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Factors Affecting the Adoption of Faculty-Developed Academic Software: A Study of Five iCampus Projects

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Factors Affecting the Adoption of Faculty-Developed Academic Software: A Study of Five iCampus Projects

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Abstract - **Instruction in higher education must adapt more rapidly to: changes in workforce needs, global issues, advances in disciplines, and resource constraints. The pace of such improvement depends on the speed with which new ideas and materials are adopted across institutions. In 1999 Microsoft pledged $25 million and staff support for iCampus, a seven-year MIT project to develop pioneering uses of educational technology. The TLT Group studied five iCampus projects in order to identify factors affecting institutionalization and widespread dissemination. Among the factors impeding adoption: lack of rewards and support for faculty to adopt innovations; faculty isolation; and a lack of attention to adoption issues among projects selected for funding. The study made recommendations for universities, foundations, government agencies and corporations: 1) continue making education more authentic, active, collaborative, and feedback-rich; 2) create demand to adopt ideas and materials from other sources by encouraging all faculty members to improve and document learning in their programs, year after year; 3) nurture coalitions for instructional improvement, across and within institutions; 4) create more effective higher education – corporate alliances; and 5) improve institutional services to support faculty in educational design, software development, assessment methods, formative evaluation, and/or in sharing ideas with others who teach comparable courses.**

Index Terms – dissemination of grant-funded projects; institutionalization of innovation; open source software; faculty roles and rewards, active learning, authentic learning

iCampus: The MIT-Microsoft Alliance

"Initiated in 1999, iCampus is a research collaboration between Microsoft Research and MIT whose goal is to create and demonstrate technologies with the potential for revolutionary change throughout the university curriculum." [1] The program was made possible by a $25 million research grant from Microsoft to MIT and involved extensive collaboration between MIT and Microsoft staff. Between 1999 and 2006, iCampus supported 26 faculty research projects and an additional 30 independent student projects. iCampus's sponsored research at MIT came to a close in June 2007, but dissemination of iCampus materials continues.

In late 2005, The Teaching, Learning and Technology Group, a not-for-profit organization, was asked, "In light of the experience of iCampus, especially those projects selected by MIT and Microsoft for close study, what can be learned about priorities for educational technology initiatives in the future and about how the spread of such innovations can be more effectively supported?"

The history of innovation in higher education abounds with large-scale faculty-developed that have had great success as pilot tests, but that failed to be widely adopted. So The TLT Group and iCampus decided to focus this study on five quite different iCampus projects that had already achieved favorable evaluation results and some degree of institutionalization and wider use. We wanted to study why institutionalization and widespread adoption were not more common, even in seemingly ideal circumstances.

The study team reviewed project documents and conducted more than 150 interviews with faculty members, staff and students at MIT and other institutions.

The five selected projects were:

1. iLabs – students can use web browsers to run experiments and collect data from distant laboratory equipment; a single piece of laboratory equipment can be shared by students in entire course, or several courses, anywhere on the Web. iCampus support of iLabs development focused on infrastructure that makes it easier for faculty to develop and share iLabs across institutional boundaries.
2. iMOAT – the Web is used to manage the process of large-scale assessment of student writing. Students use the Web download readings and essay questions, then later upload their writing. The software also manages the routing of essays to human readers and the processing of results. iMOAT software and staff are

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now supported financially by a consortium of user institutions, who get reliable service.

3. TEAL –introductory physics, MIT's largest lecture subject, were totally redesigned around inquiry, discussion, experimentation, and visualization to eliminate traditional lectures in favor of studio-mode instruction based on work at RPI and NCSU [2]; iCampus funding mainly supported development of tools for visualizing abstract physical phenomena such as electromagnetic fields.
4. XMAS – a rich media authoring tool allowing students to 'quote' video clips from movies legally in their online discussions, presentations, and projects in Shakespeare and film courses. XMAS can also be used to view and share video clips in other applications;
5. xTutor developed two computer science courses for which it provides homework assignments that can be graded automatically online with feedback to students, online lectures, and other resources. An authoring package is still under development that would make it easier for adopting faculty to use xTutor to modify these courses and to create their own.

This article summarizes and extends several of the findings and recommendations from The TLT Group's final report [3].

PROJECTS ARE WORTHY OF ADOPTION

As detailed in [3], the five selected projects did indeed have a substantial impact at MIT in their original forms. For example, TEAL reshaped one of MIT's core requirements, and produced lasting effects on students' conceptual command of physics, and iMOAT was used to assess the writing of most incoming first year students. The other three projects affected smaller numbers of students but each had convincing evaluation results, and attracted attention outside the Institute. By the end of 2006, each project's open-source software was freely available for use and modification by other institutions.

ADOPTION IS NOT EASY

MIT allocated about 10% of its grant from Microsoft – about $2.5 million in year four of the project – to promoting widespread adoption of iCampus projects. The funds went to making the software easier to use, documentation, travel for dissemination purposes, publications, a conference at MIT, web materials, and making small grants available to other institutions. The process of adoption outside MIT was presumably also fostered by the visibility of MIT's Open CourseWare program, which makes MIT course materials freely available around the world. [4]

Nonetheless the process of adoption is proceding slowly and unevenly, inside MIT and outside. Although there are roughly 10,000 institutions in the world, each of the five iCampus projects was in use, on average, by only about 10 institutions by the end of 2006, and those numbers are increasingly slowly. Why are some adoptions happening? What factors impede diffusion? And what changes in policy might accelerate the pace? Our interviews with project staff, adopters, and others who decided not to adopt were revealing.

PROJECT CHARACTERISTICS THAT AFFECT CHANCES FOR ADOPTION

Some technology development projects are more likely to be adopted than others, because of their intrinsic characteristics. Our study identified several such characteristics. Here are a few:

Recognizability: Potential adopters will notice and understand an innovation more quickly when it's a good fit with ideas and needs already in wide discussion. All five projects were easier to explain because of wider changes in the world (e.g., uses of the Web for buying products, doing research in class).

Value, or at least legitimacy, needs to be sufficient **for all the stakeholders** who are needed to implement the innovation and sustain it, e.g., faculty, IT support staff, institutional leaders in some cases, faculty development program. For example, XMAS's strategy for allowing clips from movies to be used legally requires that the user have the DVD in the drive of his or her PC; the software then brings up the clip that the author wants the viewer to see. So a limit to the use of XMAS is the ability for the viewer to get the DVD(s) that have been quoted in a paper, presentation or online discussion. The obvious place to share such DVDs is in the college's library. The library must therefore maintain a collection of reserved DVDs plus computers equipped with DVD drives and XMAS. So it was crucial that XMAS attracted the attention not just of faculty but also of librarians. These librarians saw wider value in developing facilities with computers and a reserve collection of DVDs.

Flexibility and multiple uses so that more innovators are likely to find (or even invent) a use that then deeply engages them. Louisiana State University realized it could use iMOAT to do mass assessment of writing at the end of the freshman year and, in fact, this is its main use of iMOAT today. We expect to see iMOAT use expand to other applications as well.

Conceiving of the innovation as a *service* for use and adoption, not just as a technology for dissemination. Most people think of innovations such as these as 'technology': as software or hardware. This has been called 'rapture of the technology': by focusing too much on the technology per se, conditions are created that lead failure in the use of the technology. [5] CalTech was part of the original consortium of institutions that helped MIT develop iMOAT (see below for more about this innovative strategy). Because CalTech initially conceived of iMOAT as a product, once iMOAT was complete and the iMOAT consortium asked its members to pay an annual fee to support the software, CalTech staff decided they could do better by designing their own software. Later, however, they realized value of the iMOAT consortium benefits, 24x7 service with high reliability and tech support. iMOAT was also maintaining the software, while the programmer at CalTech was no longer available. At that point, CalTech rejoined the Consortium.

Ease of use for faculty, students, and support staff. XMAS, for example, was easy enough to use that at least one adopter needed no help from the technical staff at her institution. Other projects required more effort for successful use; TEAL was at the other end of the scale because it required extensive classroom renovation and equipment, laboratory support, and a style of teaching and learning quite different from what more faculty and students were used to.

Incremental adoption possible: Some projects can be adopted incrementally. Each step has rewarding results and provides increased incentive and experience for taking the next step. With TEAL, for example, a faculty adopter could first try just one or two TEAL simulations, or homework assignments. This step-by-step approach could create a foundation for more ambitious next steps in reforming physics instruction.

Affordability (money, time). An innovation is more appealing when it can improve learning while also saving money that is needed elsewhere. Faculty find curricular innovations especially appealing when they can help with important elements of teaching while also saving faculty (and students) time. Faculty members using the xTutor Scheme course at the University of Queensland eagerly cited its value for helping them shift class time away from lecturing and toward problem-solving, discussion and coaching. iMOAT saved participating universities time during freshman orientation that would otherwise have to be used for testing and assessing student writing.

The ability of undergraduates to play a role in developing or adopting the innovation, both to help faculty and to demonstrate that implementation is feasible. The University of Queensland's engagement in the use and promotion of iLabs was triggered when an undergraduate with little supervision downloaded the Shared Architecture and then developed an iLab for a local experiment. UQ made this project, and Joel Carpenter's role in its development, a highlight of a major university event. At least one UQ faculty member reported that, while he had initially been reluctant to get involved in developing an iLab, when he saw that an undergraduate could do it, it became obvious it would be feasible for the faculty member to spend the time, too.

Projects that, when they run into difficulty, 'fail gracefully' [6] By failing gracefully we mean that, when the implementation is imperfect, there are still gains and the faculty member hasn't been subjected to a total breakdown of the course. We can explain this point best with a counter-example. TEAL marked a new way of teaching physics for most faculty members, and a new way of learning physics for most students. TEAL was initially developed for the second term of the general institute requirement in physics: electricity and magnetism. The pilot tests of TEAL were quite successful. But the first time that MIT required that all students taking electricity and magnetism take the TEAL version of the course, many students resented it intensely. One reason: attendance was a virtual requirement (because collaboration is key to the TEAL approach to teaching and assessment). This controversy drew substantial attention to TEAL. Several years later, the fading echoes of that initial resistance were still being passed along to new generations of first year students, despite the fact that evaluation shows substantial short-term and long-term improvement in the learning of physics, compared with previous approaches to teaching the course and despite the fact student ratings of the course have steadily improved since that initial offering and are now comparable to other courses. The department has now converted both semesters of introductory physics to the TEAL approach. But the faculty involved in that first offering of TEAL still wince at the memory.

Faculty members have a right to be uneasy about innovations that pose such risks. In contrast, when a faculty member at Mount Holyoke first tried XMAS in support of a single lecture, and things were awkward, the failure didn't ruin the faculty member's semester and enough good things happened that the faculty member tried again the next term. TEAL materials too have been tried piecemeal initially, with little risk. But we note that none of the iCampus outreach materials described low risk, incremental pathways for adopting the innovation in ways that, if there was failure at any step, it would be 'graceful.' iCampus left it to adopters to invent ways to prudently adopt its software and ideas.

COALITIONS FOR INSTRUCTIONAL IMPROVEMENT CAN SUPPORT DIFFUSION OF IDEAS, MATERIALS

An innovation's characteristics are not the only factors that affect its chances for institutionalization and widespread adoption. "Build a better mousetrap and the world will beat a path to your door" does not reflect what happened to these five projects.

Through study of the iCampus projects we came to understand more deeply the importance of peer-peer relationships in the adoption process. A concept such as legal use of video clips in student projects and presentations (XMAS) or sharing of lab equipment across time and space (iLabs) may seem interdisciplinary. But it is far, far easier for a faculty member to adopt a new idea if he or she learns about it from a peer who has already had success with the idea and software when teaching a similar course to similar students.

We noticed that, when adoptions happened, there was usually a substrate of relationships – trusting relationships that had developed around teaching – on which the adoption process could build. These relationships made it easier, and more comfortable, for the Principal Investigators (PIs) and iCampus staff to demonstrate their ideas and materials, and offer them for wider use. We stress issues such as comfort and trust, because, in our interviews, it was apparent that many faculty members ordinarily felt uncomfortable at risking being seen as pushing their ideas onto colleagues. We realized that many faculty saw it as risky to be seen as telling other faculty that their teaching might need to be improved. In contrast, when a pattern of previous interactions around teaching could make it comfortable and routine to discuss innovations and share help in their use, the adoption process could flow far more easily. If the relationship revolved around subject matter that all the partners taught, the discussion was easier yet: the participants likely shared assumptions and the ideas could be adopted with far less time and risk. We termed these networks of relationships *coalitions for instructional improvement* because they were defined by their shared interest in teaching something, and teaching it well.

The easiest adoption successes came from coalitions in which the PI had been active before the iCampus project, especially if the PI had a history of making contributions of this sort in the past. For example, the XMAS PI had long been prominent as a pioneer in using video clips to aid the study of Shakespeare in performance. He had been a keynote speaker at the Shakespeare Association of America and had led workshops in the yeas before receiving the XMAS grant from iCampus. So when XMAS was ready to share, he had ready-made mailing lists, he was familiar with the Shakespeare Association listserv. And, when Shakespeare faculty received his e-mails, they were likely to know who he was and to believe he was a credible resource. When such a PI announces that he has made another step forward and people can freely use it, many peers pay attention.

One of the most surprising types of coalition existed inside MIT and aided internal dissemination and institutionalization. It is a strategy for organizing the teaching of large, multi-section courses, and begins with the fact that, at MIT, sections are usually taught by faculty members, not graduate students alone. In the Department of Electrical Engineering and Computer Science (EECS), for example, a team of faculty often shares the teaching of such a course over a period of years, rotating the responsibility for leading the course. Each week the instructional team (professors, teaching assistants, and in some instances undergraduate representatives of sections) meet to discuss the last week's events and to plan the next week. So when an innovation such as iLab is made in the course, everyone gets a chance to see it in action and to share notes about how it's working. This continual constructive discussion seems to have made it much easier for faculty to learn about, appreciate and sometimes adopt innovations introduced by one of their number. What all these coalitions have in common is that they made it easier for ideas to be tested and shared, even though this was often not the primary objective of the coalition.

These pre-existing engagements had other profound impacts, e.g., motivation to develop a project that would benefit and impress this peer group; ability to use the group's communications channels to spread the word about the innovation.

These existing relationships formed a substrate on which more adoption-oriented relationships could be built. The PI of iMOAT invited other members of the Writing Program Administrators community to join him in developing the specifications for iMOAT and, later, to test it. MIT would provide travel support for meetings at MIT, and there would be no obligation to use the resulting software. Their participation resulted in software and services more likely to meet their needs and also predisposed them to budget the dues needed later on to sustain the program.

Another example: iCampus exploited MIT's educational relationships with other universities around the world in order to create collaborations for adoption. The Cambridge-MIT Alliance provided a set of discussions that led to an early collaborative use of chemical engineering iLabs at both institutions. The Singapore-MIT Alliance led to use of MIT iLabs in Asia. MIT International Science and Technology Initiatives (MISTI) helps MIT students do academic work abroad. iCampus made use of MISTI to send MIT students to China to help spread the use of iLabs and other iCampus innovations; an unexpected side benefit was the discovery by a MISTI undergraduate of a major iLabs-style development project at Zhejiang University, and subsequent collaboration between MIT and Zhejiang.

Where such coalitions for instructional improvement did not already exist, iCampus attempted to create them. iCampus recruited "hub" institutions around the world, who agreed to work with MIT on testing iCampus projects. In exchange for extra help from MIT, the hub would disseminate the innovations to other institutions in their region and help them during adoption. Most of these networks failed to accomplish the hoped-for results, although a few hubs, such as the University of Queensland (UQ) and National Chung Cheng University, had some success. One problem: these networks were defined as 'iCampus' (an unknown brand) and 'MIT' rather than by some widely felt need (e.g., 'enriching and extending laboratory experiences' or even 'active learning.'

Nonetheless the hub strategy did have some success. Queensland's interest was originally attracted mainly by iLabs, which it saw as a key to expanding its laboratory capacity, a strategy for working with high schools in order to attract more and better students to UQ, and as a way to expand its relationships with other institutions in Asia. From that base, UQ also adopted and disseminated other iCampus projects to institutions in its region.

RECOMMENDATIONS

Today it is imperative for programs to improve and adapt rapidly in order to meet a wide range of social needs, keep up with disciplinary advances, and cope with tight budgets.

So we have made several recommendations to universities, grant-making programs, governments, and corporations.

1. **Improve education by making it more authentic, active, collaborative, and feedback rich.** This may sound like a 'motherhood and apple pie' recommendation but the fact is that, in today's higher education, improving enrollments, controlling costs, and keeping curricula up to date receive more attention and rewards than improving effectiveness. Nonetheless many national reports are pushing for improvements of this type [7] and iCampus software and ideas can provide useful elements for such a campaign. Obviously, technology by itself does not guarantee any kind of improvement in outcomes and these projects are, on an international scale, tiny increments. But they are steps in the right direction. Improving the ease of adopting such improvements, and the rewards for doing so, is the goal of the remaining four recommendations.
2. **Create demand to adopt ideas and materials from other sources by encouraging all faculty members to improve and document learning in their programs**. Despite the quality of these projects, despite the fact that they were free, and despite the allocation by MIT of $2.5 million for outreach, the faculty of the world did not beat a path to MIT's door. While MIT's outreach strategy was not ideal, even the ideal outreach program can have little success if there is little demand. Few institutions support and reward all their faculty members for making aggressive, continual and documented improvements in their courses, and fewer still provide support in adopting innovations from elsewhere. Because it isn't possible, or even desirable, to invent all improvements locally, an institution engaged in continuous improvement ought to be scanning the world for promising innovations, selecting the most appropriate, and adopting them as efficiently as possible. If those innovations can save faculty and student time, so much the better. It is unrealistic to assume that faculty members can or will do this alone. Scanning for and adopting improvements ought to be seen as a team effort. Different institutions will find different ways to create such a team effort but it seems likely that library specialists will often play a role. That's because the adoption process is far-easier when the sharing is discipline-specific and even course-specific. So the challenge is to help faculty find peers in their own fields who have made educational improvements that show real promise. Then universities ought to expect faculty to document their improvement efforts in portfolios and then reward them for their efforts. One of the important and often-ignored elements of the reward system is discretionary funding. The National Science Foundation played a pivotal role in the genesis of TEAL when, years earlier, it rejected an education R&D proposal from MIT's John Belcher (later to be the TEAL PI) but offered a smaller grant if Belcher would begin working with established leaders in the physics education reform effort, work about which Belcher had previously been unaware. Belcher's subsequent work with Robert Beichner at North Carolina State led directly to the development of TEAL. In contrast, iCampus (and most other university and corporate funding programs) did not use external reviewers and did not insist that faculty proposals build on the international state of the art. Making all such discretionary funding dependent on building on the state of the art would be an important step toward accelerating the pace of improvement in every department and institution.
3. **Nurture coalitions for instructional improvement, within and across institutions, in order to create better channels for sharing and improving innovations**. Digital repositories of learning objects are popular strategies for supporting the spread of innovation, but this study indicates the necessity to complement them with active coalitions for instructional improvement. Especially in areas of high priority for instructional improvement, it's important to nurture frequent, comfortable interaction among faculty with a shared need to teach particular content and skills. Such relationships can create the trust and shared insight needed for efficient sharing of ideas and materials. The TLT Group report [3] makes many recommendations for how to create and nurture such coalitions. Some coalitions need to operate within institutions, as do the teams that teach multi-section courses at MIT (as in the EECS department). Others operate on a wider scale. Both kinds of coalitions can speed the movement of innovations across institutional and national boundaries. For a variety of reasons, such coalitions will need to foster relationships online: not just digital libraries and peer review, but also peer relationships of growing trust and comfort among faculty who teach similar subjects and who, together, are continually improving teaching. There are many reasons for coalitions to rely mainly upon online communication, not least of which the expense (in time as well as money) of travel: if a strategy for speeding the improvement of engineering education is to be effective nationally and internationally, it cannot be limited to faculty members who can travel to conferences and summer institutes. Government, foundations and corporations should each play a role in starting and upgrading such coalitions. But the long-term effectiveness of such coalitions will be determined by whether departments and universities discover that it is in their self-interest to be efficient and effective at identifying, importing and adapting innovations from other institutions: in an environment of increasing global competition and attention to assessment, it's reasonable to expect that the best adopters will also be the most successful academic programs at attracting talented students, money, and public support.

4. **Create more effective higher education-corporate alliances in order to support the development and dissemination of new educational technology materials and practices**. The MIT-Microsoft Alliance was not merely a grant; it was also a collaboration among innovators in the two organizations. For example, Microsoft staff resident on the MIT campus helped MIT staff support and manage the software development efforts. That symbiotic relationship created more successful projects than either organization could have mounted alone. We recommend that more such university-corporate alliances be created leveraging the unique strengths of both their R&D and product development organizations. .
5. **Supply faculty innovators with help in educational design, software development, assessment methods, formative evaluation, and/or in sharing ideas with others in their disciplines who teach comparable courses**. Corporations would never expect R&D specialists to market and support the products born from their innovations: that requires a team of specialists. But too many universities assume that faculty, almost entirely unaided, can scan the world for instructional ideas, adapt the best they find, and assess those experiments to see how well they work. Similarly too many universities assume that innovative faculty will then have the time, talent, resources and inclination to do expert instructional design, software development, evaluation. Obviously those assumptions are virtually never true. We recommend that universities experiment with new ways of organizing staff and resources to aid both the dissemination and the adoption of innovations. In the months since the submission of the iCampus report, MIT has created a new Office of Educational Innovation and Technology. Many of its staff had previously been in Information Services &Technology, but the new unit now reports to the Dean of Undergraduate Education, along with another new unit, the Office of Faculty Support. Other institutions were already working to develop the team concept, too. To choose just one example, Stanford has Academic Technology Specialists who work in selected departments, schools and programs. They are chosen not just for their technical expertise but also for their content knowledge. A typical ATS has a Ph.D. in the same field as the faculty members with whom he or she works. [8]

CONCLUSIONS

It is widely acknowledged that engineering education programs need to improve systematically and substantially in order to adapt to a rapidly changing world. "Innovation" is a frequent battle cry. But many observers seem to define "innovation" as a path-breaking improvement created at some leading institution. It has been unusual to find discussion of what is required for tens of thousands of typical departments to improve their programs. Are they supposed to create their own improvements? Or adopt/adapt improvements from other institutions? If adoption is the typical path (and we believe that it is), universities, government, foundations, and corporations all need to make adjustments in how they organize their work. Departments and faculty need to be selective – which kinds of improvements are most important to promote? We have recommended special attention to educational improvements that are more active, authentic, collaborative and feedback-rich. We have recommended that faculty be supported and rewarded in the effort to find and adopt such improvements as part of the larger effort to continually improve instruction. And we have pointed to the special importance of creating coalitions for instructional improvement – patterns of peer relationships within and across institutions that can help accelerate the pace at which new ideas and materials are discovered, assessed and adopted. In the end, higher education institutions must develop and support an infrastructure to aid adoption as they have for novel research and innovation. These recommendations point to key attributes for such an infrastructure for adoption and dissemination.

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