2006-1433: TOOLS FOR AUTHENTIC ASSESSMENT USED IN THE ACTIVE LEARNING IN THE VIRTUAL ENTERPRISE SYSTEM (ALIVE)

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Tools for Authentic Assessment Used in the Active Learning in the Virtual Enterprise System (ALIVE)

1. Introduction

The Active Learning In the Virtual Enterprise (ALIVE) system is an NSF CCLI sponsored effort to teach systems thinking, information technology, and business skills while integrating curriculum and disciplines. The Virtual Enterprise (VE) is a full scale manufacturing supply chain, integrated using information technology, and producing an actual product (desk clocks). Departmental laboratories are organized as business departments within the enterprise including engineering, manufacturing, assembly, and distribution.

ALIVE is a set of about twenty web-based learning modules, essentially short internships in different functional areas of the VE. As with an internship, students are given objectives, introduced to the business function, shown how the function is integrated using IT, exposed to economic and other systems issues, tested individually for comprehension, then asked to work on a team to achieve some business purpose. Students perform one or two learning modules of progressive difficulty in each undergraduate Industrial Engineering class; sometimes in conjunction with other disciplines such as business. ALIVE provides a practical and consistent means of developing realistic problem solving skills in engineering and business students reaching a variety of learning styles.

Student assessment within the ALIVE system is achieved through an authentic assessment process. The process uses instructor, industry, and student/peer feedback according to the six levels of authentic assessment: Basic Knowledge, Inquiry, Explanation, Problem-solving, Representation of Knowledge, and Metacognition. Rubrics are developed for each evaluation source to encourage development of skills relevant to practice throughout the curriculum. A scoring mechanism is described to alleviate the tension in student peer assessment between loyalty and honesty. Though this paper focuses on student assessment, system assessment is summarized.

2. Background

2.1 Engineering Education

The nature of engineering practice has changed significantly over the last three decades. The pace of change, driven by increased competitive pressures, has been particularly intense over the last decade. However, engineering education has not changed appreciably over that period. The growing gap between traditional engineering education and the result of many years of change in engineering practice has caused engineering school constituents to question the effectiveness of the programs[1]. Graduate engineers are expected to contribute immediately in competitive environments with system engineering, information technology, and soft (communication, leadership and team) skills in addition to traditional engineering fundamentals [2,3]. Such skills are particularly relevant for Industrial Engineers who often serve as a facilitator of technical and business interactions[4,5].

A number of efforts to increase these skills have been undertaken, the most common being the capstone senior design projects. Curriculum designers are increasingly more aware of developing courses that combine skills from several prior courses to practice such skills. Especially innovative approaches introduce students to systems thinking early and continuously through their program, stressing both engineering and business issues[6]. Programs that have sought to emphasize this approach have ranged from small-scale graduate programs[7]; to departmental[8]; to large-scale multi-institutional efforts[9]. Successful programs supplement traditional engineering science with practical experience in solving real problems, developing the systems, IT and business skills.

2.2 Interdisciplinary Efforts

Increasingly, such experiential learning involves working with multiple disciplines[10]. Many universities, encouraged and supported by industry, now offer capstone senior design projects performed by teams composed of varying engineering disciplines. More recently, the teams for such projects are being expanded to include business disciplines, IT disciplines, and science disciplines. Industry and Business advisory bodies regularly recommend such arrangements because they introduce students to the more comprehensive business enterprise and more closely resemble realistic practice. Other efforts in this area include class partnering.

2.3 Active Learning in the Virtual Enterprise System

The NC A&T State University Department of Industrial and Systems Engineering Virtual Enterprise (VE) is a full scale manufacturing supply chain, integrated using information technology, and producing actual product. Departmental laboratories are organized as business departments within an information system-integrated enterprise. The VE departments, their function, and conceptual structure can be seen in Figure 1. The enterprise database has been modeled, created and populated (about 80 entities) with application programs constructed for manufacturing, assembly, distribution, engineering and scheduling.

The VE system is designed with flexible processes to handle multiple products. The initial VE product is a desk clock as shown in the Figure 2 assembly (without timepiece). The desk clock is designed using parametric solid modeling and with a rapid prototyping system in the Product, Process, and Facility (Engineering) Department. Parts are manufactured using injection molding and CNC machining and inspected using a CMM in the Manufacturing Processes and Systems Department. Automated assembly is accomplished in a flexible assembly cell. The cell possesses CNC capability to custom engrave initials and vision-guided robot insertion to insert a timepiece with the correct time (according to the time zone of the customer). The assembly process allows learning of production postponement and delayed differentiation concepts. A second planned product is a disposable camera. This product facilitates teaching of reverse logistics, product recovery, and remanufacturing.

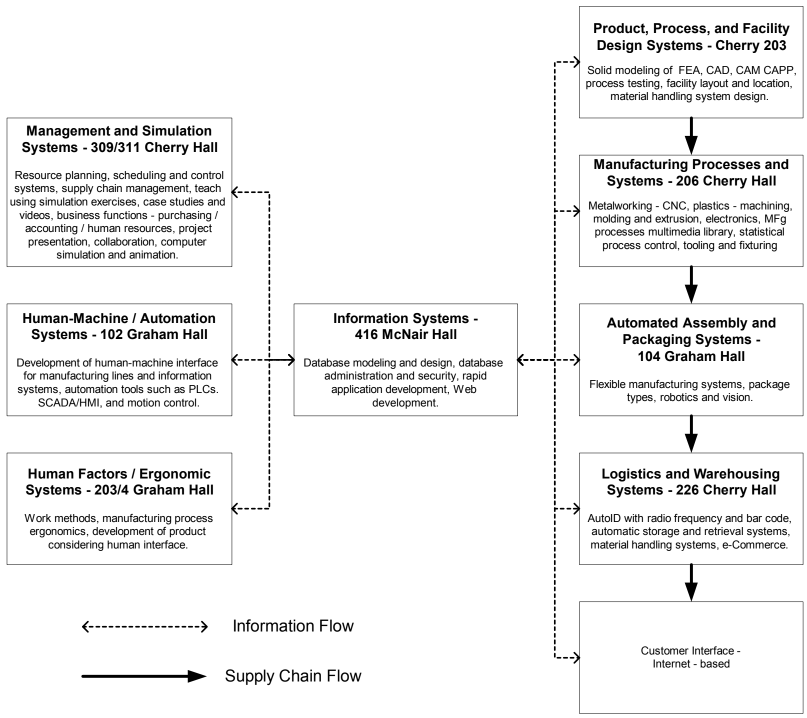

Figure 1: Virtual Enterprise Conceptual Structure

Each student learning interaction with the virtual enterprise is termed a learning module. Each course in the Industrial Engineering curriculum would have at least one associated learning module. As a result, the student learns the connections between different classes. Learning modules are performed in teams and typically will consume one week of class time. A learning module requires successful completion of the following steps:

1. Learning objectives – The module starts with a listing of module learning objectives, the basis for student evaluation. The objectives are written using Bloom's Taxonomy to encourage higher leveling thinking. The learning objectives also contain an emphasis on developing problem solving skills in students.
2. Functional training – The next step is to have the student team perform the laboratory exercise focusing on the related

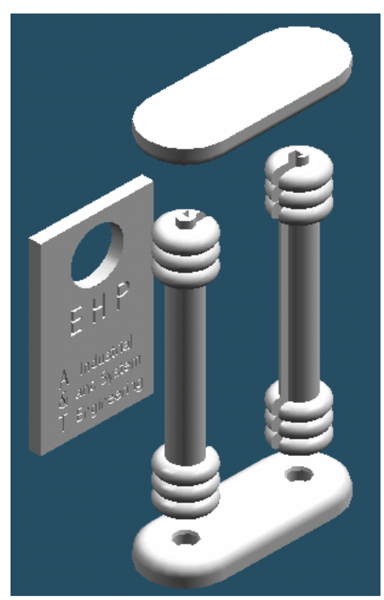

Figure 2: VE Desk Clock

functional area. This step is where most laboratory experiences begin and end, with the student left to make all inductive conclusions.

3. Data / process model – The student team will review and analyze the data and process models associated with integrating. The student will learn how to use the virtual system interface. The Web interface allows the student to navigate through the data model and see entity and attribute definitions and types. The process model interface allows decomposition to the code level. (Students will learn how to understand data and process models early in the curriculum.)
4. Economic / value issues – The business issues involved in this function are described with student teams producing a tradeoff analysis.
5. Other design issues – The student team is introduced to additional systems issues including (where appropriate) social, safety, ergonomic, global, political, and regulatory concerns.
6. Individual evaluation – Each student is evaluated to ensure learning in steps 2 and 3 above. This evaluation is done by a test of skills learned in step 2 and the ability to write appropriate database queries for step 3.
7. Case study – Finally the team demonstrates the ability to synthesize all information learned from steps 2-5 by performing a case study. The case study encourages problem solving and higher level thinking skills.

Instruction regarding the learning modules is implemented in Web-based format to enhance portability and enable asynchronous learning.

2.4 ALIVE Curriculum and Discipline Integration

As described earlier, Industrial Engineering curriculum integration of the VE is achieved through the ALIVE (Active Learning In the Virtual Enterprise) system. The ALIVE system provides the equivalent of many short intern experiences in different parts of the same small company. It provides a practical and consistent means of developing systems engineering, information technology, and business skills in engineering students. The pedagogical design reaches a variety of learning styles including active, sensory, visual, global, and inductive.

A key contribution of the ALIVE system is its usefulness in technical business classes in addition to engineering courses. This ALIVE project involves modifying learning module content to be inclusive of business school needs, yielding a core set of learning modules for business curriculum. This modification will allow not only business school use, but interdisciplinary use in universities where both business and engineering schools exist. Business programs do not have the physical manufacturing equipment, but often have the computational infrastructure to support ALIVE implementations up to the information system level. For interdisciplinary efforts, the case study step would be performed by teams composed of engineering and business students. Some exercises are performed using a "jigsaw" arrangement where each team participant is assigned a specific functional role. That person may be given additional information relative to their function. Since a learning module consumes at least one class and at most one week, the time commitment from the students is minimal. This short term project introduces students to the challenges of interdisciplinary work without sacrificing class content. The interaction could be greatly enhanced by cooperative scheduling of related classes by engineering and business departments.

Table 1 lists learning modules that have or will be developed for the ALIVE system. Those modules shown in italics may be done with business classes, those in bold may be done with other engineering disciplines. Table 2 shows the associated business classes at our university.

Table 1: Learning Module List

Module Title	**Labs**	**Classes**	**Class Title**
Application Programming	***416 McNair***	***GEEN 102***	***Computer Programming***
Introduction to Virt. Enterprise	***All***	***INEN 246***	***Manufacturing Processes***
Custom Manufacturing	**206 Cherry**	**INEN 246**	**Manufacturing Processes**
Automatic Performance Tracking	102 Graham	INEN 255	Methods Engineering
Activity vs Standard Cost Decisions	***311 Cherry***	***INEN 260***	Engineering Cost Mgmt
Enterprise Data Modeling	***416 McNair***	***INEN 280***	***Information Technology***
Enterprise Web DB Interface	**416 McNair**	**INEN 280**	**Information Technology**
Team Decision Making Using IT	*311 Cherry*	*INEN 289*	*Engineering and Teams*
Statistical Process and System Control	***206 Cherry***	***INEN 325***	***Quality Control***
Inventory Level Optimization	*226 Graham*	*INEN 330*	*Operations Research I*
Manufacturing Execution	104 Graham	INEN 346	Automation Systems
Process Reengineering/ Improvement	104 Graham	INEN 346	Automation Systems
Production Scheduling & Cont.	*104 Graham*	*INEN 355*	*Production Control*
Dist.Planning and Tracking	*226 Cherry*	*INEN 355*	*Production Control*
Material Handling and Control	203 Cherry	INEN 365	Facilities Design
Enterprise Interface Dvlpmnt	**102 Graham**	**INEN 371**	**Human Factors II**
Virtual Enterprise Simulation	311 Cherry	INEN 415	Simulation
Product Redesign and BOM	203 Cherry	INEN 424	CAD/CAM
Process Planning and Tracking	203 Cherry	INEN 424	CAD/CAM
Virtual Enterprise Business Functions	*311 Cherry*	*INEN 485*	*Systems Integration*
Ergonomic Asmt of Assembly	204 Graham	INEN 372	Human Factors I
Reverse Logistics	*104 Graham*	*INEN 485*	*Systems Integration*

Table 2: Learning Module Business Classes

Module Title	**A &T Bus. Class**	**Business Class Title**
Application Programming	BUED 342	Business Prog.
Introduction to Virt. Enterprise	BUAD 482	Production Mgmt
Activity vs Standard Product Cost Decisions	ACCT 444	Cost Accounting
Enterprise Data Modeling	BUAD 440	Business Info Sys
Team Decision Making Using IT	BUAD 426 BUAD 520	Org.Behavior Strategic Mgmt
Statistical Process and System Control	BUAD 482	Production Mgmt
Inventory Level Optimization	BUAD 481	Mgmt Science I
Production Scheduling & Cont.	BUAD 482	Production Mgmt
Dist.Planning and Tracking	TRAN 440	Intro to Logistics
Material Handling and Control	TRAN 670	Materials Mgmt
Virtual Enterprise Business Functions	BUAD 448	Systems Analysis
Reverse Logistics	TRAN 440	Intro to Logistics

2.5 Authentic Assessment

The ALIVE system affords the opportunity to perform more authentic assessment. The notion of "Authentic Assessment" or "Performance Assessment" was developed as a response to the criticism of traditional assessment methods such as standardized tests in the context of K-12 education[11,12]. According to Hart [13], "performance assessments are designed to test what we care about the most – the ability of students to use their knowledge and skills in a variety of realistic situations and contexts." As the popularity and use of project oriented classes emphasizing hands-on education continues to grow, educators are faced with the challenge of evaluating student performance in this non-traditional setting. Amos[14] discusses and provides examples of proven authentic assessment techniques, including rubrics and portfolios to validate the satisfaction of industry desired competencies. Some engineering programs (for example, West Point's systems engineering program[15]) utilize their capstone design course to assess the ability of their students in professional practice by engaging the industry clients in the process. An example of authentic assessment is the Membership by Assessment of Performance (MAP) as a new route to membership of the Royal College of General Practitioners in the United Kingdom. MAP allows experienced General Practitioners (GPs), who can show evidence of good quality practice, to become members of the College through an assessment of their performance and a demonstration of the quality of medical care rather than by sitting for the MRCGP examination[16]. Leaders in the US medical education system have advocated the use of performance-based assessment of clerkships (medical students in clinical rotations) as a credible approach for summative as well as formative evaluations[17]. The National Center for Research on Evaluation, Standards, and Student Testing suggests six components of performance assessment with relevant learning module steps given:

Basic knowledge: This component represents the lowest levels of Bloom's taxonomy, and is concerned with the facts and details that students must know. Basic knowledge can be assessed by student performance on tests that are designed to measure students' ability to recall facts. Through VE learning modules the students' ability to recall facts will be measured during the Individual Evaluation phase. Students' will be tested on the knowledge learned through the Functional Training activities and Process Model phase of the learning modules.

Inquiry: This component focuses on the process of obtaining information through hands-on experimentation and then interpreting the results to create new knowledge. The Functional Training phase of the learning modules may require some collection of data, therefore the inquiry component by be assessed by evaluating the results of the Functional Training activity.

Explanation: The component involving extending factual knowledge to describe more complex concepts and principles. The element places more emphasis on the "why" aspect of knowledge, and not so much on the "what" and the "how". During the Economic/Value Issues and Other Design Issues of the learning modules students will be required to provide justification of a current or news event based on facts and knowledge learned. The students will be authentically assessed as a team through the Case Study section of the learning modules, the teams will demonstrate the knowledge learned and explain the "why" aspect based on the Economic/Value and Design Issues phases of the learning modules.

Problem Solving: This element involves the actual task of finding a solution to a problem and also providing a reasoning that justifies the solution. The assessment of problem solving ability will be carried out during the Case Study team activity. Each team member may take on a different role (production manager, engineer, and accountant), encouraging problem solving, collaborative learning, and higher level thinking skills.

Representation of Knowledge: This area of performance is concerned with communication of important ideas in an effective manner. During the Functional Training and Case Study activities the students will work in teams and will be encouraged to communication effectively and present information, as they would in the work place. Evaluation of the team activities will take communication of knowledge and team building skills into consideration. The team product is an oral or written report.

Metacognition: This component relates to the student's ability to understand what he or she knows or does not know and to set challenging and attainable goals for learning. This is perhaps the most important aspect of performance assessment, and will be evaluated during the Individual Evaluation and Case Study phases of the learning modules.

3. ALIVE System Assessment

Program evaluation is done according to the Accreditation Board for Engineering and Technology (ABET) process. As applied to our engineering curriculum, program objectives drive program outcomes (derived from ABET a-k). Program outcomes are attached to courses through a matrix structure. Each course develops course learning objectives to achieve the associated outcomes. Students are assessed according to each associated course objective and surveyed about the perceived level of meeting these course objectives. "Course committees" are convened at the end of each semester to review the level of student performance relative to the outcomes/course objectives. The committee suggests changes in the course to address the desired outcomes. Typically, instructors maintain a list of detailed learning objectives that are driven by the course learning objectives and directly assessed in the course. The process of developing and maintaining the program objectives and outcomes is performed by a Program Advisory Council. Most council members are alumni or employers familiar with practice.

The ALIVE system is designed and assessed within this context. The formative evaluation is performed mainly through module evaluation. Module evaluation tools include a pretest and posttest, individual performance on learning module, and team performance on case study. The pre- and post-tests have two sections, each with 4-8 questions. The first section addresses the topic/business area covered in the learning module. The questions are constructed to form a "concept inventory". The concept inventory construction will be done in conjunction with practicing professionals. The second section addresses the student's perceived ability, motivation and interest. Outcome measures include change in grasp of concept, change in perceived ability, and change in motivation and interest. The individual performance on the learning module records the number of incorrect answers before successfully completing the test.

The experiments which have or will be performed include:
1. Comparing performance on case study with versus without other ALIVE steps
2. Comparing performance with lecture (no ALIVE) versus ALIVE module (no lecture)
3. Compare performance different versions of ALIVE interface
4. Compare performance of second ALIVE module after first ALIVE module (in same class)
5. Compare performance of business versus engineering students (year two)

ANOVA analysis is being used in system selection and improvement. Analysis will emphasize impact on underrepresented populations. In addition, we will survey students at the end of the semester (via course learning objective surveys) and at the end of their undergraduate study (via senior exit surveys) to determine impact of ALIVE modules.

4. ALIVE Student Assessment

4.1 Student Process

To a student, the learning module process consists of the following steps:
1. Prior to participating in any module, the student views an "Introduction to the Virtual Enterprise" and "Introduction to the ALIVE System" streaming videos. When ALIVE is used as a curriculum integrator, students would quickly become familiar with this information and would skip to the next step.
2. In some cases, students take a pre-test evaluating existing knowledge and perceived capability.
3. The student is placed in the role of a short-time intern walking into a new department of the company. The function of the area is explained and physically demonstrated to the student. The functional step may or may not involve teams. The student is required to perform the functional operation for some higher implementation levels.
4. Next, each individual student interacts with the data model for the area, the process model for the associated computer application, a spreadsheet of economic calculations, and a list of other design issues for the area. This process allows the student to learn in an interactive, graphical way.
5. Upon completion of the step 4, the student is individually assessed to verify understanding. The individual assessment allows the student to continue to work through the test until all responses are correct. The system records the number of wrong answers for each question for review by the instructor. The student may interactively look through other parts of the web page while taking this assessment. The focus is on learning and the performance on this step is not part of the module grade.
6. The student is given the case study (in the form of a memorandum to perform some work) and perhaps a role on the team.
7. The student spends a class period (we attempt to schedule classes that partner at matching times) meeting with other team members and performing the work requested in the case study.
8. After the case study is complete (written report submitted or oral presentation given), the student completes a self assessment and peer assessment rubric.

9. The case study is assessed by both teachers and practitioners using an authentic assessment rubric. Students receive detailed feedback from both in order to prepare better for future practice. Students may be required to respond to feedback.
10. In some cases, students take a post-test evaluating knowledge and perceived capability.

4.2 Student Evaluation

Upon completion of the module, student evaluation is performed based on a triangulation technique. Specifically, feedback from the instructor(s), practicing professional(s), and the student is used. The information from the instructor and practicing professional form the team base score. This base score is adjusted based on the accuracy of self assessment and the level of individual contribution. An emphasis is placed on giving qualitative feedback useful for improvement in addition to quantitative feedback useful for comparison and analysis. All feedback is to be collected using the Web with scoring performed in an automated fashion allowing modification by the instructor. Emphasis is placed on having orthogonal (independent) metrics to minimize instructor load (as with other input sources). Current methods solicit feedback on a Likert scale though alternative methods are being investigated. This process is described in more detail below.

The instructor rubric focuses on detailed collection of quantitative data. The rubric itself is generated dynamically based on four variables: topic, associated objectives, authentic assessment, and report format (written or oral). Topic questions are module specific and typically 2-5 in number. Objective data is based on the program outcomes associated with each module (and related course) with one question for each related outcome. Authentic assessment questions ask about the level of demonstration of each authentic assessment level with one question per level. Finally, report questions focus on the report type with two questions beyond the authentic assessment question associated with representation of knowledge. The instructor is provided some space for qualitative feedback.

The industry (practicing professional) rubric focuses on detailed qualitative feedback with summary quantitative feedback. The rubric questions include 1-2 topic oriented, authentic assessment, and 1 report format based question. The expectation is that the main form of feedback from the industry evaluator(s) is the verbal feedback that would be given had this work been performed for his/her organization. Two of the challenges with industry feedback are maintenance of industry personnel qualified and willing to assist with the assessment and consistency among industry evaluators. The first issue is overcome by gaining commitment from Program Advisory Council members and facilitating feedback through a web page. The second issue is overcome by having example reports of different score levels for normalization. The quantitative measures from the instructor and industry are combined (through averaging) to give a team base score.

Student feedback is solicited subsequent to report submission, also through web interface. Students are asked to assess their team and their teammates. Team assessment is based on the same questions asked of the industry representative. The consistency of the team evaluation is compared with team base score to determine the consistency. High levels of consistency might increase the team score while large deviations might decrease that score. This is another method to measure metacognition. The team evaluation submitted by the student effects the allowable input for peer evaluation. This effectively alleviates the pressure for students to rate all peers highly regardless of performance – the conflict between the positive values of honesty and loyalty is lessened. Each peer is evaluated with three measures – effort, aptitude, and teamwork. Verbal (non-Likert) scales are being considered for this stage. Such verbal scales can be converted for quantitative analysis. Additionally, the student is to input one strength and one opportunity for improvement for each peer. Industry and peer feedback is moderated by the class instructor.. One's final score is modified by the peer scores of other teammates. At the end of each module, the student receives summarized scores to assist in self-assessment and moderated qualitative feedback to assist in improvement.

5. Conclusions

This paper contains a description of the Active Learning in the Virtual Enterprise System. The system is used as a curriculum and discipline integrator to better reach global, sensory, visual, active, and inductive learning style. Specifically, this paper described the student assessment process, based on ABET outcomes, related topic, authentic assessment, and report style. Evaluation is performed by the instructor, industry representative and student. This triangulation technique allows the student to progressively prepare for practice throughout the curriculum.

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References

1. Lang, J.D., Cruse, S., McVey, F.D., and McMasters, J., "Industry Expectations of New Engineers: A Survey to Assist Curriculum Designers," *Journal of Engineering Education*, January 1999.
2. Burton, L., Parker, L., and LeBold, W.K., "US Engineering Career Trends," *ASEE Prism*, May-June 1998.
3. Morgan, R.P., Reid, P.P, and Wulf, W.A., "The Changing Nature of Engineering" *ASEE Prism,* May-Hune 1998.
4. Engineering Criteria 2000, Criteria for Accrediting Engineeering Programs: Effective for Evaluations during the 1999-2000 Accreditation Cycle: Engineering Accreditation Commission. Accreditation Board for Engineering and Technology; http://www.abet.org/download.htm, 30th November 1999.
5. Curricula 2002; Manufacturing Education for the 21st Century; Volume I: David L. Wells, Editor, Society of Manufacturing Engineers, 1995.
6. Panitz, Beth, "The Integrated Curriculum," *ASEE Prism*, September 1997.
7. Cherrington, B., "An Integrated Approach to Graduate Education in Manufacturing Systems--The U.T. Dallas Model", *Journal of Engineering Education*, January 1993.
8. Pardue, M.D., "Architecture for a Successful Computer-Integrated Manufacturing Program in a 4-year College or University", *Journal of Engineering Education*, Janruary 1993.
9. Lamancusa, J.S., Jorgensen,J.E., and Zayas-Castro, J.L., "The Learning Factory— A New Approach to Integrating Design and Manufacturing into the Engineering Curriculum", *Journal of Engineering Education*, April 1997.

10. Shields, M. A. “Collaborative Teaching: Reflections on a Cross-Disciplinary Experience in Engineering Education.” Proceedings of the 1998 ASEE Conference and Exposition, June 28-July 1, 1998.
11. Archbald, D.A. and Newmann, F.M., Assessing Authentic Academic Achievement in the Secondary School, National Association of Secondary School Principals, Reston, VA, 1988.
12. Wiggins, G.P., A True Test: Toward More Authentic and Equitable Assessment, Phi Delta Kappan, 70, 1989, pp. 703-713.
13. Hart, D., Authentic Assessment: A Handbook for Educators, Addison-Wesley Publishing Company, California, 1994.
14. Amos, S., Assessment techniques for industry desired competencies in construction education, ASEE Annual Conference Proceedings, Proceedings of the 1998 Annual ASEE Conference, Jun 28-Jul 1 1998, 1998, Seattle, WA.
15. Marin, J.A., Armstrong, J.E., and Kays, J.L., Elements of an Optimal Capstone Design Experience, Journal of Engineering Education, vol. 88, no. 1, 1999, pp. 19-22.
16. Royal College of General Practitioners to the MAP Administrator, RCGP, 14 Princes Gate, Hyde Park, London, SW7 1PU (http://www.rcgp.org.uk/rcgp/map/index.asp).
17. Pangaro, L.N., “Investing in Descriptive Evaluation: A Vision for the Future of Assessment,” Medical Teacher, Vol. 22, No. 5, 2000, pp. 478-481.
18. Austin, S., Steele, J., Macmillian, S., Kirby, P., & Spence, R. (2001). Mapping the conceptual design activity of interdisciplinary teams. Design Studies, 22, 211-232.
19. Gould, G. (January 3, 2000) Leadership in Virtual Teams. Retrieved September 13, 2002, from http://www.seanet.com/~daveg/index.htm.
20. Lurey, J.S., & Raisinghani, M.S. (October 2001). An empirical study of the best practices in virtual teams. Information & Management, 38 (8), 523-544.
21. Goldberg, D., “Change in Engineering Education: One Myth, Two Scenarios, and Three Foci”, *Journal of Engineering Education*, April 1996.