Views of MIT's Project Athena: Innovation or Invention?

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Abstract

In 1983 MIT initiated a five-year experiment to explore the uses of computers in the undergraduate education called Project Athena. This paper examines conflicts in MIT's Project Athena arising from differing perceptions of involved participants. The paper concludes that while the structure of the Project was predetermined by the structure of MIT and the political and economic realities of the time, many of the conflicts could have been avoided by early clarification of the Project's goals and proposed methods.

DRAFT2:

Contents

invention *n* **1.** A product of the imagination; a new idea, method or device.

innovation *n.* **1.** The introduction of a new idea, method or device.

Without invention, innovation is impossible. Too often, invention is mistaken for innovation. Before a technical change can be inacted in a society, a new device must be invented, but technical innovation comes about by the *deployment* of the device, not by its creation.

1 Introduction

Project Athena was announced in the Spring of 1983 as a five year joint program between the Massachusetts Institute of Technology (MIT), International Business Machines, Inc. (IBM) and the Digital Equipment Corporation (DEC) to investigate new ways in which computers could be used in undergraduate education.

It is hardly surprising that Project Athena arrived when it did. IBM and DEC forsaw great benefit from exposure of students to their newest line of equipment. Society's expectations of computer potential had grown to the point where the idea of computers in education had massive popular appeal. Finally, technical barriers in the development of high performance, affordable graphics workstations were about to be overcome. In fact, Project Athena was just one of many computers-on-campus experiments that popped up during this time period. Similar attempts at Brown, CMU, and Berkeley are indicative of educators' desires to capitalize upon this new technology.

Characteristic of MIT, Project Athena adopted sought to develop and use the most advanced technology forseeable in the near future. The very ambitious goals set at the beginning of the project have been very difficult to meet. Expectations revolving the fulfillment of the originally stated goals have led to conflict and dissatifaction.

In a recent publication, the Project states:

> "Project Athena's goal is to improve the quality of education at MIT by fostering innovative uses of a network of high performance, graphics computer workstations."****[3]

It is crucial to note that "improving the quality of education... with computers" is far different from "improving the quality of education...with

a network of high performance, graphics computer workstations." In 1982, there were many computer systems which could have been "taken off the shelf" and immediately applied to meet educational needs. By choosing to use so-called 3M technology (called 3M because the specifications call one million operations per second, one million bytes of dynamic memory, and a one million pixel display), Athena forced itself into the most ambitious posture feasible. In 1983 the major vendors faced many technical difficulties to be overcome with 3M machines. Before any innovation could take place in the classroom, substantial development had to be done on the hardware, system software and course-specific software. To complicate matters, Project Athena's original mandate to foster innovative educational practices using computers, and not experimental computer technologies, made delays due to technical difficulties seem unacceptable, unwarranted and unfair to many faculty and students.

A university is composed of a multitude of actors. At MIT, each of these groups became a constituency complete with its own perceptions of the process and interpretations of the words "innovative uses of computing." One constitutency wanted to do it in the most technically advanced manner possible. Another wanted to see immediate widescale deployment of computer power. A third group hoped to use the initial progress of the Project as a publicity tool for MIT. The innovation Project Athena proposed became a highly political process. One constituency forced a goal requiring extensive technical development which the Project continually attempted to de-emphasize in order to avoid alienating others.

Consider the football analogy:

You are a football coach, and through some stroke of luck, your school has just been granted a workout facility containing only the most modern state-of-the-art weightlifting and conditioning equipment from the two leading manufacturers. The faculty is concerned that too little is being done to integrate new exercise machine technology into the football curriculum. Your task is to "explore new, innovative uses of modern gym equipment in the football training curriculum."

You could take the approach of a researcher, partitioning off one small part of the new gym for use by the players in their regular workout schedule, while keeping the rest of the gym off-limits. Your trained sports staff would then be able to develop those optimum exercise routines making best use of this new equipment, using as their subjects small groups of athletes. Partitioning off the gym would allow you to proceed with your experiment without

fear of any sophisticated tests being disrupted by traditional uses of the equipment (e.g. players wanting to do the bench press) Of course, the small section open to the rest of the team might be terribly crowded, but that is to be expected. Your program is an experiment, not a service. If the players want to do the bench press, they can join a health club, or purchase their own personal barbell set. There will no doubt be complaints about all of the wasted equipment in the experimental part of the gym. However the program will benefit those players directly involved now and eventually all players of future football teams.

2 A brief history of MIT's Project Athena

Initially, Project Athena was divided into distinct phases. These phases were predicated on the availability of computer hardware rather than the state of development of specific educational software. In **Phase I**, Athena would install a campus-wide high-speed fiber optic network and approximately 50 time sharing minicomputers (each capiable of supporting between six to eight users at a time). Many terminal rooms, called "clusters," would be prepared across the MIT campus. A limited number of accounts would be made available for the initial development and testing of educational software.

During **Phase II**, initially scheduled to commence in Spring 1985, the Project would be vastly expanded by the arrival of between one and two *thousand* "workstations."[1] Workstations would be single user computers, each posessing the equivilent computing power of one or more of the Phase I timesharing machines. As the workstations became available for general use, the Phase I computers would be relegated to the task of file serving.

In addition to the creation of the computational substructure, Project Athena was designed to be an umbrella program for a campus-wide effort to integrate the use of computers into the undergraduate program. Departments, groups (both academic and student) and individual professors were

[1] In 1983 the concept of a workstation computer was under development by both IBM and DEC, although other companies had been marketing similar computers for over a year. A workstation is characteristically a very fast, graphics oriented computer whose primary limiting constraint is a small (or nonexistent) local disk drive for the storage of user files. Most proposals for workstation-based computing environments presuppose "fileservers" – large conventional computers connected to the workstations *via* a high speed network – to make up for this deficiency.

actively encouraged to submit proposals for projects and programs to be developed during the five year period. Some projects received funding for hiring development staff from Athena, while other projects received merely the use of Athena facilities.

From the start, Project Athena has been faced by a number of setbacks and delays, most of which were unanticipated. Setbacks in the availability of workstations from both major venders have resulted in installation and software development delays. The problems inherent in maintaining and operating fifty timesharing machines were vastly underestimated, as was the time and cost of wiring the campus with a fiber optic network. The substantual amount of system software development required by the project was not anticipated. Nevertheless, by December 1986 over ten clusters had been installed and over 98 different curricular development programs have been established. Over 87 percent of MIT undergraduates of used Project Athena[5, p.9]. In January 1987 Athena had installed experimental clusters in two living groups.[2]

3 Goals of this paper

The path of Project Athena has been erratic. Throughout its lifetime it has been fraught with controversy. Even today, halfway through the project, there exist some fundamental misunderstandings between the various actors involved in the process. It is our hope that by carefully describing the process and its interaction with the perceptions of the participants, we can both explain the events which have occurred as well as help mitigate the conflicts which are likely to take place over projects similar to this one in the future.

4 Actors

Every group of people at MIT have a different a different perception of the role, purpose, current state and goals of Project Athena. These perceptions arise from differing motivations, requirements and pressures which face these different actors.

[2] Like most of project Athena, living group installation has been delayed due to a variety of technical, administrative and political problems.

4.1 Students

Student perceptions of Project Athena has been shaped by two main forces: 1) direct student experience in the Project Athena clusters and 2) published material by Project Athena. In a recent campus wide survey of the MIT undergraduate student body conducted by Project Athena, the pollsters learned:

> It should be noted that student comments and suggestions relate primarily to the system they can already use, i.e. to Athena as it is today and for the most part they view this system as a time-sharing one. Comments on course-specific applications were sparese to nonexistent. It will be interesting in the future to follow whether or not what M.I.T., M.I.T. Information Systems and Athena itself labels Athena is what, in fact, students think of or refer to. Students seem to think of Athena primarily as their facility (exemplified by W20) for laboratory reports, papers, mail, and other activities.[5, p.17]

Student Experience To this day, the primary function of Project Athena for most students remains word processing.[3] Although for many students at MIT the writing of papers represents a minor part of their educational experience while in college, it still represents a major hurdle which must be overcome.

We believe that few students want to use computers to learn more material or the current selection course material better; instead, most students would rather use computers to accomplish the same amount of course work in less time.

Students associate the phrase "Project Athena" far more closely with the Student Center cluster than they do with individual Project Athena coursework development efforts. This is even true of students who have taken courses sponsored by Project Athena and have used other clusters. One explaination is that a student's contact with the Student Center cluster extends beyond the tenure of the student's enrollment in a particular Athena class.

Athena Publicity Project Athena has engaged in several publicity campaign aimed directly at students.

[3] 65 percent of students use Project Athena for word processing and 46 percent use Project Athena for electronic mail. Only 31 percent use it for solving problem sets.[5, p.14]

In March 1985 a four-page advertising supplement to *The Tech*[4] Project Athena announced "**The Grand Opening** on March 19, 1985 of the Student Center Cluster [emphasis in original][4]." The insert was designed to stimulate student interest and use of the Student Center cluster. It is littered with phrases such as "*The Student Center is for You,*" "*take advantage of the opportunity you have, as an MIT undergraduate, to obtain computer resources free of charge,*" and "*Project Athena has something for everybody.*" Not surprisingly, the major use of the Student Center which the insert advocates is word processing; the insert mentions ten "minicourses" which the Project will be offering for novice users: four are introductions for people with no experience, four are introductions to using the text processor (EMACS) and two are toutorials on using the text formatter (SCRIBE).

Project Athena's insert and other publicity generated a demand which the resources of the Student Center were not able to satisfy. In the September 1986 an article was published in an insert in *Tech Talk*[5] telling students what not to expect from Project Athena.[7] This article stresses that "Project Athena is *not* a service [emphasis in original]."[6]

This article was largely in response to a change in student attitudes about project Athena between Spring 1985 and Spring 1985:

> "[P]eople stopped thinking about Athena as an experiemnt and started thinking about it as a service. And what is interesting about that is that I don't think Athena thinks that it has gotten there yet. And the problem is that... a whole lot of these lists of [student gripes] are things that you would tolerate in an experiment and you don't tolerate in a service. It is a very difficult problem for Athena at this point to start behaving like a service, because its really not capable of doing that for any number of reasons.[1]"

4.2 Faculty

The single most significant pressure on an MIT faculity member is the requirement to perform high calibre research in order to be awarded tenure. Tenure committees select professors who are principally interested in conducting research rather than teaching. Even after a professor attains tenure the pressure continues, fueled by the need to preserve status and funding

[4]The MIT Student Newspaper

[5]The official newspaper of MIT

[6]In January 1987 at a panel discussion on the effects of MIT's Project Athena, Director Steve Lerman admitted that the early publicity campaign advocating text processing in the Student Center was "definately a mistake."[?]

within the community. It is not surprising that many of the faculty Athena programs resemble research projects, even projects of professors who are genuinely concerned about undergraduate education.

At this point, every department in the Institute has had at least one project using Project Athena. Faculty Athena projects have adopted two main strategies in attempting to integrate Project Athena in the undergraduate curriculum: a) using existing software and tools as they are made available, and b) attempting to develop their own software.

In the programming courses which are taught on Project Athena, no special software beyond the basic UNIX operating system has been presented to the students. In some courses, such as "Introduction to Chemical Engineering (10.01)," students have been given particular problem sets structured around commonly available number crunching programs. These program include RS/1[7], 20/20[8], and macsyma[9]. Project Athena has been slow to encourage and offer support to students wishing to use these programs in other courses.

Other professors have chosen to write their own special-purpose "courseware" for use on Project Athena. The degrees of success in these efforts vary, and most of them are far from over. [10] Faculty sponsoring athena courses which develop special-purpose software have been reluctant to additionally incorporate the generally available number crunchers.

The majority of MIT faculity has not attempted to obtain the resources for their students to use Project Athena programs and facilities, even though use of the commonly available word processing and number crunching programs could be of great benefit to the students involved.

4.3 Project Athena Staff

The primary tasks of Athena's staff have been acquiring additional equipment and funding, constructing and operating the system, and providing technical assistance to faculty. Although members of the Project staff emphasize the development of course-specific applications in their statements,

[7] A program for analyzing and plotting laboratory data sold by Bolt Beranek and Newman

[8] A spreadshead program sold by Access Technology, Inc

[9] A program for symbolically manipulating algebraic expressions, sold by Symbolics, Inc.

[10] 29 percent of the use of Athena in courses is in the form of lecture demonstrations or reinforcement. Additionally, computers are rarely used to introduce new concepts to students.[5, p.21]

problems in systems development and operations often overshadow other concerns.

The primary goal of the project's staff has been the creation of a working system, capable of sustaining intensive university-wide access. The staff wants to please the MIT community, a comunity consisting of administration, students and faculity. The staff must make the Project look good to the outside world, both as general publicity for MIT and so that they can raise additional funds requiried by the project. The staff has the responsibility of reporting to and pleasing the corporate sponsors of the Project.

Of all the players involved, the staff is at the focal point of concerns and questions about Athena. For example, students most closely associate the actions of the Athena staff with the Project's success or failure, rather than the actions of the involved faculity, corporate sponsors or administration. The staff is additionally the contact point between MIT and the rest of the world on matters regarding Athena.

4.4 MIT Administration

4.5 Sponsors

The goals of the sponsors were to cultivate a generation of engineers familiar with their equipment and their hardware. Secondly, the vendors wanted to take advantage of the technical expertise of MIT to make 3M workstations usable and desirable to universities and business. The sponsors additionally benefitted from the percieved good will towards educational institutuions. The pre-1987 tax advantage of making donation to an educational institutuion should not be understated.

4.6 General Public – rest of world

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5 A Matrix of Perceptions

Perceptions of Project Athena

Players	Ino. vs. Inv.	Goals and Expectations: short term	Goals and Expectations: long term	Impression of what is actually happening	Judgement of Success or Failure
Students	Athena should be for innovation but instead has adopted a policy of invention.	Athena's short term function is to provide students with wordprocessing and electronic mail.	Athena's long term goals have never been well defined. It might help students learn more, faster. Then again, it might not. It doesn't matter because we'll be gone, anyway.	Athena provides terrible service except for the few students who are fortunate enough to be enrolled in an Athena sponsored subject.	
Faculty	Invention now, innovation later.	Providing facilities for the development of courseware.	Improve the quality of the MIT undergraduate education.	Depends on department.	
Athena Staff	Innovation is primary goal; all technical development is secondary.	Deployment of equipment and stable working environment.	Encouraging Institute wide use of the system.	Technically upsetting, but promising to get better.	Athena will be a success if a variety of technical solutions are found and if use of computers continues after project ends.
Sponsors					
General Public					

6 MIT: Innovation becomes invention

In an ideal company, products are conceived of researched and developed within a laboratory environment isolated from both the rest of the firm and the outside world. After much experimentation and iteration, a design is settled upon which management feels will have some acceptable probability of success in the marketplace. At this point, an invention has taken place. Now the design is adopted by the production and marketing staff, who proceed to introduce the invention to society at large. This is innovation. As the process proceeds, the design is evaluated in increasingly uncertain environments. If the innovation is successful, expectations are satisfied and new ones arise. It is possible for a successful invention to be a failed innovation, but a failed invention cannot possibly be a successful innovation. We can now postulate an invention-innovation continuum upon which these kinds of processes rest, keeping in mind that it is innovations, not inventions, that have social consequences.

Project Athena consists of many initiatives, all of them falling on a different part of this continuum. For simplicity, consider the triad of infrastructural components necessary for educational computation. The first leg of this triad is hardware: Without a functioning workstation, there can be no Project Athena. MIT's decision to utilize 3M technology (which was still in the late development phase at the strat of Athena) caused the project to be burdened with continual delivery delays.

The second leg of the Athena triad is system software. Window systems, coherent operating systems, and accounts administration software are all essential to establish and maintain a campus-wide system. Yet, a project of this magnitude, let alone one utilizing 3M workstations, had never been attempted before. Athena was forced to develop many of these essential building blocks itself. A good deal of non-educationally related invention was necessary from the start.

The final leg of the triad consists of the course-specific software (courseware). This is the individual module which teaches french to the student, or interfaces with a data acquisiton device in the lab, or allows the student to use his machine as a word processor. Writing this software is what Project Athena announced to the rest of the world as the goal of the project. Besides a few word processors and spreadsheet programs, almost none of this was present at the beginning of the project.

These three components, progressing from hardware to software to courseware, form not only a triad but a pyramid. Without innovation at the previous level, invention at the next is impossible. It is impossible to completely develop a window system without the workstation, and it is equally impos-

sible to develop the finalized teaching module of the form Project Athena intended to without the window system. Of course, software development is done in parallel where possible, but innovation requires all of the composite elements to be present. By selecting such an ambitious set of goals, Athena forced itself to undertake major developments at both the software and courseware levels, even as it was delayed by late development of the hardware.

In itself, there is nothing objectionable about this approach to incorporating computers into the classroom. However, Project Athena has created problems for itself emphasizing its innovative rather than inventive nature in its publicity to students, faculty, and the general public.

> Athena is first and foremost an educationsl project whose mission is not necessarily to invent new things in computer science, but to explore the value of advanced networked workstations–a relatively new technology–throughout MIT's curricula. To the extent that Athena involves innovations in computer science, the innovations are not ends in themselves, but are included because they are important to the ultimate educational goals of the project.[8]

Paul Gray is quite emphatic on this matter:

> "Let me say at the outset [that] ... I do not think of, the faculty who are involved in the idea of developing Athena, none of them thought of, or do they think now of, Athena as in any sense a research project. That was clear from the beginning.
>
> The faculity in the Institute, wether they be in LCS or EECS or the Sloan school or wherever, did not see this as an interesting, important researchable topic. This was a project in appliations. It involved a substantual amount of development.... [W]hen the network is complete, and we have all that hardware here and the money, it will represent probably the largest scale undertaking of that kind anywhere, in terms of both number of machines and the bandwidth of the network.[2]"

Typical of Gray's statement, however, most detailed descriptions of what Project Athena intended to do describe the underlying computer hardware rather than the applications development.

Insert official Athena description here

In general, most of the articles released to the general public have phrased computer infrastructure breakthroughs as educational breakthroughs. A 1985 article published with Lerman's consent in PC Week refers to "...11 public clusters in various class buildings and one in the student center[9]." The article continues "Now that most academic areas have public clusters, the 'living groups' or dorms and other housing will get microcomputers."

In truth, even now only the student center is truly a "public" cluster. All other facilities have been used primarily software development or sporadic class exercises and are protected by combination locks. Athena's public image portray's it as more heavily innovative than it actually is. Most of the spokemen involved appear to ignore the physical necessity of doing product development before offering it for public consumption. Long term goals may be innovative ones, but invention must take place first.

After its first three years, very little educational innovation has emerged from Project Athena. As mentioned above, only one cluster consisting of some 40 terminals is open to the student body with thousands of students competing for the use of this cluster. A major portion of the effort of Athena staffers has gone toward the development of the necessary software for the maintenance of a campus net as well as defeating the numerous technical and bureaucratic difficulties which have arisen along the way. Finally, most courseware sits solidly in the developmental phase. According to Athena's own figures, only 15 percent of MIT undergraduate coursework involves any Athena exercises, with 29 percent only being used for demostrations or reinforcement. With the exception of those courses which taught programming before Athena arrived, we see few examples where Athena has become an integral part of the subject's curriculum.

6.1 Student Center

The MIT Student Center is a large, general-purpose building in the center of the MIT campus. During the summer of 1984 roughly one third of the fifth floor library was rennovated to make room for a Project Athena Cluster. The Student Center cluster is the largest Athena cluster, in terms of floor space, number of terminals and intensity of use.

The Student Center also provides users with the poorest quality of service: the timesharing computers regularly operate at a factor of *five to ten* times slower than machines in the other clusters. Accounts in the Student Center are given disk space storage quotas of 250 KBytes[11]; accounts elsewhere have quotas of 2500 KBytes. Students often have to wait in line to

[11] enough space to store approximately 30 pages of text.

Cluster	# VAX 11/750s	(# available for non-staff)[13]
Building 1	8	(6)
Building 11	6	(4)
Building 38	5	(4)
Building 66	7	(6)
Building E40[14]	8	(0)
Building W20[15]	6	(5)

Table 1: Then end of Phase I: Athena timesharing computers installed in October, 1986

use a terminal in this cluster[12]. Yet for many students the Student Center is the only computer resource available to them at MIT.

6.2 Fishbowl

All of MIT spreads out from a central hallway called "The Infinite Corridor." Every day, thousands of students, faculty and visitors to the Institute walk past the "Fishbowl," a large Project Athena terminal room on the Infinite Corridor.

The Fishbowl gets it name from the large glass windows it has for walls. Strategically located at a major intersection on the Infinite Corridor, every visitor and tour of the Institute passes the Fishbowl and peers in at the computers and the people. A large, $5-thousand wood cut sign proclaims the words "Project Athena." To many visitors, the Fishbowl represents Project Athena, the students and faculty inside the Fishbowl represent typical users of the Athena system. The irony is that, with the exception of a very small and privileged group, the great majority of MIT students are not permitted to use the Fishbowl. Like many other clusters (with the exception of the Student Center), the Fishbowl is frequently nearly empty.

The Fishbowl was one of the first Project Athena clusters; it was operational in the Spring of 1984. Naturally, only equipment from the Digital Equipment Corporation is present in the cluster. Faculty members from outside the School of Engineering walking by the Fishbowl have been continually reminded that while Digital delivered some equipment early in the experiment, IBM did not meet its original commitements. The fishbowl is often nearly empty, reminding students of Athena's inability or unwillingness to eventually distribute the load among the clusters.

[12] While terminals and computers in other clusters sit idle.

6.3 Class Structure

Among students, Project Athena has created a class structured society, dividing the students at MIT, like Gaul, into three parts. The defining characteristic of each of these classes is their accessibility to the Athena system. Every student at MIT has access to a personal account in the Student Center; students who are enrolled in Athena sponsored subjects receive an additional account, outside of the Student Center, for "coursework;" students who are employed directly by Project Athena as consultants, staff or programmers receive accounts on every Athena machine.

There is nothing unique in the annals of academic computing in the creation of a privileged class of students out of those employed by the computer center. What is unique about Project Athena is that it "rewards" students who are taking particular athena-sponsored subjects with a resource whose utility is applicable to all of the students other subjects and the use of which is unrestricted.[1]

For example, other schools which provide computer accounts to students in programming courses specifically forbid students from using those accounts for word processing.[16] Because Project Athena saw itself as supplying students with a general purpose, broad-based computing facility, it did not wish to label any use of the system as illigitimate,[1] as it could by restricting word processing to the Student Center Cluster. On the contrary, Project Athena has encouraged the use of the system for word processing by offering "minicourses" teaching students how to do wordprocessing on the system and by providing laser printers to print out the final papers. Thus, a student who received an account in the Building 66 cluster for a course in introductory computer programming was encouraged to use that same account to write humanities papers.

Unless a student is using a computer to play games or send mail, students are using computers for coursework. Project Athena's policy of restricting use of certain clusters to "Athena courses" discriminates against students enrolled in courses which the Project has not specifically sponsored.

In an attempt to out-step the limits of their class, there exists a significant number of students who register for athena sponsored subjects solely to obtain the Athena accounts which the subjects provide. These students cancel the courses a few weeks into the term. No good system exists to curtail this practice.

[16] For example, a student at the Brown Wang Computer Lab who uses a course account for word processing risks losing the account.

6.4 Courseware

One of the major goals of Project Athena has been the development of innovative educational courseware. Seven of the fourteen million raised so far has been allocated for courseware development. This courseware falls into three categories: specific tools, general tools, and teaching modules.

Specific tools are programs which operate experiments or facilitate data acquisition. IBM PC's provided by Athena have found their way into many of MIT's undergraduate labs. One procedure in the Chemistry Department's Advanced Chemical Instrumentation course (5.33) which used to require over five hours is now performed in minutes with the aid of a computer package funded by Project Athena. Utilized in this straightforward manner, computers have saved students thousands of hours of mindless manipulation. However, most of these applications are neither equipment nor software intensive. Further, few data acquisition routines are unique–there has been a ready market for years. As a result, specific tools have not been a major focus of Athena courseware development.

General tools are programs such as word processors, spreadsheets, and graphics packages. Like many specific tool applications, most of these programs have general appeal and have already been developed. Athena has not developed any general tools, although it has encouraged their use both in the Student Center and in several courses. However, only the Student Center is available for word processing or general number crunching.

Most of the money earmarked by Athena for courseware development has funded the development of teaching modules. These are futuristic programs meant to demonstrate some concept or process which is difficult to convey with normal teaching techniques. Specific examples range from "virtual laboratories" to "fancy calculators." Because all of these modules are subject-specific and the concept is new, there has been little development of these modules elsewhere. Module development has been primarily a process of invention. This process has been very equipment and labor intensive. The focus of most of the modules developed has not been to decrease student workload, but rather to teach something better than before, or to teach something never taught before. Student views of these modules range from uneasy tolerance to total disgust.[17] Because many of these modules are still in the developmental phase, used in classroom demonstrations or isolated exercises, most students tend to view them as superfluous.

The most facinating aspect courseware development is the way in which Athena's actions in the realm of software have resembled the general goals of the entire project. Most courseware development has focused upon the

[17] Do we have proof for this statement?

most ambitious task possible – the creation of teaching modules. Innovation has been sacrificed for invention. Module development is funded on a yearly basis, and continued funding requires a written proposal. It is insightful to note that these proposals are not submitted by educators, but "Co-Principal Investigators."[18]

The reasons for such ambitious software goals are embedded in the same perceptions which so greatly influenced the hardware decisions.

a **MIT's Mentality:**

There is nothing special about word processors or data acquisition systems. Teaching modules have never been developed before.

b **MIT Academic Incentives:**

In tenure decisions, research and not teaching is the first priority. The development of a successful module is a tangible creation, similar to a successful research project. True educational innovations are intangible, they have no permanence and they cannot be quoted or referenced. Further, educational innovation in the MIT classroom does nothing to increase MIT's prestige in the rest of the scientific world.

c **Faculty Bias:**

Since the courseware development program is very decentralized, it has no character of it's own. Courseware developed will tend to reflect the biases of the faculty. Since most of the faculty are self-selected researchers, they tend to view things in an inventive rather than innovative light.

d **Athena's Technical Bias:**

A humanities professor declare his subject an "Athena class" and get accounts on restricted clusters for his students to write their papers on, although this is certainly an academic use. Athena's definition of innovative discourages using computers to do something better, it encourages the use of computers for something new. Thus, in the competition for resources, word processing doesn't have the same appeal as a fluids module which demonstrates dimensional analysis, even though the utility of the former is certain.

[18] The title implies both how the professors view their role – as researchers, rather than educators – and that educational innovation is expected from these projects, but not before a great deal of research has been done.

7 Alternatives to Project Athena

7.1 Alternative #1: Personal Computers

It is not immediately clear what educational role a campus-wide fiber optic network serves, although the network is invariably mentioned in any formal or informal description of Project Athena. Electronic mail and instantaneous communication with other users of the system are fun, but they are also expensive distractions. Many of Athena's goals could have been satisfied if students carried their files with them on floppy disks or tapes, although such a system would have made the distribution of software and the management of the vast equipment resources much more difficult.

A logical extension of this approach would be to base MIT's educational innitiative on off-the-shelf personal computers such as the IBM PC/AT. Several schools have adopted this strategy (although most have adopted Apple's Macintosh computer rather than the PC/AT), requiring ever entering student to purchase the same computer. Special deals between the school and the manufacturer allow students to purchase the computers at substantial discounts.

Athena could still have developed fancy educational "courseware;" when a professor wanted to incorporate a program into a subject, he would distribute floppy disks containing the program which students could run either in public clusters or in the privacy of their own rooms.

This approach would have substantially minimized Project Athena's operational expenses, since students would have operated and maintained their own computers. However, this approach would also have locked students into an obsoleting hardware base and required all programs developed during the project to run on any piece of hardware ever sold to students.

7.2 Alternative #2: A campus-wide system of timesharing computers

Project Athena was divided into two "phases." The first phase was the creation of a campus-wide network and the installation of approximatley 50 VAX 11/750s. Phase II, which is just now starting, is the deployment of "workstations" around campus and the migration of user accounts from the timesharing computers to the workstations.

The goal of using workstations has dictated the form and intensity of much of Athena's system development. A significant effort was required

in order to make workstations usable. From the beginning, faculty and students have been told to view their accounts on the timesharing systems as transitionary. The effort spent by Project Athena to make the computational enviornment better was limited because the first generation of equipment was going to be soon replaced.

As an alternative, the MIT computers-in-education program could have been based solely on currently available timesharing system. This unexplored project could have upgraded or replaced its 11/750s with Digital's newest line of VAXes (the 8600 and 8800 series). These computers can support between four and ten times as many users; they would have solved Athena's overcrowding and performance problems. Such a decision would have been a statement that the project's sole goal was educational development, rather than to develop a triad of untried hardware, new systems software and educational software.

7.3 Alternative #3: Research only

Another option for research in computers and education at MIT could have been just that: keep the project a research project, without directly affecting current students. The pay-off of the project would be several years away, in the form of software, textbooks, and entire curriculumns which would hbe published and used at other univerties and high schools.

Students would be involved in the project to the extend that students are needed to test software and to be experimented on, but there would be no large-scale cluster such as the Student Center to unrealistically raise student expectations.

Some students would argue that, with the exception of the Student Center, project Athena is a "research only" project. Some publications by the Project have reinforced this goal. The difference is that a *stated* goal of Project Athena is educational innovation; the stated goal of a research project would be solely software development without intended wide-scale use within the MIT community.

From the perspective of the outside world, it does not matter if Athena affects every student at MIT or just a few. What matters is how much of the Athena software gets from MIT to the rest of the world. Of far secondary concern is how the project affects the caliber of students which MIT graduates durin gthe five years of the experiment.

A research-only project would have had greater flexibility, since it would not be important to consider wide-scale implementation of the programs

developed. Many more of the applications could have grown beyond the limits of the "standard Athena workstations." Although parts of Project Athena do match these descriptions, they are currently in the minority.

7.4 Alternative #4: No campus-wide program

MIT didn't have to have a campus-wide computers-in-education initiative, and if it did, that inititative didn't have to start in 1983. While advances in comoputer engineering are beginning to challenge assumptions of the past 30 years, there hasn't been a major revolution in microcomputers in the past five.

Without Project Athena, computers still would have been intergrated into the non-engineering aspects of the MIT curriculumn, but at a much slower pace. Some of the current participants in the Project might have been better off if they had waited two or five years before embarking on their programs in order to allow the computational environment time to settle.

8 Conclusions

Return to the football analogy:

What if the original lack of integration of new exercise equipment is simply due to scarcity of that equipment?

Consider what might happen if the coach were to open the new facilities to all the players, without first developing the optimum exercise routines. The staff could instead concentrate on giving all of the players more individual attention and encouraging them all to become familiar with the equipment. In time, players themselves may begin to develop new exercise routines. With so many more people familiar with the equipment, there will probably be a flurry of new ideas that the staff never would have considered. The time saved not having to wait to use the equipment may allow the players to perform a greater variety of exercises in a shorter amount of time, which may in turn result in a stronger football team with a superior attitude. Success may come much sooner than it will under a "research only" policy, eliciting with it widespread popular support for the use of modern equipment in football training.

Eventually, the coach may find that the team's marginal improvement due to the use of known exercise routines has peaked. The coach may decide to embark on a program to develop even

more effective workout methods. However, it is quite possible that the team can improve more by investment in some other aspect of their training. The goal of the jproject, after all, is to improve team performance, not to improve the utilization of high tech exercise equipment.

Will Project Athena be a success? In order for the project to succede, all of following criteria must be satisfied:

- 3M workstations must work.
- The technical barriers to establishing a network of workstations must be overcome.
- The faculty must develop courseware.
- The faculty must *use* the courseware they have developed.
- Students must accept the courseware.
- Students must learn from the courseware.

This is a very impressive set of requirements. Any alternative that MIT could have chosen for its computers in undergraduate education experiment would have reduced the chances for failure and increased the immediate innovative value. Such a program would also have decreased the amount of technical development necessary and decreased the amount of prestige derived from the project.

Athena is an ambitious long-term project with a potentially staggering payback. Yet, many of its proponents seem determined to focus attention on its educationally innovative aspects rather than its technical inventions. This is partly due to the conflicts between the perceptions of the participants and the physics of the process. Innovative uses of computers in education is a cause everyone can rally behind:

a For the general public, this is the long awaited next step in mankind's development. Anything done with a computer is almost by definition better. (Consider the popular commercial depicting a mother who genuinely fears for her son's educational future because he has not got a computer.) So long exploited by the intelligent, computers have since become synonomous with intelligence.

b For the major vendors, educational innovation opens up an entirely new market. The potential profits are substantial. In addition, since the general public prefers to hear about all of the wonderful things that computers will eventually do (instead of the current technical difficulties invloved in interfacing 2000 workstations), it is far better for these companies' public relations to emphasize the final product.

c For MIT, advantages of emphasizing educational aspects over developmental ones come from a variety of sources. First of all, in doing so they manage to please both the general public and the vendors. Secondly, it is much easier to raise money for an educational project than for the development of computer tools. Computers at MIT are old news, computer education is shiny and new. Third, this serves to placate an already overworked student body with promises of relief. Finally, emphasis of Athena's educational aspect may be reaction to prevent any conscription of Athena's capacity by any of the many computer-starved or computer science development groups at MIT. As Lerman says, "This could easily become a computer-science playpen, but it won't." [9]

d The student body is in favor of educational innovation for obvious reasons. In the short term, innovation to them means easier access to terminals for word processing, programming, data analysis, etc. allowing them to complete there assignments faster and better. In the far future, the development of teaching modules symbolizes the advent of a panacea for all of the shortcomings of the current educational process. In any event, they are the designated benefactors, and just like any heir, they want their inheritance now.

All of the parties involved with Project Athena recognize that it is an experiment. The laboratory is MIT, and the subject is the student body. This is ethically acceptable in the case of an attempt at educational innovation. But presented as a testbed for various educational uses of computers which are unlikely contribute in a substantial manner for another 15 years, Athena takes on a more controversial air.

CONCLUSION

Since the key driver of this conflict appears to be the decision to embark on such an ambitious program of development, one is led to question the motivations for such lofty goals. Computer innovation in education could have been accomplished by granting every student a MacIntosh at a fraction of the total cost of Athena. This would have eliminated most of the hardware and software difficulties, allowing all of MIT's resources to be concentrated on developing courseware. Of course, this would entail substantial limitations on future system capabilities. However, this approach has been

taken by other universities, and it certainly constitutes and acceptable educational innovation using computers. Why did MIT choose pursue their dream of fully-networked 3M workstations? There are a number of factors which played a prominent role:

a) The MIT Mentality: Project Athena gives the following words of advice to the frustrated Athena user:

"Athena will probably change your educational experience at MIT. Occasionally, you may experience some of the frustration that always is associated with being on the leading edge of a new technology. At times, the changes seem to occur far too slowly; at other times, they happen too quickly. Just remember that part of the reason you came to MIT was to be part of the excitement associated with the forefront of technology and science." (Lerman, Questions and Answers About Project Athena, 1986)

MIT views itself as a visionary institution. It does things first, it does them best, and it does them without help. For MIT to embark on any program other than the most ambitious one possible would be shirking "smart man's burden."

b) Funding Considerations: In addition to opening up a new educational market for the major vendors, Project Athena is doing a good deal of the initial development of software that the major companies would have to do at their own expense otherwise. 3M technology is a newcomer, untried and untested. No organization is going to invest a large amount of money in networked workstations until most of the bugs have been worked out. Thus, MIT is making a positive contribution to the value of a new product. No such benfits would be gained if this project were done with already proven personal computers like the IBM PC-AT.

c) Origins of Athena and the MIT Balance of Power: The initial interest in Project Athena came from the Electrical Engineering and Computer Science Department. Having taken the initiative, it was the senior faculty in this department that sculpted the final deal. Four of the main actors (Joel Moses–Head of the Electrical Engineering and Computer Science Department, Michael Dertouzos–Director of the Laboratory for Computer Science, Gerald Wilson–Dean of the School of Engineering, and Paul Gray–President of MIT) are currently or have been professors in the Electrical Engineering and Computer Science Department at MIT. Further, the EECS Department at MIT is by far the largest, with fully one third of the undergraduates majors. Thus, it is only natural that Project Athena settled on such sophisticated machinery. One wonders how the project would have been shaped had it been under the guidance of the Department of Humanities.

Athena's eventual goal envisions an environment allowing the student

to do all of his work, be it word processing, number crunching, or learning French, on a workstation linked to a campus-wide net. They have chosen to pursue this goal by developing the sophisticated learning software first. This has caused them to discourage the use of the network for more commonplace applications for fear it would impair the development of these teaching modules. The result of this heavy emphasis on long-range development has been a very unequal utilization of resources, as well much slower development of computer competence.

Simson's conclusions follow. What do you want to do with these?

Project Athena has systematically missallocated its resources resulting in tremendous overutilization of some clusters while others remain empty.

(these are not in any particular order yet)

Partitioning Project Athena into two parts – part devoted to the School of Engineering and part to serve the rest of the Institute – was almost definatley a mistake. Designating DEC to furnish equipment solely to the School of Engineering and IBM to serve the rest of the Institute further exacerbated the problem. This policy decision effectively made Athena projects outside of the School of Engineering second-class programs, continually waiting for equipment from IBM.

In much the same way that Athena's hardware deployment have been represented as innovative use of computer resources, the Project seems to think that the development of courseware is also an innovation: "How does Athena foster educational innovation? Athena sponsors curriculum development projects."[3] By definition, it is impossible for a development project to be innovative. A project may contain innovative processes or methods, but a true educational innovation would be more properly referred to as an "implementation project" – it would already have to be developed.

In 1983, Project Athena could comfortably accomidate both IBM and DEC because both of those vendors in the process of developing remarkably similar "3M" workstations. If MIT had chosen to adopt an innovative educational program based soley on timesharing systems, IBM would have been largely locked out as an equipment vender. Conversely, if MIT had decided to base an Athena-like project solely on high-performance, off-the-shelf affordable personal computers, DEC would have been locked out.

MIT's pioneering sprit forced the departments to consider and implement a campus-wide educational innititiave. Severe overcrowding in the undergraduate department of Electrical Engineering and Computer Science (EECS) led many observers to consider Project Athena to be a possible so-

lution to the problem[19] – a solution which brought computers to students who were not EECS majors.

Neither IBM nor DEC would have funded a program for installing conventional computers at MIT so that professors might develop educational software. One of the key attractive elements of Project Athena was that it would utilitze the next generation of computer hardware. As evidenced by Athena's development problems, there were substantual technical barriers to overcome before these systems were usable.

References

[1] Interview with Gregory Jackson. October 3 1986. A Harvard social scientist studying Project Athena.

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[9] Patricia Mandell. MIT's Project Athena. *PC Week*, November 1985.

[19] The faculty was specifically hesitent to adopt enrollement restrictions on the EECS department.