity and vision led to the creation of the Institute for Learning Technologies, was a pioneer in the testing movement and someone who keenly sensed the importance of tangibility in agents of educational change.

18 Indeed, one might argue that a reform as intellectualist as the Protestant Reformation took hold in those areas where the material reality of Catholic liturgy and worship were effectively suppressed and did not in areas where it survived. The reformers redesigned places of worship, radically altered their decor, changed clothing styles and all sorts of details of material life.

Educational reformers often do not distinguish sufficiently between the social processes through which an innovation takes hold in practice and the social consequences of the innovation that has taken hold and begun to reshape everyday life. Pick a major technical innovation -- rail travel, the telephone, the automobile, air travel, television, or what-have-you. The social consequences of all these systems have been generally liberating and egalitarian: once established, they have brought options of movement, communication, information, and entertainment within the reach of very wide segments of the population, most of whom did not enjoy such options previously. These social consequences need to be distinguished from the social processes associated with the introduction of the technology into use, for these processes are invariably elitist and anti-egalitarian. The wealthy and powerful benefit first and their interests drive such processes of innovation. We do not say that is the way things ought to be; simply that is the way they are.

Educators have been poor effectors of innovation because they have been too eager to be on the right side of every issue, to champion reforms that will redress injustice, to help primarily the disadvantaged and those in need. Head Start provides an example. It was a good program serving a good purpose, but its base of support was too narrow for the program to have effective staying power and its locus of operation was too circumscribed for its benefits to endure through the whole of a child's education. Many educational reforms designed to redistribute the benefits of the existing system in favor of the least advantaged succumb to opposition because the political base strongly favoring them is too narrow. A redistributive change usually starts in an aura of good will, or high-mindedness in the face of crisis, and groups opposed to it on grounds of ideology or self-interest will defer, letting the change begin unopposed, saving their resistance until the time for it is more opportune. At the first sign of hard times and dubious results, however, support for the change narrows and its natural opponents emerge, soon to prevail.

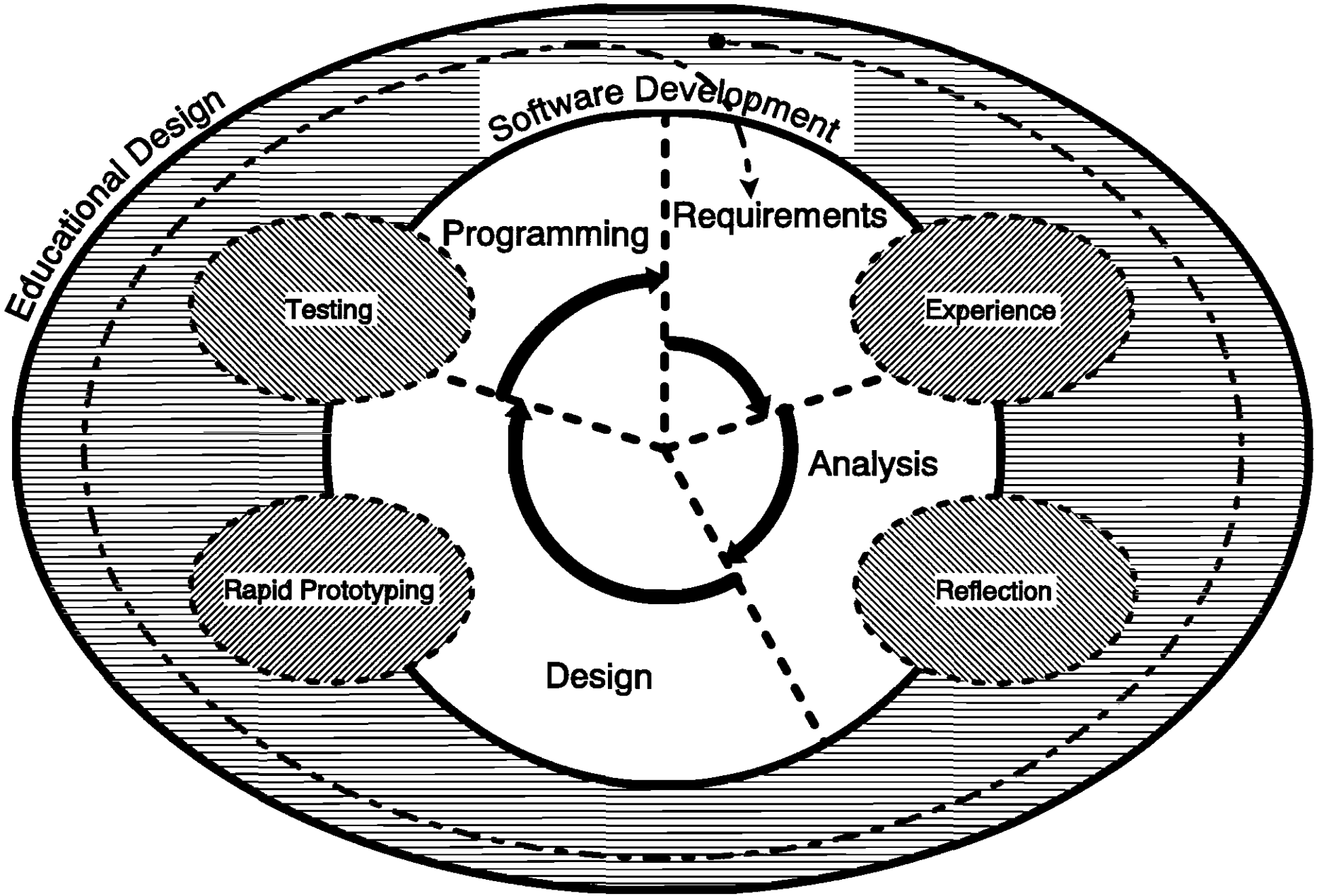
We aim, not to redistribute the benefits of the current system of education. We aim to substitute for it a new system, based on the cumulative curriculum, one that will improve the benefits for all. In doing that, we can mobilize a broad base of support, one with staying power in the face of opposition and constraint. In developing a new system, we can use the social dynamics of contemporary power to put in place innovations, the consequences of which will be liberating and egalitarian.

To change the system, educators must engage the interest and power of dominant elites, to work through their interests to the service of all. Our strategy for innovation is to mobilize the social dynamics of self-interested and powerful groups to institute changes, the social consequences of which will broaden access to excellent education and empowering cultural resources. An innovation that serves the advantaged and the disadvantaged alike is of greater relative worth to the disadvantaged, by virtue of the law of diminishing returns. For

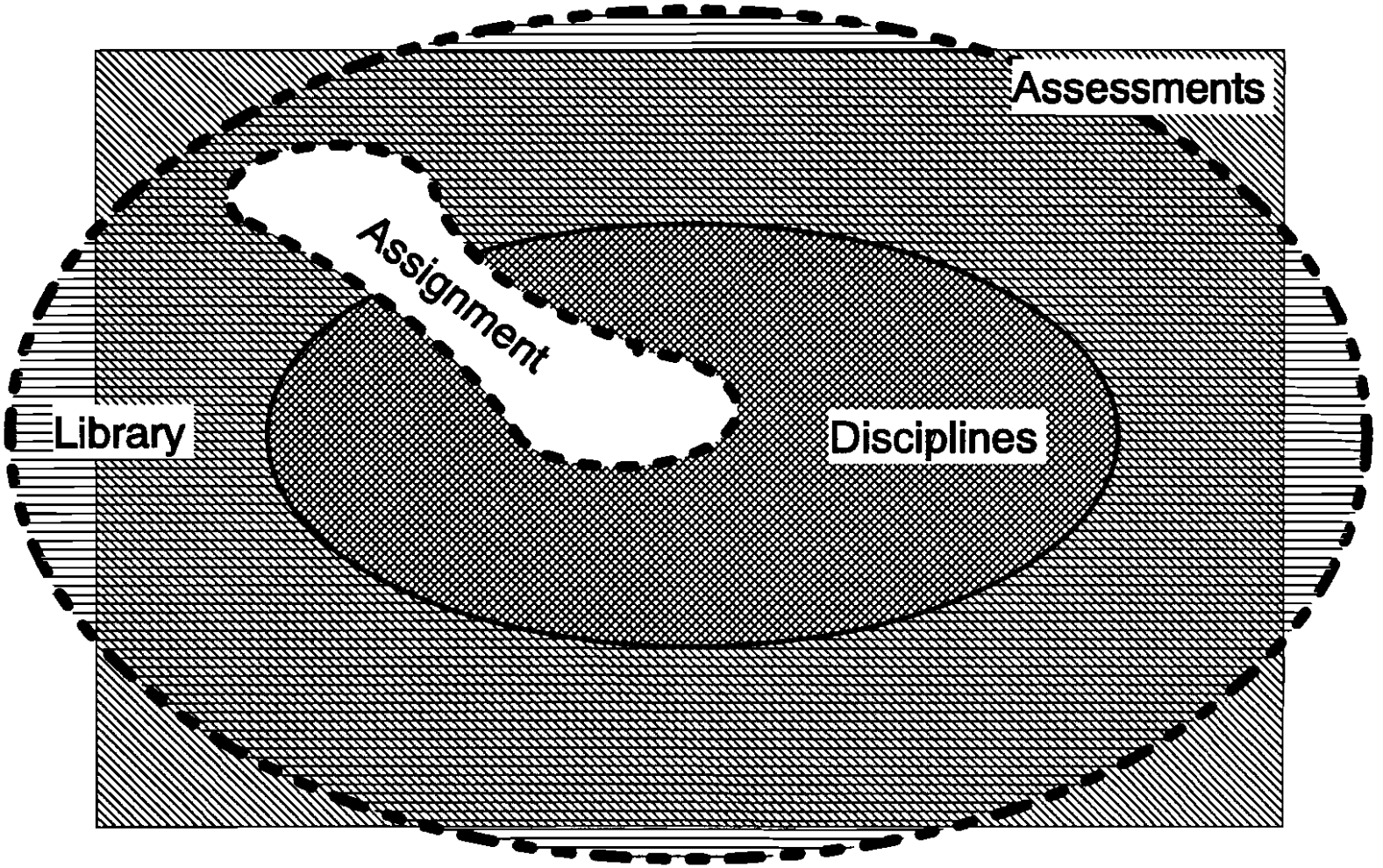
centuries this proposition has set the strategy of enlightenment, of the liberal agenda. It is time to reassert it, robust and proud.

New York, New York, with your glorious complexity of peoples and needs, with your soaring concentration of power and wealth, with your capacity to attract talent and attention, with your gruff directness and abrasive realism -- with all your contradictions, New York, New York, its up to you to implement this strategy of change. The City's elites are the most diverse of the world; and they can mobilize great power, influence, and purpose in the service of all. They want their children well educated. They want reversed and redeemed the terrible collapse of hope and life chances for the truly disadvantaged, the consequences of which continuously threaten all. They want the daily level of skill and intelligence, coursing through the intricate worlds of their activities, to rise steadily, ever more competent and humane. These are not simple amenities; these are complex developments that neither their wealth can buy nor their will command. These wants are their stake in a substantially transformed, and a powerfully transforming, system of education. If they believe that a better system can be constructed, they will seek it for their own and use their influence to spread it far and wide simply because in New York, New York, unlike more sheltered, controlled communities, the elites have a substantial stake in the common good.

The elites of New York, New York, are, at once, the Rainbow Coalition, the American tradition of patrician reform, and the communication nexus of the world. They are Black and Hispanic and WASP and Jew and Catholic, new people and old, Italian and Irish, Korean and Chinese, German and Pole, Czech and Russian, Nordic and Greek, Indian and Pakistani, and on, and on -- peoples from everywhere, pulsing with energy and aspirations. They are resourceful -- full of resources -- the resources of real estate, law, finance, communication, design, industry, science, engineering, fashion, art, film, and philanthropy. The existing educational system serves them poorly. They can change it. Simple prototypes can metamorphose into a new system of education, despite the opposition of inertia and ensconced interests, because the great energies of a great city will drive the process, from its inception, to its completion.


Educational Design
Software Development
Requirements
Programming
Testing
Experience
Analysis
Rapid Prototyping
Reflection
Design

Components of the Cumulative Curriculum



The Disciplines

A formal definition:
The disciplines will provide students with computer-based resources that enable people to explain and interpret subjects of inquiry. Disciplines will avail to students the tools, questions, procedures, methods, and standards, at appropriate levels of complexity, for making different realms of experience intelligible, manageable, and valuable.

Echoing Bruner:

"We start with the hypothesis that any subject can be (studied) effectively in some intellectually honest form (by) any child at any stage of development." *The Process of Education*, p. 33.

" . . . Intellectual activity anywhere is the same, whether at the frontier of knowledge or in a third-grade classroom. What a scientist does at his desk or in his laboratory, what a literary critic does in reading a poem, are of the same order as what anybody else does when he is engaged in like activities . . . . The difference is in degree, not in kind. The schoolboy learning physics *is* a physicist, and it is easier for him to learn physics behaving like a physicist than doing something else." *The Process of Education*, p. 14.

"Motives for learning must be kept from going passive in an age of spectatorship, they must be based as much as possible upon the arousal of interest in what there is to be learned, and they must be kept broad and diverse in expression." *The Process of Education*, p. 80.

The Library

A formal definition:
The library will comprise a comprehensive, selective representation, in multiple formats, of the key phenomena of the world and of humanity. It will include a full repertoire of the cultural constructions that people use to interpret these phenomena, in examples that range from the most simplified to the highly sophisticated.

Implications:

The library = a museum. " . . . the key phenomena of the world and of humanity. . . ."

The library = an exploratorium. " . . . a comprehensive, selective representation, in multiple formats. . . ."

The library should serve all ages. " . . . examples that range from the most simplified to the highly sophisticated."

The library should be active and expansive. " . . . a full repertoire of the cultural constructions that people use to interpret . . . ."

Assignments

A formal definition:
Assignments will put to students significant problems that draw them into constructing solutions, by using the resources of one or more discipline, along with materials in the library and in their daily environs. Assignments should challenge students to work together, extending their use of resources and materials, to question, observe, reason, estimate, measure, demonstrate, doubt, criticize, and affirm -- across the range of things at stake in the conduct of life.

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Echoing Dewey:

"The obvious pedagogical starting point of scientific instruction is not to teach things labeled science, but to utilize the familiar occupations and appliances to direct observation and experiment, until pupils have arrived at a knowledge of some fundamental principles by understanding them in their familiar practical workings." *Democracy and Education*, p. 287.

"The individual who has a question which being really a question to him instigates his curiosity, which feeds his eagerness for information that will help him cope with it, and who has at command an equipment which will permit these interests to take effect, is intellectually free. Whatever initiative and imaginative vision he possesses will be called into play and control his impulses and habits. His own purposes will direct his actions." *Democracy and Education*, pp. 304-5.

"The criterion of the value of school education is the extent in which it creates a desire for continued growth and supplies means for making the desire effective in fact." *Democracy and Education*, pp. 53.

Assessments

A formal definition:
Assessments will help students and teachers perceive what they have and have not essayed within the resources of the program, providing information relevant to the diagnosis of difficulties, suggesting possibilities for further assignments, and keeping a portfolio of accomplishments. So far as possible, assessments should take into account the needs, interests, and capacities of individuals and groups, allowing people to understand where they stand relative to the possibilities of the whole.

Implications:

Assessments should serve students.

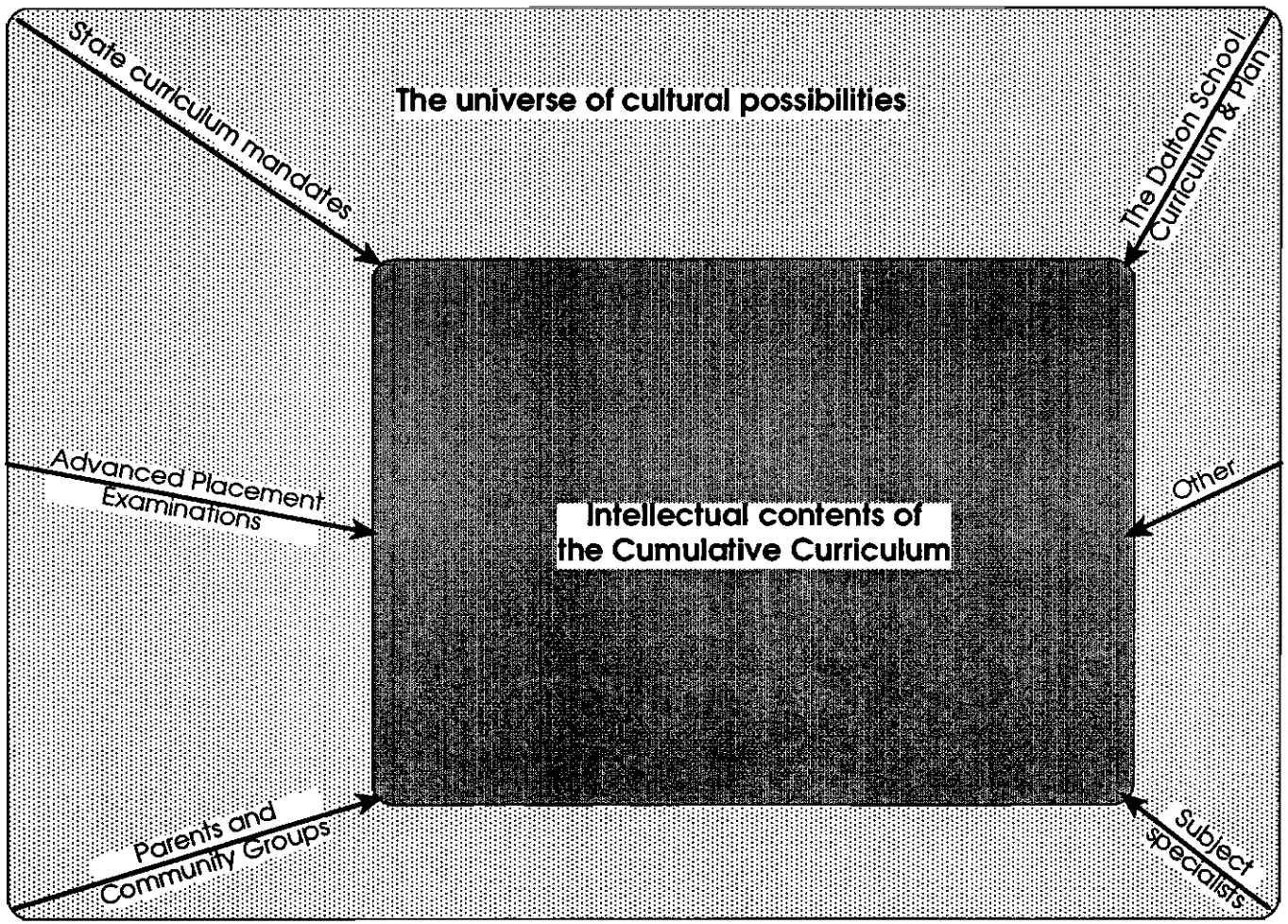
Assessments should engender cooperation among peers -- when other students do well, it should benefit all.

Assessments should culminate in enduring expressions of thought, feeling, perception, and insight.

- What are the objectives of the project?

Select intellectual content for the cumulative curriculum

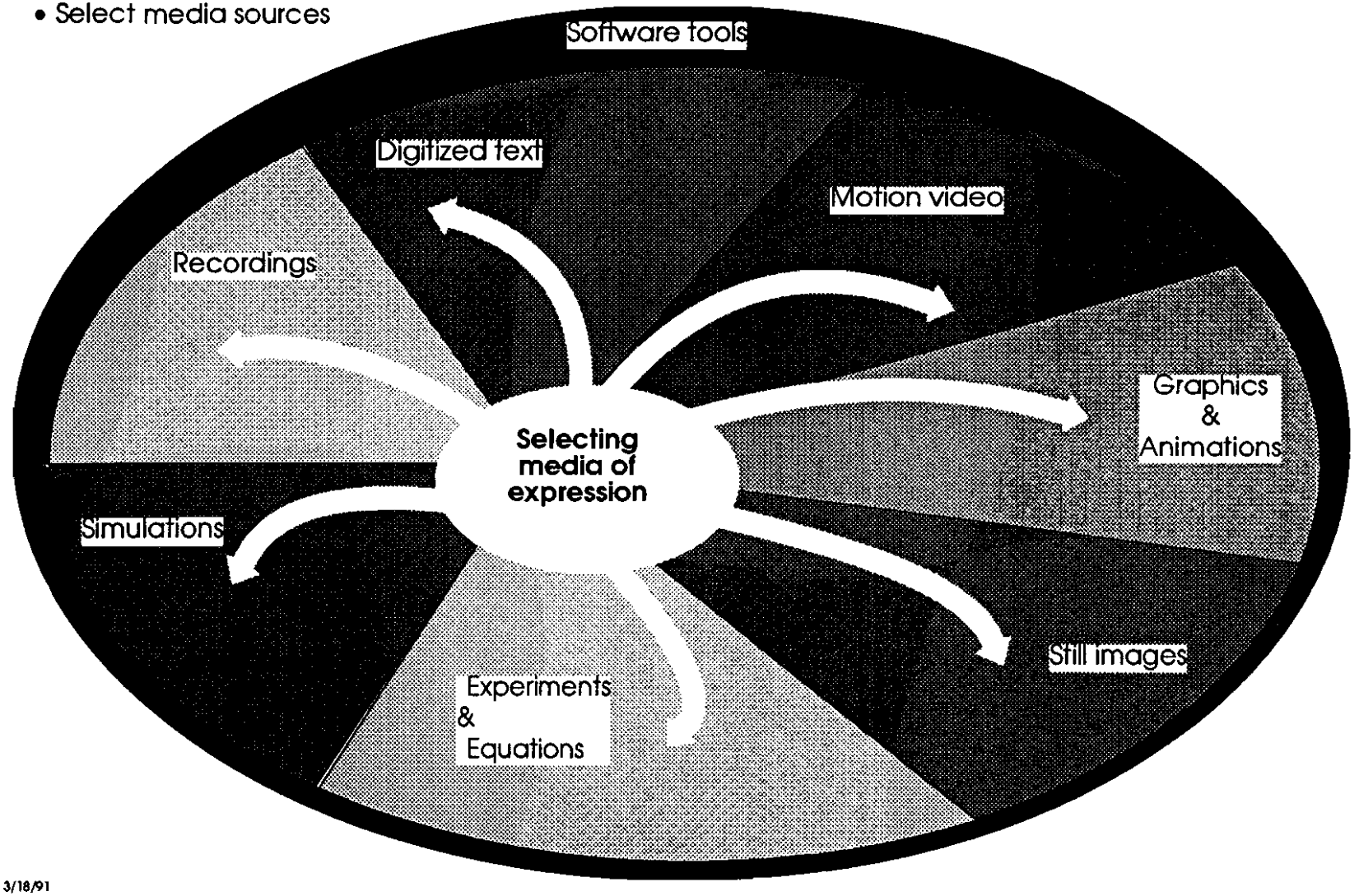
- Map current curricular contents
- Establish inclusion criteria for choosing material
- Make selections



- What are the objectives of the project?

Choose media of expression for the content

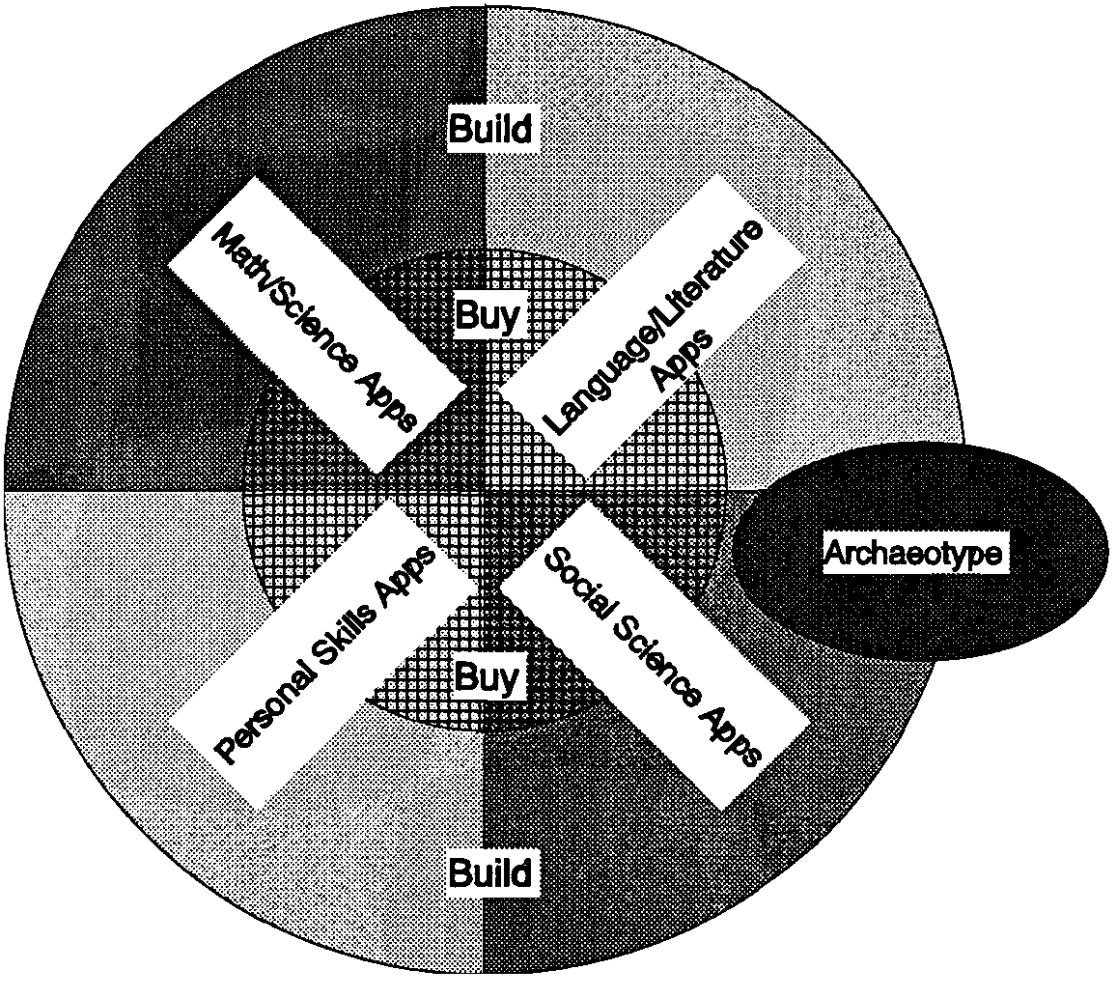
- Establish media criteria for choosing materials
- Inventory available media for topics included among intellectual contents
- Select media sources



- What are the objectives of the project?

Develop the curriculum applications

- Make an inventory of curriculum applications on the market.
- Establish criteria for deciding what apps to build and what to buy.
- Select curriculum apps and schedule the "builds" and "buys".
- Map potential "builds" and "buys" to the selected intellectual contents and media of expression.
- Design and code the "builds" and acquire the "buys".



APPENDIX A: -- ARCHAEOTYPE 3.0 PROPOSAL (SPRING 1993)

ARCHAEOTYPE 3.0: HELPING STUDENTS MASTER CORE SUBJECTS THROUGH AN ADVANCED COMPUTER SIMULATION

One: Objective:

To develop *Archaeotype 3.0*, a new version of an advanced computer simulation introducing students to the study of history and geography, along with other interdisciplinary possibilities such as math and ecology; and to institute a program apprenticing public and private school teachers in New York City in its use in culturally and economically diverse school settings.

Through *Archaeotype 1.0*, on Ancient Greece, and *Archaeotype 2.0*, on Assyria, sixth-grade students collaboratively excavate simulated archaeological sites and construct historical interpretations of the cultures evidenced by the art and artifacts they uncover. These existing versions of the program have been successful prototypes. The project we propose will create *Archaeotype 3.0*, a new site on ancient Egypt and a production version of the program that will be suitable for testing in diverse settings and will lead to its general distribution. As an effort to develop and advance a significant educational innovation, the project will include the following features:

(a) It will further develop an innovative software program created through a collaboration of key teachers at the Dalton School, working through its New Laboratory for Teaching and Learning; scholars and educators at Columbia University, working through the Institute for Learning Technologies at Teachers College; specialists in the Educational and Curatorial Departments of The Brooklyn Museum; and programmers, graphic artists, and network developers from these institutions.

(b) It will enable the New Laboratory for Teaching and Learning at the Dalton School to introduce *Archaeotype* in public schools throughout the boroughs of New York City in order to test the program in a variety of school settings.

(c) It will enable the Institute for Learning Technologies at Teachers College to expand its program for developing the capacity of teachers to use programs such as *Archaeotype* as renewal agents in their schools.

(d) It will extend on-going efforts to develop and apply novel assessment strategies in classrooms using *Archaeotype*, in which learning emerges through cooperative activities in which students interpret primary artifacts of our culture.

(e) It will make important artistic and archaeological artifacts from The Brooklyn Museum available to a wide audience that would not otherwise have access to them.

(f) It will lead to a version of *Archaeotype* that can be adopted generally in schools throughout the nation, engaging a generation of children in a deeper, more vital study of the ancient world.

Two: Need:

Archaeotype is a collaborative interactive simulation created to meet evident needs of the classroom. A class of students, divided into four teams, each working at one of four networked multimedia computers, excavate a complex archaeological site and cooperate over a period of ten to fourteen weeks to interpret the culture evidenced by the artifacts they uncover. The students must work together to construct a defensible explanation of real historical evidence, using a wide range of resources -- people, on-line collections, books and reproductions, and consultations with experts. The experience proves engaging, empowering, and enlightening. It addresses fundamental educational needs.

(a) Overall, the *Archaeotype* project addresses three primary needs:

Archaeotype, as a strategy for introducing middle school children to ancient history, emerged from explicit educational needs.

(1) *Subject-matter.* In school studies, the overwhelming need is to communicate to children the sense that they can take possession of their knowledge and their future by constructing an active interpretation of it. To do that, children need to build the skills required to make such constructions and to internalize the criteria of good reasoning when confronted with complexity of information and difficult intellectual, social, and historical questions.

(2) *Motivation.* Within the classroom, the need is to cultivate cooperation, rather than competition, as the main motivational device.

(3) *Technology.* In the implementation of computer software for educational purposes, the need is to avoid reliance on the novelty of technology to achieve effects in educational design, and to use

the tools, not as sufficient ends, but as means to engage children in exploring substantively rich resources in the world about them.

(b) The applicants identified these needs through reflective practice.

Archaeotype is the work of the New Laboratory for Teaching and Learning, a development lab that is an integral component of the Dalton School, one of the country's pre-eminent K-12 private schools. The leadership of the school and the lab have identified the needs addressed through *Archaeotype* in the course of conducting the school's educational work and in collaboration with leading scholars in the field of education. The identification of needs thus arises from the travails of reflective practice, the elements of which are as follows.

(1) *Subject-matter.* Reflecting on historical studies, we find that children unfortunately learn history as a story to be memorized. Clearly children must learn about the peoples and problems of the past. Yet, mastering the universally valuable skills of the historian, contending with diverse information and constructing plausible explanations of its character and content, is of equal value to knowing about the past. Historical and social studies in schools have been dominated by curricula informed with a grand narrative, a learnable sequence of causes and effects, often marshaling novel-like heroes and villains, who commit great and heinous acts. In this context, the teacher learns the script in her early years of teaching. With familiarity she overcomes the initial anxieties of a new teacher stemming from the unpredictability of student responses and from her own incomplete mastery of the script. Given *Archaeotype*'s interactive hypermedia capacities, regardless of the simplicity of the artifactual database chosen, teachers find it almost impossible to predict the direction of a student's inquiries. The teacher must wait and see what direction students choose before she can begin to be useful as an experienced interpreter of similar realms. Indeed, it is this unpredictability which prevents the educational environment from degenerating into an over-simplified drama in which authentic dialogue is impossible because the teacher anticipates from her experience all the possible lines of the conversants. Consider the difference between an experienced guide returning to the same sites year after year and the experienced explorer who has considerable skill in traversing unknown places but rarely retraces her exact steps. This demonstrates the difference between a teacher in the old scripted tradition, locked into a predetermined tour, and the new teacher able to respond each day to the unexpected choices and problems emerging from the study and research of her students. The student becomes the centering force rather than the worn grooves of the curriculum.

(2) *Motivation.* Owing to their demographics and to the gate-keeping functions they have traditionally served within modern societies, schools have classically relied on the force of competition to inspire students to serious effort. Given the new emphasis on the practical importance of cooperation and collaborative problem-solving in the public conversation about work and productivity, the normal view of encouraging competitive attitudes in schools has been significantly challenged. Although the demographics pertaining to student-teacher ratios have not changed, computers have put in our hands a new means of deploying scarce professional resources. A teacher no longer need position herself in front of a class to instruct a large group. Rather, *Archaeotype* allows student attention to focus on the object of study. Further, results cannot be effectively achieved either within the small group or in the context of the larger project without substantial and constant communication and cooperation. When we describe *Archaeotype* as an example of integrated curriculum, we mean to include both its capacity to be genuinely interdisciplinary (one needs the different disciplines to solve the problems one faces) and its capacity to encourage learning habits that do not require the spur of competition to gain the qualities of dedication, energy and commitment.

(3) *Technology.* Computer-based curricula are often pallid and canned. At their best, computer-based materials can be vivid and full, but often the screen presents abbreviated explanations, simplified representations, and few pointers for the curious to resources outside the system. When this happens, computer-based programs reinforce one of the great problems of the classroom -- its tendency to become a bounded intellectual environment where the cultural stimuli are generally sparse. Educational environments need to be rich with quality information and powerful ideas. *Archaeotype* meets this need in many ways. The artifacts that students uncover lead them to reach out to a wide range of interpretative contexts -- to on-line resources, to books and reproductions, to people who might have expert knowledge. For instance, in *Archaeotype 1.0* the development team provided students with a list of accessible experts in the different areas of Greek studies to whom they could go when they wish to discuss problems they encountered. They have also encouraged them to make full use of the Metropolitan Museum of Art, the best local collection of Greek antiquities, and to use on-line collections such as the *Perseus Project* and the video discs on the Louvre collections. Helping student excavators develop a mental model of learning, which focuses the questions they have presented to themselves as the significant challenge, rather than

winning the "game" in which these questions may first be encountered, stands as a primary goal of this project, and perhaps somewhat ironically, one of the true potentialities of the new technology in education. *Archaeotype 3.0* should be particularly effective in leading students to quality materials, for The Brooklyn Museum has, not only an excellent collection which students can engage through their excavations and unfolding interpretations, but it also has a very strong curatorial and educational staff that can serve as sources of human expertise, helping students make their interpretations ever fuller and deeper.

(c) *Archaeotype* meets these needs by using a networked, multimedia simulation to introduce students to the study of ancient civilizations.

Prototype versions of *Archaeotype* have given a proof of concept that an archaeological simulation using networked multimedia can lead students to develop well-considered narratives of the past, that they can do it through complex classroom collaborations, and that they will avoid the technological solipsism of relying solely on computers in the process. Our project will carry this concept toward general implementation.

Recently, at a place in Greece just north of the isthmus of Corinth, and a little more than halfway between Eleusis and Plataea, a farmer was plowing his field when he hit upon a particularly large boulder. When he tried to pull the huge piece out of the soil he could not budge it. So, the farmer enlisted the help of his sons who lived with their young families on nearby farms where they cultivated olive groves and grape vines for the export trade. Together the men succeeded in excavating a chunk of limestone with peculiar striations on one side. The farmer who remembered that his very own father had fished artifacts out of his field many years before knew that the piece of stone was in fact an artifact created in classical antiquity. He also knew that the law required that he inform the Department of Antiquities, an arm of the Greek government, of his discovery and request that an emergency excavation team of archaeologists be sent to the farm immediately. When the team arrived at the farm and had conducted a preliminary observation of the site, the archaeologists recommended that a full-scale excavation be undertaken as soon as the weather permitted. Because of the special relationship that your school has with the Department of Antiquities, you have been given the rare opportunity to join the excavation. You will be a guest in the land of the Ancient Greeks.

Thus begins the sixth grade curriculum module entitled "Lessons From the Soil: The Ancient Greeks," which is a specific deployment of a prototype software package, *Archaeotype*. Technically, *Archaeotype* is a networked, archaeological simulation written for Macintosh computers in the language *SuperCard*. Presently, in addition to the Hellenic iteration of *Archaeotype*, there

is an Assyrian excavation entitled "Tell Ahmar: An Assyrian Fortress in North Syria." The Assyrian site was built on the success of the Hellenic and is presently being beta-tested in the Dalton sixth grade. The Hellenic, which has run for three successive years at Dalton, is presently being tested at the Juarez-Lincoln School of the Chula Vista Elementary School District in southern California.

Archaeotype allows students to work in small groups to excavate a section of a simulated archeological site. As they dig and discover things, they send them to the simulated lab where they measure, weigh, and begin their research into the nature of their specific discoveries. They are encouraged to use both the resources within the library of the program as well as other resources available outside the orbit of the program such as museums, experts and library materials. The challenges built into the project are intentionally multi-disciplinary requiring the use of math, science, history and philology. As the students continue to excavate, they compile a database on the basis of which they are called upon to make inferences about the society and culture of the site. As they try to construct a picture of some coherence, they are encouraged by the team-oriented nature of the archaeological enterprise itself to cooperate with each other to achieve this goal.

Through the *Archaeotype* prototypes, we have strong indications that the software addresses the three primary needs of the project effectively. Evaluators have found that students effectively engage in constructing their own narrative context for interpreting the specific artifacts they uncover and the site as a whole. To do this, they engage in spirited cooperative work as small groups of students work together to understand their quadrant and join periodically as a whole class to make sense of the site as a whole. With such experiences, students effectively avoid technological solipsism, even if they rely primarily on the computer for information and ideas, for the experiences lead students to focus on the historical, interpretative questions, using any and every resource they can -- the computers, books, pictures, maps, videos, recordings, people and collections, throughout the school, at home, and in surrounding cultural institutions -- to construct a context for interpreting their site and the artifacts they uncover within it.

Over the long run, we intend to develop successive versions of *Archaeotype* in such a way that a school faculty can choose what culture and society should be represented in an excavation. Teachers will be able to construct an excavation around Chinese, African, or Native American materials. They will be able to control the level of complexity of the site through the selection of artifacts in the dig and through the complexity of research resources both within and without the program environment. We propose to move decisively towards these features of the program with *Archaeotype 3.0*, an Egyptian site, which the New Laboratory for Teaching and Learning will develop in collaboration with the Institute for Learning Technologies at Teachers College, Columbia University, and the Education and Curatorial Department of The Brooklyn Museum.

Archaeotype 3.0 will move the concept beyond the prototype stage toward a genuine production version that can distributed widely. We seek support for developing the software and training strategies for preparing teachers in its use. In this way, the project will turn the potential of a prototype into an emerging general implementation.

Through good schools, the young need to learn how to learn, to solve significant problems through the pursuit of their own inquiry. The design of *Archaeotype* helps students to learn how to learn. It presents real unknowns to students and provides a context of tools and resources enabling them to work creatively, over a sustained time, developing hypotheses and assessing their merits -- criticizing, searching further, and revising. In this process, they draw on a range of intellectual tools and techniques that people usually associate with different subjects -- maps, chronologies, graphs and coordinates, measuring standards, geometric and algebraic calculations, ecological analyses, geological distributions, artistic motifs, technological and scientific histories, religious and mythological studies, medical epidemiologies, economic calculations, and so on. Usually, if children have any experience of the powerful tools of inquiry in all these areas, they experience them as the ends, the objects of their labor. Yet for real inquiry and action, these resources are tools, *means* for possibly developing real solutions to real problems. *Archaeotype* enables students to use such resources as means to learning, and will thus help them learn to learn, to form a sense of how to address real difficulties. The more our educational institutions can convey this sense to our children, the more powerfully it will enhance the long-run development of our culture.

(d) The following benefits will result as the project meets its primary needs.

Archaeotype 3.0 will generate specific benefits as a result of the first year of work on it and through its subsequent development. The first-year activities will result in the following:

(1) A curriculum unit on ancient Egypt will have been developed. It will be suitable for use in the sixth through tenth grades and schools will be able to install it in classrooms either from a CD-ROM at the location or from a high-speed wide-area-network link to the development sites at Dalton, Teachers College, and The Brooklyn Museum.

(2) A generic excavation interface and retrieval resources for *Archaeotype* will have been developed, a major step in making it possible to distribute the program generally to schools and colleges.

(3) The Brooklyn Museum will have created digital representations of many objects in its renowned Egyptian collection and made these

representations, and curatorial support resources pertaining to them, accessible via wide-area-networks.

(4) An initial cadre of teachers will have learned to use powerful constructivist pedagogical tools with their students, and they will have begun to introduce new curricula and laboratory-based strategies in their schools.

(5) Assessment tools and strategies for documenting how and what students learn as a consequence of working with the new curricula will have been prepared.

(6) Feasibility of an important curriculum delivery model -- one which will use high-speed wide-area-networks to provide access to quality collections of visual, audio, and video materials -- will have been tested.

With the subsequent development of these specifics, benefits of considerable general import to the nation can accrue:

(7) Culturally, *Archaeotype* will contribute to educating citizens who have *learned how to learn*, a quality essential in an ever-changing information society.

(8) Socially, it will accustom students to learning in creative collaboration with others, an indispensable capacity for coping with the divisive stresses that beset our communities and economies.

(9) Technically, *Archaeotype 3.0* will show how schools, universities, and cultural institutions can modularize and link their educational resources and efforts in ways that will avoid inhibiting entanglements oven intellectual property rights while engendering transformative improvements in education.

Three: Plan of Operation:

Our plan of operation involves the following steps:

(a) Design and development of *Archaeotype 3.0.*

(b) Selection of schools as implementation sites.

(c) Training of teachers for introducing *Archaeotype 3.0* in the selected schools.

(d) Design of assessment strategies for evaluating student achievement in the selected schools.

(e) Supervision of the first pilot test in the selected schools and the formative evaluation of the test to ready *Archaeotype 3.0* for more general use.

The first four steps will take place concurrently during the first year of the project. The last step will follow in subsequent years, along with extensions of the first four.

(a) Design and development of *Archaeotype 3.0*.

To create *Archaeotype 3.0* we will design and develop three distinct, yet related, components:

(1) An educational scenario and interface which will present the problematic of the excavation to a class of cooperating students. This is the component that students will see on the screen of their computers as they proceed through the excavation. A group within the New Laboratory for Teaching and Learning will have primary responsibility for this component, which we will call the Pedagogical Group, directed by Dr. Frank Moretti.

(2) A representation of the artifacts to be found in the site and of the contextual materials -- explanatory texts, pictures, drawings, maps, and videos that students can call-up on-line help make sense of the artifacts they excavate. A group centered at The Brooklyn Museum will have primary responsibility for this component, which we will call the Reference Group, directed by Deborah Schwartz.

(3) A set of on-line tools such as database management programs, hypermedia notebook tools, image-analysis tools, and the like that students and teachers can employ in setting up and carrying out their excavations and reporting on their results. A group drawing from the New Laboratory for Teaching and Learning and the Institute for Learning Technologies will have primary responsibility for this component, which we will call the Tools Group, directed by Robert McClintock.

In addition, a fourth group, the Assessment Group, directed by Dr. John Black, will work concurrently to develop some special student assessment tools (see below, Section 3d, page **Error! Bookmark not defined.**).

The Pedagogical Group. The staff of the New Laboratory, along with key teachers associated with earlier versions of *Archaeotype*, have extensive experience with the pedagogical strategies employed in the program. Each version includes a carefully contrived assignment, designed to take six or more weeks to complete. This assignment informs the choice of materials in the site and the resources available for interpreting them. It is the most important and difficult part of the program to develop from an educational point-of-view. The main features of it should be created by the Dalton staffs as early as possible in the life of the project. They will start 1993-94 engaging in a general survey of Egyptian archaeology, in particular, becoming fully familiar with the Egyptian collections of The Brooklyn Museum. The Museum is currently reinstalling its Egyptian collection, which will reopen early in November 1993. At that time, the

program development staff to start discussing with the curatorial staff there various options for the design of the excavation. By January 1, 1994, they should have a general specification sheet for the excavation, setting its location, the chronological span of artifacts within it, the cultural typology of its main components, and an inventory of the intellectual constructions that students are likely to embark upon in the course of the excavation. A preliminary version of the assignment statement should be complete by that date as well. The Pedagogical Group should then turn to laying out the excavation interface which needs to be carefully designed to engender the appropriate division of labor within a class, to be clear and engaging to students using it, and to be coherent and efficient throughout the full life of the excavation. In developing the excavation interface, the Pedagogical Group will need to work closely with both the Reference Group and the Tool Group.

The Reference Group. The Brooklyn Museum has one of the premier collections of Egyptian antiquities and an excellent curatorial and education staff. They have already started to develop digital representations of key holdings. The Reference Group will work with the Pedagogical Group to determine how the objects placed in the site should be represented and to select, digitize, and organize the supplementary materials that will be available on-line as resources to help excavators to make sense of what they find and to interpret objects and the site as a whole. The Reference Group will need, at first, to concentrate on developing the representation of objects in the site. They will need to work closely with the Pedagogical Group to make sure the representation of objects they prepare reflects the educational rationale of the site and the objects in it. In addition to developing the digital representations of the objects in the site, the Reference Group needs to select and create the on-line interpretative resources that will be available to the excavators as they work, uncovering objects and developing their interpretations of them. These materials should be authoritative from the scholarly point-of-view, and even more importantly, effectively usable in helping student archaeologists formulate sound, insightful hypotheses about what they are discovering. In developing the representation of objects in the site and of interpretative resources, the Reference Group will need to work closely with the Tools Group to make sure that the digitized representations they develop conform to the data standards required by the tool set designed for the program.

The Tools Group. Both the other groups concentrate on the *what* of the educational experience. The Tools Group needs to concentrate on the *how*, creating tools that will work, insofar as possible, generically, with any site layout and representation of its contents and interpretative resources. From prior versions of *Archaeotype*, we have a good working understanding of the design requirements for many tools to be build into *Archaeotype 3.0.* By November 1, 1993, the Tools Group should have a full requirements statement prepared for discussion with the other two groups. This should be finalized by January 1, 1994, and two distinct implementations need then to be developed. The first will allow for interim testing in settings where powerful wide-area-network linkages

are not in place, a constraint we expect to pertain in most of our school locations. In this version, both the excavation interface and the representations of objects in the site and the interpretative resources will reside on one local-area-network. The second will allow for the testing of the typology that we expect for a full production version. In it, the excavation interface and the main tool set will reside on classroom computers, linked together by a local-area-network, while the representation of the objects in the site and the interpretative resources will reside on a database server at The Brooklyn Museum accessed by high-speed wide-area-network links. This second version will not pose significant difficulties in the design of the tool-set. In the near future we expect there to be a significant market for both formats, and as sophisticated wide-area-network links become common in schools by the end of this decade, the networked version will become standard.

Thus all three development groups will be working in parallel during the 1993-94 academic year. *Archaeotype 3.0* should be up and running in a preliminary version at the Dalton School, at Teachers College, and at The Brooklyn Museum by June 1, 1994, in time to prepare for the Summer Training Workshops in July (see below, Section 3c, page **Error! Bookmark not defined.**).

(b) Selection of schools as implementation sites.

Selecting implementation site schools will take place during the 1993-94 academic year. With the I-CM Project, for teaching science with the Interactive-Colloquium Method that was funded by the Secretary of Education, the DeWitt Wallace-Readers Digest Fund, and the Helena Rubinstein Foundation (see appendix), the New Laboratory for Teaching and Learning has worked collaboratively with diverse schools the New York City Public School System and it has maintained these relationships. The New Laboratory for Teaching and Learning has also been the center for the Mayor's Partnership for Public and Private Schools for New York City. In addition, the Institute for Learning Technologies at Teachers College has had several funded projects with public schools the New York City system and through the New York Youth Network, a computer-based bulletin-board for at risk youths, it cooperates with a variety of community-based groups. The Brooklyn Museum itself has a very active public education program, running funded summer institutes for public and private school teachers on ancient Egyptian art and archaeology, as well as other topics.

An Advisory Board will, among other things, help the Project Directors select schools as implementation sites. The board will include the following, who have agreed to serve:

Anthony Alvarado Superintendent of District Two in the New York City Public School System.

George Bond Professor of Anthropology and Education and Director of the Institute of African Studies, Columbia University.

Ann El-Omami Curator of Education at the Cincinnati Museum of Art.

Ogden Goelet Assistant Professor of Egyptian Language and Literature, New York University.

Toni Schmiegelow Executive Director of the City Volunteer Corps.

In past collaborations, we have learned that schools should be selected close to the actual start of implementation at the site and that broad interest in the project within the school, in addition to support from the top authorities, is essential to achieve success. Hence, we will use a range of criteria for selecting potential partners, among them:

(1) The cultural diversity of the school itself will be a very significant criterion. Our expectation is that the school must in some way represent the range of students in the New York Public School System and therefore to some extent the range of students in most urban settings.

(2) Whether or not a school has sufficient technical base without requiring extensive upgrade to sustain the project through classroom use.

(3) The level of faculty enthusiasm for projects of this type and their willingness to work for approximately five weeks in the summer before the actual implementation of the project in the school.

(4) The full support of the principal of the school and a clear indication that the principal understands that the new technologies can enhance learning in the direction of constructivist pedagogical principles.

(5) The central support of the superintendent of whichever district each school was in.

The final deadline for the selection of the five public schools, one from each of the five boroughs of New York, will be May 1st. In addition to these five school sites, we will implement *Archaeotype 3.0* at four additional locations: the Dalton School, where the New Laboratory for Teaching and Learning has developed prior versions of *Archaeotype;* Boys Harbor in upper Manhattan, with which the New Laboratory has a preexisting collaboration; the New York City Museum School, in the creation of which The Brooklyn Museum has been a moving force; and the Juarez Lincoln School from the Chula Vista Elementary School District in California, which has already become a test site for earlier iterations of *Archaeotype.*

The calendar for the process of selection is as follows:

10/15/93: Using the Advisory Board and our own educational network including Teacher's College, public school collaborators we will collect a series of recommendations of at least 15 schools that might meet the above mentioned criteria.

10/15/93 to 11/15/93: The director will make school visits which will include a demonstration to the administration and faculty of the interested school of earlier iterations of Archaeotype and an explanation of the educational principles involved as well as a clear indication of where Archaeotype can supplant in an effective way the traditional curriculum from their specific curriculum outline. The school visits will also involve a review of school facilities and interview the teachers and administration in order to determine level s of interests. Those schools that are still interested after the visit will express that interest by formally applying for participation in the project by December 1st. We will seek to get by December 15th support from the superintendent of the school district of each of the applicants.

1/10/94: The project will make a commitment to five schools and three schools on the waiting list, with the goal that five schools be one from each borough.

(c) Training of teachers for introducing *Archaeotype 3.0* in the selected schools.

From the schools finally selected, four teachers will be chosen with the principal with the goal being that at least two be social studies teachers preferably from the 5th and 6th grades and two others from other disciplines but having an interest in the project. It would also be desirable that one of the two non-social studies teachers be a librarian since the project is significantly concerned with information resources on the direction that the shaping of intellectual inform-ation resources in a specific school goes. The criteria for selecting the four teachers will be:

(1) diversity;

(2) motivation and interest;

(3) intellectual preparation for working in a constructivist educational environment, which may come from a variety of experiences, ranging from teacher-preparation courses to work on other projects that have similar essential principles but not the technological base of *Archaeotype.*

The calendar for selection process will be as follows:

1/15/94: Principals make recommendations.

1/15/94 to 2/15/94: Teachers will be interviewed by the project director in conjunction with a team from the development group and a representative of the advisory group.

2/28/94: The four teachers from each of the five schools will be selected by the above group.

4/1/94: Description and demonstration of the prototype will take place and a workshop discussion of its use, power and curricular placement.

7/1/94 to 7/31/94: Summer Training Workshop will take place. Credit will be available for taking this workshop through Teachers College or in place of credit teachers taking this workshop will receive a $1,000 stipend.

The five weeks of the workshop will be allocated as follows:

Week 1: Basic training in the use of Archaeotype and an introduction to the philosophical premises and the future of interactive networked multimedia.

Weeks 2 & 3: The twenty teachers, under the supervision of the summer training institute personnel, will do the simulated excavation with daily debriefings exploring the educational possibilities and problems implicit in the prototype.

Weeks 4 & 5: Teachers with their supervisors will work out the specific curriculum adaptations necessary for each school which take into account the material constraints of the school, its information resources, and specific characteristics of its student population.

(The Summer Institute will be run collaterally and cooperatively with The Brooklyn Museum's Egyptian Summer Institute for Teachers.)

(d) Design of assessment strategies for evaluating student achievement in the selected schools.

In Section 6 below, we describe what we intend to do to evaluate the effectiveness of *Archaeotype 3.0* as an educational resource. The subject of evaluation there is the program we propose to develop. A significant element of the program to be developed consists of assessment strategies for documenting what students learn through *Archaeotype* and providing them helpful feedback that can help make their studies bear optimal fruit. Here the subject of assessment is the student.

Traditional assessments -- quizzes and essays keyed to the text and the teachers glosses to it -- are not particularly relevant to understanding student performance with *Archaeotype*. Indeed, traditional assessments will be out of harmony with *Archaeotype* and would probably deflect students' effort into unproductive paths. We instead seek to develop three types of assessment strategies that are consistent with the goals and procedures of the program -- embedded assessment, portfolio assessment, and transfer assessment.

Embedded assessment characterizes much real scholarly inquiry and problem-solving activity, especially as it is conducted by working groups. Embedded assessment opportunities will be integral components of the work-flow in the *Archaeotype 3.0* pedagogy. Once a week each class, working together on the full site, should meet as a whole to present key findings, to explain preliminary hypotheses, and to discuss how to proceed. Each sub-group assigned to a quadrant should continually discuss how each can best contribute to moving the excavation forward and brainstorm about the artifacts they have found. The whole process of inquiry moves forward as students share and criticize preliminary findings, searching out further information, developing and overturning possible hypotheses. All this is the embedded assessment integral to active inquiry and study.

Portfolio assessment results because students work together to produce on-line site reports presenting their selection of key artifacts and their interpretations of the site based upon them. These reports will reflect both individual effort and collaborative accomplishment and a significant component of the pedagogical design will be to provide a framework helping students to develop these reports. Two cycles of formative evaluation are already available. *Archaeotype 1.0* has students learn the rudiments of *Hypercard* and then use it to create their reports. In some instances this worked very well and in others students found the added dimension of having to do some programming to present their analyses too daunting. In *Archaeotype 2.0* a preprogrammed framework for exploring interpretative hypotheses has been included. Observations of the first group of students using this tool are currently underway, and these findings will help further develop the site reporting resources built into *Archaeotype 3.0*. the basic goal with these resources should be to permit students to pose the problematic of the site and specific artifacts, to link to visual and textual resources for dealing with these problems, to incorporate new information into the system that they find useful, and to present, weigh, and explain hypotheses about their site and artifacts that seem to them compelling. The portfolio assessment tools will allow students to preserve their accomplishments and will provide work that teachers can formally assess. The educational design of *Archaeotype 3.0* will include a set of guidelines for the formal assessment of site reports.

Transfer assessment will involve the creation of special problem-solving challenges to be administered to groups that have completed *Archaeotype 3.0*. The theory here is that learning to learn is the most important achievement that can result from *Archaeotype*. A good way to assess whether this is happening

would be to devise group problem-solving challenges that would show the degree to which students had internalized key strategies and capacities through their experience with *Archaeotype* and could transfer the use of them to the new setting. The evaluation component to be developed by Professor John Black will center on creating such resources.

(e) Supervision of the first pilot test in the selected schools and the formative evaluation of the test to ready *Archaeotype 3.0* for more general use.

The full pilot test of the Egypt project will take place simultaneously at nine locations during the 1994-95 school year:

1) The Dalton School, where the New Laboratory for Teaching and Learning has developed *Archaeotype*.

2) The Juarez Lincoln School, in the Chula Vista Elementary School District, where a team from San Diego State University, led by George Mehafy and Bernard Dodge, are presently evaluating use of the Greek *Archaeotype* as a unit in sixth-grade social studies.

3) The Museum School -- one of the New Visions Schools supported by the Fund for Public Education and directed by the Board of Education and the New York City Museum Consortium.

4) Boys Harbor, a privately funded school for at risk youths in Harlem.

5-9) The five public schools selected in accordance with the aforementioned process.

The supervision of the actual pilot tests will involve visits by summer institute faculty, on-line communications through electronic mail and monthly colloquia at the Institute for Learning Technologies and the New Laboratory for Teaching and Learning focused on problems emerging in the process of implementation. The personnel conducting the supervision and training during the process of actual implementation will include graduate students participating in the Full-time Internship Cohort Masters Option, co-sponsored by the New Laboratory for Teaching and Learning and the Institute for Learning Technologies in the Department of Communication, Computing, and Technology at Teachers College. Teachers and designers from the New Laboratory for Teaching and Learning, who have had experience in working with simulated archaeological excavations, such as Dr. Neil Goldberg, will also supervise the implementations, as will professors from the Institute for Learning Technologies and museum personnel who will have been effectively involved in the actual development of the intellectual characteristics of the site.

Through the process of supervision, formative evaluation information on the design and implementation of *Archaeotype 3.0* will be gathered and communicated to the three groups -- the Pedagogical, Reference, and Tools

Groups -- that developed the program the previous year. The information will allow them to improve the excavation interface, revise and expand materials on-line that serve as interpretative resources, and to debug and perfect the operation of the connections between the interface and the representations of objects in the site. In addition, a Documentation Group will work with teachers at the nine implementation sites to develop manuals and teachers guides that help new users get the program to operate will through general distribution.

During the process of formative evaluation, the design of the student assessment tools will also be tested.

Four: Personnel

The key people in the project have extensive experience and excellent qualifications. Here are short biographies of the most important. Full resumes are in an appendix.

Principal Investigator
Director, Pedagogical Group

Frank A. Morettl, Ph.D. is presently Associate Headmaster of the Dalton School and Executive Director of the New Laboratory for Teaching and Learning. He originated the educational use of simulated excavations at Dalton and managed development of the Greek *Archaeotype*, which became the core of the Dalton Technology Project, an effort to integrate networked multimedia throughout the Dalton curriculum, K -12, financed at about $1 million per year. Moretti has been involved in innovative curriculum design for twenty years and was responsible, before coming to Dalton in the early 1980s, for the design of Bloomfield College's Teacher Training Program, New York University's Bachelor of Education Program for Adults, as well as for a range of projects related to the K-12 curriculum in public and private education. His most recent publication is "A Classicist Conversing with the Conservatives," due for publication in the *Teachers College Record* in summer 1993.

Director, Tools Group

Robert McClintock, Ph.D., directs the Institute for Learning Technologies at Teachers College, Columbia University, where he is Professor of History and Education. McClintock helped to develop the Dalton Technology Project and serves as one of the Co-Directors of it. From 1985-89 he chaired the Department of Communication, Computing, and Technology at Teachers College. He has published and lectured widely, here and abroad, on issues of technology and education and on the history of educational theory. His most recent book, *Power and Pedagogy: Transforming Education Through Information Technology* will be published late in 1993 by the Educational Technology Press.

Director, Reference Group — **Deborah Schwartz**, B.A., Vice Director for Education at The Brooklyn Museum, has been with the Museum since 1982. She previously held positions at the Landmark's Preservation Commission; the Institute of Fine Arts, New York University; and the Museum of Contemporary Art, Chicago. Ms. Schwartz received her B.A. in art history from Northwestern University and is finishing her M.A. from Queens College. She is currently Co-Chair of the Museum Education Consortium, and Vice President of the Gallery Association of New York State. She also teaches in the Master's degree program at the Bank Street College of Education. At The Brooklyn Museum, Ms. Schwartz is responsible for overseeing the planning and implementation of all educational and interpretative programs for adults and children.

Director, Assessment Group — **John B. Black**, Ph.D., is Professor of Computing and Education at Teachers College, Columbia University. Before coming to Teachers College in the mid 1980s, he taught cognitive science at Yale University. Dr. Black directs the Center for Literacy Studies at Teachers College and has wide experience in the design and implementation of educational software and alternative assessment measures. He is currently managing the effort to develop new assessment measures in the Dalton Technology Project. Dr. Black has published numerous research studies on the study of cognition and its bearing on the design of instructional efforts.

Five: Budget Discussion

The *Archaeotype 3.0* Project will be embedded in on-going efforts by the key participating groups, with the result that it will benefit from substantial cost-sharing. The New Laboratory for Teaching and Learning has already developed two versions of *Archaeotype*, with great success in the classroom. The new version will benefit from this experience and make it more ready for dissemination to schools throughout the nation. The Dalton Technology Project is one of the most advanced efforts to integrate technology, K-12, in an excellent school and the experience and infrastructure of this effort will make the *Archaeotype 3.0* project far more cost effective. Likewise, The Brooklyn Museum has a premier collection of Egyptian antiquities. The availability of such pre-existing resources will enable the project to create and test software of great power and quality for a modest additional investment.

Explanations of specifics in the budget will be found with the budget forms.

Six: Evaluation Plan

During the first year of the *Archaeotype 3.0* project, we plan to gather extensive data to serve as a base-line for evaluating the performance of the program in its pilot tests. We will document the achievements and cognitive skills of two groups thoroughly -- those of the students who in the following year will work with *Archaeotype 3.0*, and those of the students who complete this year the courses into which *Archaeotype 3.0* will be introduced next year. Information on the first group will provide a base-line for understanding the developmental effects of working with *Archaeotype 3.0*. Information on the second group will provide a base-line for comparing the achievements of those working with *Archaeotype 3.0* to those who have not.

In gathering data on the first group, we will lay a foundation for evaluating key expectations about the effects of a constructivist program such as *Archaeotype*. We would assess the full range of cognitive skills as measured against Bloom's taxonomy of cognitive skills. Here are some specific sorts of claims we would like to test, as these are the distinctive claims that indicate the unique and powerful value of the program.

- Students who have worked with *Archaeotype 3.0* will integrate factual information into explanatory arguments more often than students who have not.
- *Archaeotype* students will be more likely to extract and express principles from what they learn than other students.
- *Archaeotype* students will more frequently solve problems applying mathematical or other formal strategies.
- *Archaeotype* students will seek to use information resources available in their immediate environment to solve novel problems more frequently than other students.
- Given a problem, *Archaeotype* students will focus on it in conversation together more fully than other students will.
- *Archaeotype* students will more often mobilize teachers and texts, less as authoritative answers, and more as resources to help them construct or determine answers, than will other students.
- In writing or speaking about causal explanations, *Archaeotype* students will more often weigh multiple hypotheses, recognizing pros and cons for each, than will other students.

During the first year of the project, the evaluation team will refine the list of claims we seek to test and will gather base data for use evaluating these claims the following year.

Seven: Institutional Resources

The *Archaeotype 3.0* Project will combine the resources of significant institutions -- the New Laboratory for Teaching and Learning at the Dalton School, the Institute for Learning Technologies at Teachers College, Columbia University, and the Educational and Curatorial Department of The Brooklyn Museum. Fuller information on these institutions is included in the appendices. For a complete description of the Dalton Technology Project, see *Risk and Renewal: First Annual Report of the Phyllis and Robert Tishman Family Project in Technology and Education -- 1991-1992* (New York: New Laboratory for Teaching and Learning, 1992). For a full description of The Brooklyn Museum resources see Richard A. Fazzini, *et al. Ancient Egyptian Art in the Brooklyn Museum* (New York: The Brooklyn Museum, 1989,)

In addition, the resources of two substantial school districts -- the New York City Public School System and the Chula Vista Elementary School District in San Diego, California -- will participate as implementation sites.

APPENDIX B: -- PROJECT GALILEO PROPOSAL (SPRING 1993)

PROJECT GALILEO: HELPING ALL STUDENTS ACHIEVE HIGH STANDARDS OF SCIENTIFIC AND MATHEMATICAL UNDERSTANDING THROUGH PARTICIPATORY STUDY

Project Narrative

I: Objective:

To develop, field test, and prepare a major curriculum innovation for national dissemination.

Project Galileo, a high school science course that uses digital technologies to give students access to the practice of astronomy, helps all students achieve high standards of scientific and mathematical understanding. With the funding sought through this proposal, the New Laboratory for Teaching and Learning at the Dalton School will complete and integrate the materials that will support student work in the course and develop a program preparing science teachers to introduce *Project Galileo* into their schools. During the 1994-95 school year, we will field test *Project Galileo* in ten New York City schools and further revise both the materials and teacher preparation strategies on the basis of this experience. At the end of the project period, this innovative curriculum will be ready for distribution to schools throughout the country.

II: Need:

(a) The educational needs addressed by the project.

Even in very good schools, science and mathematics increasingly split the population into a small group of students who catch on and do very well and another set of those who have difficulty attaining high standards of understanding. Key characteristics of science itself are at the root of this educational difficulty. The phenomena with which the core sciences deal are highly abstract and inaccessible in ordinary everyday experience. Instruments suitable for investigating outstanding questions are costly and hard to handle and

data often require extensive mathematical analysis after they have been acquired to become meaningful. Hence the questions driving scientific inquiry often remain obscure to students, making it virtually impossible for them to achieve high standards of understanding.

Astronomy well exemplifies these tendencies. Throughout ancient, medieval, and early modern history, astronomy was securely one of the seven liberal arts, a core component of the curriculum. What fills the heavens above, so strangely different by day and by night, was a set of profoundly puzzling but inescapable questions put to people by their everyday experience. The resulting inquires were intrinsically intriguing and practically consequential in keeping both time and the calendar. Through the nineteenth century, astronomy was a significant component of the school science curriculum, and the orrery and the tellerion were instructional instruments present in nearly every school. The situation changed because the practice of astronomy changed.

During the twentieth century, the study of astronomy in schools greatly declined. The science of astronomy became far more powerful than it had been, but that very success in the observatory far atop the distant mountain made the subject less and less appropriate in the school. Relative to the layman, astronomical research became highly esoteric. Telescopes became very big and very expensive. Complex optical and spectroscopic instruments increasingly mediated the gathering of data through those telescopes. As observation penetrated further and further out in space and back in time, the logistics of using the catalogue of objects that had been charted and observed, became very difficult to manage, a skill marking the gulf between novice and expert. And finally, working astronomers and astrophysicists had to use very advanced mathematical concepts and to engage in voluminous, tedious calculations to make sense of their data. Astronomy ceased to be generally accessible and had to be presented, when presented at all, almost entirely through textbook abstractions. The astronomers' questions became abstract to ordinary people and the non-specialist study of their findings became a passive process of learning what others knew.

Digital technologies are making it possible to reverse the processes through which science education has been losing its immediacy. The New Laboratory for Teaching and Learning at the Dalton School has been created to find ways to use these technologies as means for improving the quality of attainments possible in education. A general principle of curriculum innovation being developed through it is that digital technologies will provide students of diverse ages and wide abilities with meaningful access to the questions and resources of advanced disciplines in the sciences and humanities. We have deigned *Project Galileo* as a specific instance of this principle.

Computers may be particularly helpful in astronomy in enabling all students to achieve high standards of understanding. The reasons for this possibility arise from the way computers are affecting the practice of astronomy itself.

1) Observations from telescopes and space probes, acquired in digital format, can be stored, reproduced, and sent inexpensively via networks to most anyplace, including the school classroom.

2) Complex analytic instruments can be simulated in the computer and applied effectively to confusing data, allowing students with little prior training to extract sophisticated insights from the digital data.

3) Computer-based data management techniques allow relative novices to work productively with the full base of acquired observations in the field.

4) Computer programs make it possible for students to mathematical computation and graphical representation to work with astronomical concepts in ways that are both rigorous and intuitive.

Such effects of the digital technologies alter the practice of astronomy itself and profoundly alter its potential relation to the classroom. *Project Galileo* is a thorough effort to take advantage of these changes in order to reintroduce the study of astronomy in the school. If astronomy can regain a core place in science education, much will be gained for astronomy is one of the great domains of interdisciplinary inquiry, drawing mathematics, physics, chemistry, and biology together in an exciting inquiry into the origins of the universe and of life.

(b) A working alternative created through reflective practice.

For a number of years, the Dalton School has had a popular elective astronomy course for juniors and seniors, most of whom are not science majors. The appeal of this course over the years shows that the basic questions of astronomy continue to excite the imagination of students, however esoteric the practice of astronomy may have become. But the problem of delivering the course by traditional means illustrated the difficulties of bridging the distance between the high school classroom and astronomy as a field of research.

A senior science teacher, who has much charisma as a lecturer and much authority as the co-author of a successful college textbook in astronomy, taught the Dalton astronomy elective.[19] Until recently, students learned the course content from lectures and the text, but the basic problem was that they often did not *understand* the material because they could neither personally entertain the questions that led to its discovery nor could they perform the intellectual operations required for its development. "The students enjoyed hearing and learning about astronomy," Malcolm Thompson observes,

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[19] Robert Jastrow and Malcolm H. Thompson. *Astronomy: Fundamentals and Frontiers.* 4th edition, New York: John Wiley & Sons, Inc., 1984. 564 pp.

> but they remained external to it as a process of thought. Little opportunity was available to them to engage their intellects in the experience of doing astronomy. Without that experience, they remained unable to make original proposals in science within the constraints of physical law. They were even less able to initiate a course of inquiry once a proposal was made. While they learned some interesting facts, they retained their feeling of lack of intellectual entitlement within the context of the discipline. The activity remained passive.

In the summer of 1991, Dalton's New Laboratory for Teaching and Learning received substantial funding to integrate information technologies throughout the school's curriculum. Astronomy immediately became a prime locus of effort. Malcolm Thompson completely redesigned his course, setting aside the text and giving lectures up, substituting a series of computer-based activities and tasks that encouraged students to plot their own pathways through real problems of the field. The resulting course reshapes the intellectual experience of students by using digital technologies to give them access to the practice of astronomy. This computer-mediated, direct access to the practice of a science is the key to participatory science study and it promises to enable all students, not only a few, to attain high standards of understanding.

During the past two school years, Malcolm Thompson and the New Laboratory for Teaching and Learning have developed an effective, project-based astronomy course. It does not use computers to teach knowledge about astronomy to students; rather it uses computers to provide students access to the observations and techniques that astronomers use in pursuing their subject. Throughout the school, networked computers give access to an information landscape that uses a desktop planetarium program, combined with images from NASA, NOAA, working observatories, amateurs, and digitized versions of the Palomar survey plates, along with comprehensive databases from the Astronomical Data Center. Students work with these materials using standard software: image processors, spreadsheets, database management programs, plotting programs, word processors, image scanners, the Internet, and the like. As a significant side effect, students consequently become highly adept with computers.

To take full advantage of such resources, students follow designed sequences of activities, working through real problems in small groups with the teacher. The presence in the workspace of multiple computers, laden with astronomical resources and "friendly" software to access and analyze the resources, provides students a measure of control over authentic scientific materials and the tools for manipulating them in a meaningful way. The course now comprises eight primary topics; the heart of each is a three to six week assignment that defines a stream of extended tasks for students to pursue individually and in pairs, using the computers and other hands-on materials.

Constructive work on these eight topics by students constitutes the primary activity of the course. The design of this work takes advantage of digital

resources to diminish the distance between the activities of astronomers and those the students can perform. Through the computer they have access and control of working images and data sets. With powerful image processing software and the like, they can analyze the red shift and follow the spectroscopic composition of stars. The planetarium program, available whenever they need it, allows them to internalize the coordinate systems used for mapping the sky and they become adept at using the cataloguing and reference systems for managing stellar objects. They can attend to the conceptual problems of tracking and measurement, leaving the labor of calculation to the computers.

All students in the course achieve high standards of astronomical understanding because their understanding develops as they perform the stream of tasks, which have been set up so that each student will successfully complete every task. It is not simply that the teacher is part of the class to ensure, as overseer, that each student completes the tasks. The teacher is there, as participant, to help each student, in the measure needed, to complete the tasks. This change is significant, making the class workspace one of a common enterprise where students learn together as apprentices with a master.

Typically, the first class of each week meets in conference to set the "week's work" by identifying the task deadlines with estimates of how much time each will take. In these conferences, some negotiation takes place and the students must make a plan of work for the week. The teacher indicates any other scheduled classes for demonstrations, lectures, or group activities, but for the most part the students are on their own, without a formal schedule, to complete their work independently, in consultation with other students, or with the teacher, as the need may be. The amount of work required each week exceeds the amount for scheduled classes by a factor of at least two.

At Dalton, the astronomers' workspace opens for business daily at 7:30 a.m. and is available continuously until 6:00 p.m. During that time, students in varying numbers do their work in collaboration with the teacher and with each other. From the student point of view, the explicit goal is to complete designated tasks. But each task has in it implicit, designed challenges which require interaction with the teacher or with other students who are more knowledgeable or more accomplished with respect to the task. The typical day involves work on the computers or with other materials interwoven with a series of highly focused conversations among small groups of students, or between students and teacher. Much learning takes place through these conversations, as happens in the ordinary practice of science.

Through these encounters, the pedagogical key to *Project Galileo*, the content and the sense of the subject unfold in the atmosphere of a scientific research endeavor. Most importantly, the new format does not split the course population into the few who get it and achieve well and the others who do not and benefit little. Instead, all the participants complete the course achieving a high standard of astronomical understanding. Students gain a working knowledge of what astronomers do and they have internalized the major

intellectual constructions essential in the conduct of astronomy. The basic strategy in *Project Galileo* is participatory science study: the students, using professional level materials in a task-oriented partnership with the teacher and other students, develop a feeling of kinship with the practitioners of the scientific community.

A senior drama major in the astronomy course, Elizabeth Davis, eloquently describes her experience with participatory science study:

> Much of the knowledge I have acquired in Astro has evolved in my brain as I proceeded through a task. I acquire knowledge by wrestling with a problem until it solidifies and makes sense to me. Then I am able to move on and teach other students what I have come to understand. I think that is a crucial phrase -- we do not "learn" as much as we "come to understand." This somehow makes the material more immediate and the struggle to understand becomes personal so the end product of knowledge is more rewarding and its quality is greater than that of other classes.

If this strategy can be transferred to other schools, a powerful means for helping all students achieve high standards of scientific and mathematical understanding will have been developed.

(c) The current challenge: dissemination and teacher preparation.

Introduced at Dalton in the 1991-92 school year, *Project Galileo* has developed rapidly with considerable institutional effect. Students see their activity as a six to ten hour work week, intellectually and socially rewarding, through which their knowledge of astronomy and computers deepens from engagement in the inquiry. Productivity and attaining the status of "knowledgeable person" are valued assets in the community of collaborating learners. Students in the course think they do more work in it than in any other course, and they describe the rewards with pride and enthusiasm to friends and to faculty members. Other students seem to wish to be a part of it as course enrollment is rising and juniors who took it want a follow-on version for their senior year.

Faculty members, in and outside the science department, query project staff and seek advice on implementing a similar pedagogy in their courses. Some of the tasks for the astronomy course and the materials to support work on them have been adapted in parts of the fourth and eight grade science courses at Dalton. Materials pertaining to geophysics and how life originated and evolved have been extended for use in tenth grade physical science. Likewise, efforts by the chemistry teachers to redesign their courses are following the strategy in the astronomy course of using the computer to provide access to the data, questions, and resources of researchers in field. In such ways, *Project Galileo* has caught on at Dalton and we seek support with this proposal to see if it can

be transferred to other schools, especially ones with more constrained resources and less advantaged student populations.

In order prepare *Project Galileo* for wide dissemination to schools throughout the nation, three things need to be done:

1) **Materials.** The course topics and the set of tasks associated with each need to be developed further and the materials to support independent student work need to be expanded and made available in a form that schools will find easy to install, maintain, and use (see below, III b&e, pp. 109-110, pp. 115-114, for a fuller discussion of our plans for materials development).

2) **Teacher Preparation.** A program of teacher preparation needs to be developed that will ensure that teachers have sufficient command of astronomy to oversee the intellectual apprenticeship of students to the field and that they comprehend how to make the pedagogy associated with it work (see below, III c&d, pp. 110-115, for a fuller discussion of our plans for teacher preparation).

3) **Pilot Testing and Formative Evaluation.** During the 1994-95 school year, *Project Galileo* will be introduced into ten selected schools that reflect the diversities of New York City so that we can formatively evaluate both the materials and the teacher preparation strategies and ready them for general distribution see below, III f, pp. 115-115, for a fuller discussion of our plans for pilot testing).

We seek funding for *Project Galileo* from January 1994 through June 1995 to develop and deploy appropriate materials and teacher preparation activities in ten diverse New York City schools. We plan to concentrate on New York City simply for reasons of efficiency in developing the materials and teacher preparation techniques. At the conclusion of the grant period *Project Galileo* should be ready for a national effort at dissemination of the course and the strategies of science education embodied in it.

(d) Benefits to the participants.

As *Project Galileo* makes the issues, tools, and strategies of practicing astronomers accessible to ordinary students in the high school classroom, a significant range of benefits result.

1) A collection of resources enabling students and teachers to participate in the work of astronomy will have been assembled and prepared for general dissemination to schools.

2) A full set of topics and student tasks within those topics will have been developed, with introductions to both the general study strategy and to each component, along with detailed guides and materials lists. These will have been field tested with diverse school populations.

3) Student evaluation resources, appropriate to the material and style of participatory study of *Project Galileo*, will have been developed and included in the course resources.

4) A program of teacher preparation for use of the materials will have been developed and tested with New York City teachers working in diverse school settings.

5) The whole ensemble will have been field tested in ten schools, with formative feedback incorporated into the materials and teacher preparation plans as these are readied for general dissemination across the nation.

6) Extending methods of participatory science study, integral to *Project Galileo*, to other parts of the high school science curriculum will have been initiated.

With the subsequent development of these specifics, benefits of considerable general import to the nation can accrue:

7) Culturally, a way of making science in its full complexity accessible to students with diverse backgrounds, interests, and aptitudes will have been prototyped and readied for wide dissemination.

8) Socially, over time, the methods of participatory science study pioneered in *Project Galileo* can alter the way the general public relates to advanced scientific work, diminishing the sense that it is the domain of esoteric experts, increasing the sense that an interested public can participate knowledgeably in it, and in democratic decision-making about it.

9) Technologically, *Project Galileo* will help demonstrate how advanced information technologies can improve the quality and character of educational opportunities attainable within our schools and colleges.

III: Plan of Operation:

(a) The overall plan.

Our plan of operation for *Project Galileo* has three main components. One centers on developing study support materials needed to implement the pedagogical program of the project. A second will develop a program for preparing teachers from diverse schools to introduce the project in their classes. Both these lines of effort will converge in the third, a full-scale pilot test of *Project Galileo* in ten selected schools in New York City during the 1994-95 school year.

With both the development of materials and teacher preparation strategies, considerable prior work will have taken place by the time the grant period begins. Development of materials through the New Laboratory for Teaching and Learning

began in the fall of 1991 and has gone through two full cycles of development and formative testing in the classroom at Dalton. Starting in September 1993, a third cycle will be initiated as part of the Dalton project. During the summer of 1992, these resources provided the focus for an eight-day workshop to train elementary and junior high school teachers in the Fundamentals of Science and the applications of new technologies in teaching astronomy. This workshop yielded invaluable experience that helps shape the teacher preparation program that we propose.

(b) Developing the materials for *Project Galileo*.

Materials for *Project Galileo* cover eight topics:

1) Classical positional astronomy
2) The contents of the universe, the basic forces
3) Stars -- The observational base of astrophysics
4) Stars -- The theoretical base of astrophysics
5) Stars -- Stellar evolution
6) Galaxies, the large-scale structure, cosmology
7) The solar system -- Earth and planetary geology
8) The origin and evolution of life.

The first six topics have been designed and written, although they need more refinement. Some gaps need to be filled and in two cases some reorganization would improve the material. For each, the evaluation mechanisms that accompany the tasks need further development. About half of the seventh topic -- the part dealing with the planets -- is well along. The part dealing with the earth itself and the eighth topic on the origin and evolution of life, are still in the design phase and a major aspect of materials development will be to implement these designs.

Our plan of operation for the Federal support of *Project Galileo* calls for intensive work developing these topics during the Spring of 1994. Essentially, there will be four distinct lines of activity during this time, each of which will proceed under the management of the Principal Investigator, Malcolm Thompson (see below, p. 115).

1) The materials for the seventh and eighth topics need to be developed. This work will be assisted by Michael Rampino, a geologist and chairman of the Applied Science Department at NYU (see below, p. 115).
2) All the materials need to be worked through by an astronomer and analyzed for scientific accuracy and completeness. This work will be done by George McCook, an astronomer at the University of

Villanova and chairman of the Astronomy and Astrophysics Department (see below, p. 116)

3) All the materials need to be gone over by an editor who will revise for clarity and uniformity of expression. An editor will be recruited for the project, starting in mid December 1993.

4) The whole set of materials, as they are completed, checked, and edited, will need to be integrated for easy, coherent use within a client/server school technology environment. Design of this computer-based integration of materials will be the responsibility of Robert McClintock, one of the Co-Directors of the Dalton Technology Plan and Director of the Institute for Learning Technologies at Teachers College, Columbia University (see below, p. 115).

These four strands of materials development will go through an initial cycle of completion, during the 1993-94 school year with an especially high level of activity during the Spring of 1994. There will follow, as an essential part of the field testing during 1994-95, a second cycle of revision and improvement based on experience gathered from using the materials in diverse school settings.

(c) Selecting schools as implementation sites for *Project Galileo*.

Selecting schools for the field testing of *Project Galileo* will take place during the Fall of 1993, before the formal start of the grant. Dr. Frank Moretti, Associate Headmaster of Dalton and Executive Director of the New Lab (see below p. 117) and Malcolm Thompson will oversee the selection of field test sites. They have significant experience collaborating with public and private schools throughout New York City. Both have been involved in the past with the I-CM Project for teaching science with the Interactive-Colloquium Method that was funded by the Secretary of Education, the DeWitt Wallace-Readers Digest Fund, and the Helena Rubinstein Foundation and have worked collaboratively with diverse schools the New York City Public School System. The New Laboratory for Teaching and Learning has also been the center for the Mayor's Partnership for Public and Private Schools for New York City.

An Advisory Board will, among other things, help the Project Director and New Laboratory staff select schools as implementation sites. The board will include the following, who have agreed to serve:

Anthony Alvarado Superintendent of District Two in the New York City Public School System.

Naomi Barber Director of the New Visions Schools for the Fund for Public Education.

Talbert Spence Chairman of Education at the American Museum of Natural History.

Jack M. Wilson Director of the Anderson Center for Innovation in Undergraduate Education, Rensselaer Polytechnic Institute.

In past collaborations, we have learned that schools should be selected close to the actual start of implementation at the site and that broad interest in the project within the school, in addition to support from the top authorities, is essential to achieve success. We will use a range of criteria for selecting potential partners, among them:

(1) The cultural diversity of the school itself will be a very significant criterion. Our expectation is that the school must in some way represent the range of students in the New York Public School System and therefore to some extent the range of students in most urban settings.

(2) Whether or not a school has sufficient technical base without requiring extensive upgrade to sustain the project through classroom use.

(3) The level of faculty enthusiasm for projects of this type and their willingness to work for approximately five weeks in the summer before the actual implementation of the project in the school.

(4) The full support of the principal of the school and a clear indication that the principal understands that the new technologies can enhance learning in the direction of constructivist pedagogical principles.

(5) The central support of the superintendent of whichever district each school was in.

The final deadline for the selection of ten public schools, two from each of the five boroughs of New York, will be January 1st, 1994.

The calendar for the process of selection is as follows:

10/15/93: Using the Advisory Board and our own educational network, including Teachers College, and diverse public and private school collaborators, we will collect a series of recommendations of at least 30 schools that might meet the above mentioned criteria.

10/15/93 to 11/15/93: Senior staff members of the New Laboratory for Teaching and Learning will make school visits which will include a demonstration to the administration and faculty of the interested school of *Project Galileo* and an explanation of the educational principles involved as well as a clear indication of where *Project Galileo* can supplant in an effective way the traditional curriculum from their specific curriculum outline. The school visitors will also review school facilities and interview the teachers and administration in order to determine levels of interest. Those schools that are still interested after the visit will express that interest by formally applying for participation in the project by December 1st and that formal application should include support from the Board of Education for public schools and the Board of Trustees for private schools.

1/1/94: The project will make a commitment to ten schools, adding five schools on a waiting list, with the goal that there be at least one school in each of the city's boroughs, eight public and two private.

(d) Initiating the Teacher Preparation Program, Spring 1994.

From the schools finally selected, teachers will be chosen, in consultation with the principal, to introduce *Project Galileo* in their science program. The criteria for selecting the teachers will be:

(1) diversity;

(2) motivation and interest;

(3) intellectual preparation for teaching an astronomy course through which students engage in participatory science study.

The calendar for selection process will be as follows:

12/15/93: Principals at each school applying to be field test sites should have recommended, as part of their application, four prospective teachers as candidates for introducing *Project Galileo* in their schools.

1/11/94 to 1/15/94: The recommended teachers from the schools chosen as field test sites will be invited to a series of open houses at the Dalton School to learn about *Project Galileo* and to see it in operation. They will be interviewed by the project director in conjunction with a team from the development group and a representative of the advisory group.

1/21/94: Two participating teachers, who will introduce *Project Galileo* their schools, will be selected by the above group.

This timetable hastens the selection of the teachers because we expect to require them to do some independent preparatory work during the Spring of 1994. In selecting teachers, we do not expect to find prospects who already possess all the skills needed to manage *Project Galileo* well. We learned from experience with the summer 1992 workshop that two things are of paramount importance as prerequisites in running a workshop on how to work with students in a participatory science study environment such as *Project Galileo* -- basic subject matter competence in astronomy and skill and confidence in using computers. If the workshop instructors must concentrate on imparting to participants the subject matter or fundamental computer skills, the participants cannot concentrate well on the real matter, learning how to work with the new pedagogy. We want to select teachers early so that prior to the summer workshops they can, wherever appropriate, systematically develop through independent study or through courses their mastery of the subject matter and their skills with the technology. We have included in the budget a lump sum of $15,000 to help finance these preparations by participating teachers.

7/1/94 to 7/31/94: Summer Training Workshop will take place. Credit will be available for taking this workshop through Teachers College or in place of credit teachers taking this workshop will receive a $2,000 stipend.

The four weeks of the workshop will be allocated as follows:

Weeks 1 & 2: Basic training in the use of *Project Galileo* by working through sample topics and an introduction to the philosophical premises and the future of interactive networked multimedia.

Weeks 3 & 4: Each teacher, paired with a student, spends the mornings working on topics under the supervision of the summer training institute personnel, with afternoon debriefings for the teachers as a group discussing the educational possibilities and problems implicit in the materials.

(e) Design of assessment strategies for evaluating student achievement in the selected schools.

In Section 6 below, we describe what we intend to do to evaluate the effectiveness of *Project Galileo* as an educational resource. The subject of evaluation there is the program we propose to develop. A significant element of the program to be developed consists of assessment strategies for documenting what students learn through *Project Galileo* and providing them helpful feedback that can help make their studies bear optimal fruit. Here the subject of assessment is the student.

Traditional assessments -- quizzes and essays keyed to the text and the teachers glosses to it -- are not particularly relevant to understanding student performance with *Project Galileo.* Indeed, traditional assessments will be out of harmony with *Project Galileo* and would probably deflect students' effort into unproductive paths. We instead seek to develop three types of assessment strategies that are consistent with the goals and procedures of the program -- embedded assessment, portfolio assessment, and transfer assessment.

Embedded assessment characterizes much real scholarly inquiry and problem-solving activity, especially as it is conducted by working groups. Embedded assessment opportunities will be integral components of the work-flow in the *Project Galileo* pedagogy. Once a week each class, working together on the full site, should meet as a whole to present key findings, to explain preliminary hypotheses, and to discuss how to proceed. Each sub-group assigned to a quadrant should continually discuss how each can best contribute to moving the excavation forward and brainstorm about the artifacts they have found. The whole process of inquiry moves forward as students share and criticize preliminary findings, searching out further information, developing and overturning possible hypotheses. All this is the embedded assessment integral to active inquiry and study.

Portfolio assessment results because students work together to solve a flow of specific tasks and problems in an environment where they can easily save their work and present it as part of their cumulative accomplishments. The portfolio assessment tools will allow students to preserve their accomplishments and will provide work that teachers can formally assess. The educational design of *Project Galileo* will include a set of guidelines for the formal assessment of these tasks.

Transfer assessment will involve the creation of special problem-solving challenges to be administered to groups that have completed *Project Galileo.* The theory here is that learning to learn is a most important achievement that can result from *Project Galileo.* A good way to assess whether this is happening would be to devise group problem-solving challenges that would show the degree to which students had internalized key strategies and capacities through their experience with *Project Galileo* and could transfer the use of them to the new setting.

(f) Supervision of the first pilot test in the selected schools and the formative evaluation of the test to ready *Project Galileo* for more general use.

The full pilot test of *Project Galileo* will take place simultaneously at ten locations during the 1994-95 school year. The supervision of the actual pilot tests will involve visits by summer institute faculty, on-line communications through electronic mail and monthly colloquia at the Institute for Learning Technologies and the New Laboratory for Teaching and Learning focused on problems emerging in the process of implementation. The personnel conducting

the supervision and training during the process of actual implementation will include Field Supervisors recruited for their expertise in astronomy and their understanding of participatory study strategies. Thomas de Zengotita, who has long worked closely with Malcolm Thompson in developing strategies for promoting scientific literacy, will be in charge of the teacher preparation efforts and will direct the Field Supervisors.

Through the process of supervision, formative evaluation information on the design and implementation of *Project Galileo* will be gathered and communicated to those in shaping materials development and teacher preparation provisions. The information will help in improving the selection of astronomical resources, in shaping the user-interface for working with them, for further developing explanatory materials, and perfecting the student assessment tools embedded in the project. In addition, experience with teachers at the implementation sites will be used to develop manuals and teacher guides further to help prepare the program for general distribution.

During the process of formative evaluation, the design of the student assessment tools will also be tested.

IV: Personnel

The key people in the project have extensive experience and excellent qualifications. Here are short biographies of the most important. Full resumes are in an appendix.

Principal Investigator Project Direction

Malcolm H. Thompson, M.S., holds the Malcolm H. Thompson Science Chair at the Dalton School, where he teaches *Astronomy* and *Fundamentals of Scientific Inquiry.* He co-authored *Astronomy: Fundamentals and Frontiers* with Robert Jastrow, a leading astronomy textbook used in introductory college astronomy courses. In 1989, with Thomas de Zengotita, he wrote a substantial report, "The New Scientific Literacy, which has led to changes in the way science is handled within general education for undergraduates at New York University. Since 1991, he has been working on the development of *Project Galileo* through the New Laboratory for Teaching and Learning at the Dalton School.

Geology and Earth Science Science Consultant

Michael Rampino, Ph.D., is Associate Professor and Chair of the Department of Applied Science at New York University. He is a Research Consultant at the NASA Goddard Institute for Space Studies and the Center for Global Habitability at Columbia University. His professional affiliations include the AAAS, the Geological Society of America, the New York Academy of Sciences, and the National Association of Geology Teachers, to name but a few. He has published widely in his field and is a frequent speaker at University and professional conferences and workshops.

Astronomy Consultant

George McCook, Ph.D., is Chairperson of the Astronomy and Astrophysics Department at Villanova University. He is a member of the PASP, AAAS, IAPAP, and Sigma Pi Sigma, the physics honor society. His extensive publications include *Small Telescope Astronomy and Undergraduate Research at Villanova University*; *CREATE, An ATIS Management Program*; *ATIS Management Software*, and *ATIS 93 and Its Impact on CREATE*. Research interests include variable stars, binary stars, data analysis software design, and astronomical education.

Technical Design

Robert McClintock, Ph.D., directs the Institute for Learning Technologies at Teachers College, Columbia University, where he is Professor of History and Education. McClintock helped to develop the Dalton Technology Project and serves as one of the Co-Directors of it. From 1985-89 he chaired the Department of Communication, Computing, and Technology at Teachers College. He has published and lectured widely, here and abroad, on issues of technology and education and on the history of educational theory. His most recent book, *Power and Pedagogy: Transforming Education Through Information Technology* will be published late in 1993 by the Educational Technology Press.

Project Management

Frank A. Moretti, Ph.D. is presently Associate Headmaster of the Dalton School and Executive Director of the New Laboratory for Teaching and Learning. He originated the educational use of simulated excavations at Dalton and managed development of the Greek *Archaeotype*, which became the core of the Dalton Technology Project, an effort to integrate networked multimedia throughout the Dalton curriculum, K -12, financed at about $1 million per year. Moretti has been involved in innovative curriculum design for twenty years and was responsible, before coming to Dalton in the early 1980s, for the design of Bloomfield College's Teacher Training Program, New York University's Bachelor of Education Program for Adults, as well as for a range of projects related to the K-12 curriculum in public and private education. His most recent publication is "A Classicist Conversing with the Conservatives," due for publication in the *Teachers College Record* in summer 1993.

Teacher Preparation

Thomas de Zengotita, Ph.D., is Co-Director of the Dalton Technology Plan, Scholar in Residence at the Dalton School, and Adjunct Associate Professor of Social Studies at the Division of Degree Studies at New York University. He did both his undergraduate and graduate work in anthropology at Columbia University. Recent publications include "On Wittgenstein's 'Remarks on Frazer's *Golden Bough*'" in *Cultural Anthropology* (4:4 1989) and, with Malcolm Thompson, "Scientific Literacy and the Language Game of Science" in the *Proceedings of the First International Conference on the History and Philosophy of Science in Science Teaching* (1989).

Five: Budget Discussion

Much work pertaining to *Project Galileo* will be embedded in on-going efforts by the New Laboratory for Teaching and Learning, with the result that it will benefit from substantial cost-sharing. The New Laboratory for Teaching and Learning has already developed two versions of *Project Galileo*, with great success in the classroom. The new version will benefit from this experience and make it more ready for dissemination to schools throughout the nation. The Dalton Technology Project is one of the most advanced efforts to integrate technology, K-12, in an excellent school and the experience and infrastructure of this effort will make *Project Galileo* far more cost effective. Explanations of specifics in the budget will be found with the budget forms.

Six: Evaluation Plan

During the first year of *Project Galileo*, we plan to gather extensive data to serve as a base-line for evaluating the performance of the program in its pilot tests. We will document the achievements and cognitive skills of two groups thoroughly -- those of the students who in the pilot year will work with *Project Galileo*, and those of the students who in the year prior take the courses which *Project Galileo* will replace in the pilot year. Information on the first group will provide a base-line for understanding the developmental effects of working with *Project Galileo*. Information on the second group will provide a base-line for comparing the achievements of those working with *Project Galileo* to those who have not.

In gathering data on the first group, we will lay a foundation for evaluating key expectations about the effects of participatory science study in courses such as *Project Galileo*. We would assess the full range of cognitive skills as measured against Bloom's taxonomy of cognitive skills. Here are some specific sorts of claims we would like to test, as these are the distinctive claims that indicate the unique and powerful value of the program.

- Students who have worked with *Project Galileo* will integrate factual information into explanatory arguments more often than students who have not.
- *Project Galileo* students will be more likely to extract and express principles from what they learn than other students.
- *Project Galileo* students will more frequently solve problems applying mathematical or other formal strategies.
- *Project Galileo* students will seek to use information resources available in their immediate environment to solve novel problems more frequently than other students.
- Given a problem, *Project Galileo* students will focus on it in conversation together more fully than other students will.
- *Project Galileo* students will more often mobilize teachers and texts, less as authoritative answers, and more as resources to help them construct or determine answers, than will other students.
- In writing or speaking about causal explanations, *Project Galileo* students will more often weigh multiple hypotheses, recognizing pros and cons for each, than will other students.

During the pilot test of the project, the evaluation team will refine the list of claims we seek to test and will gather base data for use evaluating these claims in subsequent years.

Seven: Institutional Resources

The Dalton School is a leading K-12 independent day school in Manhattan. A fact sheet on the school is included in the Appendices. The New Laboratory for Teaching and Learning is a research and development group based in the school that has carried out numerous innovative curriculum development projects. Since 1991, one of its major initiatives has centered on the Dalton Technology Plan, a effort to integrate networked multimedia resources throughout the school, K-12. This effort has been funded at the rate of one million dollars per year by the Phyllis and Robert Tishman Family Fund. The accomplishments of this work, with *Project Galileo* central among them, were featured as the harbinger of the school of the future in a one-hour video in the *Imagine* series, produced by Apple Computer, Inc., and released nationally in April 1993. For a complete description of the Dalton Technology Project, see *Risk and Renewal: First Annual Report of the Phyllis and Robert Tishman Family Project in Technology and Education -- 1991-1992* (New York: New Laboratory for Teaching and Learning, 1992). "Excerpts and Summaries" from this document are included in the Appendices.

APPENDIX C: -- KEY PEOPLE AND GROUPS

Teachers College, Columbia University

Institutional Context and Resources

Founded in 1887 to provide a new kind of schooling for the teachers and poor children of New York city, Teachers College is the oldest, largest, and preeminent graduate school of education, psychology and health. The College's goals are research, graduate education and training and the promotion of mental and physical well-being across the life span. TC graduates receive the M.S., M.Ed. and Ed.D. degrees, and, in conjunction with Columbia University, the M. Phil. and Ph. D. degrees, and are prepared for careers of professional service in schools, colleges, community agencies, government bureaus, research facilities and business. In any academic year the student body of the College numbers four thousand. The students come from most of the fifty states and from more than seventy foreign nations.

The College's faculty includes some of the world's foremost scholars and practitioners in such university disciplines and professional specialties as: educational administration; curriculum and teaching; educational technology; cognitive, organizational, developmental and clinical psychology; sociology, anthropology and history of education; mathematics and science education; health education; measurement, evaluation and statistics; and higher and adult education. The 130 member faculty is complemented by an equal number of lecturers and instructors, many of whom hold positions of distinction in education, psychology and health services.

Teachers College has a long and fruitful history of working with schools and other members of the education community, of finding the practical implications of scholarship and theory, of bringing the findings of educational research through the development stage (creating such-instruments as new curricula, software and other educational technology, and model service and training programs) to practice and dissemination. Members of the College community often serve as bridges and translators between business, government and education leaders and the teachers and other practitioners who determine the course of American education, between those who create products and services for schools and other educational facilities and those who use them.

The College became part of the Columbia University constellation in 1898, under an arrangement whereby the faculty of Teachers College was designated

a faculty of the University, but the College retained its legal and financial independence. The College remains a separate corporation, with a board of trustees responsible for the general oversight of its affairs and for its financial support.

In any academic year the student body of the College numbers approximately four thousand. The students come from most of the fifty states in the Union and from over seventy foreign nations. They pursue their studies on either full- or part-time bases throughout the calendar year. Day and evening classes are available to provide the greatest flexibility in program planning and to offer the widest individual choice. There is a strong school-wide emphasis on consultation and field research and on the close faculty-student relationships that are essential to the successful pursuit of professional and academic goals.

Instruction and research at Teachers College are organized within five divisions, whose collective work seeks to attend to critical aspects of education, applied psychology, and health services, as these relate to the needs and opportunities of the larger society.

The College also sponsors a number of programs in collaboration with other schools and faculties of Columbia University as well as with Union Theological Seminary and the Jewish Theological Seminary of America.

- **The Division of Philosophy, the Social Sciences, and Education.** This division applies the perspectives of anthropology, economics, history, politics, philosophy, religion, and sociology to the study of education, psychology, and health services. The College's programs in Comparative Study, International Educational Development, and the Entry into the Educating Professions are also located in this division. The division's degree programs and courses are organized within a single department, the department of Philosophy and the Social Sciences.

- **The Division of Psychology and Education.** This division is concerned with the psychological foundations of human behavior, with emphasis on development, learning, teaching, and remediation. The division prepares scholars in the various psychological sciences as they pertain to education, change, and remediation in individual, group, and organizational settings. The programs of study develop skills in instruction, assessment, inquiry, and consultation. They also prepare practitioners who work toward the prevention and alleviation of behavioral disorders and communication deficiencies. The degree programs and courses of the division are organized within the department of Clinical Psychology; the department of Developmental and Educational Psychology; the department of Measurement, Evaluation, and Statistics; the department of Social, Organizational, and Counseling Psychology, and the department of Speech and Language Pathology and Audiology

and the programs in Neuroscience and Education and in Psycholinguistics.

- **The Division of Educational Institutions and Programs.** This division focuses directly on the organization and functions of educational institutions and programs. One emphasis is on the administration of schools, school systems, colleges, and universities. A second emphasis relates to the analysis of teaching and learning in school, community, and family settings. A third emphasis is on the needs of individuals, both normal and exceptional, in educational programs at all levels. The degree programs and courses of the division are organized within the department of Curriculum and Teaching, the department of Educational Administration, the department of Family and Community Education, the department of Higher and Adult Education, and the department of Special Education.

- **The Division of Instruction.** This division focuses on the nature and organization of the curriculum -- art, communication, computing, dance, languages, literature, mathematics, media and technology, the movement sciences, music, science, and social studies -- and on the processes of teaching and learning in these fields at all age levels and in a variety of educational settings. The degree programs and courses of the division are organized within the department of the Arts in Education; the department of Communication, Computing, and Technology in Education; the department of Languages, Literature, and Social Studies in Education; the department of Mathematics and Science Education; the department of Movement Sciences and Education.

- **The Division of Health Services, Sciences, and Education.** This division is concerned with education as it relates to health, health services, and health practices and with the organization and administration of institutions and agencies that are part of the health-care and health-delivery systems. The degree programs and courses of the division are organized within the department of Health Education, the department of Nursing Education, and the department of Nutrition Education.

- **Libraries.** Teachers College's Milbank Memorial Library--housing over 900,000 books, periodicals, and other reference materials related to education, psychology and health broadly defined--is the largest collection of education materials in the United States. Also available are the outstanding research libraries of Columbia University, the eleventh largest of American university libraries, containing over 5.7 million volumes, 3.7 million microform units and 25 million manuscript items. Milbank Library receives on microfiche all the materials of the Educational Resources Information Center (ERIC), and through its membership in the Research Libraries Group (RLG)--a consortium of the libraries of Columbia, Yale, Stanford, Princeton, other colleges and

universities and the New York Public Library--and the American Library Association (ALA) it can extend its resources dramatically. A computerized database lists the holdings of member libraries.

In addition to online access to DIALOG, an information agency containing 375 databases, and Bibliographic Retrieval Service (BRS), Milbank Library offers free compact disc (CD ROM) access to ERIC and Dissertation Abstracts. Reference librarians are available to assist with or conduct database searches.

- **Teleconferencing**. A major renovation during the past ten years has transformed Milbank Memorial Library into one of the most technologically advanced education libraries in the nation. A satellite link supports distance-learning and teleconferencing, including a teleconference viewing room for 100 participants with interactive computers and video playback equipment. This facility has been used to bring together educators from all over the United States to share information and expertise. In addition, television and video studios and equipment are available as tools for research and analysis.

- **Computing Facilities**. The College maintains a wide array of computing capabilities for research and instructional use. The primary mainframe computer is a new Digital VAX 8810, a fast, current-generation machine capable of supporting scores of users simultaneously. The VAX is connected to BITNET, allowing users to send and receive electronic mail and files with other computers around the world. In addition, all individual faculty and staff computers are being joined through local area networks. This will allow faculty to communicate freely by electronic mail, and will facilitate collaboration on research and manuscripts. Statistical software (SPSS-X, BMDP, SAS, LISREL), editors (e.g., EDT, EVE), and relational data base managers (e.g., ORACLE), as well as disk, file and printer resources, can be shared between Macintoshes and IBM-compatibles through local area networks. In addition, a VAX 11/750 is reserved exclusively for research use.

  Teachers College's **Center for Computing and Information Management Services** (CCIMS) provides extensive support, training and consultation. An Academic Computing staff conducts classes on the use of software, advises on the purchase of new equipment, and helps overcome difficulties with using computer programs.

- **Word Processing Center**. Resources of the Teachers College Word Processing Center include a staff of 10 wordprocessors, an optical scanner to convert printed text for use in wordprocessing, and a fax machine. In addition to high speed photocopiers at several sites, the College provides a well staffed printing and binding center for proposals, reports and other large documents. In addition, Columbia University has

a well-equipped printing operation available to College programs at a minimal cost.

» **Office of Development and External Affairs.** The College's Office of Development and External Affairs helps obtain financial support from individuals, foundations and corporations, and plan and execute conferences and special events. A Media Specialist provides access to local and national press, writes press releases about College research and publications, and advises with videotape productions, and a Publications Officer helps design special brochures and publications and offers editorial services.

Teachers College has access to the unequalled resources of New York City, one of the nation's major corporate, financial, cultural and media centers. At the hub of transportation, both within the United States and overseas, the City is readily accessible to the world's leading scholars, government officials and corporate executives. Its proximity to Washington, D.C. and other major cities on the Eastern Seaboard has facilitated the ability of College researchers and scholars to give testimony before governmental bodies. The presence of network news operations, major magazines and publishing houses has helped to make College researchers one of the first sources journalists call when reporting on educational issues.

The campus of Teachers College is a city block of interconnected buildings, which allows faculty and administration easy access to and exchanges with their colleagues. The College is directly across the street from the campus of Columbia University.

Teachers College currently attracts over $9 million a year from government and private sources to support the research and development (R&D) efforts of its faculty and staff. Extensive experience with such R&D efforts has produced a set of institutional structures dedicated to assuring their nurturance and proper administration. A centralized Grants Office serves as the ultimate link with the Federal government for reporting and fiscal accounting. The Grants Office is located in the Office of the Controller, which reports to the Vice President for Finance and Administration.

In coming months, all accounts monitoring will be radically improved as a new interactive electronic accounting system is introduced. The Banner system will link all administrative and academic units through the College's new VAX mainframe computer. It will be possible to get up-to-the minute reports on expenditures and account balances.

Urban and Minority Education Initiatives

In addition to being at the forefront of every major educational movement from special education to nurse training, from preschooling for gifted children to professional education for adults, Teachers College has an especially distinguished history of involvement with urban education. The College has been

a partner in many successful collaborations with public schools, particularly in New York City, where the Board of Education has turned to TC for expertise and guidance in dealing with many of its critical problems. The College has an unsurpassed record of success in conducting high quality research in urban education issues and in operating special purpose inservice training programs. Notable examples include:

- **IUME (Institute for Minority and Urban Education).** Founded in 1973, IUME is a college-wide research and development enterprise which works toward improving the quality of urban and minority education through a three-pronged approach: (I) conceptualizing fundamental problems and formulating systematic research programs to discover solutions; (2) translating and applying the research to practical situations; and (3) developing new programs, techniques, instruments and materials that can be disseminated. To meet the needs of schools and other educational programs, the Institute conducts training, service, technical assistance and evaluation projects. Recent IUME studies have included an evaluation of dropout prevention programs in New York City, and research on literacy and on the affect of immigration on educational outcomes, particularly of Haitians and Dominicans.

- **The Educational Resources Information Center/Clearinghouse on Urban Education (ERIC/CUE).** One of sixteen specialized clearinghouses in the ERIC system, ERIC/CUE collects and disseminates published and unpublished materials on urban education for a wide audience of educators, researchers and professionals in a range of disciplines, as well as interested members of the general public. Operating out of Teachers College since 1968, the Clearinghouse is an extraordinary facility for establishing and maintaining networks with disparate communities.

- **Institute on Education and the Economy.** For the past three years the Teachers College Institute on Education and the Economy, and the National Center on Education and Employment housed within it, has been undertaking important, policy-oriented research on what today's economy requires of the nation's educational institutions--schools, of course, but also corporations, governmental organizations, community agencies and other entities concerned with the development of human capital. Supported by grants from the U.S. Department of Education and several smaller grants from foundations and other sources, the Institute has emerged as the nation's leading specialized source of research on the nature and creation of the skills and knowledge that future workers need to improve America's competitive economic position in the world.

- **Center for School Reform.** The newly-formed Center for School Reform, funded by the Leon Lowenstein Foundation and the New York City Board of Education, supports current efforts to restructure schools in New York City so that they become more responsive to students' needs

and more effective in their teaching methods. Among the activities to be conducted through the Center are research, documentation of successful change efforts, information and resource exchange, provision and brokering of staff development and technical assistance services for restructuring schools, and policy analysis aimed at developing policies and organizational structures that will support rather than impede the efforts of schools to become more responsible, responsive, and effective on behalf of students.

» **Center for Cooperation and Conflict Resolution.** Conflict in schools can lead to violence, vandalism, religious and racial quarrels, strikes, disciplinary breakdowns, chronic absenteeism, high drop-out rates and teacher "burn-out." To avoid these destructive outcomes of conflict and to aid in the shift to school-based management, The Center for Cooperation and Conflict Resolution conducts research in inner-city high schools, and provides training, information, and consulting services to school systems seeking assistance in cooperative learning, conflict management, effective collaboration techniques, and dispute mediation. The Center is supported in part by a grant from the William T. Grant Foundation.

» **The Literacy Center.** Funded in part by the McGraw-Hill Foundation and the State of New York, the Literacy Center brings together TC faculty and staff from a variety of fields in a multidisciplinary approach to literacy. To address the immediate needs of the individuals it serves, to advance basic research, and to produce models, techniques and materials that can be used by others, the Center is currently engaged in five projects: intergenerational literacy, literacy assessment, types of literacy, literacy program evaluation, and workplace literacy. Current intergenerational literacy projects take place at community and day-care centers in Harlem. A workplace literacy project helps adolescent parents develop the ability to apply written instructions to work situations.

» **Peace Corps Fellows Program.** The Peace Corps Fellows program trains returning Peace Corps volunteers for teaching careers and places them in the New York City public schools where they are most needed. Originally designed to address the critical shortage of math and science teachers in the City's schools, at the request of the Board of Education the program has been expanded to include teachers of English, special education, and English as a second language. Funded in part by the Xerox Corporation, the Hebrew Technical Institute, Chase Manhattan Bank and the New York City Board of Education, the program has been highly successful in providing culturally sensitive, exceptionally dedicated and qualified teachers who combine their Peace Corps experiences and their TC education to ably serve the City's children.

» **Teacher Opportunity Corps.** The Teacher Opportunity Corps, supported by a grant from New York State, is aimed at attracting minority

educators to teach in some of New York City's most challenging public school settings. Many students brought to the College through TOC are already per diem teachers for the New York City Board of Education who now have the chance to obtain their masters degrees and become full-time teachers. They receive both a top-notch education and the chance to obtain the kinds of teaching positions that will help keep them in the City schools where they are so greatly needed.

» **Public School Partnerships.** Other initiatives in urban teacher training include the recently established **Professional Practice School,** funded by the Ford Foundation to improve the clinical training experiences of preservice teachers. Through the Teachers College **Writing** Project, more than 800 New York City teachers have turned their classrooms into writing workshops, and thousand of children have become insiders in the world of written language. The **Nutrition Education Resources Project** provides technical assistance to strengthen and encourage food and nutrition education in New York City schools.

» **Fellows in Teaching Program.** One of the most successful new programs producing highly qualified and creative teachers for urban schools is the **Fellows in Teaching Program,** which was initiated with support from the Andrew W. Mellon Foundation. Now in its fourth year, the program recruits liberal arts graduates from some of the nation's finest colleges and provides them with fellowships and a special course of study at TC focusing on issues of urban education. It is particularly important to attract minority teachers, who are needed as role models to spark the imaginations and draw out the abilities and talents of the large minority populations of our great city schools. To that end, a new **Minority Fellows in Teaching Program,** supported by grants from the Bristol-Myers Company and the Surdna and William Randolph Hearst Foundations, has been designed with special recruitment and training methods to attract and prepare highly-qualified minority candidates for teaching careers.

» **Minority Leadership Fellows.** At present there exists a particular shortage of minority members in leadership positions in urban schools. This fall, the College has begun two new programs to promote minority leadership in school administration. The Minority Leadership Fellows, supported by a grant from the Henry Luce Foundation, is a five-year program to prepare Black and Hispanic men and women for careers in secondary school administration. The Aaron Diamond Foundation is funding a project that will generate competent minority candidates for high school principalships and encourage established principals to volunteer to administer "schools in need."

Institute for Learning Technologies

The Institute for Learning Technologies, founded in 1986 at Teachers College, works to advance the role of technology in education, with special attention to the technologies promoting visual learning. Its program of research and development seeks to produce changes which will facilitate:

- expanding the scope of educational attainment by making more quality material available for study with less effort in managing it productively;
- making educative resources more productive by amplifying with artificial intelligence what the student can achieve unguided by teachers, so that teaching resources may be reserved for those crucial points where fully humane interventions can make a substantial difference; and
- expanding the visual and auditory forms of knowledge so that they cease to be merely illustrative of knowledge stored and retrieved in written form and become instead full-fledged knowledge-bases-- coherent, intelligent storage and retrieval systems, subject to direct access in response to the inquisitive play of curiosity.

Funded by endowment, gifts, and grants, the Institute brings together faculty and students from a broad range of academic backgrounds for work exploring the potentials of electronic technologies, striving always to build structures which will further both excellence and equity. Functionally the Institute works both as an internal funding agency, soliciting proposals and making awards, and as a project development office, organizing and supporting efforts to obtain grants from external sources. Currently the Institute can provide researchers with well-equipped facilities for working with advanced learning technologies, especially in areas of multi-media. Its research and development resources are continuously developing, and through them the Institute provides an important base for advanced work with the learning technologies at the College.

A board of senior Teachers College faculty members advises on Institute policies and programs. Members are

- Harold F. Abeles, Professor of Music Education and Director of the Division of Instruction
- John B.Black, Professor of Computing and Education and Director of the Literacy Center
- Nathan Dickmeyer, Vice President for Finance and Administration and Chair of the Teachers College Technology Committee
- Herbert P. Ginsburg, Professor of Psychology and Mathematics Education
- Robert McClintock, Director and Professor of History and Education

- Ernst Z. Rothkopf, Cleveland E. Dodge Professor of Telecommunications and Education
- Margaret Jo Shepherd, Professor of Education
- Robert P. Taylor, Associate Professor of Computing and Education and Chair of the Department of Communication, Computing, and Technology

The Institute has had a variety of technology related projects funded by external sources since its inception five years ago. Among these have been the following:

- From 1985 through 1988, a component of the Institute, the Center for Intelligent Tools in Education, directed by Robert P. Taylor, received a grant of $645,000 in funds and more than $500,000 in equipment from IBM University Relations.
- A $500,000 equipment gift from the late Dr. Ben D. Wood to extend and upgrade the LAN development environment begun with IBM University Relation's grant to start the Center for Intelligent Tools in Education.
- A $200,000 project with the Russell Sage Foundation to design and develop a networked microcomputer environment for their facilities.
- A $160,000 contract to design and do the initial development of an interactive information program called *BranchOut* for ESI and InsightGuide.
- The New York Youth Network, an electronic bulletin board for at risk teenagers, funded by NYNEX ($100,000), the New York Community Trust ($35,000), and the Robert Bowne Foundation ($25,000).
- A $70,000 contract from Narcotics and Drug Research, Inc., to design a microcomputer network for their research staff.
- An $84,000 grant from the National Science Foundation for work on computer based simulation of harmonics for a high school physics course.
- A grant from the Fund for the Improvement of Post-Secondary Education to develop a model for long-term inservice training of technology teachers ($150,000 plus $23,000 in equipment from Apple, Inc.)
- A gift of $151,000 in equipment and $14,000 in funds from Apple, Inc. to equip an instructional lab.
- A $100,000 joint study contract with IBM ACIS to develop hypertext help materials for novice mircocomputer users.
- A $145,000 grant from the U.S. Department of Education to explore translation of a Japanese mathematics curriculum using manipulables as the basis for instruction.

Recently, the New York Youth Network received further funding from NYNEX and Professor John Black received a grant upwards of $400,000 from Morgan Stanley, Inc., to develop a computer simulation for high school students to interest them in financial careers.

Robert McClintock, Vita
Director
Institute for Learning Technologies
Teachers College, Columbia University
New York, New York 10027
212 678 3734

Goal

To ensure that the changes in education wrought by new information technologies enhance the public pursuit of humane culture and democratic equity.

Education

Princeton University, Woodrow Wilson School	A.B., high honors, 1961
Columbia University, History Department	M.A. 1963
Columbia University, Teachers College	Ph.D., with distinction, 1968

Teaching

Teachers College, Columbia University	
Department of Communication, Computing, and Technology	
Professor	1984 to now
Chairman	1985 to 1988
Department of Philosophy and the Social Sciences	
Professor of History and Education	1982 to now
Associate Professor of History and Education	1970 to 1982
Assistant Professor of History and Education	1968 to 1970
Instructor	1967 to 1968
Columbia University, University Seminars	
Co-Director, Seminar on Innovations in Education	1980 to now
The Johns Hopkins University	
Department of Education	
Assistant Professor of Education	1965 to 1967

Research and Development

JHM Corporation, Palm Beach Gardens, Florida	
Director, The Freedom Project (initial work on a technology-delivered social-studies curriculum, grades K-12 +)	1988 to 1990
Teachers College, Columbia University	
Institute for Learning Technologies, Director	1986 to now
Center for Intelligent Tools in Education	1984 to now
Institute of Philosophy and Politics of Education	1969 to now
Goethe University, Frankfurt am Main, West Germany	
Pädagogik Seminar, Visiting Scholar	1974 to 1975
Philipps University, Marburg, West Germany	
Pädagogik Seminar, Visiting Scholar	1970

Government Service

U.S. Department of Health, Education, and Welfare, Immediate Office of the Secretary, Special Assistant for Policy Studies 1976

Awards and Honors

The Gale F. Johnson Prize, Princeton University 1961
International Fellow, Columbia University 1963 to 1964
Special mention, The Ansley Award, Columbia University 1968
Man and His Circumstances: Orgeta as Educator chosen by *School and Society* as an "Outstanding Education Book of 1971" 1971
Distinguished Service Award from David Mathews, Secretary of the U.S. Department of Health, Education, and Welfare 1977

Memberships

American Educational Research Association
Association for Computing Machinery
IEEE Computer Society
American Historical Association
American Political Science Association
Society for the History of Technology
Conference on Political Thought
Society for Scholarly Publishing
International Communication Association
International Interactive Communication Society
American Society for Information Science

Books

Computing and Education: The Second Frontier. Edited and introduced. New York: Teachers College Press, 1988. xiii, 98 pp.

Man and His Circumstances: Ortega as Educator. New York: Teachers College Press, 1971, xix, 649 pp.

Henry Barnard's School Architecture. Edited and introduced with Jean McClintock. New York: Teachers College Press, 1970, xviii, 339 pp.

Reports and Guides

Maxwell's Demon: An Aid to Sorting Options for Study. Version 2.1, September 1987, Department of Communication, Computing, and Technology, Teachers College, 90pp.

Prospectus, Institute for Learning Technologies, Teachers College, October 2, 1986. 15 pp.

Thinking about the Budget: An Informal Report to the Teachers College Faculty. Prepared for the TC Faculty Executive Committee, Fall, 1978.

Scholarly Articles and Essays

"Kant in the Culture Factory: Design, Study, and Technology in Education." In progress.

"Marking the Second Frontier," Guest editor's introduction to a special issue of the *Teachers College Record* on Computing and Education: The Second Frontier, Winter, 1987/1988.

"Into the Starting Gate: On Computing and the Curriculum." *Teachers College Record.* Vol. 88, No. 2, Winter 1986, pp. 191-215. (Spanish translation: "En el cajon en la linea del salida: Sobre la informatica y el curriculo," Revista de Educacion, num. 280 (September 1986)

"On Computing and the Curriculum." *SIGCUE Outlook.* Vol. 19, No. 1/2, Spring/Summer 1986, pp. 25-41.

"El nacimiento de la historia de la educacion: Los antecedents alemanes de la pedagogia historica." *Revista De Educacion.* Fall 1985. 17 pp.

"From the Ought that Is to the Is that Ought To Be: Ortega and Dewey on the Pedagogical Problem." Paper for the Centennial of Jose Ortega y Gasset's birth. CUNY Graduate Center, Spring 1983.

"*Enkyklios Paideia*: The Fifteenth Edition of the *Encyclopaedia Britannica*." *Proceedings of the National Academy of Education.* 1976, pp. 179-216.

"Rousseau and the Dilemma of Authority." *History of Education Quarterly.* Vol. XIV, No. 3, Fall 1974, pp. 309-333.

"Universal Voluntary Study." *The Center Magazine.* Vol. 6, No. 1, January/February 1973, pp. 24-30. Substantial excerpts reprinted as "Compulsory Education No Longer Suits Our Society" in the Opinion Section of the *Los Angeles Times*, Sunday, January 31, 1973, pp. 1 & 6.

"Toward a Place for Study in a World of Instruction." *Teachers College Record.* Vol. 73, No. 2, December 1971, pp. 161-205.

"Ortega y Gasset: The Partly Faithful Professor." *School and Society.* Vol. 99, No. 2,334, Summer 1971, PP. 304-315.

"On the Liberality of the Liberal Arts," *Teachers College Record.* Vol. 72, No. 3, February 1971, pp. 405-416.

"Ortega o el estilista como educador." *Revista de Occidente.* Madrid. No. 75, June 1969, pp. 267-292. English version: "Ortega, or the Stylist as Educator." *The Journal of Aesthetic Education.* Vol. 3, No. 4, October 1969, pp. 59-79.

"Architecture and Pedagogy." Co-authored with Jean McClintock. *The Journal of Aesthetic Education.* Vol. 2, No. 4, October 1968, pp. 59-77.

"Machines and Vitalists: Reflections on the Ideology of Cybernetics." *The American Scholar.* Vol. 35, No. 2, Spring 1966, pp. 249-257. Spanish version: "Maquinas y vitalistas: Reflexiones sobre la ideologia cibernetica." *Revista de Occidente.* Madrid. No. 63, June 1968, pp. 279-301.

Occasional Articles

"The Dynamics of Decline: Why Education Can No Longer Be Liberal." *Phi Delta Kappan.* Vol. 60, No. 9, May 1979, pp. 636-640.

"In Defense of Ideas." *Quad: The University of Alabama.* Vol. 2, No. 2, July/August 1978.

"Pestalozzi." *Teachers College Record.* Vol. 76, No. 2, December 1974, pp. 344-8.

"Diderot." *Teachers College Record.* Vol. 76, No. 1, September 1974, pp. 143-9.

"Some Thoughts on Permanent Education." *Notes on Education.* No. 3, December 1973, pp. 1-3.

"Ortega y Gasset Rediscovered." *Columbia Forum.* Vol. XIII, No. 2, Summer 1970, pp. 33-6.

"The Ides of March, 1969," (signed Robert Oliver). *Teachers College Record.* Vol. 70, No. 8, May 1969, pp. 761-3.

"Competence," (signed Robert Oliver). *Teachers College Record.* Vol. 70, April 1969, pp. 655-9.

"The End of an Order." *Perspectives on Education.* Vol. II, No. 3, Spring 1969, pp. 1-5.

"Of Privacy and Public Schooling," (signed Robert Oliver). *Teachers College Record.* Vol. 70, No. 6, March 1969, pp. 559-563.

"Pedagogical Praxis," (signed Robert Oliver). *Teachers College Record.* Vol. 70, No. 5, February 1969, pp. 459-463.

"On Pedagogy and Student Power: A Proposal," (signed Robert Oliver). *Teachers College Record.* Vol. 70, No. 4, January 1969, pp. 374-9.

"In Praise of Humble Heroes." (signed Robert Oliver). *Teachers College Record.* Vol. 70, No. 3, December 1968, pp. 251-3.

"A Message on the Media," (signed Robert Oliver). *Teachers College Record.* Vol. 70, No. 2, November 1968, pp. 139-142.

"Towards the Separation of School and State," (signed Robert Oliver). *Teachers College Record.* Vol. 70, No. 1, October 1968, pp. 73-6.

"Foreword," to R.L. Nettleship. *The Theory of Education in the REPUBLIC of Plato.* New York: Teachers College Press, 1968. pp. vii-xi.

Book Reviews

"Review of Education and Culture in the Barbarian West by Pierre Riche." Comparative Education Review. October 1979, pp. 460-1.

"Review of Learning for Tomorrow by Alvin Toffler." The Chronicle of Higher Education. Vol. VIII, No. 25, March 25, 1974, p. 12.

"Imagination in History." Review of An Interpretation of Universal History by Jose Ortega y Gasset. The New Republic. Vol. 169, No. 4 & 5, July 28 & August 4, 1973, pp. 28-29.

"The Humanization of Science." Teachers College Record. Vol. 74, No. 1, September 1972, pp. 103-8.

"Review of Giambattista Vico: An International Symposium edited by Giorgio Tagliacozzo." Comparative Education Review. Vol. XVI, No. 2, pp. 376-378.

"Reconsiderations: The Revolt of the Masses by Jose Ortega y Gasset." The New Republic. Vol. 166, No. 16, April 15, 1972, pp. 30-31.

"Beyond Anarchy." Review of Superman and Common Man: Freedom, Anarchy, and the Revolution by Benjamin R. Barber. The Progressive. Vol. 36, No. 1, pp. 56-58.

"Review of The Degradation of the Academic Dogma by Robert A. Nisbet." Teachers College Record. Vol. 73, No. 1, September 1971, pp. 123-9.

"The Fall and Rise of Modern Europe." Trans-Action. Vol. 8, No. 11, September 1971, pp. 70-75.

"Review of Design with Nature by Ian L. McHarg." Main Currents of Modern Thought. Vol. 27, No. 4, March-April 1971, pp. 133-5.

"Review of Science and the Federal Patron by Michael D. Reagan." Comparative Education Review. Vol. XIV, No. 1, February 1970, pp. 113-4.

"Review of The Spanish Press by Henry F. Schulte." Comparative Education Review. Vol. XIII, No. 2, June 1969, pp. 235-238.

"Review of Other Schools and Ours by Edmund J. King." Teachers College Record. Vol. 65, No. 5, February 1964, pp. 471-2.

Selected Talks and Presentations

"Technology, Work, and Education," Keynote Address, 5th Annual AHA/WEA Issues Conference, Seattle, Washington, January 27, 1990.

"Future Learning Systems," NECC '89, Presentation, June 22, 1989, Boston, MA.

"Prototyping Curriculum Materials with HyperText," IBM Symposium on Authoring Languages, February 27, 1989, New York, NY.

"Interactive Multi-media Curriculum Design," invited talk at the conference on "Connecting with the Future: Interactive Technologies in Education," sponsored by the Albany Symposium on Cognition, Education and New Technologies, April 21-23, 1988.

Panel presentation on "Misperceiving Media: The Mass Media and Historical Analysis," The Center for American Culture Studies, Columbia University, February 2, 1988.

"Emerging Technology, Applications, and their Educational Uses." Presentation to the IBM ACIS Conference on *Instructional Delivery Technology*, November 17, 1986, Fort Lauderdale, Florida.

"Technological Displacement and Cultural Responsibility", Invited lecture in the Science and Society series at IBM Research Yorktown. May 19, 1986.

"Interpretation and Explanation: Some Methodological Reflections on the Study of Technology, Education, and Communication." Lecture at the CCT Colloquium, Teachers College, Columbia University, February 20, 1986.

"Ortega, Quixote, and the Dream of Europe." Keynote lecture at the University of San Francisco Symposium, *Life is a Dream: Ortega, Unamuno, Falla*, August 7, 8, and 9, 1980.

"Citizens and Subjects: Educational Politics in Historical Perspective." Three lectures as Visiting Scholar, General Studies Program, New York University. April 15, April 22, and May 2, 1980.

The Dalton School

Dalton's Headmaster, Gardner P. Dunnan, writes:

> Many consider Dalton a large school. Our enrollment is approximately 1,250 students, with senior classes each year numbering about 100. This size allows Dalton to support a breadth and a depth in programming that smaller schools cannot offer, while our student/faculty ratio of seven to one facilitates the personal attention and special rapport usually associated with a small school.
>
> As we approach the end of this century, Dalton is tailoring the best of our heritage to the most current educational concepts in order to prepare leaders for the future. We continue to believe in Helen Parkhurst's innovative educational philosophy: educating the "whole" child is of primary importance. Children are social beings, and school should be a community where students can learn the civility to live and work with others. The school as a community should devote itself to the total enrichment of the mind, body and spirit. We believe that the relationships among all members of the Dalton family are important, and encourage friendships between students of different ages, student organizations which include students from different grades, and the development of a partnership between parents and professionals.
>
> Dalton's academic program is rigorous and demanding. Students are expected to participate actively in an extensive and challenging curriculum as well as in the school community. This high academic standard is complemented by a dynamic performing and fine arts curriculum, a comprehensive physical education and athletic program, and use of the computer as an integral part of our instructional program. Supervised school and community services further enrich the curriculum while inculcating important values.
>
> A process of careful teaching and guidance helps each student to gain independence gradually. Students are provided with freedom to the extent that they demonstrate the responsibility to use this freedom wisely in the further pursuit of their education.
>
> Our "City as a Classroom" program makes New York City's extraordinary facilities available to the inquiring minds and special interests of our students. Dalton funds a lectureship at The Metropolitan Museum of Art to expose students to the staff and collections of that great institution. Many students enroll in courses at nearby schools and universities where they can pursue particular interests in highly specialized courses. Dalton also supports internships and study projects in area hospitals and business firms.

The Dalton Plan, as embodied at The Dalton School, was conceived, and continues to thrive, as a living, growing process based on the creative interaction of teacher and student. The Dalton Plan, as developed by Helen Parkhurst in her writings and practical experiments, has these objectives: to tailor each student's program to his or her needs, interests and abilities; to promote both independence and dependability; to enhance the student's social skills and sense of responsibility toward others. These objectives are achieved through the three unique components of the Dalton Plan: the House, the Assignment and the Laboratory.

Each Dalton child is a member of a House which, as the name implies, is his or her base in the School. The House advisor for children in the First Program (age three through grade three) is also their teacher in a multi-age classroom. In the Middle School, the House advisor guides and aids each student as he or she makes the transition to semi-departmentalized classes. In the High School, the House advisor is the student's counselor and coordinator. In every program, the House advisor works closely with the student, directing and guiding the learning process. The relationship between the House advisor and the student is a special one during every phase of the student's education.

The Assignment is, in effect, a contractual agreement between the student and each teacher. It is designed by every Dalton teacher for his or her respective class as a primary supplement to daily class and homework. Modestly introduced in second grade, it becomes increasingly important as the student progresses at Dalton. Given at first on a weekly basis and later on a monthly basis in every academic course, it outlines for the student a problem or area to study, suggests ways to research and solve the problem, while providing a variety of options for satisfying its requirements. Assignments are often individually tailored to satisfy special needs and to develop particular strengths.

Within the Dalton Plan, teaching takes two forms: the familiar one of classroom instruction, and the tutorial sessions, unique to Dalton, known as Laboratory. The School has separate Laboratories or resource rooms for different subject areas. The Lab is where students meet with teachers for individual or group conferences, and where they work independently to fulfill assignments. The Laboratory encourages a close, highly individualized working relationship between students and teachers. The expression "Lab Time," as used by Dalton students and teachers, means all nonscheduled time within the school day.

The New Laboratory for Teaching and Learning

The goal of Dalton's New Laboratory for Teaching and Learning is to explore and develop the technologies and techniques that will most effectively prepare students for the 21st century. An outgrowth of Dalton's historical commitment to experimentation and reform, and of the School's efforts to maintain a healthy evolution of its own programs, the New Laboratory provides a vehicle for Dalton faculty to pursue innovative projects and, through collaboration with universities, museums, corporations, and schools, to enhance and disseminate them. The New Laboratory also provides an opportunity to extend student-centered learning at the School.

Those closely connected with the New Laboratory believe their efforts eventually will benefit teachers and students throughout the nation. Indeed, work pioneered in the New Laboratory already has changed the educational environment at dozens of other schools throughout the city and country whose administrators and teachers have come to Dalton to be trained .

The New Laboratory represents The Dalton School's most advanced thinking on pedagogy. Dr. Frank Moretti, its executive director, says that as a result of work being done there by his staff and other colleagues, teachers can better anticipate how and when learning will occur: "They can try out various applications in existing and emerging technologies, multi-media education, and new strategies for teaching and learning mathematics and science."

"The New Laboratory for Teaching and Learning makes us focus on how and what we teach, and helps keep Dalton at the forefront of American education," Dr. Moretti adds. "We seek to imagine what the schools of tomorrow will be, and to begin building them."

New Laboratory projects fall into two main areas. The first concerns the enhancement and transformation of education through the use of technology, with particular emphasis on interactive media. The second focuses on the teaching of mathematics and science.

Exploring the educational potentialities of multi-media technologies is one of the New Laboratory's goals. Creating and sustaining interest, excitement, and dialogue about mathematics and science education, and encouraging collaboration and cooperation among disciplines, is another. In both cases, the purpose is the "intellectual empowerment" of students.

In all project areas, the New Laboratory depends on a close association with independent and public schools, corporations, universities, and museums interested in the use of new media for educational purposes. Here is a sampling of the projects currently being developed in or disseminated by the New Laboratory for Teaching and Learning.

- Playbill: A Place for Study in a World of Instruction Through the Use of Interactive Hypermedia. In the New Laboratory's interactive hypermedia project, efforts have focused on the linking of text and visual material, allowing open-ended exploration of a work of dramatic literature. The Playbill program allows a person reading a Shakespeare play to pull up video replays of a scene in several different versions. He or she can browse through the text of a play, and follow links to glossaries, critical essays, and one or more video productions of the play. The hypertext environment makes it easy to navigate through the information, bringing a page of the play into view, a brief glossary definition, a notepad on which the user can enter comments or read the comments of others. On-screen texts are available, complete with discursive footnotes. At the click of a button or mouse, analytic and critical background materials appear on the screen.

- The I-CM Project for Science and Mathematics: Thinking and Acting Like a Scientist. The Investigation-Colloquium Method (I-CM) approach to teaching science and mathematics replicates what has been found to be an essential part of the discovery process: the need for scientists to participate in an on-going dialogue with other scientists. Using the I-CM, students are encouraged to think and act like scientists and mathematicians. Through observation of phenomena, discovery of patterns, discussion directed towards clear definitions, and the formation of testable hypotheses, they learn the scientific method. Through the teachers who have been trained to use the Investigation-Colloquium Method, a new kind of science study has been introduced to thousands of children from school districts throughout New York City. A special feature of the project is the participation of cooperating scientists and mathematicians who provide insight into applications of science and mathematics in business and industry.

- The Language of Science: The New Science Literacy Project. Why do so many people have difficulty dealing with natural events in mathematical terms and how can they be helped? The New Science Literacy Project staff provides a curricular response to this central problem of science education. They believe that approaches to scientific literacy which minimize the math connection beg the hardest question, however valuable they may be in other ways. Within the curriculum, using Newtonian mechanics, the problem of mathematics in relation to phenomena is directly confronted.

- The Civil War Project: History on a CD-ROM Disc. With the aid of a grant awarded by one of the leading manufacturers of compact discs, the staff and a select group of Dalton students are creating a disc of primary sources covering the Civil War. The students, high school juniors and seniors, are participating in a course for academic credit in which they select, gather, and edit the text and graphics to be included on the disc.

They are also composing introductory essays for the documents selected for inclusion, and will design the computer interface for the disc, which will allow users to search for information in a variety of ways: by dates and timelines, by individual names, by location of an event, by music of the time, and by a variety of other means.

- Learning to See: The Visual Literacy Project. What new forms of understanding are necessary in order that we become critical observers of the surrounding universe of images? What are the new grammars required for an understanding of its dynamics and structures? Questions such as these guide the work of the Visual Literacy Project. Specifically, the Visual Literacy Project focuses on discovering new curricular resources in the fields of architecture, environmental design, fine arts, mass media studies, and anthropology. Project staff are developing models for integrating these varied perspectives into all disciplines, with emphasis on the deployment of resources of New York's cultural institutions.

- The Archaeology Project: How We Know What We Know. New Laboratory staff believe that archaeology, with its emphasis on discovery, hands-on investigation, and inference making, offers a model of what a school curriculum should promote as a learning paradigm. The Archaeology Project, which moves from physical simulation in the earlier grades to a computer simulation in the middle grades and a planned site investigation in the latter grades, is staffed and being developed by Dalton's four professionally trained archaeologists.

- The Local Area Networks (LAN) Project: Using Networks to Heighten a Sense of Community. The New Laboratory for Teaching and Learning is currently exploring ways to enhance natural networks through technological support. An instructional network of personal computers incorporating new channels for communication, including electronic mail, computer conferencing, local area networks (LANs), and computer-based bulletin boards, will offer links between children, teachers, and the outside world in educationally powerful ways. These new forms of activity support a change in the teacher's role. He or she becomes less a provider of content-specific information, and more the facilitator of students' acquisition of knowledge. Instruction shifts from emphasis on information-giving to emphasis on helping students to find relevant information, solve problems, ask questions, think critically, and communicate ideas. This new computer enhanced instructional network will include several multi-use networked classrooms and will support access from student and faculty home computers--as well as from "kiosks" of personal computers throughout Dalton. It will also include capabilities for shared storage and access to numerous data banks.

Laboratory Directors
Frank Moretti, Executive Director

Jeanne Heymann, Administrative Planning
Luyen Chou, Academic Planning
Steven Taylor, Technical Operations

Frank Moretti, Vita
Executive Director
New Laboratory for Teaching and Learning
The Dalton School
108 East 89th Street
New York, NY 10128-1599
212 722 5160

Education

St. Bonaventure University	B.A., Greek and Latin, 1965
Columbia University	M.A., Latin, 1967
Columbia University, Teachers College	M.A., History & Education, 1973
Columbia University, Teachers College	M.Ed., History & Education, 1976
Columbia University, Teachers College	Ph.D., 1983

Present Positions

Associate Headmaster, The Dalton School 1986 to now
Executive Director, The New Laboratory for Teaching and Learning
Adjunct Associate Professor, Department of Communication, Computing, and Technology, Teachers College, Columbia University 1985 to now

Related Professional Positions

Board Member
- City Volunteer Corps
- Corporation for Entertainment and Learning, The Video Encyclopedia
- Earth Environmental Group
- National Advisory Board, Center for American Culture Studies, Columbia University
- National Conference Committee

Committee Member
- Committee to Explore New York University's Relations with Black South African Schools and Colleges 1986-88

Seminar Member
- Innovation in Education, University Seminars, Columbia University
- Scientific Literacy, University Seminars, Columbia University
- Joseph Priestly Society

Previous Administrative Positions

The Dalton School
- Assistant Headmaster for Curriculum 1981-1986

New York University, School of Continuing Education	
Director of Degree Programs in Liberal Arts	1978-1981
Director of the General Studies Program	1977-1978
Bloomfield College	
Director of Methodology Workshops (AIDP Federal Grant)	1975-1977
Assistant Director of Grant Program, sponsored by the N.J. Council on the Humanities	1975-1976
Supervisor of Area of Life and Continuing Education	1973-1975
Director of Teacher Education	1973-1975
Barnard College, Columbia University	
Associate of the Faculty	1970-1973

Previous Teaching Experience

New York University	
Adjunct Associate Professor of Humanities	1971 to now
Bloomfield College	
Assistant Professor, History & Philosophy of Education	1973-1976
Barnard College	
Associate in Department of Education	1971-1973
Adelphi University	
Lecturer in Greek and Latin	1969-1971
Union Catholic High School	
Teacher in Social Studies Department	1969-1971
St. Bonaventure University	
Instructor in Greek and Latin	1967-1968
St. Peter's Prep (Jersey City, New Jersey)	
Teacher of Greek and Latin	1966-1967

Recent Professional Activities

"The Playbill Program," International Conference on Technology and Education, Brussels, Belgium. March 1990.

"Hermeneutical Pedagogy," Reality Club, New York, NY, April 1989.

"Moral Education: Private School Dilemma," Progressive Education Conference, Chicago. April 1989.

"Interactive Hypermedia Project: The Electronic Workstation," The Educational Records Bureau Conference, New York, NY. October 1989.

"Social Class and Its Relationship to Schooling." The Annual Conference of the Headmistresses Association of the East, November 1989.

"Vergil and Politics," Boston College, Honors Humanities Lectures, Spring 1988.

"Education and Racism," Presentation at the Center for American Culture Studies, Race and Racism in American Society Series, Spring 1988.

"Politics, Hypocrisy and Eduction: Past and Present," New York University Homecoming, May 1987.

"Twin Dynamos of Education: The Quests for Power and Truth," Columbia University, Seminar on Innovation in Education, December 1986.

Distinguished Resident and Visiting Scholar, Westminster College, Utah, November 1986.

"Educator's Response to *A Nation Prepared*," Joseph Priestly Association, November 1986.

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New York City Mayor's Public/Private School Partnership

There are nearly one thousand public schools and over one hundred private schools in New York City. Many of these institutions are situated side by side. Often, these schools serve the same age group of students and perform similar functions in terms of their educational missions. Undoubtedly these schools face many of the same problems. However, the potential for public and private schools sharing resources has often gone unnoticed due to their traditions of operating independently.

The Public/Private School Partnership, based upon the recognition that public and private schools have much to offer one another, was founded to exemplify the late Chancellor Richard R. Green's long-held belief in the value of such cooperation. Therefore, its primary mission is to provide a mechanism for these neighbors to become partners-to share resources, identify common problems, and assist each other in finding solutions by providing linkages between faculties, administrations, students, and parents.

In the process of exploring and developing collaborative approaches to education, the Public/Private School Partnership seeks to become a model for inter-institutional collaboration between schools -- public, non-public, and independent.

These five focus areas were chosen at the Partnership's inception to provide guidance for growth and planning sessions. They have proven broad enough to include every collaborative activity to date.

- **Curriculum Design**. This focus area is for partners interested in enhancing curriculum in their schools. Curriculum design focuses on innovative and practical strategies for improving the delivery of educational services to students. The goal of collaborative activities within this area is to explore ways of working together to share materials, planning, and expertise.
- **Joint Service Projects**. Schools involved in this focus area are oriented towards community action and involvement. Paired schools consider collaborative work that can improve their shared environment. These activities also include parents and parent-teacher groups.
- **Shared Creative Programs**. This focus area emphasizes each school's unique cultural and artistic strengths. Paired schools seek to understand and develop ways in which their respective students can share these powerful aspects of themselves and their families' heritages. Partners are strongly encouraged to bring parents into the planning and implementation phases.

- **Staff Development**. This focus area is directed toward stimulating new teachers and experienced teachers to seek professional growth. Activities can include in-service training of their teachers, joint think tanks, and retreats. Schools are also encouraged to share what they do best.
- **Student Support Services**. Schools involved in this focus area seek to develop both in-school and out-of-school extracurricular activities that serve to broaden their students' horizons and enrich their lives. The goal of activities in this area is to encourage school communities, including parents, to act innovatively in support of their students.

Currently the Partnership consists of twenty-six pairs of schools, located in all parts of the City.

The Cooper Union for the Advancement of Science and Art

The Cooper Union for the Advancement of Science and Art occupies a special place in the history of American education. Founded by industrialist and philanthropist Peter Cooper, who believed "education should be as free as water and air," the college opened on a tuition-free, nonsectarian basis in 1859. The Cooper Union continues to fulfill its historic responsibility, offering a tuition-free education "equal to the best."

Of the 979 students enrolled at Cooper Union, 912 are undergraduates. In the School of Art, there are 120 men and 159 women; in the School of Architecture, 109 men and 46 women; and in the School of Engineering, 388 undergraduate men and 90 undergraduate women as well as 60 men and 7 women working toward the Master of Engineering degree.

Most members of the current first-year class are 18 years of age and come from the New York area. About 5 percent of the students are foreign citizens. There are three fraternities and two sororities on campus in addition to numerous social, special-interest, and religious clubs. A strong intramural sports program is available. The college has three buildings, including a full-service cafeteria and student lounges.

Cooper Union is situated on the edge of Manhattan's East Village, within easy walking distance of Washington Square Park and the bookstores, galleries, and film houses of Greenwich Village. Students have the opportunity to take advantage of Cooper Union's location in New York City, an international art center and the information hub of the country. New York offers extraordinary resources and stimuli for learning--great museum collections; performances by orchestras, chamber music groups, jazz musicians, and dance companies, constant exposure to the work of artists from all over the world in the galleries of Soho, Greenwich Village, and upper Manhattan; the curricula and public programs of nearby colleges and universities; and the ever-changing street life of the city itself.

Degree programs are offered in architecture, fine or graphic arts, and engineering. The Bachelor of Architecture is offered in architecture (five-year program); the Bachelor of Fine Arts in drawing, film/video painting, photography, printmaking, and sculpture; the Bachelor of Engineering in chemical engineering, civil engineering, electrical engineering, and mechanical engineering; and the Bachelor of Science in engineering. In addition, a certificate program is offered in art.

Cooper Union uses a semester calendar. Each curriculum is designed to meet the professional needs of students entering any of the college's specialized fields. Graduates are well prepared to enter these fields or to continue their education in graduate school. Requirements for the Bachelor of Architecture are

168 credits; for the Bachelor of Fine Arts, 128 credits; for the Bachelor of Engineering, 135 credits; and for the Bachelor of Science, 135 credits. The requirements for the certificate program in art are approximately half the studio course credit requirements of the B.F.A. degree.

In the School of Architecture, an interim year is offered during which students may work in architectural firms or study and travel. In the School of Art, foundation courses in studio art and art history are required, and independent study projects are available. All first-year engineering students in the School of Engineering take core courses in math, chemistry, physics, computer science, and humanities. Students have the opportunity for hands-on experience in city agencies, cultural institutions and the offices and studios of the many professional architects, artists, and engineers who live and work in New York.

A consortium arrangement with nearby Eugene Lang College of the New School for Social Research permits Cooper Union students to take courses for credit not normally offered on their own campus.

The School of Art offers a semester of nonresident study at member schools of the Consortium of East Coast Art Schools and at art schools in Switzerland, England, Italy, and France.

The Cooper Union library contains more than 97,000 volumes. The collection also includes 70,000 photographs and 50,000 slides related to fine arts and architecture. In addition, Cooper Union is part of a library consortium including New York University, Parsons School of Design, and the New School for Social Research. There are also studios, a printmaking shop, a full floor devoted to a sculpture and woodworking shop, laboratories, darkroom facilities, an animation room, and lecture halls. The Arthur Houghton Art Gallery, the Center for Design and Typography, and the historic 900-seat Great Hall auditorium all contribute to the academic and cultural life on campus.

The college's computer center, with access provided by forty terminals, is linked to two computer systems: a VAX-11/780 and a PDP-11/45; there are also four Intel 86/380s, each supporting five terminals. An instructional time-sharing environment supports education in programming and computation. This system is driven by five AT&T 3B minicomputers that are networked together and utilize the popular UNIX V operating system. A special microcomputer classroom houses 25 IBM PS/2 Model 80 microcomputers. The Computer Center also houses an engineering workstation laboratory. All of the systems are networked together to provide ease of access as well as data and program portability.

There are specialized laboratories for work in structural engineering, water resources, soil mechanics environmental and sanitary engineering, air-pollution control, thermal science, fluid mechanics, and bioengineering; a shop for fabrication of models and prototypes; a robotics laboratory; and a computer graphics laboratory.

The cost per year is a $300 student fee. The Cooper Union is tuition free. All students admitted to the Cooper Union are offered a full tuition scholarship, which is equivalent to approximately $40,000 each in the School of Art or School of Engineering and $50,000 each in the School of Architecture.

The Cooper Union has a full-time faculty of 57 members and a part-time faculty of 116. Eighty-one percent of the full-time faculty have earned advanced degrees. The faculty-student ratio is 1:10.

The faculty in the School of Engineering is both a teaching and research faculty, with the former responsibility emphasized. The same faculty teaches undergraduates and graduate students. Graduate students do not serve as instructors. Most faculty members in the School of Architecture and School of Art are practicing professionals. All faculty members are expected to counsel students, and many participate as advisers in extracurricular activities.

The Cooper Union Research Foundation (CURF) was established in 1976, as a not-for-profit corporation to encourage and support basic and applied research by faculty and students at the Cooper Union. The Foundation augments the educational opportunities for the students, enhances the professional development of faculty, and provides services to the community by performing research and development for industry and government.

Over the past several years, CURF has provided students in the School of Engineering with opportunities to work with the faculty on research and development projects. These students, a select group of young men and women with demonstrated potential for high achievement in their field, have been able to go beyond the confines of the classroom and explore, experientially, the technological world of the future. CURF brings to these students engineering research projects at the cutting edge of technology. Many of these projects are undertaken in response to a pressing societal problem or the perceived market potential of a specific process or product.

Students working on CURF projects have critical responsibilities: As active participants, they attend project meetings, and, under the guidance of the faculty, aid in the conception, design and implementation of the research. They confront the challenge of moving a novel idea from the drawing board to implementation. From this they gain the satisfaction of conceiving the solution to a problem rooted in reality. During the academic year 1986-87, ten senior projects and seven master's theses resulted from students' research on CURF projects.

Since Cooper Union is a small, primarily undergraduate institution, research opportunities available to our faculty are relatively limited as compared, say, to graduate faculties at larger institutions with doctoral programs. To the extent that research augments educational resources without detracting from the basic undergraduate mission, participation in research activities by faculty members on a voluntary basis is essential to the vitality of educational programs. In attempting to meet this objective, CURF plays an important role for all faculty

members with research talent who wish to pursue sponsored research individually or in concert with other faculty and students.

All faculty members are encouraged to communicate with the Executive Director (Dean Baum) or the Director of Research (Professor Ahmad) to explore the development of potential research proposals and possible sources of funding, especially in interdisciplinary areas. In 1986, The Board of Directors approved the establishment of a faculty research initiative program. Under this program, during the summer of 1987, four faculty research initiation grants totalling $12,000 were awarded on a competitive basis. The program is expected to be continued in the coming years.

CURF furthers Cooper Union's goal of community service by undertaking projects for industry, business and government in environmental planning, chemical and industrial processes, hazardous waste management, computer engineering, telecommunication and information processing, infrastructure rehabilitation and biomedical engineering. The goal of community service is furthered by bringing faculty and students into closer professional contact with the needs of the society and with the solutions related to those needs.

CURF is administered by a Board of Directors, consisting of the President of The Cooper Union or designee, Dean of the School of Engineering, a member of the faculty of Engineering, three members of the Board of Trustees of Cooper Union, and an alumnus of The Cooper Union. The board sets policies and guidelines for the operation of CURF. The responsibility for the selection of projects to be undertaken by CURF rests with the Program Committee of the Board. This Committee consists of the President (or designee), the Dean of the School of Engineering, and the faculty board member.

The day by day operation of the Foundation is the responsibility of the Executive Officer and the Director of Research. The Executive Officer is the Dean of the School of Engineering while the Director of Research is a part-time position presently held by a member of the engineering school faculty. The Executive Officer oversees the Foundation's operation and also serves as chairman of the Program Committee. The Director of Research is responsible for developing interdisciplinary research collaboration among the faculty members, preparation of proposals, and providing liaison with potential sponsors and outside agencies.

Projects are undertaken on the basis of their relevance to CURF's mission, i.e., educational value and social importance. Other selection criteria include availability of faculty and students for the expected duration of the project and the availability of resources and facilities. CURF receives projects from both the private and public sectors, and welcomes collaboration with small to medium-size companies in research and development work leading to patentable inventions.

CURF also collaborates with the medical and legal community in undertaking projects in the interdisciplinary fields of biomedical engineering and the regulatory aspects of environmental engineering. Such projects are especially welcomed

by some of our students who are eventually planning careers in medicine or law upon completing their engineering education.

CURF projects for 1986-87 covered a broad range of areas: environmental, energy, health, industrial needs for new materials, and computer systems. During the year, the projects involved 20 undergraduates and 10 graduate students who worked in professional collaboration with 12 faculty, 4 technicians and several outside consultants. Some projects began in the current year, some the year before; the start and conclusion of projects does not necessarily coincide with the academic year. Each project was guided by a faculty director, who was assisted by other faculty, and undergraduate and graduate students from the four engineering disciplines. On most projects, consultants from other institutions and professional personnel from the clients or sponsors were also involved.

District 2 Lab Schools

The New York City Laboratory School for Gifted Education in Community School District 2 offers a model of gifted education for the junior high school years that is committed to innovation, exploration and intellectual choice within the framework of a warm, personalized environment that is child centered. At the Lab School, every child can be known and is known. The rigorous academic program provides students with intellectually and aesthetically challenging opportunities so they can pursue their talents and interests, work hard and have fun.

The Lab School nurtures each student's spirit of inquiry by encouraging individual and small group projects. Four periods per week of elective courses permit students to pursue individual areas of study and interest. Electives include: Russian language and culture, studio art, drama, creative writing, video workshop, journalism, chorus, math team, psychology, dance, meditation ß yoga, astronomy ~ space, and chess. Special features of the academic program include advanced placement math, high school prep for Stuyvesant, Bronx Science, Brooklyn Tech, and LaGuardia (art, drama, and dance), literature and writing, Regents courses in math and science, Spanish, social ~studies~ research, and computers integrated into the subject areas. The Bank Street Technology Project provides students with the opportunity to do state-of-the-art research using computers in all subject areas.

Curriculum at the Lab School is interdisciplinary, extending beyond subject limitations while consistently reinforcing concepts and values. Children come from all parts of District 2 to form a community of learners that reflects the diversity of New York City.

In addition a Lab School for grades 4 through 6 is being started and Anthony J. Alvarado, Superintendent of District 2 has the authority to start further special schools and is willing to do so if one will be needed to accommodate the Cumulative Multi-media Curriculum prototype.

Kids at the Wheel, P.S. 92

The "Kids at the Wheel" project represents an effort to accomplish several educational goals, using styles of student learning and thinking that are based, although not exclusively, on forms of self-expression. Expressive learning locates the child towards the center of the thinking process. This is more common outside of school than inside of school. An expressive learning mode includes activities of judging, challenging, integrating, hypothesizing, reformulating, remembering, accumulating, collaborating, and producing a point of view, an analysis, or something new. The content is seen as relevant to the child as a person, rather than simply the child as a student. The child more typically has a sense of ownership of what he or she is learning, what he or she is creating. Expressive learning does not preclude, for example, learning to add. It reconceptualizes learning to add in terms of meaning rather than duty.

Expressive learning can be contrasted to "learning by being taught," which is the current ambient mode in classrooms. Learning by being taught relies on a status for the child that is decentered. The child's role is to receive information selected and presented by an authority, and to be able in particular to recall the material under very pressing circumstances -- a test. The child needs to assume a role, in order to function as a successful student, that is quite different than he or she experiences outside of school, and that is quite different than he or she will need in order to function as a responsible adult.

The Kids at the Wheel project at P.S. 92, District 5, located in central Harlem, is an experimental project in collaboration with IBM, based on expressive learning, with goals to enhance the child's image of himself or herself as a student, and academically, to improve language comprehension abilities and abilities to deal with social studies issues. P.S. 92 currently (1989) ranks 603rd out of 619 New York City public schools in reading.

The experimental project began February 1990 and will resume in September 1990. Participants are children in grades 3 and 4. Children work in groups of 8 to 10, with a teacher who has been trained in expressive learning techniques. By September 1991 it is expected that the program will be moved into the normal classrooms.

The program consists of three interrelated components.

(1) The children and the teachers collaboratively discuss reading materials with a focus on elaborating the inferential connections in the materials. The reading materials are created specifically for the project, based on guidelines from prior research in comprehension. The content used in February through June in 1990 mainly dealt with the 1960's Civil Rights Movement. The purpose of this first component of the Kids at the Wheel project is to show the children that reading is thinking, and that much of

the meaning of a text comes from the way the child relates the text to his or her background and awareness of the author's intent. The children determine through discussion, and a gradual explicit awareness of the mode of the discussion, how the text coheres, and what it says. The teacher is a catalyst and a partner.

(2) Children work with a multi-media computer system called "Making a Scene", which enables them to produce video essays combining motion video, sound, the child's recorded voice, and text. The activities in creating a video essay include reading background material, viewing video segments, designing a framework for expression, dealing with the vicissitudes of a computer, trying out an interactive version of what they are intending to convey, iteratively changing it or completely reconceptualizing -- all in collaboration with a cohort. Upon completion the children have something to show that is technically impressive and often quite powerful. They can relate to it in terms of its meaning as well as its showmanship. Furthermore, the children's level of knowledge is deeper as a result of their activities and their evolving relationship to what they do. A computer system with a Making a Scene type of interface, and with a multi-media knowledge base (in this case books, posters, maps, souvenir post cards and photographs (the researcher visited the Martin Luther King Jr. Center for Non-violent Social Change in Atlanta during the semester), videodisc news clips and audio clips, current newspaper articles) has particular potential for placing the child at the wheel.

(3) The general milieu in the room consists of more noise and movement than in a regular classroom. Children talk to each other as a part of being there in both activities (1) and (2) above. In addition, time is set aside for group discussions that relate to work in progress, as well as anything else. The teacher is interested in what the children have to say. Gradually the children become interested in what others have to say.

The following provides a brief example of the progress of the group from the February-June 1990 semester. Materials provided for the children were books about the 1960's Civil Rights Movements, with a focus on Martin Luther King, Jr., along with a videodisc of news footage from the period, and stories written by the researcher for activity (1) above. The materials and the interactions provided constitute a prototypical knowledge base.

During the semester children read and discussed the books, with each other and with the teacher; discussed the inferential aspects of the books and the materials written for the project; and created video essays. The children decided to present their essays live to other classes. Prior to their final presentation, they wrote and practiced speeches of introduction, revised and tested their video essays, checked factual material, and took a stance towards their effort. They were proud of what they had done. Their teachers were surprised at "what they had learned".

Kids at the Wheel will be pursued experimentally in the next few semesters. We have been encouraged by the fact that the children were able, gradually, to work together; that their understanding of the civil rights issues and personalities was more sophisticated than rote; and that they themselves felt connected to what they had done. We expect to explore these issues more thoroughly, as well as additional issues. We expect to revise the materials and the environment accordingly.

The Center for American Culture Studies

Jack Salzman directs the Center for American Culture Studies, an innovative, interdisciplinary institute for the study of American culture and society that combines scholarly research and public discourse from a wide range of perspectives. Its programs seek to:

- engage in a sustained discussion of New York City as the paradigm of a multicultural society,
- understand the origins of the relationships that exist among various groups of people in the United States,
- determine the kinds of new relationships that need to be forged among people in this country and with people around the world,
- identify those American values essential to our survival and prosperity in the world's changed, and changing, political, economic, and social arenas and to explore their evolution, and
- examine unresolved social and political problems in the United States and to devise ways of addressing *new* issues as they emerge.

Since its founding in 1982, the Center for American Culture Studies has been engaged in an ongoing consideration of the ways in which the American identity and public expression of its character have evolved during the past two hundred years. To this end, the Center has provided a forum through which scholars, writers, and artists have joined with the public and academic communities in exploring the extraordinary ethnic diversity and variety of cultural activities that characterize the American experience.

The Center was established as a unique effort to explore life and culture in an evolving democratic setting *and* to determine the effect that this culture has had on the complex issues the United States has confronted over the years. In the relatively short period since then, the Center has become the most influential institution of its kind in the country.

The recent emergence of far-reaching domestic conflicts, a shift in the balance of world economic powers, increasing demands for human rights, and the rise of democratic movements throughout the world are some of the recent events that have made the Center's innovative work on the evolution of a democratic society and its varied forms of expression even more timely and relevant.

A number of new issues now demand our attention. Of particular concern in the l990s is the United States' relationship with those societies that have recently experienced crises in government and identity. This has spurred renewed commitment to an exploration of American society and its complex cultural

identity, as well as an examination of that culture's relationship with, and influence on, other political systems.

To stimulate debate and discussion of these important issues, the Center plans to focus on such key concerns as:

- the position of the United States in a changing pattern of global economics,
- how the relationship that exists in the U.S. between politics and intellectuals, particularly writers, differs from that in other countries,
- the relationship of architecture to the built environment and the ongoing transformation of urban settings,
- how changes in American culture as a whole relate to changes in corporate culture and business practices,
- how patterns of immigration and assimilation today differ from those in the 1890s,
- the relationship of the U.S. model of democratic government to the revolutionary fervor in contemporary Europe,
- the exploration of the tensions that exist between ethnic and minority groups, and
- public and private censorship of the arts in the U.S.

The Center has developed scholarly tools and resources for students of American culture, integrated academic studies and the concerns of the non-academic community, and brought together foreign and American scholars through the international exchange of personnel, materials, and ideas. In these efforts the staff of the Center has been guided by a Steering Committee of eminent Americanists from the Columbia faculty, as well as by a National Advisory Board, which provides the Center with a support network that extends beyond the bounds of the academic community.

APPENDIX B: -- PEDAGOGICAL HYPOTHESES

Section 1: Toward a System Specification

Through the Cumulative Multi-media Curriculum, we need to solve a basic technical-cultural difficulty: How can multi-media materials of sufficient quality and diversity be mobilized for educational purposes without incurring impossible production tasks? This difficulty can be solved by repurposing existing productions on a sufficient scale. There is a vast stock of film and television production, audio recordings, photographic collections, and texts from which to draw. Our task will not be new production, but the creative organization and use of existing materials.

In part, organizing and using these materials present technical difficulties which we will need to solve. Technical advances are making them highly solvable, however. With the Real-Time Mode in DV-I systems or their equivalent, the use of videotape libraries as a key resource in a Cumulative Multi-media Curriculum is becoming feasible and economical. Essentially, we will seek to specify as powerful a system as possible to support school-wide study through interactive multi-media information retrieval.

In the larger part, cultural difficulties will prove more challenging. In the cultural sense, it is not enough to create a complex work that functions usefully. Culturally, it is important that we create, with such a work, standards of criticism and evaluation, appropriate to it, that will sustain the ongoing development and improvement of type, not just the instance. Publishing and scholarship are culturally more fertile than the printing industry that manufactures books because they carry within them such standards for criticizing existing works and goading creators to further effort.

We will need to attend to such issues through this project in trying to develop a system specification. The following text gives an early indication of ideas pertinent to defining such standards, which Robert McClintock prepared in the Fall of 1986 to accompany a presentation at the IBM ACIS conference at Fort Lauderdale, Florida. It reflects experience with a program for managing the *Visual Encyclopedia of the 20th Century*, that Steven Taylor developed through a joint study project between the Institute for Learning Technologies and CEL Communications.

The Stimmir

Study Through Interactive Multi-Media Information Retrieval

by

Robert McClintock

"Stimmir" is a word manufactured from "Study Through Interactive Multi--Media Information Retrieval." It is not an acronym meant to stand for a particular thing or organization, like NASA or COBOL. Rather, a stimmir is a generic thing, in the same way that a book is, and "stimmir" should be used as an ordinary noun, one that has been consciously constructed with an origin that is acronymic, not etymological. Its pronunciation, should veer in the Anglo-Saxon, not Middle Eastern direction, with the accent on the first syllable. As the word becomes established in the language, its meaning secured by usage rather than by its acronymic origin, its spelling will evolve to "stimmer." But for now, we use the correct form, stimmir.

A stimmir is a collection of materials suitable for study through interactive multi-media information retrieval. In this sense, stimmirs are in the broad class of cultural products that include books, magazines, films, videos, symphonies, ballets, paintings, photos, and similar modes of creative expression. Like these, the motives served by a stimmir may range from entertainment to edification; a stimmir may excel for reasons of imagination or scholarship; it may contribute to knowledge, commerce, amusement, power, or any combination of these and other consequences. Stimmirs may in time displace books as the main vehicle for creating, transmitting, and preserving our culture. Whether they do or don't do that, stimmirs will become significant means of cultural communication.

What defines a stimmir, like a book, is its content, or what the stimmir is about. Each particular stimmir, like each particular book, will have a material form, but its subject, its content, will actually determine what it is. The material form of books is variable -- some are very small, folios are very large; bindings differ, as does the paper, ink, typeface, layout, and the like. A few bibliophiles may care more that a book is bound in such and such leather, stitched in one or another way, set in an esteemed type, printed on a renowned stock, and so on, but most real readers care whether it is Jean-Jacques Rousseau's *Emile* or Voltaire's *Candide* and they would distinguish between those two works not merely by their physical attributes, but far more profoundly by their differences of substance, tone, import, scope, style, and significance. So too, stimmirs will be distinguished, one from another, according to their content, not according to the peculiar combination of technologies used in each.

One can, of course, describe the physical attributes of a typical book, and the writer needs to have these somewhat in mind as he or she sets about to create a work. We can do the same with a typical stimmir. First off, a stimmir

will be a lot "bigger" than the average book, and here "bigger" really describes content more than physical size.[20] The quantity of information in a stimmir will greatly exceed the quantity of information in a book. With a stimmir, a personal computer controlling diverse mass storage devices will be like the cover, binding, and pages of a book. The typical stimmir will include an extensive collection of video and other visual materials, all of which will be carefully indexed for management with the computer. By extensive collection of visual materials, think here, not of one interactive videodisc with its half-hour of video to a side; think instead of a collection of two-hour video tapes, say fifty or more of them, each time-coded with its contents carefully indexed in a computer database. The stimmir may include also lots of stills and short videos on a videodisc and recordings on compact disk or tapes -- the important part is that all be indexed and easily controllable through the computer. In addition to such a video collection, the stimmir will also include, thoroughly referenced in the same index, an extensive collection of written materials, texts, statistics, what-have-you. By extensive collection of written materials, think here, not of a single handbook; think instead of an assemblage of materials more extensive than that of the most comprehensive encyclopedias. And as with the visual materials, the key to the textual part of a stimmir will be powerful indexing so that the reader can control it for easy retrieval and intelligent navigation through it substantively.

Because stimmirs serve to sustain study, they must be extensive. Training materials are designed by circumscribing and closely defining what is to be learned and concentrating astutely on imparting those particulars. Study environments must encompass much more than any single student can master, short of becoming a renowned authority. To study a matter is to explore it, to reflect on different aspects of it, to inquire into those dimensions that peculiarly strike one's interest, to wonder about it, to be curious, to draw connections, ultimately to form views of it that are all one's own. Hence, well-designed study environments, stimmirs, should invite different people to chart unique, unfolding itineraries of inquiry through them.

> Bees pillage the flowers here and there, but they then make honey of them which is all their own; it is no longer thyme and marjoram; so the fragments borrowed from others he will transform and blend together to make a work that shall be absolutely his own; that is to say, his judgment. His education, labor, and study aim only at forming that.[21]

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[20] In physical size, one stimmir will be a lot bigger (and much more complex) than a single book, but a set of books with a content equal in size to that of the single stimmir may prove to be much the bulkier.

[21] Michel de Montaigne, "Of the Education of Children," *Montaigne: Selected Essays*, Blanchard Bates, ed., New York: The Moden Library, 1949, p. 22. My distinction between study and instruction is developed at greater length in my essay "Toward a Place for Study in a World of Instruction," *Teachers College Record*, Vol 73, No. 2, (December 1971), pp. 161-205.

Stimmirs should be flowered fields to sustain such labor, and to so serve study, they need to be copious collections, less like a single text and more like a well-chosen topical library.

Fortunately, learning technologies are developing in ways that will permit such substantive expansiveness. Optical media such as CD-ROM -- "Compact Disk/Read Only Memory" -- make collections of visual and written materials on the scale requisite for study both feasible and economic. The developmental task, however, is not primarily a hardware problem, but a task of creative cultural innovation. CD-ROM, or whatever optical storage technology becomes commonplace, will be a crucial hardware component of most all stimmirs, but the cultural power of stimmirs will arise because through them we will be able to index ideas and information more fruitfully for thoughtful retrieval than has hitherto been possible. Essentially, a stimmir will reference in a single computerized index a comprehensive collection of material stored in many media -- written, audio, visual -- and it will allow the user to interact with those media, retrieving ideas and information from all of them, according to the play of his or her curiosity: study through interactive, multi-media information retrieval. Organizing thought so that it can be so studied: that is the developmental task.

New technologies develop through working examples. What we have now is a prototype, an indication of what we want to develop, but something that we have had to put together from available components. Consequently, the prototype lacks some of the features we expect fully developed stimmirs to possess. All the same it is a prototype, sufficient to give a feel for the concept, the idea of a stimmir. Having linked existing materials in such a way that we have made a prototype stimmir, with that experience to draw from we are proceeding to plan several more fully developed stimmirs, one on infancy, one on American history, and a third for educating teachers.

What have we done with the prototype? It consists in linking, as closely as we can under computer control, two major textual and video resources that have recently come on the market -- the *Grolier Electronic Encyclopedia* and the *Video Encyclopedia of the 20th Century*. The linkage that we have been able to attain is close, but far from satisfactory. It is actually less a linkage than it is a juxtaposition. The problem here is that the *Grolier Electronic Encyclopedia*, one of the earliest CD-ROM applications on the market, is an entirely self-contained, black-box program. One runs it from DOS as is or not at all. One can imagine such a program and resource functioning as a memory resident program as part of a stimmir, there ready to be accessed whenever one wants some factual information about this or that. We have simulated such memory residence by using the program *Double Dos* to enable us to switch in and out of running programs almost as quickly.

We have been able to do a lot more with the *Video Encyclopedia of the 20th Century*, although, from the point of view of a stimmir, a lot more needs to be done with it. It comes in the form of 75 one-hour video tapes, accompanied by a volume of indexes and four volumes of fact sheets. As part of a joint study

project with CEL Educational Resources, the creators of the *Video Encyclopedia*, we have transferred the indexes into machine-readable form and are in the process of converting the fact sheets as well. All this material is going into a large database we have designed that presently permits keyed searches and eventually will permit full-text retrieval of the material from the fact sheets. In addition, we have put timecode on the tapes consisting of both tape and frame identifiers and we have converted the references in the computerized indexes to these forms. Consequently, the database can output instructions directly to a VCR so that virtually all the management of the tapes is done automatically.

In implementing this prototype design, we have realized a number of interesting things about the technology. A stimmir can easily have a videodisc as a component of it, and as a repository of still images for a stimmir, it would be an invaluable component. For the foreseeable future, however, costs dictate a major place for interactive videotape as a component of a stimmir. Volume sales for separate stimmirs will not be terribly high and the mastering costs of videodiscs will remain substantial. With only half an hour to a side on a CAV disk, the only kind with a real gain in interactivity relative to videotape, the user of a large collection would be spending considerable time changing disks, as he or she would be changing tapes, and videodisc has no advantage of ease or speed in this aspect of the process in comparison with videotape. The production of a videotape, however, does not require a mastering process, which currently runs about $2000 per videodisc. If the stimmir collection consists of a hundred hours of video, not much, all things considered, the capital needed up-front to defray the mastering to put it all on videodisc would be substantial, some $200,000 more than what the resource on videotape would cost. This consideration has suggested to us that videotape will be a significant part of stimmirs for some time to come.

Having decided that videotape has a significant future in interactive, multi-media study environments, we been considering how to optimize them for interactive use. Timecode has traditionally been primarily a feature of video production, useful in facilitating the editing process. It is essential, however, if one is to put video presentation under computer control. As soon as one tackles this process, one begins to realize that, Marshall McLuhan notwithstanding, our experience of film and video has usually been thoroughly linear. Tapes reverse wind to the beginning, ready to play forward from beginning to end. With a computer controlled tape, timecoded for random access, this is thoroughly irrational: we have made our rewind commands seek the midpoint, immediately cutting average access time in half. Still tape handling is a delay taking out one, inserting another, letting the computer seek the designated spot. Is it an objectionable delay? That depends on the measure of comparison. If a stimmir is like a personal library, the delay is no more, perhaps a bit less, than that incurred in pursuing a reference to a book you know you have and are pretty sure whereabouts it is shelved.

With our prototype linking the *Grolier Electronic Encyclopedia* and the *Video Encyclopedia of the 20th Century*, the main drawback involves content. As one may include an encyclopedia in a personal library, so may both these encyclopedias be included within a fully developed stimmir. But few people make their personal libraries consist of an encyclopedia or two; one might even say that families whose libraries are restricted to encyclopedias are families without serious readers in them. Consequently, substantively there is something not quite satisfying about our prototype. One can engage in interactive multi-media information retrieval with it, but the information retrieved is uneven and lacking in depth, something that should not be the case with a properly developed stimmir. The main challenge in carrying through with the development of the concept is one, neither of hardware engineering nor of software engineering, but of drawing together multi-media materials that are of sufficient intellectual depth and quality to make the stimmir containing them the delivery mechanism for intellectual experiences that will have great meaning to people and that they could acquire only thorough this medium, not through another.

All sorts of stimmirs might be imagined, combining video, audio, stills, and text, all controlled through a common, shared index. I could close by sketching in imagination a few such prospective stimmirs. Instead, I'd like to do something similar, something that can serve the same function although it would start off from something somewhat more familiar. Let us imagine a book, a book about the stimmir, a survey of the concept trying to place it in the history of communication and trying to concretize it with sufficient examples to give the concept a bit of substance. Here is a description of such a book, one based on our experience with the idea so far, one that might, in describing the stimmir, amount to an interesting essay on the cultural uses of technology.

The Stimmir, An Imaginary Book

1 **The Stimmir: An Introduction to the Thing Itself.** In this chapter one would describe what a stimmir is and contrast it to other forms of presenting ideas and information. Central themes of the whole book would be introduced here, especially the importance of random-access to addressed information, something that the stimmir, as an intellectual tool, will greatly enhance.

2 **The Stimmir in Historical Perspective.** In this chapter one would reflect on parallels between the emergence of the stimmir and the emergence of the printed book. One would explain that culturally significant innovation can take place quite rapidly on the level of hardware, but only much more slowly with respect to the process of disclosing its substantive cultural significance. To develop the stimmir, what we need are not astounding technical novelties, but intellectually significant substantive achievements with the technologies.

3 **A Prototype: Putting the Available Pieces Together.** In this chapter one would describe a prototype stimmir created by putting the *Visual*

Encyclopedia of America, 75 hours of film and video news footage, under computer control, with its index and fact sheets in a large computer database, with all that linked to the Grolier *American Encyclopedia* on CD-ROM in an information field that the user can explore as a single, unified domain. In the course of describing the prototype, one would begin to indicate how the intellectual experience of study through interactive multi-media information retrieval may differ from other forms of study.

4 **Infants and Parents**. In this chapter one would describe a joint project at Teachers College between the Institute for Learning Technologies and the Center for Infants and Parents to develop a stimmir that would help advance our knowledge of early childhood. Usually, people treat the problem of indexing visual materials as one of going from text-grounded concept to the appropriate visual material that would illustrate the context. In this project, the problem is being reversed with the visual material in video being used, not only to illustrate concepts presented through text, but more centrally as the referencing index itself so that the user can look-up text stored on a CD-ROM by pointing to things shown happening on computer-controlled video tape without necessarily knowing anything about the specialized terminologies used to describe the phenomena.

5 **American Experiences**. In this chapter one would describe an effort getting under way to create, using the stimmir, a genre of historical discourse, different from, but analogous to, the historical monograph or journal article. How might stimmirs be used to create a decentralized, multi-centered system of coherent discourse, with a diverse range of creative contributors and thoughtful consumers, one similar in scale and complexity to the arena of discourse defined by the authors writing historical monographs and articles and the sum of all their readers?

6 **Inquiring Teachers**. In this chapter, one would discuss the difference between training and study and show how interactive media organized to train people differ from stimmirs that have been organized to promote open-ended study. Here a project for a stimmir to be used in the education of teachers would be presented, and one would reflect on how the mode of applying knowledge to practice implicit in it differs from the modes of application inherent in traditional teacher-training.

7 **Costs and Benefits**. In this chapter, one would discuss the costs of stimmirs, indicating that they are substantial but not prohibitive. One would indicate certain parallels with respect to the cost-benefit curves to the shift from manuscript to printed book. Over-all, one would argue, the decision to make the investment of cultural energy would turn less on pure economics than it would on the substantive cultural fruits that accompany the early efforts to create stimmirs.

8 **The Politics of Cultural Innovation.** In this chapter, one would reflect on politics in the ancient sense, the pursuit of the good life, or the attempt to define and achieve, through conflict and cooperation, purposes that those who participate have judged would be worth their efforts. In this sense, cultural innovation should be political and one would close by describing what the political implications of a culture of stimmirs would be.

Such a book, were it ever written, should amount to a high-level case for full use of the emerging interactive, multi-media technologies in education. It would present one particular vision of how CD-ROM/CD-I technologies can be best used, and readers would come away from the work not only with a clear sense of how these technologies can be used, but also of why it may be important to use them in these ways. Stimmirs are feasible cultural tools and the time is at hand to move from prototype to actuality.

Section 2: Toward a Pedagogy for the Cumulative Curriculum

Robert McClintock prepared the following pedagogical reflections, "On Design," during the Fall of 1989 as an effort to think out pedagogical principles useful in developing educational applications for multi-media information technologies. The educational ideas formulated here are not specific to educational technologies. It will be a hypothesis at the outset of the Cumulative Multi-media Curriculum project, however, that this curriculum will be particularly powerful when work with it follows a pedagogy of study.

Frank Moretti prepared the reflections on the role of technology in restructuring pedagogical authority in 1988. Moretti indicates how intensive use of technology can surround the student with a set of influences that can guide without activating emotions of resentment.

On Design, Study, and Technology in Education

> It is the mark of an educated man to look for precision in each class of things just so far as the nature of the subject admits....
>
> Aristotle. *Nichomachean Ethics*. 1094b24[22]

Notes toward the Definition of Study

Here are some definitions that may help clarify educational relations. I set them forth with attention to neither nuance nor amplification. Those will follow. The bare definitions make an ensemble. Part of the meaning of each arises from the set. Unfortunately, they must be written in some order. Indeed, their sequence has some meaning. You should read through them, once, to get the set; then you can read each again, critically assessing it as part of the set. Following this set, I amplify the key ideas to clarify the principles of study design.

These definitions are epistemic, not ontic. One tests epistemic definitions by using them to build up sound knowledge about phenomena. The purpose is not to define what education *is*. The purpose is to define how we think about education. We have here a preliminary table of categories in a critique of educational thought, one done in the spirit, if not syntax, of Immanuel Kant.[23]

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22 W.D. Ross, trans., *The Complete Works of Aristotle: The Revised Oxford Translation*. Jonathan Barnes, ed., Bollingen Series LXXI. Princeton: Princeton University Press, 1984, Vol. 2, p. 1720.

23 In my use of Kant in this essay, I intend to be neither nostalgic nor anachronistic. For our purposes here, Kant should be taken as a living presence. Kant is to pedagogical design as Newton is to aeronautical design. Although physics has progressed far beyond Newton's version of it, his version is still the one appropriate for describing the flight of airplanes. In a similar way, although epistemology has progressed far beyond Kant's version of it, his critiques still give us tools appropriate for describing educational relationships.

Grounding Definitions

Culture All capacities, skills, and acquirements that have not been given to the living through their strictly biological endowments.

Education The processes by which people create and acquire culture.

Inquirer The person who experiences education. *Learner* might serve as well here, especially for the acquisition of culture. *Inquirer*, however, stresses generality and includes place for education as the creation of culture.

Mentor A person helping an inquirer in the acquisition of culture. *Teacher* might serve as well, but we need it for a more specialized meaning.

Domain The given cultural resources directly involved in an educational process: the educational attainments available as grounds for current educational effort. Both the inquirer and the mentor have domains.

Universe All possible cultural resources that an inquirer might master in the full course of her education.

Horizon The portion of the inquirer's universe that her domain enables her to perceive. The horizon includes what the inquirer knows, her domain, plus what she knows she does not know, the part of her universe of which she is aware.

Perspective The portion of the inquirer's universe that the mentor's domain enables him to perceive. Note the cross-over here: perspective involves the mentor's view of the inquirer's universe.

Objective The particular capacities, skills, acquirements that an inquirer seeks to master through an educational process; the specific culture the inquirer seeks to create or acquire in an educational process. An inquirer can formulate an objective only about matters within her horizon.

Intention A general aim in an educational process arising from the inquirer's sense that all specific objectives evident within his horizon do not exhaust the possibilities of his universe.

Note: A common pedagogical difficulty arises when the perspective of the mentor leads him to define something as an objective when the horizon of the inquirer is such that she can only pursue it as an intention.

Development An educational process that extends the inquirer's domain further towards her horizon. Development can purposefully result from the pursuit of objectives and intentions.

Discovery An educational process that extends the inquirer's horizon further into his universe. Discovery can *purposefully* result from the pursuit of intentions, but not objectives. Serendipitous discovery can result from the pursuit of objectives when the unexpected happens and the inquirer responds intentionally to the possibilities it reveals.

We need several sub-definitions because the *domains* of the inquirer and the mentor overlap but do not coincide. How their domains overlap distinguishes between different ways people can participate in educational processes.

Teacher A mentor whose domain in an educational process includes and exceeds that of the inquirer, e.g., the teacher knows the subject better than the student.

Coach A mentor in an educational process in which the inquirer's domain includes and exceeds that of the mentor, e.g., the player can outperform the coach.

Pupil An inquirer who assumes that the domain of the mentor is the universe.

Student An inquirer who believes that the universe may exceed the domain and horizon of the mentor.

We also need several sub-definitions because the *objective* of an educational process may refer to the pertinent domain, or beyond the domain to the broader horizon. Where the objective stands in relation to domain, horizon, and universe distinguishes between different forms of education.

Education as the *acquisition* of culture

Acculturation Mastering available capacities, skills, and acquirements that differ from those set by the objectives of the educational process.

Training An educational process in which the objective lies within the domain of both the inquirer and the mentor. A tool or procedure is a given for both trainee and trainer, and the latter must ensure that the former masters its use.

Instruction An educational process in which the mentor believes that the objective lies within his domain. The instructor must impart the skills and knowledge he possesses. Instruction can result in training or learning.

Learning An educational process in which the inquirer believes that the objective lies within her own horizon and within the domain of the mentor. Learning can result from training or instruction.

Education as the *creation* of culture

Research An educational process in which the inquirer pursues an objective within her horizon, but not within her domain, without direct help from a mentor.

Study An educational process that results as an inquirer pursues an intention in addition to the operative objectives, with or without the help of a mentor.

Note: An inquirer can engage in study during training, learning, and research, all of which derive their teleological structure from objectives. Study is a responsiveness to intentions in the midst of work towards objectives. Objectives point to specific goals within the horizon; intentions to unspecific possibilities beyond the horizon.

We turn now to reflect on principles that we can use to develop educational systems that meet the needs of people studying.

On the Principles of Design for Study

> Behind this shift from the imagination to the understanding is Kant's conception of our relation to the world as a cognitive or intelligent one and so to be sought for in the understanding, as opposed to Hume's conception of it as a causal or mechanical relation and so to be sought for in the imagination.
>
> Arthur Melnick. *Kant's Analogies of Experience.* p. 164

What principles should guide the design of educational resources to improve the work of study? Study results when the inquirer pursues intentions in addition to the operative objectives. Intentions suggest to the inquirer that the universe harbors more possibilities than those charted by the operative objectives. Intentions arise because the inquirer intuits that interesting possibilities exist beyond the horizon. Study guided thus by intention is an openness to possibility, a readiness to respond to it. We need to understand how people respond to possibility, how they move from the known to the unknown.

Let us reflect on five ways of extending the cultural horizon into the universe -- *recognition*, *production*, *control*, *selection*, and *commitment*. I do not suggest that people use only these five capacities to respond to possibility. I do not

pretend to give an exhaustive account of the modes by which people can move beyond their horizons into the realm of unperceived possibilities. Likewise, I do not suggest that people use these five capacities exclusively in intentional activities. Quite the contrary, people may use these capacities also in learning, in pursuing objectives. Our interest here, however, is in understanding how people use them in pursuing intentions, possibilities beyond their horizon that they cannot define precisely as objectives. Reflection on these capacities will give important clues about the principles of study design.

- **Recognition**. This is the "Ah ha!" experience, the sudden awareness that in the buzzing confusion, something substantial, identifiable, inheres. An objective may activate recognition. For instance, if you ask June to find Jim to tell him that you need his help, she will have the objective of recognizing Jim. But much more often recognition arises in response to a general intention. Thus, when I'm walking down the street thinking deep thoughts and I see a familiar face which I suddenly recognize as Jim's, I recognize Jim, not by objective, but by intention. Intention, a responsiveness to possibility, most deeply guides recognition of something new, something hitherto vague, murky, incoherent.

- **Production**. This is the "Look, Ma!" experience, the activation of a causal sequence to the point of suddenly doing something one had not done before. Production also can be done by objective, as often occurs in offices and factories where managers have carefully planned the causal sequence to come to a well-specified conclusion. But frequently people produce works in response to an intention in which the precise outcome is fuzzy, the result is creative. Simple speech gives us endless examples. Under certain circumstances, diplomats and lawyers may shape an utterance precisely according to a conscious objective. Most of us, most of the time, in contrast, produce our utterances more spontaneously in response to our intentions, sometimes surprising ourselves on discovering what it was that we really had to say. What is true of speech is true of most creative making: the maker has intentions and produces unexpected results through the sequence of causalities that translate the intention into a completed work. The sequence carries the maker beyond her horizon.

- **Control**. This is the "I got it!" experience, the maintenance of complex interactions in a dynamic equilibrium that one can steer or guide in useful ways. Many examples of control involve objectives, like the simple thermostat that keeps room temperature close to the objective set for it. But many other examples of control equilibrate around intentional goals, states of mind and states of being -- curiosity, fun, health, happiness, fulfillment, influence, power, love. Control consists in the capacity to maintain approximations of these states. Efforts to maintain control are deeply, integrally intentional because one cannot limit the significant interactions to the predictable ground within one's horizon.

Control often overlaps with production, but they are conceptually distinct. Production results from a distinct sequence of causes and effects; control manages a complex of reciprocally interacting simultaneous influences. Take riding a bicycle as a simple example. Peddling is a clear example of production. Most anyone can clearly explicate the sequence of causes and effects that move the bike forward. Balancing the bike is the example of control. Few people can clearly explain how they do it and it depends heavily on the cyclists' ability to coordinate multiple senses to register the reciprocal interaction of many forces, continually wielding those he can to shift the mass of the system towards the direction of fall.

- **Selection.** This is the "It fits, it suits me!" experience, the formation of preferences through judgments about form and beauty. Selections can be managed according to objectives, otherwise major industries -- cosmetics, advertising, public relations -- would not exist. Yet selection more deeply offers individuals and groups the opportunity to express their intentions. We might say that people *choose* in response to their conscious objectives, but that very often they find that these do not suffice to effectively discriminate between the available alternatives. At that point, people *select* through judgments that reflect their intentions, their sense of possibility, an ineffable sense of form, fit, beauty, compatibility.

- **Commitment.** This is the "Here I stand!" experience, the conviction that this or that course of action is worthy and right regardless of the immediate consequences that will come of it. One can form objectives while carrying out a commitment. But insofar as a commitment is a conviction that something is right independent of the specific results that come of it, commitment is an intentional act, one that does not reduce to a set of objectives. The person acting from commitment reaches beyond his horizon to take a stand in a world in which foreseen consequences cease to matter. The committed person acts simply because he knows the intention entailing his action is right.

Let us summarize the essentials as they have so far unfolded. Education is the process by which people create and acquire culture. At any particular time a person has a domain, consisting of previously mastered culture, and a horizon inside of which he perceives things that he knows he does not know. Cultural possibilities within his horizon can serve as his objectives for learning. In addition to his horizon, he has a more encompassing universe in which there are cultural possibilities that he does not perceive distinctly but that may nevertheless be very significant possibilities for him. Intentions are general aims that a person senses, suggesting that all his current objectives do not exhaust his possibilities and that, in addition to the objectives, those possibilities are worth pursuing. Intentions can be powerful motivators in the creation and acquisition of culture because the person intuits that it is worthwhile to be

receptive to prospects that are significant yet indistinct. I define *study* as educational effort motivated by intentions, *learning* that driven by objectives. I further suggest that five significant forms of activity in which intentions, as distinct from objectives, can be highly significant are *recognition*, *production*, *control*, *selection*, and *commitment*. Educational systems designed to make study fruitful will challenge people to use their capacities fully to recognize things, to create works, to manage systems, to judge fitness, and to affirm principles. How?

One item that we have not yet defined is *design* itself. How should we think about design in order to make sense of the infinite particularities of it?

» **Design.** A process through which people use epistemic definitions, criteria, and models to shape the stuff of experience to accord more closely with their knowledge, principles, and preferences.

Design builds knowledge into the world we make. "Art is long, life short, judgment difficult, opportunity transient. To act is easy, to think is hard; to act according to our thought is troublesome."[24] Design is that troublesome effort to act according to our thought; it makes judgment easier and opportunity more stable.

Take any example of design. Central to it will be an effort to render the work knowable, understandable, predictable in one way or another. What drives the design of a tool, simple or complex? The user wants to *know* that the tool will work for the purpose which guided its design. The worker gets angry at his tool when it fails at the task for which it was designed and abashed when he breaks it trying to use it for some purpose for which it was not designed. Materials design serves to make the performance of materials knowable, predictable. Handbooks of specifications and standards give ready access to the knowledge built into such materials, clear statements of the stresses they will bear. Manufacturing design serves to make the outcome of production predictable, foretelling both the character and quality of the product and, even more, making its cost knowable, an essential component in designing its marketing.

Design, understood as action that incorporates knowledge into the stuff of life and matter, holds a fundamental place in our culture. Hume and Kant destroyed metaphysics, ushering in the era in which epistemology has primacy over ontology. Increasingly, people recognize all the sciences to be cognitive sciences, describing the world that our knowing reveals, giving an account of how and why we know it, and adopting a principle of uncertainty about all the rest. The positive test, complementing the negative one of falsification, is not verification, but suitability as grounds for design, if not of practical applications

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[24] J. W. von Goethe. *Wilhelm Meister's Apprenticeship.* Thomas Carlyle, trans. New York: Collier Books, 1962. p. 447.

then of further cognitive experiments and explorations.[25] Hegel laid down the ontology of the emergent universe-by-design that the human spirit makes as its habitat. "What is rational is actual and what is actual is rational."[26] This is absurd if said willfully about things in themselves, but it makes fine sense said, as Hegel said it, about a reasoning spirit that draws itself out of itself, that educates itself, to design itself as the actuality of the inchoate chaos. So too, Kant's claims about a synthetic a priori, in which propositions are at once prior to experience but substantively informative about experience, make simple sense in the context of design. Categorical principles are prior to experience but informative about it because we can act with those principles to design the experience, to give it human form, substance, and significance.[27]

Through design for study, we will use our conception of study as intentional inquiry to shape the stuff of educational practice. We will not do that by pinioning study on the prongs of pedagogical objectives. Study occurs when students expand the apparent objectives with their own intentions. Study is something that students do; it happens when their intentions expand our objectives. Design for study will be a complement to instructional design, not an alternative to it. Educators can use instructional design to promote learning, but they can additionally design educational systems so that they will be responsive to study. As understanding of design for study develops, we will see that it serves as a significant resource in improving the cumulative *instructional* effectiveness of educational systems.

Through our definitions, we have identified two levels of study. One level we might call unconditional study. It is a level at which the student extends her horizon into hitherto unchartered courses, possibilities that not even the wisest mentor can then perceive. This is study as enshrined, say, in the Princeton Institute for Advanced Study. Educators cannot do much to provide directly for such study, except to furnish suitable opportunities, tools, and resources. All the same, the provision of such opportunities, tools, and resources makes a big difference to the person engaged in unconditional study. Furthermore, since conditional study, from the vantage of the person engaged in it, differs little from unconditional study, provision of such assistance proves to be the basic principle of design for study. Happily, however, mentors will find it easier to identify which opportunities, tools, and resources will be suitable for students engaged in conditional study.

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25 For a useful discussion, see Robert J. Ackermann. *Data, Instruments, and Theory: A Dialectical Approach to Understanding Science*. Princeton: Princeton University Press, 1984.

26 G.W.F. Hegel. *Philosophy of Right*. T.M. Knox, trans., Oxford: Clarendon Press, 1952. p. 10. "Actual" translates *wirklich*, which relates etymologically to "working." One might almost translate Hegel as saying that the rational is effective and the effective is rational.

27 Kant set the problem of synthetic *a priori* judgments in the introduction to the *Critique of Pure Reason*, Norman Kemp Smith, trans., New York: St. Martin's Press, 1965, pp. 41-62.

Most often, study occurs conditionally. Here the student extends his horizon into possibilities that more accomplished mentors can plainly perceive. A teacher might define the outcome of conditional study clearly as an objective, but the student's achievements are such that he cannot yet firmly grasp it as such. Examples abound: all learning problems that turn on developmental discrepancies between the instruction offered and the readiness of pupils to absorb it. In such situations, which are frequent, a good educational system will provide both instruction and opportunities, tools, and resources for study. Provisions for study will complement programs of instruction. Indeed, we will show that good provisions for study will make instruction more effective by reducing the burden on instruction and by enhancing the students' readiness to learn.

Toward a Technology for Study

How should educators design provisions for study? What opportunities, tools, and resources should they develop? When studying, the student follows her intentions. Let us look again at the five modes of intention introduced above -- recognition, production, control, selection, and commitment. Each of these modes of intention correlates with types of knowledge and thinking. Good design for study will clarify what these are and then ensure that a rich selection of them surrounds the student.

Materials for Recognition

To begin, therefore, we need to provide students with opportunities, tools, and resources for spontaneously exercising their powers of recognition. How do we do this? We need to provide a rich surrounding of conceptual definitions and examples along with fields of activity where they are in significant use. The problem here is to create a cultural environment that will promote concept formation by students. The world confronts people with a flux of appearances, a buzzing cacophony of sounds, an ever-changing sequence of sensations. "Ah ha! Here is a thing, here is a word, here is a situation. I recognize it and I am beginning to understand how to use it." Recognition exploits the principle of permanence as Kant developed it in the first of his analogies of experience. We can reason about experience, whatever its sort, because we postulate that "in all change of appearances substance is permanent," some thing is there through changing states about which we can think.[28] Seeing that stability, that permanence of substance, the student recognizes it.

Recognition closely links to production and control, but for the moment let us concentrate on recognition by itself. People can be instructed to recognize many things, to know the definitions of many words and concepts. But they can also generate the recognition through study. Powers of recognition acquired through

[28] Kant, *Critique of Pure Reason*. p. 212.

instruction alone are powers liable to the limitations of rote learning, knowing definitions and when they apply without genuine recognition of their meaning. Learning without study will often culminate in a lamed mastery of material. There is an inwardness to recognition that makes it hard to discuss. What happens when the student suddenly sees a face or understand a word? Perhaps she suddenly recognizes it as a permanence, a stability, that has a place in her capacity for intentional life.

Let us leave this intriguing question. Here are some things that might be done to create an environment of study conducive to the recognition of objects and concepts. Design is, happily, an empirical endeavor that starts with practical postulates based on partial understanding and then leads through trial and reflection to strengthened understanding and to improved postulates. First off, make sure that the student's work environment has many potential objects of recognition in it. Present these clearly; exemplify them well; use them consistently. Be honest that many matters carry with them problems of recognition that need to be surmounted. It may be better to explain the difficulties of recognition that a student faces than to try to engender a premature recognition.

Note how certain books for infants center on the problem of recognition, presenting sample objects for tactile recognition, a piece of satin for smooth, sandpaper for rough, and so on. Infants begin acquiring their culture through study; adults do not instruct but situate all sorts of chosen objects in the infant's universe. This same practice carries over into the nursery school and the first few grades where the good teacher fills the environment with invitations to discovery, to awareness, to the posing of that wonderful question, "What's that?" This practice recedes in the later grades largely because the objects that require recognition become increasingly numerous and increasingly abstract. Yet it is the principle embodied in Hirsch's ideas about cultural literacy.

I do not think that cultural literacy makes a good objective for instruction, but then I'm no Henry Higgins of the humanities. As objectives for instruction, the materials provided as resources for engendering cultural literacy by Hirsch and his colleagues will not work. For instance, a reader cannot really get my reference here to Henry Higgins by consulting the *Dictionary of Cultural Literacy*.[29] One really needs to cultural experience -- seeing *Pygmalion* or *My*

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[29] You can get a sense of the problem by consulting *The Dictionary of Cultural Literacy* to clarify my reference here.

> *Pygmalion* A play by George Bernard SHAW, about a professor, Henry Higgins, who trains a poor, uneducated girl, Eliza Doolittle, to act and speak like a lady. Shaw based his story on a tale from Greek MYTHOLOGY about a sculptor who carves the statue of a woman and falls in love with it (*see PYGMALION under "Mythology and Folklore"*). Higgins and Eliza develop a strong bond, and he is furious when she announces her intention to marry someone else.
>
> * The MUSICAL COMEDY *MY FAIR LADY* is an adaptation of *Pygmalion*.

Fair Lady, or reading Shaw's script. Then one can recognize the implications of a reference. Hirsch puts things the other way around, trying to distill the recognition, providing that in a capsule entry. Unfortunately, it leaves out what is significant in this context in this reference. Higgins believed in his power to effect positively the most thorough-going transformations by setting clear instructional objectives and pursuing them single-mindedly. The charm of the play turns on the primacy of his underlying humane intentions, that lead him on despite his arrogance and objective snobbery. Eliza takes responsibility for her own transformation. As a reference that a reader may recognize, "Henry Higgins" has, in the context of this essay, much to communicate, about both the substance of the argument and the tone I wish to evoke.

Experience precedes consciousness. Having students experience endless distillations of complex cultural works will not evoke cultural literacy. Students need an ever-widening range of cultural experience, direct contact with the works, undistilled, unexplained, mystifying and mystical. To this experience, they will respond bored, to another boorish, to many confused, to some wondering and enthusiastic, enchanted, star-struck, angry, sad, embarrassed, determined, and who-knows-how. What is important for the student's efforts to build her powers of recognition is less the immediate response, but her filling her coffers of experience, for the moment when something significant comes into her field of awareness and she can grasp it -- "Ah ha! I recognize what this means, how I can use it, where it fits. I see now."

Educational technology has great promise as a means to broaden access to the numerous, intense, diverse cultural experiences that people can use to recognize their world and their possibilities. Here I speak of educational technology in the broad sense, as the system of systems that people are developing through the current and the coming century. We face innumerable issues in extending this system of systems in such a way that it maximize people's access to materials of educative value to them. Suffice it here to lay down as the first of our formal design principles for supporting study with educational technology in formal educational settings.

E.D. Hirsch, Jr., Joseph F. Kett, and James Trefil. *The Dictionary of Cultural Literacy*. p. 130.

My Fair Lady An American stage MUSICAL of 1956, with words by Alan Jay Lerner and music by Frederick Loewe. *My Fair Lady* is based on the play *PYGMALION*, by George Bernard SHAW, about a professor in ENGLAND who teaches a low-born flower girl how to speak and act like the nobility. The songs "On the Street Where You Live" and "I Could Have Danced All Night" come from *My Fair Lady*.

E.D.. Hirsch, Jr., Joseph F. Kett, and James Trefil. *The Dictionary of Cultural Literacy*. p. 175.

The *Dictionary* doesn't really help identify Higgins as representative of the positivistic belief that everything can be reduced to instruction.

> Design the system so it offers students a continual flow of new cultural experiences. The school, its classrooms, and especially its educational technologies should be a spectacular picture window on the world. Do not structure access to all these sources as a formal part of the program of instruction. Keep it free of objectives, free of assessment. Provide it as an opportunity for study, a resource for recognition.

Make no mistake; this design principle will not be easy to implement. But let us not trouble ourselves over the difficulties here -- they are the sort of difficulties it would be nice to have. Let us turn instead to the next principle of design for study.

Causal Alignment

Think of an everyday mechanism, a pair of scissors, a bicycle, an eggbeater, what-have-you. The proper alignment of its parts largely determines how well it performs. If the screw holding the blades of the scissors together is loose, the blades will not align smooth and flat to each other and the scissors will make a short and crooked cut. With causal production systems, good alignment is essential. This holds true for the intentional pursuit of possibilities in study: the means to cultural production should align well.

Production lends itself to instruction. Pull this; push that; rub it smooth; put the gear wheel on the axle; tighten the screw; label it; heat the wire then apply the solder.... Hence a lot of schooling involves instruction in how to do things. The pupil learns how to read and write, how to do basic mathematics, how to think critically, how to keep informed about public affairs. As alignment is important in the everyday mechanism, so it is equally important in the instruction about causal processes. It is not too hard to teach production skills, but if the skills taught do not align well with the skills used, the effort is largely a waste.

Alignment of skills determines largely whether instruction for production will be useful. For production to become a domain of study, one in which the inquirer's intentions control the process, the means of production need even more to align effectively. Mastery of production culminates in a "Look! Ma!" experience, which differs significantly from the "Ah, ha!" experience of recognition, or the "I got it!" experience characteristic of control. We validate both of these inwardly, through what Polyani called "personal knowledge." Mastery of causal processes culminates in a demonstration to the external world, a first, a best, one for the record books. "Look, Ma!" is an appeal to the significant other for approval. Insofar as skills imparted through instruction do not align well, level to level, students will have great difficulty taking over and pursuing them according to their own intentions, for they will not find much by way of an arena of external validation.

Take a simple case, fairly late in education, where generally we would judge that the system works reasonably well. Students in the later years of college and in graduate school incessantly engage in production, writing papers for course

after course. Usually, however, all this production thoroughly misaligns with the production processes of advanced scholarship. Functions, conventions, and standards derive from the grading system, not the system for advancing knowledge and understanding. Students write cautiously, *for their instructors*, who receive the mass of work as a gigantic chore, plowing through it knowing they will learn little from it. If writing were well aligned to the full academic production process, at this level publication would be the indicator of excellence. Students would write less and revise more; they would venture an ascending spiral of projects that carry their efforts to the threshold of creative production -- "Look, world! Here's what I've made!" The system does not align in this way, however.

Note that the case is different on the gridiron. From high-school through college, football aligns well with its professional version. Scouting talent can begin early. The better talents win scholarships to the most intensive programs where they get excellent coaching. But the whole system aligns well enough that the pros easily recruit excellent prospects from small schools in out-of-the-way places. As production systems, sports align better across the levels of formal education than do academic disciplines. As a result, sports have been more Jeffersonian than the mind, a better channel upward for those gifted with unusual talent.

Many educators presume that aligning productive efforts by students with the production processes of the world-at-large miseducates. Sports smack of professionalism. Aligning learning with the work of the world is banausic, as Aristotle stigmatized it, banal, tainted by vocationalism, the trade school. This prejudice should be re-examined. Were a lack of alignment in production skills good educational strategy, professional education would never have developed. To begin making sense of this problem, we should distinguish between the problem of alignment, per se, and that of the complexity of skills to be aligned. Aristotle's critique can be saved, while espousing the principle of alignment, by recognizing that in aligning skills one should preserve their range and complexity. Try assembling a mechanism of many parts, each fitting together at close tolerances. Almost always it would be easier to get the thing together by leaving out one or two parts -- all the others would then easily snap tight in place. That is not a good way to assemble the mechanism, of course, and the educator who attends to the alignment of skills must avoid such shortcuts.

Let us not, however, leave our example of the complex mechanism quite yet. Given the parts, properly tooled to the specifications of the mechanism's design, we cannot leave any out during assembly. But in every area of activity, a great deal of design effort goes toward simplifying and improving the set of parts required to perform a given function. Design efforts of this type are changing the sets of skills important to production in numerous fields. Information technologies simplify and integrate complicated and disparate production systems. Educators know too little about these changes.

Suffice it here by way of summary to advance the following propositions.

> In general, design the instructional system so the skills it imparts align well with the skills that have real use in spheres of activity in which students will engage throughout their lives. If the alignment between skills imparted through instruction and those of use in everyday activity is accurate, then students will be more able to develop such skills through intentional study, in addition to learning in response to instructional objectives. If the instructional system misaligns the skills it teaches and does not give students palpable evidence of worthwhile achievement, many will drop out and seek on their own to develop skills that they can validate in their immediate surroundings. If it aligns the skills well and introduces students early to tools of real use in powerful production systems, students will study those systems, building their growing mastery of them into productive places in social and economic life.

This problem of causal alignment within educational processes relates closely to that of control and we need to examine control to deal with the problem of alignment further.

Locus of Control

Here we can state the basic design principle right at the outset.

» To improve the opportunities for study, design the system so that students are at the locus of control for as many significant decisions about their educations as possible.

A worried buzz arises. Students will drop out; they will take the course of least resistance, or they will do other foolish things that make it necessary for us to exercise sound judgment on their behalf, for their own good, you know. After the buzz subsides, a more sage dissent will resound with weighty words: to put the student at the locus of control will be to misalign the system in the most radical way possible. In virtually all things the student must learn to live and work displaced from the locus of control. Perhaps. We live and function within complex hierarchies of control. We cannot be at the locus of control with all of them. With those matters, therefore, we must learn to live and work displaced from the locus of control. Having to do that is our condition, not our purpose. We can better understand this condition by referring back to Kant.

As Kant suggested in discussing the analogies of experience, we can think about a phenomenon, either according to the principle of production or according to that of community. *Production* lets us examine something according to the principle of succession in time by using the law of causality. "All alterations take place in conformity with the law of the connection of cause and effect." Interpretation of phenomena according to this according to cause and effect will start at an arbitrary beginning. One cannot work back endlessly through the succession in time to some first cause. Instead, one must be content to start the causal sequence somewhere. *Community* lets us examine phenomena according to the principle of coexistence by using the law of reciprocity. "All

substances, so far as they coexist, stand in thorough-going community, that is in mutual interaction." When we stand in coexistence with things and in thorough interaction with them, to exercise our will we must try to control the system of which we are a part. As one cannot, with production, go back to a first cause, one cannot, with community, encompass everything in a complete system. These are elements outside the system of control and if they threaten to destabilize it, people will try hard to find ways to bring them within the system.

Students of information have made great advances in understanding the dynamics of control within a given system. The locus of control at any time is the vantage from which a person can use information about the past and current conditions of the system, along with hopes and expectations about its future states, to alter its operations. We should properly speak, I think, of loci of control, for in most systems numerous people find that they have such a vantage from which they can exert partial control within the system. Only the megalomaniacal villains of Bond films believe they are at *the* locus of control. Locus of control should refer thus a partial, constrained condition, a subjective state, but a most important one nevertheless. A scandal of educational theory is the paucity of work that has made good use of the concept of control. As a result, within the confines of this paper, we cannot clarify important aspects of the matter. Yet we can make clear a fundamental point about control by addressing several matters briefly.

One of these matters is the tendency that educators have to pay more attention to issues of organizational control than to those of educational control. Complex organizations display numerous structures of control. Precisely what we mean by "being at the locus of control" differs significantly for a passenger in a 747, a voter in a presidential election, a shopper at the suburban mall, an assembly worker on the line, a CEO receiving a take-over bid, and so on. Educational organizations have their control structures, totems that students tend to be at the bottom of.

[[[technology empowering students' control of their education.]]]

Alienation -- displacement from locus of control

Stake -- interest in the outcome of control

Power -- degree to which the over-all outcome of control is determined from one's locus

Responsibility -- degree to which control can be destabilized from one's locus

Increment -- portion of the control process managed from one's locus

Blinkers -- a deficiency of information needed for control to be exercised.

Whereas production lends itself to instruction, control does not. We have defined instruction in such a way that causal sequences will most often be adduced as instances of it.

Selective Identification

[[[Design the system so that students will find they have the opportunity to identify themselves by making characteristic patterns of selection. New technologies as arenas for self-definition.]]]

Thresholds of Commitment

[[[Design the system so that appropriate thresholds of commitment confront students, thresholds that are neither non-existent nor overwhelming. Technology as a means to modulate the threshold.]]]

Conclusion

[[[At the outset, I suggested that epistemic definitions have their value because they enable us to know phenomena better than we could without them. To test the value of the definitions of study developed here, we should look for ways in which they may help us understand outstanding questions. I think they help explain two puzzling yet significant educational phenomena. These are the persistence of class differences in educational achievement, and differences between siblings in educational achievement.]]]

[[[Younger siblings generally do not achieve as well educationally as the first-born in their family. Why is this? I hypothesize that the older sibling unwittingly disrupts conditions for study in the surroundings of her younger sibling. Thus, even though instructional opportunities would remain constant between the older and younger sibling, the conditions for study would favor the first-born. Examples.]]]

[[[Even where instructional opportunities have been relatively well equalized, class differences tend to reproduce with the middle and upper-class children out performing working class children. My hypothesis is that the middle-class environment spontaneously provides conditions for study -- there is a richer selection of cultural materials for recognition, better alignment of production systems, a higher chance that the child will be at the locus of control for significant aspects of life, more opportunity to select a positive self-identity, and more manageable thresholds of commitment. Although the objective correlates of middle-class life provide better conditions of study, the disadvantages of the underclass can be overcome because the conditions of study are partly in the eyes of the beholder. Dreams and anger -- Martin Luther King and Malcolm X.]]]

Technology as the Liberator of Education

by Frank Moretti

> The *genuine spiritual struggles of European humanity as such take the form or struggles between the philosophies... ...to decide whether the* telos *which was in bom in European humanity at the birth of Greek philosophy--that of humanity which seeks to exist, and is only possible, through philosophical reason, moving endlessly from latent to manifest reason and forever seeking its own norms through this, its truth and genuine human nature--whether this telos, then, is merely a factual, historical delusion, the accidental acquisition of merely one among many other civilizations and histories, or whether Greek humanity was not rather the first breakthrough to what is essential to humanity as such, its* entelechy.
>
> Edmund Husserl, *The Crisis of European Sciences and Transcendental Phenomenology*

Educational dialogue in the public arena has begun to polarize itself around two distinct and seemingly incompatible subjects: morality and ethics, on the one hand, and computers, on the other. This essay is an attempt to define certain issues in moral and ethical education with an eye to creating a context for envisioning the relationship such concems might have to the rapidly shifting universe of educational technology.

The Institutional Perspective: The Tradition In the School

> *So the lessons that any school conveys about power...may be among the school's most distinctive features.*
>
> Charles Chatfield, *Commonwealth School Newsletter 1985*
>
> *Because success is whatever passes for success, it is in the regard of others that I prosper or fail to prosper; hence the importance of presentation as a -- perhaps the central -- theme.*
>
> Alasdair MacIntyre, *After Virtue*

The following is an attempt to define two co-existing but antagonistic realities. The first pertains to the large scale dominant forces of a social and cultural order which are the result of the reciprocities and societal relationships of the institutions the modem mind identifies as synonymous with education,

schools and universities. The second pertains to the metaphorical apparatus, the labyrinthine lattice work of those institutions, that is, the curriculum which, as a separate reality, has a genesis comprised of the collective accretions and siftings of three thousand years of continuous and serious conversation about what we are.

Most educational institutions are driven by these two realities as motors which provide two conflicting impetuses in the experience of each student so that each educational moment is in some way qualified by these forces. The first and most obvious of these is related to a much larger societal process through which the young come into their social and economic inheritance. Schools are central to this process. Unfortunately, many of our schools are vicious, that is, the inheritance they legitimate is unemployment, alcoholism, drug addiction, and violent crime. Further, the nature of the legitimization process is such that, more often than not, the condemned walk away from their educational "opportunity" believing they "had a chance" and failed! The inheritance of others is substantially more benign; for them schools legitimate a process in which "success, " societally defined, is the probable end. Just as for their counterparts at the other end of the spectrum, the experience of "opportunity" and the concomitant fear of failure is necessary so that "success" is experienced as earned and deserved. All participants (faculty, administrators and parents), who feel the need to construe the "success" or "failure" of the children as a result of their own willful actions, fuel this process.

In general, the apparatus and nomenclature of the school sustains the belief that it is a testing ground for determining who is able and deserving. Consider: the public view of the college admission process (to be admitted requires "accomplishment,"); the on-going review of student progress with grades at the center (implying a standard which represents an end separate from the students); the use of "next-world" tactics to motivate students to achieve; ("either you do this or you will get what you deserve"). In a word, students live under the constant threat of not measuring up and, therefore, not inheriting their places; for the fortunate, these places are in college, corporation, law school, country club, etc; for the less fortunate, it is a matter of having any place at all.

The above dynamo directed at power and survival, one we share with all other forms of life, is not inclusive of all experience within the school. There are forms of activity which differentiate us from other forms of life. In contrast to the greater certainties of social and economic inheritance, there exists another compelling reality, a set of questions, concerns, and needs pertaining to the nature of society and culture; the meaning of death; in a word, to all those questions which are the result of the burden of consciousness, of our specific difference. The search for solutions and answers to fundamental human dilemmas in all realms of experience, the quest for defining modes of expression, are pursuits whose meaning does not depend on externals for validation; they are the legacy of all humans qua human and, as such, the ultimate democratizer impervious to the arrogance of social, racial or economic distinction. They stem

from the fact that humanity has the power, the burden, to reflect on itself as a finite creature in a universe of immeasurable enormity and complexity, which, by virtue of humanity's mental and social constructions, has become infinitely more complex. The curriculum of the school, no matter how battered, abused or disguised, is an artifact of the tradition of ruminations, of that extended conversation which represents a codification of the struggle of humanity to formulate and describe itself to itself, not for the sake of anything else, but because it must.

Thus, the record of the searching human spirit trammeled by its pragmatic and powerful partner, beckons for the attention of the student, urging that much of what is being presented as a form of personal power is disabling the truly human pursuit of understanding. For example, what is "confidence" in the order of power is viewed as the capacity to dissemble in the order of the spirit. To be more valued and viewed as genuine confidence in that order is the willingness to experience and express uncertainty, when uncertain, and search for assistance, when needed. What is viewed as "facility" in the order of power is in the order of the spirit perceived as the power of self-deception and to deliberately blur difficulties. Truer facility is the ability to define the limits of your understanding so that the structure of your thought does not stand on ignored uncertainties. In order of power, the emphasis on control and determining the outcome of events and the perception of others leads the student to focus on the ability to disable any truly strong opponent and patronize that person perceived as weaker. In contrast, in the order of the spirit, empathy with the position of another must always precede the act of criticism.

The potential for irony in this situation can be brought quickly to view if one imagines a high school or college student being exhorted to consider the issues of Plato's *Apology* whether Socrates should conduct his defense with lies about himself and plead for his life in order to save himself. Consider the content of this educational transaction. Most instructors consciously or unconsciously validate Socrates choice of the truth over his survival; thus, Socrates continues to exist symbolically as a standard of inner directed behavior. At the same time, the instructor is clear to communicate that the value of the student's answer, once measured, will become part of the "dossier" which will determine the student's success or failure. Therefore, the student is often put in the interesting and confusing situation of arguing eloquently for Socrates' choice of death over capitulation, as part of the student's own effort to survive his court of jurors (externally motivated in a discussion of internal motivation). How can the student take the Platonic question seriously? How can the student decide which message is the true one or the relative significance of each message? Is the student to believe that we take the question seriously or see it as a puzzle, the real life meaning of which is ultimately measured by external criteria of a material order? Some may object that the example of Socrates is a remote one. Then substitute, if you will, classroom discussions and/or curriculum units on apartheid in South Africa. What does it mean if students grow to believe that our main interest in that question pertains to their facility in answering it? This brings up

the question of how the students experience and respond to this rightfully confusing conflation of antagonistic forces.

The Personal Perspective: The Alienation of Reason

> *I ask them (my accusers) to grant me one favor. When my sons grow up, gentlemen, if you think that they are putting money or anything else before goodness, take your revenge by plaguing them as I plagued you; and if they fancy themselves for no reason, you must scold them just as I scolded you, for neglecting the important things and thinking that they are good for something when they are good for nothing. If you do this, I shall have had justice at your hands, both I myself and my children.*
>
> Socrates' last request to his jurors. Plato, *Apology*

> *School does not ask you to be the best you can be, but better than anyone else.*
>
> A Ninth Grade Student

> *Has my education and maturation improved on the little form, who like many little people, used to have to stick his tongue out to concentrate? Certainly, I have become a better speaker, I am a better mathematician, I know more history, I'm more polite and my jump shot has improved...slightly. In general, I'm a lot slicker than I was before all of this happened. In this way, I'm sure all of us graduating today are very much alike. But how much of this process that we have just completed constitutes improvements in form only and how much is real substance.*
>
> Paul Schoeman, *Dalton School Graduation Address,* 1987

If one accepts the view elaborated in section one as reasonably accurate, certain inferences about student psychology and values necessarily follow. First and foremost, it cannot be denied that students quite sensibly believe that each learning experience is a counter in a much larger game which extends far beyond the school and the classroom. Students are aware that the responses of the institution to their work and behavior are not only indices of their levels of competency, understanding and maturity, but also establish their relative position in the general competition for college among the fortunate, for sheer survival economically among the less fortunate. From this perspective, how well one is doing is often associated with a feeling that to not do well means, in the regions of the subconscious, not to survive, that is, to backslide into the dark chasm of failure. Thus, each learning experience is invested with an external significance which halos the experience itself, and inflects the student's reception and address of ideas. As a result the curriculum becomes a complicated game, the

meaning of with comes not from the ideas and questions themselves, but from the contest created by the school as certifying agent.

The fortunate student plays the game, anticipating success. For him, certain skills are more valuable than others. To be "facile," "to be good on your feet," "to be confident," "to be able to write quickly and well" are all premium capacities. (A certain student from a past year was praised by a present student, with some conscious irony, for being able to write an English paper at `A' level in a half hour at the typewriter. Imagine with word-processors!) To be noted and underscored here is how these "skills" are completely external in character. They depend on the student being able to sustain himself in competition with like creatures in the effort to win praise and ultimately, the "prizes" - good grades, good college, good job, etc., etc. (A student once called the successful student one capable of "good bullshit, bullshit that works.")

The less fortunate student, anticipating failure, often responds with confusion. Knowing within that the deck is stacked, but perceiving no alternative, he plays and doesn't play. He assumes a passive aggressive pose (exacerbated by compulsory education laws) in which his legal presence is counteracted by his psychological and physical absence. Trapped in the violent reciprocities of institutional educational life, bred for disinheritance, most frequently, despite the health of his rebellion, he learns his failure. Only seldom does he reject within himself the situation which condemns him and even then, only seldom, does that rejection allow access to views which allow emergence from the societally defined underworld.

For those who choose to actively play and engage the institutions, however, dramatic moments await. They learn school. They learn the script and the roles the institution offers. The drama's script is complex and a detailed description of it is here out of place. Allow me to address just one of its central features, that is, the premium it places on having opinions, having opinions on everything and having them as quickly and as frequently as the situation (read scene) demands. As the students say "being able to find a thesis and back it up" is what will "get you someplace". As a gloss on the old adage, one does not only have the right to an opinion, but one must have as many opinions as there are situations and one must proffer them with certainty, even though students are quick to assert the view that no opinion is really better than another!

Many, trained classically, might expect that this fluid world of opinion would exist for students in contrast to the world of knowledge. Wrong. The contrast most often made is between it and the world of belief which the students present as a personal world outside the orbit of debate. Indeed, if a matter of belief is identified as such and subjected to debate, it becomes by virtue of its verbalization part of the world of opinion and, according, disenfranchised from the world of personal significance, symbolized and contained in the concept of belief. When asked what can change a belief if not reason, students respond, vaguely, "circumstances."

Driven by the mechanisms of institutional educational life, students strive to preserve a place of authentic self-hood in the irrational quarters of their person, deeming the world of reason, learned by them as that of opinion-making, a world separate from themselves as they really are. This is a complex phenomenon. If one focuses on the level of alienation, which it implies is the product of much conscious educational effort, it is a cause for lament. If one focuses on the fact that students are instinctively driven to preserve some locus for their unique person-hood, even if that haven is by default of the educational process and is in the realm of unreason, one might see in it a hope for the spirit.

There is a great irony in our making the young into answering machines who strive to appear certain and in our creating an educational culture which gives certainty and visible self-assuredness the place of preference. For we live at a time when the status of the conversation to which we are heirs and of which we are obligatory participants requires first, that our loudest assertions be of our uncertainty, and second, that the Rousseauian amour-propre, the dominant mode of self-description in the sum-zero game which constitutes the central drama of our institutions of education, be still the object of attack as it has, reiteratively, from Homer to Virgil to Nietzsche to now.

Reason, Uncertainty, and Self-Respect

> *...no blight can so surely arrest all intellectual growth as the blight of cocksureness; and ninety-nine out of every hundred good heads are reduced to impotence by that malady--of whose inroads they are most strangely unaware!*
>
> Charles S. Peirce

In our age, whether one searches in philosophy or literature, the significant voices of our conversation with ourselves, one encounters statements about our confusion, statements about how hard it is to know anything about what life means or how to live. It is only the perversion of that conversation, by virtue of its entrapment in institutions serving other purposes, which allows it to become that by which the young cut their teeth of arrogance. What Milos Kundera says of the world can be said of much more:

> A novel does not assert anything. A novel searches and poses questions. I don't know whether my nation will perish. I don't know which of my characters is right. I invent stories, confront one with another. But this means I ask questions. The stupidity of people comes from having an answer for everything. The wisdom of the novel comes from having a question for everything. It seems to me that all over the world people nowadays prefer to judge rather than to understand, to answer rather than ask. So That the voice of the novel can hardly be heard over the noisy foolishness of human certainties.

People nowadays, as good well-educated souls, prefer to judge rather than to understand, to answer rather than talk and in that is the philosophical tragedy

of our age. Public and private dialogue is filled with the noisy foolishness of human certainties - from evangelists to zealot anti-soviets. The situation declines further if I am correct that reason itself in the world of the young has achieved complete identification with the role-playing of education and, as such, is not related essentially to the elements of their experience they hold sacred. The situation worsens if one assumes that, with time, the experience of that special inner world, beyond reason, fades and all we have is a universe of opinions mobilized in a world, as MacIntyre would have it, in which there exists no distinction between the manipulative and non-manipulative, in which all reasons are rationalizations.

It is difficult to go beyond this point without engaging in serious contradiction. Quick answers are a betrayal of the problem. However it is no answer to say that our experiment with reason and reflection demands that we respect our present state of uncertainty even if that state, perceived in its entirety, inspires terror. To remain committed to a conversation which has been and is faced with the terror of uncertainty, to attempt to protect it from the viciousness of institutions focused on making it into an answer game in service of the invidious distinctions of our social order is an act of faith in all that we know we are, animals which think, and have thought, live and have lived.

What we face today are the dangers of *Deus Ex Machina* solutions whether they are politically motivated pronouncements on moral education or the expression of frustrated, frightened intellectuals who yearn for the communal solidarity they imagine made a meaningful life possible in the past. The master of the *Deus Ex Machina*, Euripides, understood well that such endings only go to prove and highlight the false nature of easy solutions which can only be asserted of complex problems. His endings, never resolutions, were often beginnings, contexts which required a living, a choosing, yet to take place. In a way, his dramas were really prologues to dramas, contexts for searching, and questioning. If there were moments in the past when a metaphysics thrived which made certainty possible, those moments are not with us now and to deny what we have already denied is truly to refute and reject ourselves, a futile and suicidal act.

It is left to ask the question with which we began about what place technology has in this morally confusing world I have depicted.

Toward a New Curriculum: Technology as Nature

> *It is a disposition natural to man to regard everything in his power as his. In this sense Hobbes's principle is true up to a certain point. Multiply not only our desires but the means of satisfying them, and each will make himself the master of everything. Hence, the child who has only to want in order to get believes himself to be the owner of the universe; he regards all men as his slaves. When one is finally forced to refuse him something, he, believing that at his command everything is possible, takes this refusal for an act of rebellion. All reasons given him at an age*

when he is incapable of reasoning are to his mind only pretexts. He sees ill will everywhere. The feeling of an alleged injustice souring his nature, he develops hatred toward everyone; and, without ever being grateful for helpfulness, he is indignant at every opposition.

One summer day when it was very hot, Viscount de Turenne, wearing a little white jacket and a cap, was at the window in his antechamber. One of his servants happened along and, deceived by his clothing, took him for a kitchen helper with whom this domestic was familiar. He quietly approached from behind and with a hand that was not light gave him a hard slap on the buttocks. The man struck turned around immediately. The valet saw with a shudder his master's face. He fell to his knees in utter despair. "My lord, I believed it was George!" "And if it had been George," shouted Turenne, while rubbing his behind, "there was no need to hit so hard."

Remember that as soon as amour-propre has developed, the relative I is constantly in play, and the young man never observes others without returning to himself and comparing himself with them. The issue, then, is to know in what rank among his fellows he will put himself after having examined them.

Jean-Jacques Rousseau,
Emile; or on Education

Many have rehearsed the arguments against the use of educational technology all the way from the fear of a loss of social training (children locked into machines for a large part of each day!) to radical views of it as a preparation for performing functional roles in the military industrial complex. In a way these are easy. In contrast, what will be briefly attempted here is a description of how technology, properly deployed, might provide a source of liberation from the dilemmas of modern education, indeed, of modern morality as I described them.

The man our system seeks to train, when he is a chosen survivor, is one who as Allan Bloom summarizes on behalf of Rousseau, "when dealing with others, thinks only of himself, and on the other hand, in his understanding of himself, thinks only of others." If one follows the Rousseauian formulation,, the question we are bound to put to the new technology is whether there is something about it which can lead to the love of self, the *amour de soi*, which enables one, on the one hand to act on behalf of things beyond oneself and, on the other, to judge who one is without the outside world. To put it otherwise, are there resources in the new technology that can help the young avoid the alienating force of the sum-zero game of modem education. The key to a response lies in the infinite characteristics of technology as an antidote to the finite characteristics of that game.

Many of the accoutrements of educational institutions can be subsumed under the rubric of finite characteristics. As such, they share one quality. They are part of technology of control or in the words of James Carse (*Finite and*

Infinite Games), the rules, the parameters of finite play. Thus text books, tests, canonical book lists, canonical historical topics, grades, grading, periods of the day, schedules of all kinds, diplomas, awards, titles, passage rituals, etc., all constitute the definition of the field of engagement. Success within or on this field means internalizing the rules, shaping your responses, your self to meet the criteria of winning. Winning itself is such that one only knows one has won when the "title" is conferred either in the short run with a "grade" or, in the long run, a "degree", and so on. A person's power, as defined by the game, is a result of deference to these symbols, an architectured auctoritas (the word Romans used for personal authority).

The characteristics of winning in such a context are not unlike those characteristics one finds in Homeric society in which it was clear that one man's glory was always at the expense of others, both friends and enemies. Even though a friend may not be vanquished, all glory even among the Achaeas was heightened or diminished by the number above you, who had more, or the number below you who had less. Thus everyone emerges both winner and looser and everyone's identity is bound to the human configuration of comparative communal judgments, the world of Rousseau's *amour-propre* with a vengeance or, as Rousseau says, "the relative I is constantly in play." Further, all successes point backward, the results of honors conferred, but have their force in the future in the establishment of an identity, external to the person, separate, enduring and ultimately producing a life in death.

What follows is difficult to describe because although it is not in the realm of sci-fi, it still requires that we exercise our imaginations by bringing certain burgeoning possibilities to their full operational development. Let us imagine that we have the potential to create educational environments in which a student working at a station can have access to a vast galaxy of data of a wide and various sort from photographs to films to all existing print resources, audio resources and unprinted manuscripts. These environments would include in all languages, the universe of commentary, ethnographic files, as well as all critical reference works. This environment will also include self-contained sequences for the mastery of skills such as languages, which utilize the gamut of media and methodologies.

What would study in such an environment be like? How would it be different from the world which we describe as one characterized as a finite sum-zero game? Here are some of the possibilities:

- The degree of predictability that one discovers in the traditional context is superseded by a serendipitous open-endedness. Where a student begins will not determine where a student will end.
- The outer directed quality of the finite educational experience, in which the context and outcomes are determined, will be superseded by a situation in which the student, by virtue of the constant process of search and inquiry, will be constantly modifying his goals as his search for

understanding leads him to travel various routes through the open electronic field. Along the way a student may stop a line of inquiry to master a skill, in which case he will make use of a predetermined sequence of activities but this will only be a pause in his journey.

» In contrast to the old world in which study and inquiry are bound and colored by the relations of power of the institutions in which they are embedded, the new environment will make possible a clearer separation of those moments when one is negotiating others in the finite game of education and those in which ones limits are determined by ones own personal capacities to implement ones intellectual Eros within the objective electronic field of information. The only constraint that will effectively limit the student's educational Eros is the product of the interaction of his will with the universe of possibilities implicit in the open field of information available.

In sum, the universe of technology has the potential to create a situation in which the infinite electronic field of information will function effectively in the same manner as Rousseau envisioned nature functioning, unmediated by adults, in the lives of young children. His goal was that children not perceive the wills of others as the effective restriction on their capacity to effect their desires but, rather, the conjunction of natural circumstances and their own wills. Thus, the person so trained does not plan a life based on the skill to manipulate others but, rather, on the ability to act within the conjunction of personal resources and objective circumstance. In our age, this possibility produces the irony that what some would call the progressive dehumanization of education might lead us further toward the realization of the highest humanist goals - a world in which our efforts to educate the young do not foster the creation of alienated selves from which the only harbors are in the irrational quarters of private consciousness.

FROM INSTRUCTIONAL DESIGN TO STUDY DESIGN TOWARD A NEW PARADIGM FOR THEORY AND PRACTICE

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Study is a key idea in developing a new paradigm that will make design more fruitful in education. However well it has worked for industrial and military training, instructional design has had minimal effect in the everyday work of schools and colleges. This paper will report on alternative design principles developing in a focused, well-funded effort to use information technology as a change agent in an established, progressive school.

Theory

Traditional instructional design is a paradigm built on the teacher-learner construct.

> At the most general level, ISD is a process for determining *what* to teach and *how* to teach it. The assumption is made that there is a target population (somewhere) that should learn something. To determine what is to be learned, the designer analyzes a goal statement to identify subordinate skills, and formulates specific objectives and associated criterion-referenced assessments. How the information or skills will be taught is spelled out in an instructional strategy, which is the blueprint for the development of the instruction in a selected medium. The instruction is formatively evaluated with appropriate learners until the desired criterion level of performance is met. (Dick, 1993)

This paradigm works where "the learner" adequately characterizes the recipient of instruction.

Young people populating schools and colleges are called *students*, not *learners*, and their business is to *study*, deriving from the Latin *studeo* --to be eager, zealous, earnest; to take pains about something; to strive after; to be busy with; to seek after or aim at. Traditional instructional design postulates a direct causal connection from teacher to learner. Study is not a process causally controlled by the teacher, school, or curriculum. The teacher, the school, and the curriculum can invite and support study, they can command, cajole, and plead for it, but they cannot cause or control it. The student causes study, and

the teacher-student construct is the crucial one for a new paradigm of design in education. (McClintock, 1971)

In the place of an Instructional System, designers should create a Study Support Environment (SSE). Study arises in the process of interpretation, when problematic particulars require the student to make sense of them by interpreting their origin and meaning. Educational relationships are not causally rigorous if-then arrangements. Schools are not sites where predictable production processes work. Educational relationships are reciprocal couplings that may conduce this way or that way. Hence the designer cannot directly cause students to study, but they can encourage them to do so and abet their efforts at study once the process has begun.Such design principles are thoroughly constructivist in orientation. (Spiro, *et al.* 1991; Harel and Papert, 1991)

Practice

During the 1980s, the Institute for Learning Technologies at Teachers College, Columbia University, and the New Laboratory for Teaching and Learning at the Dalton School developed a collaborative effort to make schools a more effective place for study. In 1991, the Dalton School, an academically selective, private, K-12 day school in New York City, received a substantial gift to develop the first fruits of these efforts fully. The result is the Dalton Technology Plan. It aims to develop a *digital* knowledge-base and information infrastructure for all aspects of the educational experience, K-12, and to implement educational strategies designed to make use of this infrastructure, enhancing significantly an already excellent educational experience.

Essentially, we are designing a comprehensive project, on site, as we go along, following a fairly simple vision of how the technology and the educational program should interact. Networked multimedia will greatly enlarge the range, power, and quality of materials that participants in a school can access and use. The technological resources we are designing are a study support environment, one crafted to enhance the student's power to study productively, whatever the student's age and whatever the subject at hand. We are developing the Dalton Technology Plan, drawing on hermeneutic principles and advanced information technologies to conceptualize a theory of Study Design and to implement a school-wide SSE. We do not seek to cause study. We aim to increase the probability that students will engage in study and to provide them with resources by which they can sustain and make their study productive. (Moretti, McClintock, Chou, and deZengotita, 1992)

Seven Goals of Study Design

As an interim report on the conjunction of our theory and our practice, we think that well-designed study support environment will help students do seven things.

1) **To Problematize**: The system should present students with particular cultural objects (events, writings, images, artifacts, statistics, scores, observations, equations, experiments, rules, what-have-you), in such a way that they experience the objects as problematic, obscure, perplexing, a challenge to the understanding.

2) **To Contextualize**: The system should provide students with open-ended access to contextual materials that may help to clarify and interpret the cultural objects presented to them. Provide pathways, spiraling through both the digital and the human environments, traversing out from the problematized objects through a comprehensive assemblage of pertinent contextualizing materials. On the one hand, the context should be *immediate* to the problem, and on the other, it should be *inclusive*, with all that is possibly pertinent included within it.

3) **To Engage**: The system should situate the perplexing problem and its pertinent contexts emotionally in ways that will encourage students to feel personally involved, so that they will grasp strong ownership of their on-going effort to make interpretative sense of the problem and its contexts.

4) **To Cooperate**: The system should invite students to collaborate in their quest for interpretative understanding, helping them learn to empathize with the interpretative actions of their peers.

5) **To Expand**: The system should use cognitive apprenticeship to show students how to amplify the scope and power of the contextual materials that they bring to bear on interpreting the text, assisting them to move the interpretation toward that ideal condition in which all significant contextualizing materials have been taken into account.

6) **To Abstract**: The system should draw students into identifying interpretatively powerful contexts that will be applicable to numerous, diverse particulars, and it should provoke them to apply these in interpreting multiple, different cultural objects, thus helping students develop the capacity to transfer their growing interpretative skills to making sense of novel problems.

7) **To Diversify**: The system should incite students to situate complex cultural objects in many different significant contexts, yielding an understanding, based on multiple perspectives, that has a comprehensive, aggregate value, through which students will develop the cognitive flexibility to understand things from many points of view.

SSE's that seem most suitable for helping students to problematize, contextualize, engage, cooperate, expand, abstract, and diversify are sustained simulations that model significant domains of intellectual inquiry, professional service, or productive activity. It will take sustained efforts by diverse groups to build up an educational repertoire of such simulations adequate to sustain study by the young from early childhood through early adulthood. But once such a repertoire has been built up, our progeny will enjoy educational opportunities many times more influential than those now available to our young.

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