With the recent growth of the computer and informational sciences, and the corresponding growth of new ideas and methods in various disciplines, our society is rapidly discovering new ways of thinking about the world, and new ways of approaching traditional problems. For educational and research institutions, such as Cornell University, there is a unique potential for becoming a leader in this global change. However, in order for that potential to be realized, there are a great number of factors and ideas, which must be considered. Many of the initial structural issues, which are relevant to Cornell, have been outlined in the June 1999 report entitled 'Initial Report of the Task Force on Computing and Information Science: Cornell in the Information Age'.

I am pleased to find, via this report, an active interest in providing new structures and relationships which will encourage a new level of research and education in computer sciences at Cornell. In reading this report, I have discovered a great number of organizational and conceptual ideas, which I feel, will undoubtedly be helpful in creating a new home for computing at Cornell. These ideas, which have their expression in the newly proposed Faculty of Computing and Information (FCI), will be of great value if they can be successfully implemented. As a dual-degree student of Computer Science and Fine Arts who has struggled with the lack of contact between my disciplines for the past three years, I recognize the benefit of an academic structure which is not limited by departmental boundaries and which provides service and facilities to students and faculty in many disciplines. In relation to the FCI as a proposal for providing computing services to the Cornell community, I would like to emphasize my support for the overriding goals and concerns of the authors of this proposal. That is, to help make Cornell a leader in computational education and research and to allow both faculty and students an opportunity to participate in this global change.

As a response to this initial report, however, I would like to distinguish between two concepts which I feel need to be elaborated. That is, the distinction between the administrative structure of the FCI and the goals of this structure. The Initial Report has outlined many goals for the FCI, with the primary mission of creating "broad-based programs of education and research that span the campus." (p. 5). In this sentence, we find a statement of both structure and goal. However, since the success of the final program will depend largely on its goals, and its ability to meet these goals, I would like to elaborate and examine some of the goals found in the initial report. My hope is that in clarifying and understanding these goals, we will be in a better position to implement a successful program. I have organized these goals from least to most complex.

**Basic Computer Education**

The first and simplest goal which I would like to address is only briefly mentioned in the initial report. This goal, which I feel deserves additional attention, is summarized in the statement "Our students must learn how to think computationally, not just how to use computational tools - although the tools will be taught as a necessary prerequisite." (p. 17). This is a summary of two key goals of the Undergraduate Computing Program: the instruction of computing concepts, and the instruction of the computer as a tool.
I have frequently been approached by both faculty and students who explain that they have no prior knowledge of computers, yet are eager to be introduced to this tool. Unfortunately, it is likely that a significant number of faculty and students across campus are in this position. In these cases, the instruction of the computer as simply a tool will be the most beneficial as a first step.

In order to learn how to write well, one begins by making several initially crude attempts which gradually develop into a more fluent and creative style. Similarly, when one first approaches the computer, it is natural that the student (or faculty) moves slowly and demands explanation of every detail. This is the natural first step in studying any new tool which is unfamiliar. Unfortunately, the rapid pace of the computer revolution makes this type of interaction between the student and the tool very rare. As briefly mentioned in the initial report, the goal of a prerequisite course in computing would be to provide this introductory first step for faculty and students campus-wide.

In my opinion, such a prerequisite course should be considered with equal care and attention as the more complex goals of the FCI. The rapid acceptance of the computer as universal tool for society, coupled with the diverse backgrounds of student and faculty results in a large variety of understanding and knowledge about computers. We should not expect a freshman at Cornell who solves homework problems in mathematics by writing computer programs to be required to sit through a semester on how to use a word processor if he or she already knows how. Similarly, a student who has no prior knowledge with computers will benefit greatly from an instructor-guided introduction to computers in addition to having access to the tool. The beginner computer student must be shown the very basics of computer operation (i.e. how to make folders and copy files) with attention placed on that student's level of expertise and knowledge. In some cases, it may be beneficial to have trained undergraduate and graduate assistants who are already knowledgeable in computing involved in the teaching process, in order to allow faculty and staff to focus more effectively on the higher levels of computer education required by the FCI.

Although I feel that both computing as a concept, and the instruction of the computer as a tool are necessary and important aspects of computer education, it is difficult to speculate on which deserves more attention without a concrete study of the needs of the Cornell Community in this respect. At present, I am unaware of any recent assessment of needs within the Cornell Community which definitively answers this question. However, lacking such a study, it seems that both levels of computer education should be given equal attention and care in planning, so as to maximize the reach and effectiveness of the program to serve the entire community.

**Interdisciplinary Computer Education**

As outlined in the initial report, the goal of the Undergraduate Computing Program will be "to teach all students the fundamental ideas of computing and information systems, in a context where they can apply these ideas within their own areas of study." (p. 17). This goal differs from that of basic computer literacy in that the focus is on teaching concepts and ideas in computing as they relate to other disciplines, rather than the basics of how one uses a computer. On this goal, which appears to me to be the most important and complex of the goals of the FCI, I would like to make two key points.

The first point is that the FCI is a proposal for bringing together on a large scale, a variety of disciplines which have previously had little contact with one another. In the past, any education or research which has crossed departmental boundaries at Cornell was possible through the efforts of key faculty interested in branching away from their home disciplines. With the Information Revolution, we are discovering a new meeting ground of communication and discovery for many vastly different disciplines. The question is, what are the requirements for successful education of digital concepts
which cross such a variety of disciplines? The goal is to make the Undergraduate Computing Program flexible enough that it serves all disciplines in a way that is useful, interesting, and challenging to students and faculty.

The analogy of the Knights Writing Program may be helpful with this question as well. Although the mechanics of writing are well defined, the process of writing is universal in the sense that one can organize and write about any topic. In this process, the writer organizes concepts using intuition and creativity which eventually converge on expressing the desired idea. Similarly, the mechanics of the computer are rigidly defined, but the process of combining computer concepts and theory with other disciplines is a creative endeavor. In other words, because the crossing of computer science with other disciplines is still a relatively new process, there are no proven theories or methods for combining computer science with other fields. Nor is there any consensus on how one would combine the two in a classroom. Rather, one explores both fields in a creative way and arrives at some new idea or theory which combines the two. This new method or theory is then tested, modified, and reworked like any other creative design process.

My first point, and recommendation, is that a great deal of flexibility be given to the requirements and suggestions which the FCI places on the departments which wish to offer introductory computer science courses in their fields. A successful inter-disciplinary teaching plan is one which will involve real, on-going communication and dialog between the FCI and professors in other disciplines, rather than a set of requirements which must be met by various disciplines wishing to offer computer science in their field. This essential need for communication may mean focusing more on faculty education, which I will discuss below.

Where my first point speaks to the relationship between the FCI and the professor of a given discipline, my second point will be to address the "lack of contact between students and faculty." (p. 18). I find it surprising that the initial report offers only a brief explanation and resolution for this critical problem. From my experience at Cornell, I have found communication between students and faculty to be the key to a healthy and enjoyable educational experience for both. For this reason, I would like to address this issue by looking at the perspective of both faculty and students. I understand that it is impossible for me to provide a completely objective view, yet my sincere hope is that by initiating a dialog, we may begin to understand and resolve this problem. In the process, I will suggest that active communication between faculty and students is necessary for the successful education of computers in an interdisciplinary context.

From my interactions with faculty at Cornell, and from my communication with other students, I find a common argument against student-faculty interaction being that students may sit quietly in a classroom while the professor attempts to explain a certain topic without showing any real interest (by not speaking up). Certainly there are exceptions, but we must begin somewhere, and in my experience most faculty would agree with this observation. Similarly, from my interactions with the students at Cornell, a common argument among students is they are not permitted to learn what they would like. Some students may disagree, yet I believe that the majority of students would agree with this observation as well (although not in the presence of a professor or on an official survey, of course). The idea that students are permitted to take whatever classes they choose is countered by the fact that for the majority of undergraduate students, their time is spent fulfilling required courses in which the class material was the primary concern rather than the interests of the students. Clearly there are many subtle arguments here, but in my opinion, the arguments of students and faculty are two sides of the same coin. Together, we must begin to understand the issues involved and to reach for a solution. I believe that in such a solution the task of establishing and maintaining a real, continuous connection
between faculty and students will prove more important than the process of presenting and absorbing new material, even in large classes.

These arguments, and their resolution, may be understood by looking at the theory of education upon which Cornell University (and the majority of colleges and universities across the nation) is based, and their relation to the current changes and trends in the digital revolution. The traditional method of education, which has served Cornell University well in the past, approaches the student as an individual who comes to the university as a "clean slate", with a drive to learn, and the willingness to take in whatever knowledge is offered by the university. The role of the teacher in this process is to provide the student with the knowledge that they have acquired in their field through experience and education. The result is lecture-based education, where students are expected to listen while the instructor is expected to explain a predetermined topic. This is still the format of most classes at Cornell.

In the new Information Revolution, however, we are experiencing a rapid growth of new ideas and theories which are the result of an on-going process of discovery. In this processes of discovery, which is currently driving the information age, new knowledge and ideas are emerging at an ever growing pace. This is also the reason why "entering students often know more about computing tools than the faculty who are teaching them." The computer, as a conceptual tool, places no inherent limits on its ability to express and enhance whatever ideas we choose to explore. Thus, anyone with a creative idea and a minimum level of computer skill will be able to realize their ideas if sufficiently driven.

Through the context of global social change and creativity brought about by the computer revolution, we may begin to understand the issues involved in student-faculty communication. The students, in a society where exploration and discovery are of key importance, do not wish to be limited to the predefined knowledge of their instructors. In the same context, faculty would like to see an increased interest in exploration and discovery of historical knowledge which is the cornerstone of present knowledge.

Because the students and faculty are indivisible parts of the single process of learning, I suspect the answer to this problem lies in a balance. Clearly a student of Theoretical Physics will not be able to participate at the forefront of his or her field without a firm background in the historical knowledge of atomic models and quantum mechanics. And yet, a student will likely have equal difficulty in really understanding and grasping these concepts if they are unable to explore and demonstrate these ideas to themselves in a creative setting - through freely exploring examples. It is understandable that a student which has neither the time, nor the guidance to creatively explore a process or idea will most likely feel discouragement to continue. Both the historical knowledge of a discipline and the creative process of exploration seem essential to a successful education.

Now let us apply this idea to interdisciplinary computer education. Because of the newness of interdisciplinary computer education, there exists little or no historical knowledge on the subject of computer theory in relation to other disciplines. What exists is a collection of examples which combine computer science with other disciplines (some examples are described in the initial report on page sixteen), but no widely accepted general theory of how to apply computer education generally. Certainly the various disciplines themselves contain a great deal of historical knowledge and content. The field of computer science as an independent field also has a brief but very dense history. At present, the creative process of exploration rather than a historical framework is leading the way in the application of computer theory to other disciplines.
For this reason, I would suggest that interdisciplinary computer education focus on the exploration of creative processes which combine computer education and other disciplines, rather than attempting to define a syllabus of important concepts and theories to be taught to the students for each discipline. Because of these concerns, I believe that any interdisciplinary course in computer theory will not succeed unless the creative interests of the students and communication between students and faculty are the primary focus. In terms of the functions of the FCI, this would translate into a conscious effort to encourage project-based, rather than lecture-based interdisciplinary courses, and an organization of goals and projects which are based on feedback and communication with students rather than a rigid syllabus.

**Teacher Education**

As mentioned above, the theoretical combination of computer science with other disciplines is a relatively new and exciting process. For this reason, we must recognize that the experts of these new theories are just now emerging. As the initial report mentions, "One pressing challenge is the need for the faculty to stay ahead of, or in many cases to catch up with, the students." (p.2) The issue raised is that most faculty at Cornell, and all over the country, are just now being introduced to these new ideas and theories, and so, in this respect, the faculty in many disciplines are on an equal footing with their students.

The reason for this can be understood from the existing structural models of universities, given on page three of the Initial Report. Specifically, it is mentioned that many disciplines at Cornell operate using the departmental model. Each department operates independently of the others, and provides a framework and foundation for faculty to education and research ideas in a specific discipline. Since this structure and method has become the standard for higher education in America, I suspect that the majority of faculty presently teaching at the college level were educated under this model. Thus, most faculty presently teaching at the college level have had little encouragement and experience in their own education to explore interdisciplinary methods and ideas except when they pursued them independently. This can be considered another disadvantage of the departmental model for higher education.

This fact raises two important issues. First, it demonstrates the necessity of teacher education regarding interdisciplinary education as well as computer education in general. And secondly, it suggests another reason for caution regarding the policies and methods of interdisciplinary education.

On the issue of teacher education, I would like to make one point. For those professors who have little or no prior knowledge of interdisciplinary education or computer concepts, the primary means of education are still the most important. One gains the most experience of a process or tool through hands on experience and interaction, just as the beginning student. We should expect to instruct professors on the use of computers using the same methods that students expect of their professors. That is, the facilities and environment in which to explore ideas and tools freely, with a minimum of requirements or restrictions. In terms of a recommendation for the FCI, this would translate into a general faculty-training program with no expectations placed on the faculty, and no concrete policy of what the teacher should or should not be required to learn. The focus being, instead, on hands-on experience which is guided by someone knowledgeable in computers capable of providing information and direction when it is desired. Due to rapid advances in technology, there is an unfortunate tendency in computer education for instructors to proceed at a pace well beyond the immediate attention and ability of the student (or professor). I have observed this phenomenon in the computer education of professors as well as students.
On the issue of policies and methods of interdisciplinary education, the fact that most teachers are unfamiliar with methods of interdisciplinary education, and ways of combining their discipline with other disciplines, suggests that policy regarding interdisciplinary education should proceed cautiously. As mentioned above, there is a general tendency to approach education by having a predetermined syllabus and set of concepts and ideas which are used to instruct the student. However, present interdisciplinary study defies this approach since it has no specific method, but rather evolves through a process of discovery and experimentation. Despite the desire to create a syllabus for combining computer theory with other fields, we may have greater success by focusing on the process itself in the classroom and encouraging project-based classes.

In increasingly frequent cases where a student's need to explore is hindered by the method and syllabus of the lecture-based approach, the result is a great deal of hidden frustration and lack of interest on the part of the student. Unfortunately, the large number of demands placed on faculty time for teaching, research, and meetings as well as the limited time available to students make it increasingly difficult to find time for faculty and students to resolve these issues together. Yet the need for student and faculty to move towards a common goal in the learning process may be the most important task of all, and cannot be resolved until time is found for its resolution.

Because of recent trends in the digital revolution, and the increased availability of computing tools and resources, students are often the ones to present new ideas and concepts which incorporate computing science with other fields. This is yet another reason why interdisciplinary education must proceed from the needs and interests of the students rather than a fixed syllabus with a set of fixed requirements. If the goal of the FCI is to provide the best possible education in interdisciplinary studies, and to combine computer technology with other disciplines, it will be the job of the FCI to overcome this limitation and encourage a new approach to teaching in the classroom.

**Research**

As a research institution, Cornell University is, I believe, in an excellent position to take advantage of the opportunities in research and development of digital and computational concepts. Again, the goal of the university in this respect is of primary importance. If Cornell wishes for a few key faculty to lead the way in interdisciplinary and computation research, then it must find some way to attract and retain those key faculty involved in such research. This cannot be accomplished unless Cornell can provide an atmosphere and environment which is already sufficiently knowledgeable in digital and computational thinking. Thus, general campus-wide education becomes the prerequisite for providing a flexible and interesting research atmosphere.

If, instead, Cornell wishes for the whole of the Cornell community to be involved in interdisciplinary research with digital technology and concepts rather than a few key faculty, then it must consider the problems of campus-wide computer education from the very beginning. Research, as described above, is the exploration of a new process. This, of course, assumes a sufficient background knowledge and education of supporting concepts. Cornell has the potential to become a leader in interdisciplinary and computation research across the entire campus, but only after sufficient education has moved it into that position.

I would like to make one last point regarding research. It is clear that research and development are leading the way in digital and computational technology in our culture. Yet without education, civilization in general suffers the consequences of misunderstanding and misapplying new technology. The American ideal that any individual, or group, may survive and eventually succeed by developing and researching new concepts and inventions has the obvious effect of isolating individuals and
groups, and encouraging competition. Unfortunately, the concepts of isolation and competition do not
acknowledge the fact that civilization is a collection of members whose overall success and survival
depends on a balanced interaction of its members and an intelligent use of its resources. Considered in
another way, research encourages the success of individuals and groups, while education and
communication seek a balanced understanding and relationship among all members of society.

For these reasons, I would maintain that education and communication, rather than research and
development, are becoming increasingly important not to the progress of our society, but to its
survival.

**University Goals**

In addressing the goals of the FCI, it is also necessary to consider the larger goals of the university
under which the FCI will operate. These goal include, but are not limited to, the need to provide the
highest quality of education and research possible, the "need to attract and retain outstanding faculty in
core CIS disciplines" as well as other disciplines, the ability to attract funding and support outside of
the university, and need for administrative structures to operate as efficiently and effectively as
possible. The first goal, providing the highest quality of education and research possible, has been
addressed in the preceding sections. The other university goals will be addressed now.

The second university level goal, stated on page two of the Initial Report, is the "need to attract and
retain outstanding faculty in core CIS." As the Initial Report mentions, the primary barrier to attaining
this goal is the difficulty in providing the intellectual challenge, creative environment, and financial
support which can be found in industry jobs. The fact that universities "cannot match the financial
opportunities in industry" means that they must create an environment which is "more intellectually
stimulating" if they are to succeed in the goal of attracting students and faculty. The benefit that a
university has over industry is that it can explore and educate on a much broader range of disciplines in
a much more tightly knit community. Thus, the solution to the "goal to attract and retain outstanding
faculty" is synonymous with the need to provide the highest quality of education possible. This is done
by exploring and understanding the subtleties and issues involved in interdisciplinary education.

The third university level goal is the ability to attract funding and support outside of the university. All
means of funding, including educational grants, alumni, and business and industry level donors will
involve demonstrating that Cornell is committed to the highest level of excellence in computing and
interdisciplinary education. As mentioned in the initial report, "many alumni recognize, perhaps better
than we do ourselves, the broad impact of computing and information science on our economy and our
culture" (p.11). Thus, the challenge of attracting funding and support has already begun. What remains
to be demonstrated by the university is a commitment to exploring and addressing education and
research of these issues, and their impact on our culture. Unfortunately, since Cornell is just beginning
to address the problem of interdisciplinary computer education, it is difficult to show Cornell's degree
of commitment. In the initial stages of such a program, what can be demonstrated is a sincere effort to
understand and address the problems of education and research of computer concepts. This means
questioning current methods of education and developing and exploring more flexible methods which
can encompass the challenge of interdisciplinary computer education. One gains attention by providing
something useful and valuable to a larger community. As long as this is the primary focus, funding will
follow as a matter of course, and the demonstration of a commitment to excellence for outside sources
will naturally follow.

The final university level goal is the need to operate as efficiently and effectively as possible. For the
FCI, this is briefly stated as "the need for any new structure to be lightweight, not having a large
administrative structure." (p.8). This recommendation is important when considering the above discussions on the nature and need for flexible programs and methods of teaching. The ability for an administrative structure to operate efficiently, however, despite its size, depends primarily on a clear definition of its functions and a means of carrying out those functions. In the case of the FCI, the function will be to provide education, research, and facilities for faculty and students from a variety of disciplines. This requires a thorough understanding of the needs and issues related to computational education and research. Thus, in summarizing the administrative goals of a university, we find the solutions are all identical. The ability to provide a flexible, efficient, well-funded, and attractive program in interdisciplinary computer education depends on exploring, and finding a solution to, the problems of a flexible classroom environment, educating computer concepts, and the student-teacher relationship. The more that this is possible, through a subtle understanding and resolution of these issues, the more successful the result. I am confident that Cornell University will become a leader in interdisciplinary digital education and research, if it applies itself to these problems wisely.

Starting Points

The goals described above, and an examination of their solutions, are the tasks which the supporters of the FCI have set out for themselves. In my opinion, the FCI will not function unless these goals, and their solutions are clearly resolved before the implementation of the FCI takes place. However, this should not prevent us from taking action immediately in order to address the challenge. As mentioned in the Initial Report, the present step is to "solicit reactions and suggestions" in order to understand the goals and the issues involved. Our ability to understand and resolve these subtle issues will directly effect the productivity and effectiveness of the FCI.

Several starting points have been suggested for the proposed FCI. These include having "some initially joint appointments with a limited term" (p.6), expecting the Dean of the FCI to have "some teaching and research responsibilities" (p.8), and creating an "Undergraduate Computing Program" (p. 17) in order to address the basic needs of students and faculty in computer education. Although these starting points depend on the approval of the FCI proposal for funding, the primary challenge of understanding the issues and goals involved and the subtlety of their solutions requires only time and effort.

Of the starting points mentioned above, I would like to address only the first. All others seem very reasonable and excellent first steps for the FCI once it is in place. The need for initial joint appointments with a limited term is also an excellent first step, in my opinion, if the conditions and issues related to its success are resolved before the first class begins. In these initial stages, it is likely that the issues of how to teach interdisciplinary education with computer concepts, how to provide a flexible, creative environment, and how to increase communication between students and teachers will need to be resolved by the professors involved in the class itself. Since these initial joint appointments will serve as pilots for the larger structure of the FCI, it is necessary that as much can be learned about these underlying problems as possible. We must also evaluate them fairly and closely, with as much communication and feedback with students as possible. If students seems dismissive or lacking in interest, it is most likely that the underlying goals and needs of interdisciplinary education have not been met (from my perspective, students show an enormous interest in computer-related topics when they are taught in a creative, flexible setting).

Overall, the most important aspect of this initial process will be communication between the students, faculty, and administrators involved. Thus, if communication fails in the classroom, every effort must be made to understand why it has failed, and to modify the proposed FCI accordingly. I am confident that through a careful analysis of educational methods, and the real needs of the students and faculty, Cornell can become the leader in this new and challenging area.
Conclusions

What the Initial Report demonstrates, and what the concept of interdisciplinary education suggests, is the need for a more holistic approach to education. This means a flexible, carefully maintained policy which allows a great deal of freedom and creativity at the classroom level. Unfortunately, there is a tendency at large institutions for the policy to be determined through a process of refinement from the highest levels of administration to the professors who teach the classes. At the highest level of administration, broad (non-specific) policies are established in order to encompass all disciplines, materials and approaches. At the departmental level, the content is partially filled in while the method of instruction remains flexible. At the classroom level, the content and method are finalized by the instructors. Thus, because of the lack of teacher experience with interdisciplinary education and computing tools described above, the result will not be a holistic approach to education of these new concepts.

There must be a conscious effort to separate the content of education from the method. That is, I believe it is acceptable and necessary for the administration to implement an open policy on the material that is taught in the classroom in order to cover all possible disciplines and ideas which will be taught. However, it is equally important for the administration to implement some real and specific policy regarding the method of instruction. As stated above, by leaving the method of education entirely in the hands of professors and faculty, there will be a tendency towards a lecture-based classroom with a rigid syllabus which is contrary to the process of interdisciplinary studies and the digital revolution.

In summary, my hope is that this response will address many of the goals outlined in the Initial Report on "Cornell in the Information Age," in order to understand some of the subtle, yet critical, aspects of implementing these goals for Cornell University. In the process, I have outlined some important issues and consequences relating to these goals, such as the need to address students interests, the relationship between the faculty and students, the role of the administration in making policy, and the organizations tendencies of large institutions in the lack of explicit policy. Although these issues have been raised in order to explore the foundation of educational methods and policies regarding interdisciplinary and computer education, my goal is the same. That is, to provide Cornell University with "broad-based programs of education and research that span the campus" and the best possible educational experience to students and faculty.
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