Creating a Quality Online Masters Program

by

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Abstract. The details of the inception, development, and implementation for an online masters of mathematics degree, primarily for K-12 mathematics teachers are given. While the program is not yet complete, insofar as all of the courses having being written and taught, we know at this point enough information to begin a process of reflection and refinement about the creation, administration, and operation of such a program. We have as well a good profile of the typical student.

The Masters Degree Program

This paper will develop a sketch of the current completely online masters of mathematics program as developed at Texas A&M University. This program has been under continuous development for the past two years. Though online masters degrees have been emerging by the score on a weekly basis, no other online masters of mathematics degree other than this one seem to be available. Its developers have extensive experience in the creation and operation of online courses, mostly at the undergraduate level. This paper addresses a number of issues of programmatic development, many of which involve the issues of quality, in its many forms. We discuss program administration, course services, content matters, measuring student performance, admission of students, measurement of student performance, and faculty recruitment. Ranging from technical to traditional to political, each aspect of the program requires careful attention. The clients of the program, that is the students, are almost without exception fully engaged in another life. Applying one's perception of and knowledge about traditional graduate student behavior, skills, and experience is not valid in this venue. For example, when teaching a traditional graduate course in mathematics, it is natural to assume that each of the students has satisfied the course requirements in the recent past. With the online program, course requirements may have been taken twenty years earlier. As can be expected this does create teaching challenges.

Program Inception

The masters of mathematics degree program originated from the response to an RFP from the Provost of Texas A&M University issued in the spring 1999 term. Our proposal was directed at one of the most critical educational needs of our day, the mathematical preparedness of our mathematics teachers. The opening paragraph of the proposal, cited below, could well apply to any state.

> With current State of Texas mandates to offer more AP level courses, the educational needs and demands on the teaching faculty of State high schools are greater than ever before. These and state requirements for CEU's (Continuing Education Units) give a ready market of potential students for a distance master's level program in mathematics education that in numbers alone exceeds almost every other potential distance masters program. That this program already exists in traditional format and has graduated about six students/year serves to establish that it already enjoys a credible market. The facts that Texas is the largest producer of secondary school teachers in the United States and that Texas A&M is the largest producer of mathematics teachers in Texas make it natural, and even expected, that Texas A&M should provide leadership in innovative distance education programs for teachers. … the individuals who complete this program not only will have received education at a distance, but will know how to use the technology and to create content!

Indeed a key provision is the technology component. The program intentionally includes a three-hour math communication and technology course. Teachers have a chance to catch up with their students, while learning to use technology to convey mathematics. Indeed, we should add another technology course. The practicing teacher has scarcely enough time to perform their job, let alone learning cutting-edge technologies.

Most teachers, particularly those in rural areas, have no access to regularly scheduled (synchronous) graduate courses within their local service area. Even more have work and/or life schedules that preclude taking such courses, even if there is a suitable institution nearby. In fact, at least one nearby large urban university is developing a similar program that targets teachers in their own metropolitan area. The reason is that synchronous course offering still require up to an hour commute plus parking, all at less than favorable meeting times. There are many, many teachers seeking to improve their mathematical knowledge and to enhance their professional credentials. Indeed, there are few subject areas for a distance master's degree with a greater or more justified need than this one, a degree that will serve well the next generation.

One important requirement mandated by the Department and University was that the program should fit within an existing masters program. The same course requirements were to be met, the only difference being the asynchronous course delivery. The quality of the online program was to be paramount. In selling the idea to the Department and to the College, quality was the pervasive touch point easily on par with content and mastery issues. The nature of mathematics is different than purely text oriented disciplines; strikingly the teacher's classroom presence and performance are crucial in subtle ways. The issues important to us all continue to be (i) content, (ii) online help, (iii) question feedback, and to a lesser extent (iv) interactivity. We note the two key issues are content and communication. The reason interactivity stands behind the other points is that this is after all a graduate program and the inclusion of interactive applets seems less important owing the more theoretical nature of the materials. Students do see a good sampling of applets (in Java, JavaScript, and ActiveX) that they can later adapt to their own uses, but except in the technology course, it is not a portion of the content mastery.

The University, College and Department offered support as available, though without all three, the program could not have begun. Continuing support from these essential university administrative branches remains critically important, though for different reasons. We have found that maintaining a continuing dialogue with all administrative levels of the university helps to maintain the support and to convey difficulties. Distance education is a singular area where almost all experience academic administrators have no experience. While they understand that online learning has been remarkably effective in industry and while they believe that online learning is now a fact of the college academic programs, nonetheless they are rather uncertain about what to do. A near inverse law seems to apply: The more experience the administrator has the less able he/she is to bring online learning within the college context.

Faculty Recruitment

There remains a fourth venue, also critical for support, the faculty. Owing to the twenty percent teaching rule[1], this support has been the most difficult to realize. One the one hand, we have been recommended to recruit from among those faculty that seem the least active with the reasoning that they have available time and they are usually good teachers. This has not worked at all. The reasons have been hashed and rehashed and will be avoided here. The fact remains. Nonetheless, we have had the most support from those most professionally active mathematicians in our department. It has been a long time coming. However, we are gradually recruiting some of department's best people to the effort. To our good fortune, they have determined their own reasons to develop online materials and are fully able to produce high quality materials. To their good fortune, they have at hand experienced developers that can recommend just the right steps to affect a gradual entry that will yield over several semesters a fully online course. Their work will provide the next tier of online courses. We believe an active recruitment of faculty may not have been successful. Numerous problems, most notably those of time commitment, would surely have discouraged many.

Rewards for online course production are not materializing as might be hoped or predicted. Part of the problem is that colleges can only partial fund the efforts. Too frequently, they offer faculty only a pittance for what is normally a considerable effort Sometimes the investment, small or reasonable, generates a good course. However, as faculty develop expertise in Java, JavaScript, video streaming, and the like and apply these skills to computer assisted learning, the burden for the novice increases. The time is near that individual efforts may not produce a successful product. In the meantime, the vigilant publishers are extracting the best of the ideas and combining them with needed funding to generate refined products. In reality, the textbook publishers, who endured early financial losses in this business, have recovered and regained their stride with clear goals. With their marketing expertise, it is probable that online courses will soon be professionally produced much as textbooks have been for decades. It is not uncommon these days to see a traditional textbook supported by a publisher financed Web site containing supplementary materials, Web resources, online tutorials, online testing, and video streaming. For a best selling text, the additional Web-related production costs may reach several hundred thousand dollars. Graduate courses have escaped this business

[1] The 20% teaching rule is this: For most faculty, teaching is a pleasure, a privilege and a job. Most faculty are willing to do more to improve their teaching efforts. If the amount more exceeds 20%, the majority will decline the effort, if possible.

solution so far, but one of the more important Web techniques, that of materials reuse, indicate that many graduate materials will eventually be available commercially.

Program Services

Enrolled students have expectations and disappointments. We emphasize here that our online mathematics program is very technical and requires several communication channels. Teaching mathematics requires more teacher presence that may be thought necessary. The slightest classroom gesture or simplest questions can make a large difference. In mathematics, the distance between concepts understood or not understood can be minute. Even though the lecture may engender a passive transmission model of learning, discussion in class may enhance the learning process. Moreover, formal group discussions can be extremely valuable for the learning student. (Townend S., (2001) and J. MacBean, E. Graham and C. Sangwin (2001), Berry J. and Sharp J. (1999) and Berry J., Nyman M. and McIntyre P., (1999)) All these advantages of the classroom, lecture, discussion, and group interaction, are absent in the online format. Discussion or chat rooms have limited use when the lingua franca of the discussion, mathematical notation, is so difficult to produce. In spite of these difficulties, the area of computer aided learning and online mathematics education in its various forms has become a dominant theme in modern mathematics education. *Teaching with technology* are three words are heard daily. There is a growing belief and mounting evidence that it works, though most admit it is not for all.

Students coming for help can be served sometimes with a brief encounter where the instructor immediately understands from very little (spoken) information just what the problem is and how to help. When the student is asked to articulate this question in type or even over the phone, there may result no significant communication whatever, for the simple reason that the student doesn't quite understand the key point that is the true problem. This persists at both undergraduate and graduate levels. The problem is compounded in our program in that some of the students have had little formal training in years. Surprisingly, instructors do count very much on similar backgrounds, study skills and cognitive abilities among their students.

We address this problem in a variety of ways. First note that for graduate-level students and particularly practicing teachers, the email communication problem is not that severe. They can communicate well and have little trouble understanding the responses. However, this does create additional burdens on the instructor. One solution has been the abstraction of student inquiries to a more general/generic form and posting it together with a suitable response to the Web. WebCT, for example, has this capability. We have used a variety of formats from our own CGI-bin scripts to Java based interrogatories. Specific for mathematics students, where these devices are somewhat inadequate because of the difficulty of inserting mathematics, we have a simple HTML page on which we log the questions posed in proper looking mathematics notation[2] with

[2] Just what proper mathematics notation means referred to the typography of the mathematics is expressed, and implies that it would appear virtually identically to a text. Of the several ways to achieve this, we have used screen capture methods, because they are by far the simplest to deploy and always look very good. Two programs, Snagit by TechSmith and Corel Capture by Corel Corp., work excellently, both capturing mathematical images – even whole paragraphs – an storing them in sequentially numbered files. Another method that works well on Linux/Unix systems is the LATEX 2HTML program by Nikos Dragos. Freely available, it converts LaTeX, the standard mathematical typesetting language to HTML. This point

pop-up responses. This allows the students to scan more quickly the available questions. The types of questions range from correcting typos, to clarifying instructions, to giving problem hints, to giving further explanations of concepts. Versatility is important. Overly much categorization is time consuming to navigate and to maintain.

We have tried to place as much content online as possible. Three-fourths of the courses currently online in our program have complete content associated with them. The history of mathematics course contains a dozen sections each with multiple chapters of text presented in PDF[3] format. It contains associated problems, tied to each of the chapters, and it contains a number of links to related history of mathematics Web sites. This simple design, which contains no interactivity, has proved to be successful. The alternative of assigning a textbook was deemed less attractive, partly due to the variety of textbooks with suitable content/level in a readable/self-study form. In short, mathematically, they are too simple or too difficult.

Providing help is challenging. With regard to telephone communication, even. Though we regularly tell the students that we will call them at an agreed time, few have taken advantage of the possibility. E-mail is the method of choice, though the respondent must exercise some vigilance. A rapid turn around time is important, a few minutes is best, a few hours good, longer than that diminishes the sense of importance both student and instructor feel. A lengthy turn around time may convey to the student quite the wrong impression. These students are adults, and quite courteous about being demanding. If no response is sent, their progress may be shut down and their enthusiasm with it. Yet, a one or even two-day turn around, especially on weekends, is unavoidable. Students seem remarkably understanding of delays, but like anyone learning a new thing, having questions answers quickly is best. Another, indirect way of giving help is to provide alternative venues for the same or similar material. Some instructors screen-capture their lectures as AVI files and then encode them for streaming video. (For general methods and software see Cunningham and Francis 2001 and Brusilovsky, P. 2000). Though there may be no talking head with these lectures, students tells us that just hearing the voice of the instructor has great communication value. This you may note seems to contradict the near absence of direct instructor-student telephone communication.

Teaching an online course can easily exceed the twenty percent rule, and because of that we advise instructors to be economical with their own time, as well. It is possible to become a bit obsessive about providing total answers to each question and responding within minutes or hours to each email. Fatigue does set in; and services can diminish.

Measuring student performance

Five types of performance assessment are used: homework, projects, book reports, term papers, and examinations. Usually weekly homework assignments are given, parallel in content and type as those given to local students. In mathematics

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illustrates some of the technical difficulties of putting mathematics on the Web. Subjects with large symbol classes are subject to serious impediments with respect to Web delivery.

[3] PDF format is a proprietary format of Adobe Systems, Inc. It seems to be ubiquitous, at least in the United States. It is successful because it renders the printed page virtually identical to the page form on the software that created it. It is universal in the sense that it works through the printer daemons, not the software itself, and thus works with all software. Free readers are available; the Adobe PDF document distiller does cost money, however.

courses, these are problem set. Learn the method; work a problem using the method. Extra effort is taken to state problems clearly, with only one possible interpretation. Projects may range over a wide set of options. Book reports are excellent vehicles to allow the students to learn more about what they are learning in an applications setting. For example, in the history of mathematics, hundreds of biographies of notable mathematicians are available. Term papers or capstone projects are an important part of independent study. They require the student to be resourceful and to learn well a course related topic.

So far we have not addressed the difficulties of administering distance examinations. Two options, the proctor administered exam and the online exam with student validation offer their individual problems. The security aspects of both enterprises are not simple to resolve in both a reasonable and cost-effective manner. Some virtual universities regard security as the main priority, at times selecting assessment venues that offer rigidly tight security at the expense of other factors. Using proctors is cumbersome. Perhaps one day an administrative infrastructure will make issue transparently simple. But today, the element of trust is key. Fortunately, administering online mathematics examinations is not suitable for graduate level courses. Even in local graduate classes, take-home examinations are often the norm. This is our general course of action.

Recruitment of students

We use just a few methods of recruitment. The most productive is to give talks at various mathematics teacher meetings and conventions. For example, this summer, we had more than 200 teachers show up at a meeting in San Antonio. The usual procedure is to give a short talk on the program, give a few testimonials, and pass out relatively complete information with an application form. The remainder of the time is spent answering the many dozens of questions. The talks are among the most enjoyable to give, in that the audience is truly interested and also very grateful that such a program exists.

We also maintain a Web page about the program. It is rather extensive, including the complete content from a couple of the online courses. Well over half our inquiries have come from people that found our program using the ubiquitous search engines. Numerous links to other resources on campus are included, together with a FAQ page. This has served us very well. By this time, we've heard almost every possible question. Besides the technical how-to type questions of program logistics, one other question seems to arrive disguised in various forms. Summarized it is: "Can I handle the level of difficulty?" Not having a serious mathematics course in twenty years can dull mathematics skills. These folks know this and are properly concerned. Fortunately the program has two courses that are not mathematically intense, the history of mathematics and the communications and technology course. These courses are remarkably popular in the traditional mode and even within other departments and while they offer their own challenges, they do require problem solving ability but not within the context of an advanced body of mathematical knowledge. I have steadfastly suggested incoming student begin with one of these courses. So doing with reacquaint the students with college, with graduate level course demands, and will sharpen lost mathematical skills.

We have, in addition, a cohort plan, though it is hardly underway. Though it, we will solicit school district superintendents and high school principals to the prospect of enrolling a cohort (three-ten) of teachers in their district. Each cohort will take the same courses during the same terms. This gives the student a little more contact with peers and may well help them over the numerous hurdles that accompany mathematics courses. The groups will also help sustain their programmatic continuation and hopefully their enthusiasm. Presumably, the principal or superintendent will help finance the tuition costs, which though not excessive can still stress a teacher's available funds. Cohorts of numerous constituencies are often used on the educational scene for a variety of reasons; the concept is hardly new.

The quality of the students

Can a program maintain a high quality if the students have marginal abilities? We suspected that the mathematical strength of our new distance students would not be up to full time regularly enrolled students. What was the case was that they were mathematically weaker than we hoped. Many teachers in the field for several years or those that focus on educating the very young have seen those skills erode over time. We emphasize that these students have seen some their problem-solving skills diminish and not their core intelligence. We have accommodated this reality in several ways.

Whereas the traditional mathematics program stresses knowledge of mathematical structures and methods such as found in theorems and proofs, these skills will have less impact on a teacher's quality of instruction that a solid foundation of mathematical technologies and a threaded knowledge of selected mathematical strands of information. For example, in linear algebra, a required course in the program, we take up in detail the Jordan normal form for matrices. While this has great importance within matrix theory and particularly in its applications, it would almost never be a topic of instructional consideration for a high school teacher. However, the application of certain types of matrices such as stochastic matrices that occur in probability may well fit into the lesson plan because it fits so nicely within a number of real-life examples that will enrich the classroom experience of all, even though it may not be taught, *per se*. Naturally, the entire content of the technology and communications course, from mathematical document preparation to computer algebra systems, from HTML and JavaScript to mathematical graphics, may have direct and continuing application in the classroom. Even more closely connected to the classroom are the hundreds of mathematical anecdotes and ideas that appear in a history of mathematics course. There is a growing trend to teach mathematics with historical, if not original, resources. (Laubenbacher, R. and Pengelley, D. (1992), (1996), and (1998)). By accentuating and emphasizing what our students can do and what will make them better mathematics teachers we produce a product more suitable for today's classroom that the traditional student well grounded in the classical 19th mathematics curriculum.

Every undertaking has it own extremes. This one is no exception, with the greatest of them being the extreme diversity of experience, mathematical skills, and expectations of those in the program. Concatenated with that is their extreme diversity of present circumstances. Many are teachers, of course. Others are military wives, exmilitary, community colleges instructors, and women on maternity leave. We have, as well, a couple of practicing engineers. All the students have full and complete lives – job – family – children – community involvement, etc, and many of them are taking several courses simultaneously. Indeed, a couple are teaching full time and taking three graduate courses! We have tried hard to be flexible about assignment dates, realizing that these students are fully mature individuals and do not merely shirk their scholastic duties. It is important to accept these facts about this new educational landscape, and to remember that the educational service we are providing is crucial to many, many people. Strict construction of assignment dates seems somehow inappropriate. We have also seen it necessary to "back-load" content, by moving a bit slower in the beginning weeks of the course, increasing the pace toward the end. At every step, we have maintained the integrity of the courses.

Never has the homogeneity of the traditional college classroom been more apparent than that when we undertook this effort. It is difficult to prepare material for such a cross-section of students. It takes some considerable coaching to keep those with the weakest background up to speed. Yet, there seems to be a remarkable tenacity of these students. They are clearly more focused and determined than most undergraduates, and this is renders a most positive overall teaching experience.

Although our intent has been to improve the quality of K-12 instruction by providing teachers with more useful mathematical tools and an expanded depth of their knowledge, it must be noted that several students have told us they intend to move to community college teaching as their number of graduate mathematics hours increases to about 18, the minimum requirement in this state. On balance, we have a number of professionals in the program that wish to leave the business world to pursue a teaching profession, in some cases in the high school.

Intellectual Property

Our university was sufficiently savvy about the measure of work to create a program to award the authors a 100% ownership in intellectual property (IP), with the University to reserve a share of eventual royalties from the sale of materials as compensation for their investment. Yet even within that relatively generous IP policy, the area is fraught with complexities. We emphasize that without such a policy, no professorial faculty, with successful careers well under way, would risk taking a step into the realm of online programmatic development.

For example, with two authors producing content under the terms of the proposal, with the University contributing funds toward the production, and with the assumption that the materials generated have market value, the natural question to ask is: ***Who owns the material?*** Concomitant with that question is another one of equal importance: ***How should the distribution of royalties or income from these materials be made?*** Before outlining what contractual terms we regard as fair, it worthwhile to mention and discuss other questions that may be even more complex.

1. If Professor X writes online content for Math YYY partially using institutional resources, does the institution have the right to revise those materials at some future point? (Naturally, the "shelf" life of one of these early efforts of online courses is brief – perhaps two years. To keep the course viable, it will need to be

updated or upgraded. Who controls that process? What remedy is accorded the institution if Professor X declines the task?

2. What if an author permanently leaves the institution? Does the author have the right to load the course on a server at a new institution? Can he subsequently revise it there and offer it in competition with the version running at the original institution?

3. Should students at the home institution pay to use the materials?

The answers to these questions hinge critically upon the definition of the term "substantial resources." For example, if the faculty or staff member is assigned the task of creating an online course and that becomes part of the job requirements, the "work-for-hire" model may apply. In this case, the university owns what is created, and may at its discretion distribute future income to the creator. When the compensation is more than just an office computer and secretarial help but less than the full salary, the question becomes this: Does the contribution of the institution measure up in a tangible way as a substantial contribution to the production of the online course? Some institution will argue in even this case that ownership resides with them because an employee created the product. We regard this view, which makes sense in industry, to be stifling to the creativity of their faculty. Such a narrow and constrictive policy may well result in diminished quality or quantity of production that over the long run may be more costly, when that same institution, in order to operate their Web-based and distance education programs, will have to license products generated elsewhere. The literature on this important subject is immense and is still growing. (Barlow, J.P. 1993)

Conclusions

Creating an online degree program today has very much the same comprehensive, all encompassing nature of forming a new business. There is little one can simply plug-in to existing infrastructure. The delivery is different; the assessment is different; the student demographics are different; recruitment, retention, and motivation of students are also different. The desire for learning is intense. However, the need for temperance of course administration is essential. As well, an acute understanding of student backgrounds in contrast to regular on-campus students is paramount. To highlight the most critical of our needs we note (1) recruitment of faculty to online teaching, (2) development of more online courses, (3) developing more robust methods and time savings of processing students through the course, (4) honing methods of giving online help.

Finally, as must always be mentioned, we are in a transition period. In just a decade, perhaps less, online education, online degree programs, and the like will be institutionalized. Students will have clear expectations, and faculty will again have established ground rules. Course administration will be established in comfortable grooves. Methods universities use to compete for and recruit students will be once again transparent to faculty, and developers such as these authors will spend all of their time developing online courses, new techniques, and learning new skills for the next generation of interactivity. We definitely need more course content online and a greater variety of mathematics courses.

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