AC 2009-932: ON-LINE MANUFACTURING ENGINEERING TECHNOLOGY COURSES: THE GOOD, THE BAD, AND THE UGLY

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Online Engineering Technology Courses – the Good, the Bad, and the Ugly

Abstract:

There has been increasing interest in developing web-based engineering and engineering technology courses and in converting traditional face-to-face college classes into online courses. The Manufacturing Engineering Technology BS Program at Minnesota State University, Mankato, strategically developed all core senior-level courses into a multi media infused online delivery mode over the past few years with flexible Face-2-Face labs or capstone course projects. With the assistance of state grant funding, this strategy was based on our industries' call to retain students for a greater term for internship experiences and to benefit the student's career competitiveness while still providing equal or superior learning in the engineering management based core courses of the program. The program is now debating whether to continue this form of delivery, add more online classes, or to return some or all of the classes to traditional face-to-face campus lectures and laboratories. Highlights include where expectations were exceeded, met, or fell short in online conversion from Face-2-Face traditional delivery and succession planning for new faculty or content driven changes.

In the process, we have developed a number of considerations and questions to help engineering and engineering technology programs decide whether a given class is a good candidate for online web-based delivery. We have also found that there are a number of factors, problems, and costs, often hidden, which must be considered when developing or converting online classes. This paper will present the questions and considerations which we are using to determine the value of placing each course online, and will discuss the advantages, factors, costs, and problems involved with implementing these online courses, based on our research and experience. Also included are twelve learned Best Practices for asynchronous online and a "Take Home Strategic Online Planning Sketch" to help foster other online learning models. Student learner feedback also included.

The Good:

"*It is not necessary to change, survival is not mandatory*" W. Edwards Deming. It was in 2004 where the spirit of this quote coupled with broad university strategic support for innovative online course and program course conversion, that the department began the journey to meet the call for competitive change. With the Higher Learning Commission's recent awarded accreditation approval for Minnesota State University, Mankato, to begin delivering online courses and programs, the Manufacturing Engineering Technology (MET) program of the Automotive and Manufacturing Department was in a good position to pursue attractive funding mechanisms. This was matched with a willing faculty and a department strategy to meet a need for more flexible delivery modes while maintaining effective pedagogue. Data from an earlier 1999 Noel-Levitz marketing study for the state university system documented student demand for technology and scheduling flexibility that teaching with technology allows including[1]:

Students' Definitions of "Quality" Increasingly Include Technology. Of current students, students ranked "up-to-date computers and technology" as a top concern (4.3/5), valuing a college's access to technology resources on the same level as the ability of graduates to "get good jobs in their fields." There is a similarly high ranking among high school students.

Students Need and Expect College Scheduling/Delivery to be Flexible. Between 33 and 45% of The state university system students work full-time, while between 42 and 53% work part-time. Students are increasingly drawn to alternative delivery and flexible scheduling that allow them to succeed both at work and college.

Flexible Course Scheduling Improves Retention. When non-returning students were asked "could we have done anything to enable you to remain enrolled," "more flexible course scheduling or course formats" was the top response. Among other recommendations, Noel-Levitz concludes that "The state university system may be able to reduce the 'stop-out' rate among the 31+ population by exploring more flexible course scheduling and delivery."

Life-Long Learners Seek Flexibility in Scheduling and Delivery. This growing and important population ranks flexible scheduling as a top concern (4.3/5), well above location and even considerably above cost. Asked to rank their preferred course delivery format, student preference for "internet or distance learning courses" (3.17/5) was only slightly behind "traditional" delivery (3.37). The Noel-Levitz presenter insisted that this trend is growing significantly and that their "strong recommendation" is that " The state university system should put up as many internet or distance courses as possible…Schools must fit into [students'] already full life; they expect colleges to meet them where they are."

Noel-Levitz Recommendation: Alternative Delivery. "Offer additional classes via the internet and incorporate web-based assignments into the curriculum to support student desire for more flexible course scheduling. This is a major trend in educational program delivery."

Further, a new state university system online entity emerged in 2003 to aid all state university system institutions to serve learners by advancing and facilitating the delivery of online curriculum and services. The Minnesota State University System consists of 33 state universities, community colleges, technical colleges and combined community and technical colleges located on 53 campuses. The system serves approximately 235,000 students annually in credit-based courses and another 130,000 in non-credit courses. A primary vehicle for the state university system's online entity support is largely demonstrated through seed grants for online course or program development. As pedagogically necessary, portions of the online program or course were able to be customized to use applied activities such as a course cohort activity. For the department courses either a capstone project or a lab experience were integrated. Deliverable characteristics required by the grantor and desired by the Manufacturing Engineering Technology courses developed from the 2004 e-curriculum grant awards were to:

- Meet the definition of 100% Asynchronous Online criteria which allowed a maximum of one face-to-face campus meeting as the instructor determines. [2] ***Asynchronous*** *describes teaching and learning that occurs when students set their schedule within a predefined time period.*

- Develop courses for delivery on the university Instructional Management System "Desire To Learn"™, a commercial classroom management system similar to Blackboard, etc.
- Continue to provide the asynchronous online courses developed through the funding for three years beyond the conclusion of development (FY 07, 08, 09).
- Be equal or superior in learning effectiveness to traditional delivery in face-to-face format

2004 also marked the successful award of $178,756 out of $850,000 made available through the system's online entity grant round for e-curriculum credit and non-credit offerings. Fifty three proposal applications with a combined total of $6,097,834.00 were submitted in this competitive round. The department's grant was the only one of eleven proposals from the university to be funded. The grant principle investigator was the developer and instructor for the targeted courses. Roughly $5,000 per credit based hour was consumed for faculty release time, curricular development and review, graduate assistants, and integrated multi-media. The award success was largely based on:

- lack of any other system delivery available for upper division coursework in a high demand engineering related program
- focus on Lean curriculum integration to ground students with base Lean knowledge thereby avoiding the need to retrain new graduates in the field
- strategic placement of senior year coursework more appropriate for online delivery due to an engineering management content base versus more lab intensive coursework
- increased industry ability to access internship students for longer terms and broader geographic locations
- the attraction of industry to capture "hit the ground running" students ready to move seamlessly into career positions based on more rigorous internship exposure

30% of this award was to also develop online customized training to meet the growing needs of Lean curriculum demand for the incumbent workforce. While only 12% of the funds would eventually be expended to the incumbent workforce e-curriculum, the remainder was directed to support related online infrastructure with the system's approval. This paper attempts to deal with the credit based experience only. The grant formative life was 18 months for the conversion of 15 credits or 79% of the senior year face-to-face course work and 11 credits of graduate 500 level coursework were also leveraged with related curriculum. Figure 1 presents the courses converted, credit value, face-to-face required element best fitting the desired pedagogue, the first term offered in 100% Asynchronous Online, and initial enrollments. All courses have maintained or grown their enrollment base in their online format with no disparate quality indicators as evaluated by direct and indirect assessment.

Figure 1: 400/500 COURSES CONVERTED FOR 06/07 TO 08/09 ACADEMIC YEAR DELIVERY*:*

Course Title and Credit	Face-to-Face Component	First Online Ready Term	Enrolled Initial Term
Manufacturing Resource Planning & Control (4 credits) undergraduate	Capstone Project Required	Spring 2006	21
Manufacturing Resource Planning & Control (4 credits) graduate	Capstone and Industry Applied Project Required	Spring 2006	5
Ergonomics & Work Measurement (4 credits) undergraduate	Mid term face-to-face Lab	Spring 2007	23
Project and Value Management (4 credits) undergraduate	Capstone Project Required	Spring 2006	19
Project and Value Management (4 credits) graduate	Capstone and Industry Applied Project Required	Spring 2006	3
Quality Management Systems (3 credits) undergraduate	Mid term Lab	Fall 2006	23
Quality Management Systems (3 credits) graduate	Mid term Lab and Industry Applied Project	Fall 2006	2

Courses matured through intentional continuous improvement. Refinements to curriculum and instructional delivery modes were based upon three key criteria:

1) Identification, access, cost, and effectiveness of new repositories or other sources for coursework and related learning objects
2) Multi-media best fit and best practices from benchmarking of other online developers and learners
3) University, college, department, and degree program goals

Patience was exercised for the best multi-media technology to use for instructor talking head components. Over investing development time in a key technology during earlier phases of course development would have resulted in non-value added "rework" as more capable technology emerged and was benchmarked for efficacy. The continued search for more capable multi-media provided flexibility to learn and move to even better technologies. Finding relevant texts and supporting reference materials to best support 100% asynchronous delivery often required modifications to previously developed online content. In spite of a common tendency with online course development to avoid updating content, changes were made as needed each term to avoid static content which would hinder learning quality.

Each course was structured using a module format timed with the weeks of the semester. This was implemented to counteract a common learner tendency to procrastinate. Students appreciated this balance of accountability with flexibility. Each module week was opened in its completed state on a regular day of the week. All required interaction or evaluations were due by

the close of the following week. This allowed students 7 days to accomplish each modules work with time and place freedom to a predetermined period to comply with the Asynchronous definition. Courses were developed with common structural attributes to create a sense of navigation continuity, organization, and expectation for learners. As an example:

- Module One runs 1/23/09 to 1/30/09
- Student Learning Outcomes
- Reading Assignments
- Personalized delivery of "mini" lecture streams for three types of complementary learning fitting to topics:
    - *Informative: topic background formation e-lecture)*
    - *Application: for example, the working out of mathematical formulas, video case study, etc*
    - *Judgment*: *pointed learning objects*
- Discussion – (optional)
- Bonus Links as relevant without overloading the students with content
- Assignment Requirements
- Quiz or Exam Instructions

There were many good attributes to the integration of online to the MET program. Surveys of all the developed courses from 2006 to 2007 determined several interesting learner characteristics:

- 65% of students were able to take internships due to the online flexibility
- 73% responded online courses encouraged more reading versus face-to-face courses
- 80% stated the course's multi-media components were essential over "flat" or non multi-media infused course content
- 77% preferred online over face-to-face
- 80% usually procrastinate until due date *(addressed the value of weekly paced accountability structure)*
- 82% found the SME video case studies valuable
- 78% were MET majors
- 88% did their study online at home *(serving the traditional and non-traditional students)*
- 34% study over the weekend
- 91% have high speed internet access & computer at home
- 9% have high speed access but not a computer *(course participation still successful)*

Professional Partnership with Society of Manufacturing Engineers:

A unique venture to provide higher quality case studies for the online learner beyond what we could develop effectively with our own resources involved The Society of Manufacturing Engineers (SME). Their strong content ties to the Lean Process Technology curriculum and other related educational concepts made SME a great partner to approach for a licensing agreement for selected video titles. This was unique because SME had not previously established a format for sharing their content to online learners with license capacity to stream the content online. Once a budgetary target was established 34 titles were purchased for a period of 3 years

at a negotiated rate for the purposes of integrating real industry case study examples capable of being ripped and inserted to elevate subject matter learning.
SME was of particular importance to the credit based content areas of this grant since it is made up of industry constituents and is the professional body which develops the department's program criteria for ABET TAC accreditation. A secondary benefit is that SME is the most active professional society for certification in manufacturing technology and manufacturing engineering. Helping off campus students be more connected to the on campus SME Student Chapter and eventually certification opportunities provided a multiple benefit.

Beta Testing and Quality Indicators:

A small but diverse (two to three) beta user group was effectively used in course content development versus an entire class. When problems with multi-media developed the feedback and corrective action loops were addressed quickly on a "system to system" and "instructor to user" basis.

Quality indicators used included those used with face-to-face delivery and a few new tools to address the unique needs of online:

External quality indicators:

The department's Industrial Advisory Board informal evaluation: Held during a bi-annual meeting with positive results.
Direct feedback on quality and utility of the courses by experienced students of industry: 2% to 3% of students in the courses when initially offered worked in an industrial or engineering based management capacity. 50% were currently employed with industry and 11% had some level of industry experience.
ABET TAC evaluation review during 2008 visit: Successfully reviewed the courses in the MET program through direct access to the online courses
Student retention: 98% student retention and very consistent with previous face-to-face retention rates.
Successful university peer review audit: Only one online course was selected for voluntary audit using the Quality Matters Online criteria since a similar structural and student engagement model was used by the author. It provided validation of the model used for the other courses developed in this initial round.

Internal quality indicators:

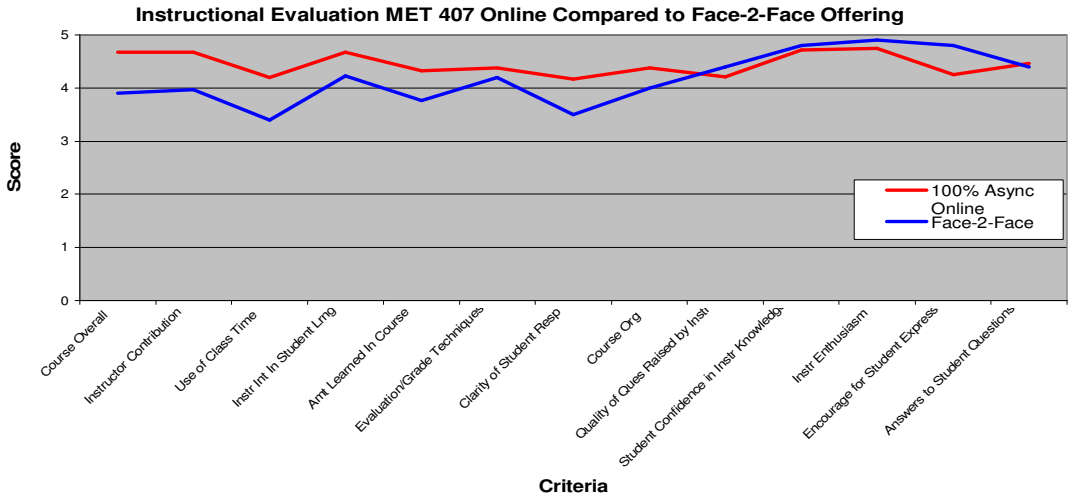
Grading techniques: Effort was given to put the highest amount of points on two key portions of the course. First, the face-to-face lab or capstone experiences and second, one proctored exam. All other single attempt quizzes and exams were open book and open notes with time limits enforced. Comparison to previous face-to-face course offering in the same content areas indicated no significant grade inflation and in some cases a slight deflation.
Application success after 1 to 2 years post graduation: Students in the Senior Design capstone projects reflected excellent ability to use the concepts for industry applications,

and recent graduates were anecdotally polled for capability to use curricular content from the online courses in the field with positive results.

Student Learning Outcomes Survey: in the same manner as the other program face-to-face courses for departmental discussion and continuous learning actions, Student Learning Outcome surveys presented no significant grade deflation or inflation with the online courses.

Course Evaluation: This common course instructor and course evaluation doesn't focus on Student Learning Outcomes; however, it does provide a common comparison in other areas of importance such as organization, and instructor engagement. Two online courses were compared during 2006 terms to provide a key assessment comparison baseline between face-to-face and online. Figure 2 below is a comparison.

FIGURE 2



Twelve best practices were developed from this initial round of online course development and assessment.

1. **Not all high speed internet is created equal:** 48% of students surveyed stated they had trouble with streaming media when working to access it at peak times at their homes or dormitories. Band width in and out performs differently and ISP's do not all serve at the same constant bandwidth.
2. **Be a cowboy, not a lone ranger**: Engage with other online developers, key IT staff, colleagues, funding agencies, and students. They tend to shorten timeline to course delivery and help keep new technology on the radar screen for others seeking optimization.
3. **Create a delivery rhythm:** A common structure as described earlier makes the content less overwhelming, especially to new online learners. It also reduces the need for high text density which is more inviting to the learner**.**

4. **Dribble is for babies:** Present content when scheduled in complete context to avoid confusion. Some students are non-procrastinators and will enter the content early and be surprised by content opened after the "start" of a new period.
5. **Stretch and leverage resources:** The SME video integration referred to earlier provides an excellent example. Other e-learning objects are becoming more available through dedicated online repositories such as MERLOT[3].
6. **Create at least one learning bridge:** For this case study, introduction of the online course characteristics and practice with success techniques were introduced in the Junior year to students in a face-to-face class.
7. **Avoid unidentified flying objects:** Make expectations clear but in as simple and short of terms as possible. The phrase "due by midnight" caused some students to ask if that meant 11:59 pm the day of Module close or 12:00 am the day before the Module closed. Additionally, state the time zone. The intergenerational Baby Boomers, X, and Y are the learner pool.
8. **Record multi-media for multi flexibility:** Avoid recording intensive topic content into labeled Module numbers, text specific page numbers, and current events which may become obsolete in a short time, etc. This limits the flexibility.
9. **Keep recorded content as short as possible:** The attention span seems shorter for online lectures and content feedback indicates a strong preference for multiple short "mini" lecture media pieces versus a few long "real time" lectures.
10. **Measure the good, the bad, and the ugly:** If honest constructive feedback isn't wanted then don't ask for it. Be prepared to listen and improve upon meeting the various student learning styles and helping students evaluate their role and responsibilities as well as your own. Invite students to provide feedback early and often in the course. It's the best chance to close the gap between the instructor intensions and learner expectations. Most traditional students are digital natives as opposed to many instructors.
11. **Require a one time face-to-face or web cam aided meeting:** For an engineering technology course, even those more management focused, benefit from this required interaction and student verification of key learning outcomes.
12. **Prepare for pressure in other face-to-face courses:** An online course developed as those MET offerings describe, delivers an organized and highly communicated set of expectations. Other face-to-face courses may rely more on highly verbal communication of expectations which may be missed or misunderstood by students. In comparison the face-to-face course may seem less organized and the communication of the faculty, when not as highly engaged in email communication with students, may seem less attentive to student needs.

The Bad:

Time is money and time needs money. The initial large grant provided ample time and funding which elevated the quality as evidenced by the survey data presented as compared with anecdotal commentary on other later courses converted with very minimal funding and time. All projects start with time, cost, and performance (quality) targets. During development courses were beta tested, evaluated, and refined in a one by one fashion. Expectations at the start of the grant were that multi-media and streaming delivery readiness would be more advanced to allow a minimal

authoring learning curve leaving content development as the primary focus. The project was anticipated to take on a S Shaped project curve shown in Figure 3. Instead, both the multi-media technology discovery and the content development were time consuming. It would have been a grave mistake to have over invested in any early multi-media technology and content development which by now would have needed to be replaced by a more efficient and effective technology. Therefore, the development life cycle took on a J shaped pattern shown in Figure 4.

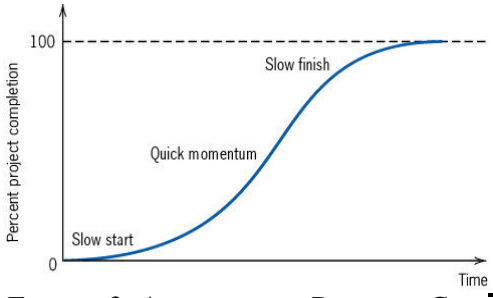


FIGURE 3: ANTICIPATED PROJECT CURVE

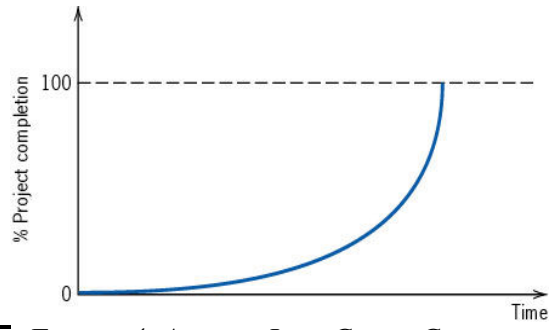


FIGURE 4: ACTUAL LIFE CYCLE CURVE

The goal of multi-media used to provide a more dimensional course was software which provided consistent delivery video and audio quality, streaming efficiency, and effective use of instructor authoring time to meet the pedagogical needs.

Several multi-media technologies needed to be evaluated prior to finding a preferred technology. This best fit technology wasn't settled on until the third generation in software evaluation. This was Visual Communicator Pro, by Serious Magic was evaluated a second time after being eliminated early in the grant due to problems in the preview stage by the difficulty with the hardware. It was reconsidered after the instructor benchmarked its use by a colleague at an October 2005 conference. It was selected and still used by the primary author for the following strengths:

1) Final rendering to a universally available and embeddable Windows Media Player format
2) No negative experiences for PC or Mac users reported
3) Single full screen contains versatile slides, audio and video, web links, and graphic features to create a variety of presentations from basic to splashy.
4) Video clips can easily be inserted "inside" the file for effective content layering.
5) Authoring presented the shortest learning curve, improved authoring management using a teleprompting feature
6) Close caption option within the software for ADA needs and straight forward final rendering.
7) Use could be expanded to create student e-folios and presentation for other educational/corporate promotion more feasibly than the other options presented.
8) Highly mobile to create streamed content, needing a web cam and earphones. Green screen may also be used to provide a variety of unique or customized backgrounds.

The department and university were able to purchase additional Visual Communicator Pro licenses at to share with other department faculty and for broader university faculty and student

use in a dedicated Teaching and Technology Lab. However, this studio lab isn't used with high enough frequency for this particular software for support staff to ensure all the technical audio and video work "right the first time" for efficient production. There are too many other uses of the peripherals.

In 2007, two additional faculty, one tenured and one adjunct were awarded MSU grants at $1,100 per credit to convert the rest of the face-to-face MET senior year courses in an asynchronous format, with help from the initial faculty developer. Seed funding of $1,100 per credit was made available by the university for each of the two new two credit courses. While this funding was appreciated, it failed to compare with the estimated $5,000/credit provided by the initial university system funding. The state university system funding wasn't pursued for these courses due to timing of the round. As a result, two additional MET faculty worked toward developing their first online course offerings using the same course structural format within the instructional management system, however, they prepared video lecture delivery through taping of entire face-to-face course lectures and converting the live lectures to streaming media afterward. In other words, the exact same course was offered to the next term of online students. This was efficient from a cost per time basis, however, the pedagogy indicates these may not have had the same preferred quality indicators.

The Ugly:

There is not a sustainability model for new faculty and significant curriculum changes which drive time and cost consuming course changes. Effective fall 2009, the 38 credits of online department courses will no longer be offered in a 100% asynchronous online format. With the fall 2009 semester, these courses will return to the face-to-face format used in the remainder of the courses in the program. While the department will continue to utilize technology to enhance its course offerings, at this time (and for the immediate future) the offering of courses online is not seen as sustainable especially in light of limited resources, the revisions being made to the curriculum, and the end of our agreement to offer courses in this format. The department will be evaluating the results of the offering of the above courses online, the appropriate pedagogue for the above courses as well as others in the curriculum, and researching sustainable ways to offer effective and efficient technology-enhanced and online courses on a course by course basis.

Not all online courses are created equal. There are as many ways to deliver the online course as there are people and as such, varied degrees of effectiveness. However, when referring to online courses, effectiveness and success are determined based on the presumption of one common delivery approach.

Online course characteristics, quality indicators, and dissemination were shared with the academic community outside the department, but not shared within the department well to assist in evaluating the benefits of the initial course offerings and the improvements planned for the later course offerings. For example, features such Learning Quizzes, where students are encourage to take a first attempt of a quiz to aid study for a second attempt may have been mischaracterized as cheating when observed by a faculty colleague. In other cases, some multi-media content streams did not allow immediate access with a slider button to return to a point where the learner may have had to stop watching lecture or case study content. The student may

have been playing the lecture on lab computers while awaiting to re-engage in the point where topic discussion left off and would appear disengaged to an observing faculty colleague.

Epilogue:

When our department evaluated the results of offering online classes, unfortunately we decided that these classes were not cost-effective enough in terms of time and money to justify continuance. Grade distribution was similar between face-to-face classes and online classes, except for a few students. But some students reported that the online classes were easier to complete, because parts could be repeated, and because they were comfortable with the technology. Thus we determined that online classes offered remotely had good features, bad features, and only a few ugly features.

But many of the students who took the online classes were on campus to take other classes, and could have taken these classes in the traditional face-to-face setting also. Budgets are tight, and course loads have been increasing. Thus we could not justify the additional time or dollar costs at this time, so we made the decision to change the online classes back to traditional face-to-face classes. But we learned many lessons, and would consider returning some of our classes online when conditions change sufficiently making time and budget available.

Bibliography

1. "**Minnesota Online: A System Request to Deliver Programs at a Distance",** L. Olson; E-Learning Accreditation Project Director, Office of the Chancellor, Minnesota State Colleges & Universities, The state university system Office of The Chancellor, October 2003
2. "**e-Accreditation Project and Coordinated Program Approval Process - Final**", Higher Learning Commission Academic Service Workgroup, March 11, 2003 http://eassessment.project.the state university system.edu
3. MERLOT http://www.merlot.org/merlot/index.htm