# Development Process for a Virtual Learning and Teaming Environment

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## Introduction

The MS – Engineering Management (ENMA) program (www.mu.edu/msenma) at Marquette University is jointly offered by the College of Engineering and Graduate School of Management. The program is designed to support the world's growing need for technologists who can lead in the conceptualization, development, and globalization of new generations of commercially viable technology-based products, processes, and services [1]. Students acquire knowledge, skills, and direct hands-on experience in:

- Generating innovative technical solutions to existing and emerging market needs;
- Transferring technical solutions into entrepreneurial products and services; and
- Developing global supplier and customer bases to apply technical solutions worldwide.

Currently, the ENMA program has about thirty students, with the majority being evening students working as engineers and managers at companies within approximately 50 miles of campus. Core courses for the program come from both the College of Engineering and the Graduate School of Management.

This report outlines the process being used to design and implement on-line versions of the ENMA core courses offered by Engineering (www.technologyforge.net/enma). A significant constraint on the development and offering of these courses is that no incremental budget or faculty time is being allotted for the work; all courses must be developed with currently-available funds and faculty time commitments.

**Identify Problem** - Why do we need on-line courses? (complete)

Starting around 2005, it was noted that absentee rates in the MS – Engineering Management program courses were rising. By 2008, some classes were experiencing 20% absent students. While several factors contribute to absenteeism, it was found that the primary cause is work-related travel. Given that most of the students in the program are working full-time in industry, that most of the students are "high-performance" employees with expanding work responsibilities, and that companies continue to expand outsourcing and offshoring activities, increases in work-related travel and resulting class absenteeism was not surprising.

The problem of growing class absenteeism was aggravated by two aspects of the program core courses offered by the College of Engineering. First, most of the courses do not use textbooks, with knowledge content being provided through lectures, skills and experience elements being provided through tutorials, homework, and student final projects. Since course knowledge content in these courses tends to build sequentially in support of the final project, missing a class can result in missing a key component of a knowledge content sequence, thereby compromising the student's performance on the final project.

The second aggravating factor is that the Engineering core courses for the program are held once per week, so missing one class is equivalent to missing an entire week of a fifteen week semester. Missing three classes is equivalent to missing 20% of the course knowledge content.

**Define Goals** – What do we hope to accomplish by providing on-line courses? (complete)

Given the problem of increasing excused absences in MS - Engineering Management program core courses offered by the College of Engineering, the primary and obvious goal of the activities described here was to *implement a system capable of conveying course knowledge content without requiring students to physically occupy a particular location at a particular time*. An obvious means of achieving this goal was to put the course lectures on-line, which became the focus of the activities described here.

Given this general solution to the primary problem of increased excused absenteeism, three secondary goals were identified. First, initial discussions with institutions providing on-line courses indicated that well-executed on-line courses in a program that accommodates this learning mode can actually provide an *improved learning experience*, so a goal of this activity was to realize this potential. Second, opportunities for *improved efficiency* present themselves. In addition to travel time and cost savings, a stroll past a typical lecture hall where 20% of the students in attendance are "virtually absent" indicates that typical live "chalk-and-talk" lectures can be an extremely inefficient means of delivering knowledge content. (Even an excellent instructor will be challenged by maintaining student attention during a three hour class on Monday night – while the spirit may be willing, the flesh will eventually weaken). Third, as mentioned, students in this program are predominantly employed and living within a 50 mile radius of the campus. On-line courses have the potential of increasing this radius, thereby *increasing program tuition revenue*. In this regard, on-line courses accommodate students who refrain or delay enrolling in the MS program because of heavy current or anticipated work travel commitments.

In the summer of 2008, seven engineering management students executed a project focused on tasks 3-5 of the process outlined above for defining and implementing on-line program core courses offered by Engineering. The team consisted of five working engineers and managers and two Navy ROTC instructors. The results of their work are outlined in the next three sections. Note that the three tasks were executed more-or-less in parallel.

**Determine Customer Needs** – What do the students need from on-line courses? (complete)

The members of team executing the project described here represent the primary customers of the project, i.e., students that will be enrolling in the on-line courses developed through the project. An early step in the project was for the team to outline their needs, and also the needs of faculty preparing and offering the courses (represented here by the author of this publication). A summary of major needs is shown in Table 1. It will be noted by people involved in on-line learning that there are no "surprise" needs here – all the needs are well-known to people working in this area. The primary point to this is that the needs represent actual voice-of-the-customer inputs from real customers of the particular program that would be offering on-line courses. Thus, the customers will be getting exactly what they asked for!

**Table 1: Customer Needs**

| | |
|---|---|
| 1 | Asynchronous (on-request) delivery of material for non-co-located students and instructors. |
| 2 | Supports all material: lectures, tutorials, homework, supplemental materials, team projects. |
| 3 | Supports virtual teaming and project management for student team projects. |
| 4 | Single website for all class elements available 24/7 anywhere in the world. |
| 5 | Clear schedule of target completion dates for all course elements. |
| 6 | All course elements available at beginning of semester. |
| 7 | Ability to work ahead on all course elements. |
| 8 | Timely feedback from instructor to student and teams. |
| 9 | Discussion forums and live chat available to students, teams, and instructor. |
| 10 | Project document drop box available to teams, instructor, and external team sponsors. |
| 11 | Full multi-media capabilities (text, audio, video). |

Having documented these needs, the student team voiced one over-riding requirement: live student and faculty interaction is considered to be a primary value-add of the ENMA core courses. So, all of the preceding goals and needs must be met while retaining a "live" element to the courses.

**Benchmark Existing Solutions** – How are others solving the problem? (complete)

Literature and web materials for a number of on-line programs at other institutions were reviewed, but the main benchmarking activities involved evaluation of the on-line Master of Engineering in Professional Practice (mepp.engr.wisc.edu) program at the University of Wisconsin – Madison's College of Engineering (a close equivalent of the ENMA program), and the BlendEd® program at the Kellet School of Adult Education at Lakeland College (lakeland.edu/BlendEd). Student team members and the author interviewed key staff at both of these programs.

Probably the most important take-aways from these interviews were: 1) a well-designed and executed on-line program can, in fact, meet all of the general goals and customer needs referenced here; and 2) preparation of such a program takes considerable effort (the UW program has undergone continuous improvement for over ten years), and delivery of on-line courses consumes more instructor time and energy than live courses.

**Review Existing Tools** – What tools are available and who is using them? (complete)

Marquette University uses DesireToLearn (D2L - www.desire2learn.com) for courses currently being offered on-line, so this would seem to be the logical choice for implementing on-line versions of the courses being considered here. However, the student team was requested to review other toolsets as well. The rationale was this: If D2L does not meet the goals and customer needs stated here, or if other systems provide significantly superior solutions, then the program's on-line courses will not be built on an inferior system. Further, if access to superior tools was not possible, change-over to on-line courses will not be pursued.

In addition to D2L, the team investigated Blackboard (www.blackboard.com), a major competitor of D2L, and Moodle (www.moodle.org), a free open source course management system (CMS), also known as a learning management system (LMS) or virtual learning environment (VLE). Lakeland College used Blackboard, and the UW-Madison benchmarked is built on Moodle.

Detailed evaluations of D2L and Blackboard were conducted by applying a methodology used by a team member to evaluate software packages. The dimensions of the evaluation were:

- Functionality
- Support
- Performance
- Scalability
- Usability
- Flexibility/Customizability

A preliminary evaluation was also performed on Moodle, which highlighted the flexibility of this toolset as major advantage (a conclusion supported by examination of the UW-Madison system). However, as an open-source solution, significant resources are required to develop and support a Moodle-based system. Because the on-line courses being considered here must be developed without additional resources, Moodle was eliminated from further consideration.

The evaluation indicated that D2L performance appears to be on a par with Blackboard and adequate for the goals and needs of this project. Since the University already holds D2L licenses, the student team concluded that D2L would b a suitable toolset for their on-line courses.

**Specify Solution** – How will the on-line courses be structured? (complete)

Work done to this point was organized by the team into as-is and to-be matrices, shown in Appendices I and II. These formed a specification for development of the on-line courses. Comparison of the two matrices reveals the specific elements of the existing courses that needed to be changed for on-line versions. Regarding implementation details shown in the to-be matrix (on-line discussions, drop boxes, etc.), all features are within the capabilities of D2L (subject to

certain limitations noted in the evaluation of D2L), and implementation details will not be discussed further. However, certain high-level elements of course structure remained to be defined.

Regarding the need to preserve the live student and faculty interaction considered to be a primary value-add of the ENMA core courses, the student team proposed that live classes be held every other week at the regularly-scheduled time and place, meaning that only half of the class periods would actually be on-line. This would allow live discussion of key or confusing topics, and would have the additional benefit of insuring that student project teams would meet in-person on a regularly-scheduled basis for a longer period of time than typically allotted in all-live versions of the courses. Students felt that this compromise would still significantly reduce absenteeism because it would allow them considerable flexibility in scheduling work travel (in essence, a thirteen day travel window).

Since all student work (individual and team) would be submitted on-line, this approach enables a key element of any engineering management program: peer evaluation. Therefore, it was decided to include mechanisms for peer review as well as instructor assessment of student work as part of the on-line offerings. This capability is especially beneficial in an engineering management program because project and personnel evaluation is an important function performed by engineering managers, but often gets short-changed in an engineer's training.

Regarding conversion of existing course materials to on-line versions, it was decided to keep the existing PowerPoint presentations as the primary source of knowledge content, but to enhance the presentations in two ways. First, a "notes" page would be added to each slide explaining the slide content. In essence, this is what the instructor would say when the slide was shown during a lecture. Second, an audio file of the spoken notes page would be embedded in each slide. The audio would play when an icon on the slide is clicked.

PowerPoint presentation files with notes page and embedded audio would be linked on the course web site, as they currently are. Students would open or save the presentation, then print out the presentation, and then run the presentation as a slide show. Students would scan over slide contents, then click on the audio icon to play the slide narration. Students could take notes on slide print-outs, and reference the speaker notes for clarification of the audio narration.

**Build and Test Prototype** – Does the concept work? (complete)

Four prototype lectures for the ENMA course "System Modeling, Analysis, and Simulation" were rolled out in Spring 2009 (see Decision Trees 1 & 2 and Monte Carlo 1 & 2 lectures at www.technologyforge.net/enma/6010/ENMA288CourseScheduleS09.htm).

In alignment with the requirement that no incremental resources be allotted for development of on-line courses, the instructor purchased a digital audio editor software package that plays, records, edits, processes, and converts audio on a personal computer (www.goldwave.com), and worked evenings and weekends preparing speaker notes for existing PowerPoint lectures, recording and editing audio narrations from the notes, and embedding the audio into the slides.

Initial trials revealed some problems related to computer/software/network incompatibilities, so zip file versions of PowerPoint and audio files were prepared. If lectures failed to run by saving and opening files from the course web site, downloading and unzipping the zipped files overcame the compatibility problems.

In addition to working out start-up bugs, experiences with prototype lectures have revealed several unanticipated benefits of on-line courses. First, ambitious students can start working through lectures and tutorials before the official start of classes, thereby softening the hard boundaries between semesters. This further reduces travel-related absentee problems. Further, since the ENMA courses offered through the College of Engineering are typically highly project-oriented, but project deliverables typically depend on course content delivered through lectures, students getting a head-start on lectures are in a position to also get a head-start on team projects and deliverables. The result is more ambitious and better executed student team projects.

Second, on-line courses can significantly enhance ENMA international outreach [2-4]. The author is conducting cooperative research on data mining and machine learning in manufacturing (www.technologyforge.net/KDAM) with partners at the Warsaw University of Technology's Faculty of Production Engineering (http://eng.pw.edu.pl/Faculties/Faculty-of-Production-Engineering). The on-line data mining and machine learning course which will be the first fully on-line ENMA offering (see next section) is being developed with the cooperation of the Warsaw researchers, and will be offered at both Marquette and Warsaw. The asynchronous (on-demand) non-co-located student and instructor requirement for on-line ENMA courses enables long-distance joint course offerings.

Third, prototyping efforts have revealed that preparing on-line lectures requires the virtual lecturer to take special care to insure that key concepts are conveyed clearly, completely, and concisely so that effective knowledge transfer can occur without human intervention. This need becomes especially acute when preparing lectures for student whose first language is not that of the instructor (watch vocabulary, grammar, colloquialisms and abstruse cultural references!), as is the case for courses to be jointly offered with international partners. Results indicate that careful attention to on-line lecture content and delivery can, in fact, improve the quality of the knowledge transfer process (i.e., you can't just make stuff up as you go along).

Finally, it was noted during prototyping that on-line submission of assignments, on-line discussion of lectures and assignments, and on-line peer review enhanced the instructor's ability to assess the "virtual class participation" of students (quantity, quality, and timeliness), thereby further improving the quality of the on-line course learning experience.

Prototyping work did reveal one other issue. The author can now confirm that, as stated by benchmarking sources, the overall workload for instructors is, indeed, higher for on-line courses than for live courses. However, this is offset by the same primary benefit that this approach offers students, namely, the instructor need not apply this additional effort at a particular time and location. It is this author's experience that increased work-load is more than offset by increased work flexibility.

**Roll Out First Offering** – Doe the concept work for an entire semester course? (Fall 2009)

The first complete on-line ENMA course, "Innovation and Technology" is going on-line in Fall 2009. The course schedule is shown in Table 2, and provides an example of how on-line courses are being structured. Seven on-line lectures are provided (coded as O for "on-line), with target completion dates every second week. Homework assignments are provided for each lecture, due the following week. Class will meet on these weeks (coded as L for "live") to discuss lectures and homework.

**Table 2: Schedule for On-Line Version of "Technology and Innovation" Course**

| Wk | O/L | Lecture | Hwk. | Tutorial (O) | Assig. | Sol. | Project Deliv. |
|---|---|---|---|---|---|---|---|
| 1 | O | 1 - Introduction | | 1 - Start-Up | | | |
| 2 | L | | Hwk. 1 | 2 - Concepts | Assig. 1 | | |
| 3 | O | 2 - Classification | | 3- Classification | Assig. 2 | Sol. 1 | |
| 4 | L | | Hwk. 2 | 4 - Clustering | Assig. 3 | Sol. 2 | Deliverable 1 |
| 5 | O | 3 - Clustering | | 5 - Association | Assig. 4 | Sol. 3 | |
| 6 | L | | Hwk. 3 | 6 - Explorer | Assig. 5 | Sol. 4 | Deliverable 2 |
| 7 | O | 4 - Association | | 7 - Knowledge Flow | Assig. 6 | Sol. 5 | |
| 8 | L | | Hwk. 4 | 8- Rule Classifiers | Assig. 7 | Sol. 6 | Deliverable 3 |
| 9 | O | 5 – Neural Networks | | 9 - Naïve Bayes Classifier | Assig. 8 | Sol. 7 | |
| 10 | L | | Hwk. 5 | 10 - Neural Networks | Assig. 9 | Sol. 8 | |
| 11 | O | 6 - Bayes Networks | | | Assig. 10 | Sol. 9 | |
| 12 | L | | Hwk. 6 | | | Sol. 10 | Deliverable 4 |
| 13 | O | 7. Genetic Algorithms | | | | | |
| 14 | L | | Hwk. 7 | | | | Deliverable 5 |
| 15 | L | | | | | | Final Presentation |
| 16 | O | | | | | | Final Report |

In addition to the lectures and homework, ten on-line tutorials with assignments and solutions are included in the course. This course covers fundamentals of data mining and machine learning, and uses the open-source Weka data mining software (www.cs.waikato.ac.nz/ml/weka/) to demonstrate data mining techniques and execute team projects. The tutorials are focused strictly on learning to use these software tools. These tutorials are equivalent to the "supplemental material" column in the as-is and to-be matrices in the appendices.

Finally, project deliverables are due on days when the class meets live with each team presenting deliverable updates to the class, except for the final report, which is uploaded to the associates course drop box.

**Obtain Feedback** – Best/worst practices? (Winter 2009)

Marquette University uses a standardized on-line student survey to assess courses and instructors. This tool provides a convenient validated mechanism for performing comparisons

within programs, and across programs, colleges and schools, and the University. Additionally, the University requires instructors to complete student performance assessments for each course. These tools will form the primary mechanisms for assessing effectiveness of on-line conversion of ENMA courses.

In addition, a specialized web-based survey tool has been developed specifically to assess if on-line ENMA courses have met the specific goals and needs outlined above, and to see if the anticipated benefits revealed through prototyping transfer to full-semester courses. It is anticipated that this tool will provide specific direction for continuous improvement of on-line ENMA courses

**Revise Specification** – What needs to be improved? (Spring 2010)

On-line course goals, needs, and benefits will be reviewed based on the assessment tools outlined above, and will be revised as needed. Additional course conversions will be based on revised specifications, as will be continuous improvement of converted courses.

While this work lies in the future, it is clear that one element of the on-line courses being implemented here needs improvement. D2L tools do not provide the level of support for virtual team and projects required for this graduate level engineering-based program. While D2L should be adequate for initial ENMA course offerings, projects in ENMA courses have become significantly more ambitious over the last five years, and these tools will not be adequate as the program moves into the future. Efforts to find better-suited tools for this aspect of the ENMA program are currently underway.

**Convert Remaining Courses** – Do it again, and again… (Spring 2013)

Table 3 shows the lecture-based ENMA courses offered by Engineering suitable for conversion to on-line versions, along with projected semesters that courses would be available. Given resource constraints, a conversion rate of two courses per semester seems reasonable. All courses are anticipated to be ready by Spring 2013.

**Table 3: Schedule for Converting Courses to On-Line Versions**

| Number | Title | Certificate | Avail. |
|---|---|---|---|
| ENMA 6010 | System Modeling, Simulation, and Analysis | ENIN/NPPD | F '10 |
| ENMA 6020 | Strategic Technology Planning and Development | ENIN | S '10 |
| ENMA 6030 | Engineering Six-Sigma Design and Development | NPPD | TBD |
| ENMA 6040 | Lean Manufacturing Systems | NPPD | F '11 |
| ENMA 6050 | Reliability, Failure Analysis, and Risk Assessment | NPPD | TBD |
| ENMA 6060 | Innovation and Technology | ENIN | F '09 |
| ENMA 6070 | Engineering Project Management | NPPD | TBD |
| ENMA 6080 | Front-End Engineering Product Development | ENIN | TBD |
| ENMA 6090 | New Product and Process Portfolio Management | ENIN/NPPD | TBD |

| ENMA 6961 | Intellectual Property Generation and Protection | ENIN | S '11 |
|---|---|---|---|

The table also includes a column that shows which of the ENMA-related College of Engineering certificates (www.mu.edu/enmacerts) each course is associated with. IN essence, the Engineering Innovation certificate (ENIN) is directed toward doing the *right* things, while the New Product and Process Development certificate (NPPD) emphasizes doing things *right*. Four of the designated courses are required to achieve the certificate. The intent behind the availability dates for the courses is to get four courses from the ENIN certificate on-line first so that certificate can be offered as an on-line certificate.

**Summary** – So what?!

Prototypes and current course conversion efforts indicate that on-line courses for the MS – Engineering Management program offered through Marquette's College of Engineering can meet the goals and needs outlined in this document. The specific implementation approach outlined here permits conversion to on-line courses at the rate of one per semester without requiring allocation of additional time and funding resources. Conversion of ENMA Engineering core courses is anticipated to be complete by Spring 2012.

In conclusion, an additional benefit of the general approach outlined here must be noted. Organizations in general will continue to rely more and more heavily on creation and support of web-based virtual workplaces. First building and then effectively functioning in such environments will become an increasingly important "core competence" of organizations of all types and the individuals functioning in such organizations.

Nowhere is this more true than for the engineering profession. In addition to meeting the goals and needs outline here, participation by students in the virtual work environment provided by on-line courses will enhance the student's effectiveness in this environment, thereby significantly enhancing the overall learning experience offered by this program. In the end, this may prove to be the most beneficial aspect of the work described here.

**References**


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## Appendix I: Engineering ENMA Course As-Is Matrix

| As-Is | Description | Primary Material | Supplemental Material | Team Projects |
|---|---|---|---|---|
| **Delivery** | How is information delivered to students? | Weekly PPT lectures delivered live by instructor to on-site audience; available at beginning of semester on course website. | Course "non-textbook" is assigned to augment course topic; case study readings are selected to augment specific lecture materials; target completion dates are provided; materials available on course web site at beginning of semester. | Instructor works with student project teams after weekly lectures to develop project descriptions and deliverables; generic project deliverables defined at beginning of semester. |
| **Application** | How do students apply information? | Weekly homework assignments corresponding to lectures available on course website at beginning of semester; typically prepared by students as individuals (vs. teams); prepared as PPT and presented live by students during class. | Study questions derived from supplemental material available on-line at beginning of semester; includes "your opinion" question to stimulate integration of information; prepared by individual students as .pdf and presented live by students during class. | Teams work on ad-hoc basis using primarily e-mail and out-of-class face-to-face team and sponsor meetings. |
| **Feedback** | How do students obtain clarification and expansion of information? | Q&A conducted during lectures and homework presentations; instructor and peer review of student homework presentations allows students to see the "right" answer to the homework. Instructor also posts solutions (where applicable) on the course website. | Students present answers to study questions in class; instructor and peer review of student presentations allows students to see the "right" answer to the study questions. Instructor posts study question "suggested" answers on course website. | Time is set aside at the end of class for teams to review progress and determine next actions and responsibilities; instructor is available to teams as consultant. Out-of-class meetings with instructor scheduled as needed. |
| **Student Assessment** | How is student assimilation of information assessed? | Instructor reviews homework submissions and provides individual grade based on effectiveness of student's application of course material to homework. | Instructor reviews study question submissions and provides individual grade based on the effectiveness of student's application of supplemental readings to the primary course material. | Students submit final written report and PPT presentation. Instructor grades deliverables. Peer/sponsor assessments obtained for final presentations. Students assessed as teams. |

**Appendix II: Engineering ENMA Course To-Be Matrix**

| To-Be | Description | Primary Material | Supplemental Material | Team Projects |
|---|---|---|---|---|
| **Delivery** | How is information delivered to students? | PPT slides with speaker notes and with/without voice over or video lecture; with target completion dates; available on course website at beginning of semester. | Course "non-textbook" assigned to augment course topic; case study readings selected to augment specific lecture materials; target completion dates provided; materials available on course web site at beginning of semester. | Generic outline of project provided by instructor on course website; generic project deliverables defined at beginning of semester; additional information obtained via live instructor and sponsor meetings. |
| **Application** | How do students apply information? | Homework assignments with target dates corresponding with primary material available on course website at beginning of semester; typically prepared by individuals (vs. teams); uploaded as .pdf to course discussion folder. | Study questions derived from supplemental material available on-line at beginning of semester; includes "your opinion" question to stimulate integration of information; prepared by individual students and uploaded as.pdf to course discussion folder. | Teams conduct virtual web-based project meetings, with live team and sponsor meetings as-needed. |
| **Feedback** | How do students obtain clarification and expansion of information? | On-line instructor and peer review of homework uploaded to discussion folder allows students to see "right" answer to homework. Instructor also posts solutions (where applicable) on course website. | On-line instructor and peer review of submission uploaded to discussion folder allows students to see the "right" answer to the study questions. Instructor posts study question "suggested" answers on course website. | Teams use web discussion board for daily communication, and web drop-box for document sharing. Instructor monitors discussion board to provide feedback as needed. Instructor meets live with team as needed. |
| **Student Assessment** | How is student assimilation of information assessed? | Instructor and peers review homework submissions and provide individual grade based on effectiveness of student's application of course material to homework. Instructor evaluates student's participation in homework discussions. | Instructor and peers review study question submissions and provide individual grade based on effectiveness of student's application of course material to study questions. Instructor evaluates student's participation in study question discussions. | Students submit final written report and PPT presentation. Instructor grades deliverables. Peer/sponsor assessments obtained for final presentations. Students assessed as teams. |