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Enhancing Industrial and Systems Engineering Education through Academic-Industry Alliances

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Abstract
Industrial and System Engineers (ISE) utilize a wide breadth of knowledge and problem solving skills to engage people, technology, and organizations with the goal of understanding a system to improve performance. Since an efficient supply chain is critical to business success, ISE curriculum typically includes supply chain management concepts to effectively prepare students to work within manufacturing operations. At the heart of a manufacturing supply chain are production, distribution, and logistics systems, which are thus integral parts of supply chain management education. Typical textbook approaches employ situational analysis and chapter problems to convey mathematical models and heuristics. However, case studies and simulation methods are preferred approaches to enhance learning, problems solving, teamwork, and foster concept retention.

This paper will illustrate the implementation and utilization of a strategic academic-industry collaboration partner with a global support system and pedagogy to teach supply chain management through case studies and simulations. The academic alliance is used to promote practical and future-oriented education while providing access to the latest ERP software and data analytic technology. Case studies integrating enterprise management software provide hands-on experience, conceptual development, and an understanding of key business process often impacted by engineering initiatives. A manufacturing simulation is also used to engage students in key supply chain management concepts including demand planning, production planning, materials requirement planning, bill of materials management, and managerial accounting. The simulation operates a manufacturing company in a commercial software environment, and requires teamwork and coordination of effort vital to good systems engineering.

Included in the analysis are the resources needed by a University to engage with an academic alliance, example curricula and simulations available, training methods, and start up plans. An undergraduate course framework designed to provide a comprehensive pedagogy for supply chain management concepts within an engineering discipline is also provided.

Introduction

Industrial and Systems Engineering (ISE) is a systems oriented, interdisciplinary engineering field encompassing engineering, management, and human factors with the primary purpose of analyzing interactions within complex networks. For example, ISE is the "distinguished home" of the Industrial and Management Engineering program, founded in 1933 at Rensselaer Polytechnic Institute.[1] ISE integrates a quantitative engineering approach with qualitative insight, and works closely with other disciplines, such as computer science and management. A review of nationally ranked University web pages show that typical career paths for ISE graduates included careers in manufacturing to improve operations inside manufacturing plants. More recently, ISE roles have expanded outside the plant to design and improve supply chains and transportation systems that connect manufacturing facilities.[2,3]

The need to incorporate supply chain management (SCM) content is indirectly confirmed as the Society of Manufacturing Engineers' (SME) "four pillars" includes "manufacturing systems and operations" as part of manufacturing knowledge for product producing enterprises.[4] An exploratory study by a paper presented at the 2015 ASEE Annual Conference and Exposition postulated the criticality of integrating SCM concepts within manufacturing curriculum.[5] Based on a study of two and four year colleges with manufacturing engineering technology curricula located within highly ranked U.S. manufacturing regions, the authors established "the importance of supply chain efficiency and reliability to ensure the timely launch of product" and continued cost control. Critical skills identified for manufacturing oriented graduates included procurement and logistics, which are key SCM components. The research determined that only approximately 50% of industrial, manufacturing, or manufacturing technology engineering departments offered supply chain courses. The data in the 50% was also skewed, with industrial engineering typically being the department providing some level of SCM courses, whereas the manufacturing related disciplines were less frequent.

Nepal and Kumar (2015) identify the next research into skills gaps related to information technology and the globalized marketplace, this paper proposes a solution based on Enterprise Resource Planning education supported by global Academic Alliances. As Enterprise Resource Planning (ERP) is a core application of information technology Academic Alliances, the relationship between SCM and ERP is first established by this paper. Next, Academic Alliances are defined along with their place within higher education by establishing benefits to students, academic institutions, and faculty pedagogy. As Academic Alliances are primarily a tool for active learning content, the Kolb Learning Cycle is introduced as the foundational theory for the application of Academic Alliance pedagogy presented herein. A quantitative assessment of over 200 students and nine course sections is discussed to confirm the positive impact in utilization of Academic Alliances and the technology access they provide.

Background

Supply Chain Management and Enterprise Resource Planning Systems

SCM may be considered a network of autonomous, or semi-autonomous, business enterprises synergistically engaged in procurement, manufacturing, and distribution of product. ERP systems are designed to integrate the many business processes and databases needed operate a given business (an enterprise). Therefore, considering that SCM is a core competency, ERP is a clear path for operational, managerial, and strategic systems thinking.[6] Fundamentally, ERP systems enable an enterprise, and by extension a supply chain, by inputting "instance" level information, accessing relevant "process" data, and utilizing multiple business processes for decision making. Recent research has shown an increase of importance on integration of planning, control, and execution of materials, resources and operations upon business performance, and hence, the relative importance of ERP as a critical system.[6] In general, enterprise systems' education equips students with a process-centric background that emulates today's corporate climate.[7]

As ERP is a highly automated practice, it prospers from adoption of best practices, which can be a key contribution of ISE. Dhillon (2005) hypothesized that the real benefits of ERP reside in the changes to organizational activities that can be engineered, and then implemented by an information technology function.[8] A research model by Su and Yang (2010) utilized five ERP constructs: operational, managerial, strategic, IT infrastructure, organizational benefits, and three SCM competencies: operations, planning, and control. Their work concluded that ERP tenants of operational, managerial, and strategic processes are significant predictors of SCM success. Additionally, they supported the majority of research that ERP systems can become the "backbone of company operations"[6], which will avail itself as a primary application point for industrial and systems engineering.

Academic Alliances

An Academic Alliance is a coalition of member Universities and a commercial enterprise, acting as a catalyst and sponsor to bring together academia and technology. The goal of academic alliances is to form a symbiotic relationship between faculty, commercial software providers, and students. The business entity is generally a software provider with products and services typically cost prohibitive to Universities, but with global impact and wide commercial use. Typically, academia cannot afford licenses and/or maintenance fees for cutting edge information technology, resulting in a hodgepodge of applications being taught within and across departments.[9] Thus, selection of commercial software is usually based on hardware and software availability[9], rather than an extensive selection process intended to find an "optimal" application or provider. With an Academic Alliance, the provided software becomes a common denominator for all parties as commercial enterprises attempt to bridge a pedagogical gap between academic/theoretical training and "skills" training.

This is not a completely altruistic endeavor by the software provider, as the commercial intent is to create a generation of future engineers and managers conversant with their products, making the academic alliance an investment. Through an academic alliance, faculty working on a common platform gain access to a world-wide network of like-minded colleagues engaged in common academic pursuits, peer reviewed curriculum content, academic conferences for idea sharing, and access to state-of-the-art commercial software. The sponsor provides their products along with an infrastructure for central repository of exercises, case studies, simulations, and other pedagogical content to create a resource for faculty to incorporate material. Content is developed by member faculty in conjunction with the sponsors. The central storage of curriculum material by the Alliance helps Universities advance through the early stages of an "ERP Maturity Model for Higher Education", as proposed by Antonucci et al.[7]

From the University standpoint, Academic Alliances are a cost effective and efficient way to bridge the gap between University missions and demands created by the financial realities of decreasing state support. The competition among state schools for students becomes increasingly important as the percentage of financial support derived from tuition becomes a larger percentage of overall funding. Retention and graduation metrics are becoming the new norm as public Universities are increasingly challenged to demonstrate quantifiable economic benefits. States look to Universities to produce graduates that will provide near term economic impact, thus hiring statistics and entry level salary are also becoming key performance indicators. With these metrics and financial realities, a harder look at University mission statements reveals some scope creep. Words like "skills" are starting to enter individual University missions, supplanting more esoteric phrases like discover, create, transmit, and apply knowledge. This provides a degree of anecdotal evidence allowing for skills related training to compliment traditional theoretical/conceptual higher education pedagogy.

This paper is based on the SAP University Alliance (SAP UA) which includes 2,400 universities worldwide and provides access to the entire SAP license portfolio free of charge, including curricula, webinars, events, learning platforms, and certifications / awards.[10] The stated goal of the SAP UA is to prepare students and gain a presence within college curricula while simultaneously developing "job ready" graduates with SAP skills and knowledge.[9] However, SAP is not the only software provider sponsoring academic alliances. Another widely used Alliance is supported by Microsoft which hosts the Microsoft Dynamics Academic Alliance (DynAA) to over 1,400 educational institutions.[11] Microsoft provides a full installation of Dynamics and markets leadership, relevance, curricula, academic research, and innovation. Membership in the DynAA provides software licenses and product upgrades, documentation, knowledge bases, e-learning, training material, curriculum and related materials, and certifications. The goal of both of these alliances is to engage with partner companies and Universities to enhance students' job opportunities, as well as foster technology and student success. Typical learning modules from both providers are shown in Table 1.

Table 1. ERP Modules and Related Content from Academic Alliances

Business Process Management	Production Planning
• Sales & Distribution	• Materials Masters
• Materials Management	• Bill of Materials
• Production Planning	• Routings
• Financial Accounting	• Forecasting
• Management Accounting	• Sales & Operating Planning
• Human Capital Management	• Master Schedule
• Warehouse Management	• Materials Requirement Planning
• Project Systems	• Purchasing
• Asset Management	• Financial Accounting
• Customer Service	

Student Benefits

The student is also a benefactor of the alliance as they are provided with marketable skills to complement foundational theory education, critical thinking, and other top tier Bloom's hierarchy. *Preparing Students for Industry by Integrating Commercial Software into Coursework,* a paper presented at the 2015 ASEE Annual Conference and Exposition, Untener et al. (2015), posited that engineering graduates are "best positioned to serve industry well "through pedagogy and courses that provide foundational principles and experiential/active learning to apply those principles to realistic problems."[12] Further, they state that students have difficulty dealing with real-world situations that often require a multidisciplinary understanding and approach to resolve.[13]

Additional student benefits are realized in job search and relative marketability. Research by Fedorowicz et al. (2004) concluded that employers expected new hires to "understand how companies function" and require "knowledge of basic business processes and technology."[14] Additionally, they conclude integrated enterprise software curriculum "exposes student to the elaborate interdependencies" of internal business systems, which may be considered a critical concept to operational related initiatives to be undertaken by ISE and Engineering Management graduates. Research by Ma et al. (2014), determined that some enterprise managers felt that higher education ignores hands-on skills training, and that there was too much "isolation" between teaching and practice.[15] The ramification was graduates were out of touch with business needs and were unfamiliar with popular commercial software. The common thread in these two research papers spanning ten years is that there is a continual concern that newly graduated millennials need an appreciation for business processes, workflow, and inter-organizational dependencies to manage complex systems, such as supply chains.[14]

The proposed approach to meet these challenges for an undergraduate student demographic that has little or no hands-on experience is founded in active learning and the Kolb Learning Cycle. The use of application-oriented software, first supported with a theoretical underpinning, may facilitate an enhanced learning pedagogy including an active learning component. The benefit of mixed teaching approaches within an engineering pedagogy is defined herein by the Kolb Experiential Learning Cycle[16,17] and Felder and Silverman model.[18,19] The application of the Kolb Cycle to combine lecture and active learning supports the best approach to an undergraduate pedagogy. Figure 1 shows the Kolb's experiential learning framework, learning styles, and learning cycle used to model how experience can be translated into conceptual competencies.

The Kolb Experiential Learning Cycle proposes that the most effective instruction involves repetitive teaching around the cycle. Untener et al. (2015) prefer a similar approach, recommending a variety of experiences that match different learning styles in order to achieve varied and higher levels of Bloom's taxonomy.[12] The proposed inclusion of integrating commercial software attained through Academic Alliances create activities that alternate between theory and experiential learning, which tend to propagate the Kolb cycle and enhance learning.

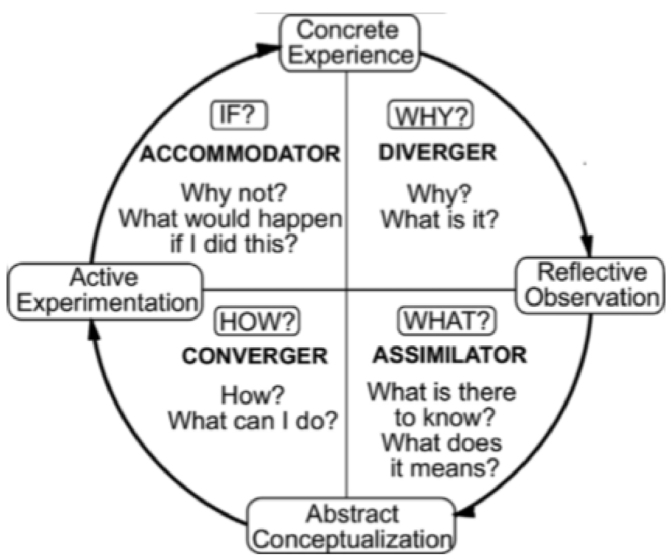

Figure 1. Kolb's Experiential Learning Cycle

The addition of active learning and Academic Alliances is not meant to replace traditional textbook and lecture pedagogy, but rather to enhance student outcomes through inclusion of skills to compliment theoretical concepts. A prior command of principles and theory must be developed to facilitate the transfer of knowledge from the experiential learning gained through utilization of commercial software.[12] The textbook becomes a reference for students to continually seek explanations for the "why" to understand the "what" and "how" of the software applications. A review of literature by Althouse and Hedges (2015) determined that Generation X, Y, and Z students will "adapt" to traditional textbook learning, but "gravitate" to activity based learning" that provides theory and some type of "instant gratification."[20] In using the UA exercises and case studies, the "point and click" activities become the instant gratification, to complement traditional lecture and text book content.

Pedagogy

The pedagogy utilized for this research included fundamental SAP software modules based on a UA provided data set for a fictional enterprise as a nucleus company within a supply chain. Business processes included: 1) the sales quote to cash cycle, 2) procurement of trading goods, 3) production planning of finished goods, and 4) warehouse management for inbound, transfer, and outbound material. SAP ERP exercises and case studies provided for each module were independent of each other but related to the same enterprise. As any commercial software will be new to students, a navigation module is first required to gain a rudimentary understanding of the point and click methodology. After the introductory navigation work, each module contains individual learning and assessment applications. An introductory exercise provides an abbreviated overview of the business processes that will be modeled in the subsequent case study. "Point and click" instructions are provided along with screen captures where critical entries are required. Purposeful "text boxes" are used for higher level explanation at select points for "why" and "what" as needed.

Most ERP systems are not very intuitive, especially to students without any real-world experience. A critical success factor tied to "point and click instruction" is practice, feedback, and repetition.[21] Thus, bookending the software modules for face to face (FTF) students are two different ERP simulations, a preliminary manual simulation and an SAP driven distribution simulation at the end of the course. Students teams of four fill roles of sales manager, materials manager, operations manager, and accountant. Simulations "enhance material retention and foster critical thinking" via an experiential learning approach to supply chain processes.[22]

The first simulation is conducted prior to any utilization of the ERP software and is designed as an introduction to business processes, information flow, and the nuanced requirements of communication and cooperation needed to operate a production facility. This is conducted as a manufacturing company that purchases sheets of paper as raw material and subsequently manufactures paper rectangles in a just-in-time operation. Included are purchasing and sales business processes, looking upstream and downstream in the supply chain. The game is played in weekly time buckets for a simulated ten weeks. To represent market forces, raw material costs and finished goods prices change weekly via a random draw from the instructor. Weekly student decisions include quantity of raw material to purchase and amount of finished goods to sell. Teams are responsible to track metrics on procurement and sales, while accounting for profit and loss. For the 18 – 22 year old student demographic, this introductory simulation is the first building block toward developing competencies surrounding an ERP system. The simulation recap includes business process, information requirements, and financial considerations.

At the end of the course, a final SAP driven ERP simulation is employed. The simulation is a simple distribution company, with a single supplier and six products. Student teams operate within a common market and compete against each other. The simulation is based on daily time buckets, extending over three simulated twenty day months. Teams are required to create a forecast, run a Material Requirement Planning (MRP) application, and generate purchase orders. Customer orders are automatically created by the simulation; demand is price elastic. Financial applications are automated at the team level. The goal of this closing simulation is to tie all the semester's business processes together within the context of a fully operational commercial ERP system.

Assessment

The research question may be defined as: Does the inclusion of "point and click" ERP exercises from the SAP UA have a positive effect on learning supply chain related concepts? In-depth research by Hepner and Dickson (2013) summarizes the current state of assessing the benefits ERP integration through a literature review of information system curriculum within business programs for management information systems and accounting courses, which are classical applications of ERP software. Their research determined that there is very little quantitative data on the efficacy of ERP integrated courses providing tangible benefits for students or Universities.[24] Lack of quantitative evidence is represented by the work of Rienzo and Han (2011) in which they cited multiple references that self-assessment is appropriate as no validated instrument exists to measure process knowledge of ERP systems.[25] Assessments using pre and post activity question sets to relate high-level activities to business processes were employed. They theorized self-assessment is appropriate as the role of ERP exercises is to increase awareness of business processes' complexity and level of integration into an organization.[25] Their results concurred with previous studies in that student self-assessments showed a positive relationship between business process comprehension and hands-on ERP skills work, but failed to demonstrate empirical evidence of an improvement of business process knowledge.

The design for this research takes a quantitative approach using correlation analysis to establish if there is a positive association of demonstrated SAP skills against final exam SCM content questions. Using data collected from nine sections of a 2000 level Introduction to Enterprise Resource Planning course, from Fall 2013 through Fall 2015, 106 face-to-face (FTF) student gradebooks and 98 distance education (DE) student individual exam questions were evaluated. Each course section followed a similar learning process using textbook material, lectures, "point and click" SAP ERP exercises, SAP case studies, and SAP software challenges. For each learning module, students first read textbook material accompanied by lecture and discussion. Next, SAP "point and click" exercises were utilized to introduce high level fundamental business processes, followed by SAP case studies with deeper dives into process and detail. After completion of SAP work, a module exam consisting of SCM content and SAP proficiency questions was conducted. A semester final exam consisting of SCM content and SAP proficiency questions was also completed.

To assess the effectiveness of the repetitive SAP "point and click" active learning assignments based on the Kolb Cycle, all of the module and final exams included a combination of "hands-on" SAP proficiency questions and supply chain related content questions. For the exam SAP questions, students were required to navigate the software to look up answers to "open response" questions. SCM content questions were a variety of multiple choice, multiple answer, matching, fill in the blank, true/false, and open response. Within each semester, FTF and DE students utilized the same SAP active learning assignments and questions, although there were differences semester to semester due to continual improvement actions by the instructor. The only pedagogical difference between the FTF and DE sections was completion of the pre and post business process simulations. The instructor's contextual theory is that DE students are generally adult learners with some level of business experience**.**

Analysis

The nine course sections each included a "Sales and Distribution" module exam, a "Materials Management" module exam, and a final exam. Data was organized by student, year, semester, and delivery method (FTF or DE). The difficulty in analyzing the data stemmed from variation of point values, degree of difficulty for each class section, and the number of SAP and content questions in each exam. Also, module and final exam grades could not be utilized due to mixed question types, point values, and curves. Thus, individual exams were analyzed to categorize question by types, including SAP related, general supply chain concepts, or two other non-relevant categories. In total, the population of students included 235 SAP proficiency and 487 final exam SCM content questions. In order to get a single variable to represent SAP proficiency, questions from the module and final exams were analyzed to determine the total percent answered correctly for each assessment, and then an average of the averages was computed. As the SCM content questions were only taken from the final exam, they were assessed for correct percentage.

Distribution statistics were generated for the entire population, which revealed six outliers with an extremely low Ave SAP score. Since the presence of an outlier is not in itself a reason to exclude data from analysis, the raw data was reviewed. Ultimately, three outlier data points were removed from the calculations as students had either missed an exam, were non-degree seeking, or were FTF attendance outliers. Summary statistics, shown in Appendix A, were generated for Average SAP scores and final exam SCM content questions. Averages for both were centered in the mid-70s, with standard deviations of 11 - 13. Data for both variables appeared to be normally distributed and with sufficient sample size to proceed with analysis.

Next, correlation analysis was conducted for each individual class to measure the degree of association between the SAP question average score and the SCM content scores of individual student final exams; Table 2 summarizes the nine course sections. The results show a positive correlation between percentage of SAP proficiency questions and SCM content questions from the final exam. While correlation does not mean causation, the implication of the data tends to support the qualitative assessments discusses earlier.

To complete the analysis irrespective of individual course sections and other considerations discussed above, scatter plots and regression lines were plotted and analyzed, results shown in Appendix B. For the entire population, a Pearson $r = 0.533$ was determined, still exhibiting a positive association. When segmented by delivery method, the correlation coefficients showed FTF = 0.512 and DE = 0.611. These results are in-line with the results of Table 2, and demonstrate a decreased association attributed to the variances afore mentioned.

Table 2. Pearson Coefficients by Class Section: SAP Proficiency v. SCM Content

Course		FTF Sections		DE Sections	
Year	Semester	Students	Pearson r	Students	Pearson r
2013	Fall	19	0.611		
2014	Spring	17	0.532	28	0.514
	Summer			26	0.505
	Fall	17	0.673		
2015	Spring	23	0.674	23	0.615
	Summer			20	0.649
	Fall	28	0.695		
Total Students		104		97	
Weighted Average		0.645		0.563	

Start-Up and Participation

Prior to embarking into an Academic Alliance with the need to establish a level of faculty technical and skills competence, a University or Department must consider the capability maturity model shown in Figure 2, as developed by Corbitt et al. (2000). This was developed from an ERP implementation using the SAP UA. If the target is not to achieve Level 3 (Defined), the investment of energy and time should not be undertaken.

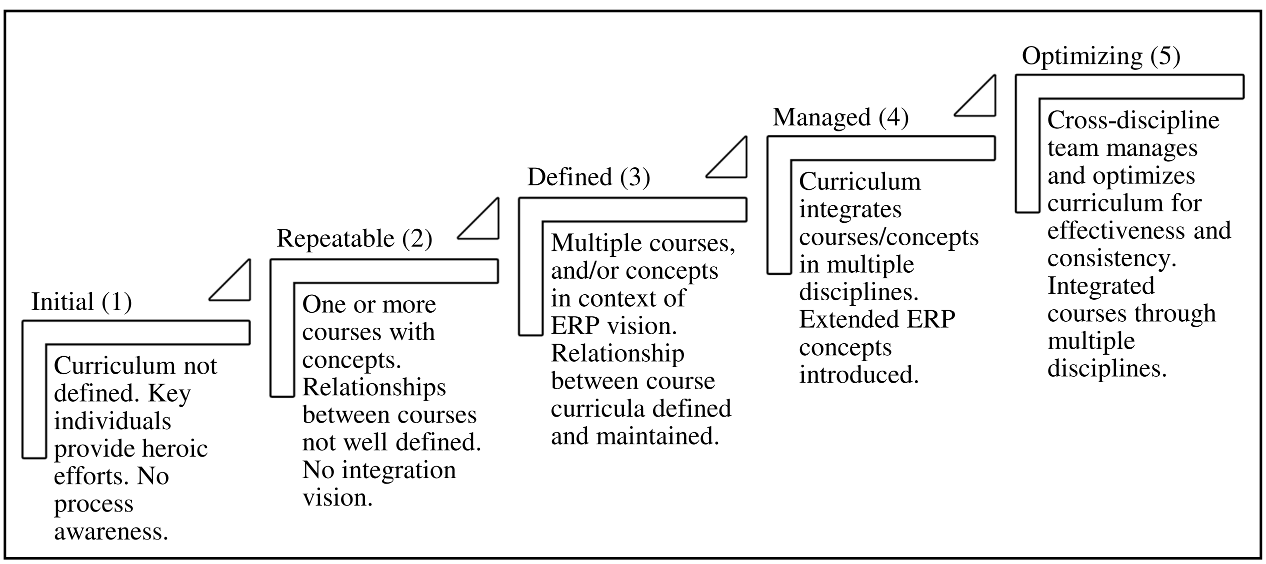

Figure 2. ERP Integration Maturity (adapted and modified from Antonucci et al. (2004)

Fedorowicz et al. (2004) proposed a model for successful integration of ERP across a curriculum, addressing curriculum, training and support, and student and faculty issues.[14] Corbitt et al. (2000) delineated challenges to implementation of an Academic Alliance using an

ERP curriculum. Table 3 is a summary of these works, updated based on implementation experience of the authors and further developed below.[9]

There must be a vision established prior to joining an Academic Alliance, and along with the vision, goals and objectives. Level 3 implies an integrated curriculum between multiple courses within at least one discipline. This is advantageous on several fronts, including wider breadth of experience, deeper dives into key concepts, and the ability for adoption of recognition awards and/or certifications from the hosting software provider. The vision will require an implementation plan and a supporting budget. While the SAP UA provides content for free, the hosting University Competency Centers (UCC) charge an annual fee to provide infrastructure needed to deliver the software. Additional funds are required to support faculty training and annual conference participation, establishing a total approximate annual budget of $15,000. This budget does not include any internal resources or infrastructure to distribute the software to students and faculty, although this may be easily implemented through direct download or thin clients on virtual networks.

If the vision, funding, and infrastructure can be established, the linchpin to any implementation is a core faculty team. The conflict many faculty have with learning SAP or Microsoft Dynamics tends to fall into the realm of "what's in it for me?" Thus, team is the critical concept, as evidenced by Level 1 on the Capability Maturity Model, which points to (unsustainable) heroic efforts of single faculty. As least two faculty must be motivated, and preferably more for several reasons. First and foremost is difficulty learning the software, which may take years of trial and error. While all UAs provide web based and face to face training, most instruction is "point and click" oriented. Real faculty learning comes when students deviate from the prescribed instruction, venturing into unknown territory and software dead ends. The faculty learning curve is realized by forensic analysis of these problems, which builds up expertise over time. Second, and perhaps more important, is a faculty team collaborating on pedagogy, curriculum integration, and academic productivity. If there is no calling for these key aspects of academia, entering into a UA will be a short lived, expensive endeavor. Finally, pedagogy and content inclusion should consider industry applications from the degree discipline, industry advisory boards, and recruiting companies. Adoption of commercial software provides an avenue for experiential learning, but may also be considered skills based training, and therefore should be properly positioned to maximize faculty and student benefits.

Table 3. Academic Alliance Implementation: Resources and Requirements

Resource	Requirements
Leadership	Departmental vision and desire; faculty curriculum integration
Funding	Hosting center fees, training, conferences, curriculum development
Infrastructure	Software access, student accounts, virtual networks, labs, student monitors
Faculty	Desire, experience, training, learning curve, curriculum coordination, retention
Pedagogy	Complimentary text books, exercises, case studies, simulations, innovation
Industry	Recruiting, student placement, curriculum direction

Summary

There is a conflict in the research between ERP curriculum aimed at implementation of a system versus skills necessary for successful use of an ERP system. Hepner and Dickinson posit that broad educational goals of business operations may be best served by focusing upon use related skills.[24] Rienzo and Han (2011) concluded from student self-assessments that there is a "positive relationship" between students' comprehension of business processes and hands-on experience with ERP software. This research extended their work through quantifiable data collected from approximately 200 students over two years and nine separate course sections of an introductory ERP class to demonstrate a positive association between ERP skills training and SCM concepts.

Relatively few engineering disciplines are geared toward a multidisciplinary approach, but ISE and Engineering Management are seemingly designed to address it. There is a growing body of research showing that the "business" nature of industry, and particularly SCM, is taking on an increasingly important role in engineering and technology education. Within SCM, ERP systems are a core concept and there is a growing number of Universities world-wide aligned with either the SAP UA or Microsoft DynAA. These universities are using an active learning, hands-on approach to teach ERP utilizing commercial software successfully to students. Future research is recommended to validate these findings, with regard to incorporating alternative ERP software provided through other academic alliances.

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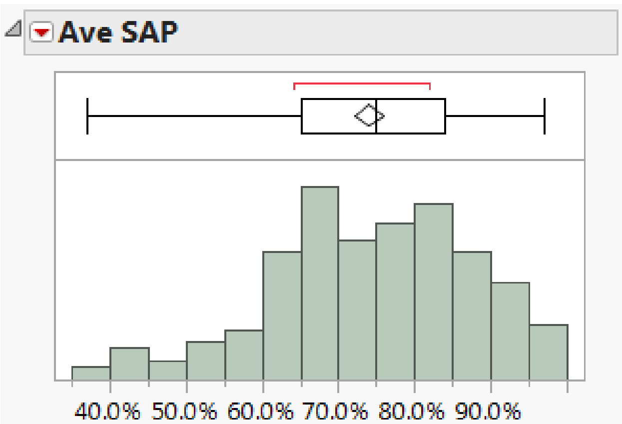
Appendix

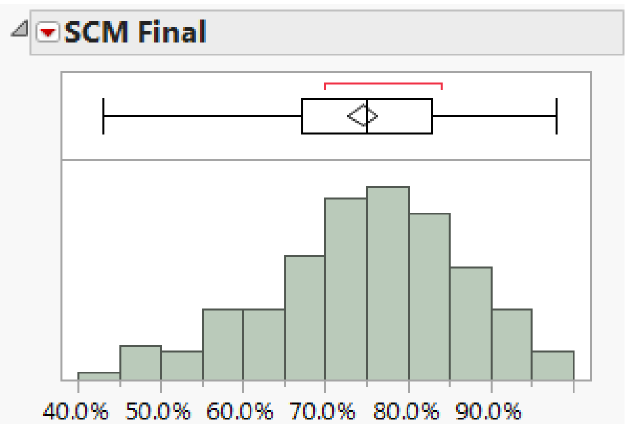
Appendix A: Summary Statistics for FTF and DE Sections



Quantiles

Summary Statistics

Mean	0.7400995
Std Dev	0.1312973
Std Err Mean	0.009261
N	201
Skewness	-0.465536
Kurtosis	-0.135358
Median	0.75



Quantiles

Summary Statistics

Mean	0.7442289
Std Dev	0.1174799
Std Err Mean	0.0082864
N	201
Skewness	-0.386792
Kurtosis	-0.196114
Median	0.75

Figure A1. Population Descriptive Statistics

Histogram with outlier box plot, generated with exclusion of three data points from the population. The center box of the box plot shows the interquartile range (IQR) representing the middle 50% of all values, with the median as the vertical center line within. The diamond within the plot shows the mean value at the center and the upper and lower 95% confidence bands at the diamond edges. The upper and lower fences are located 1.5 IQRs from each quartile line. As outliers were excluded from the data set and recalculated, these plots do not show any subsequent outliers in the data. The horizontal bracket represents the smallest grouping of points representing 50% of the data.[26]

Appendix B: Correlation SCM Content score to Ave SAP score

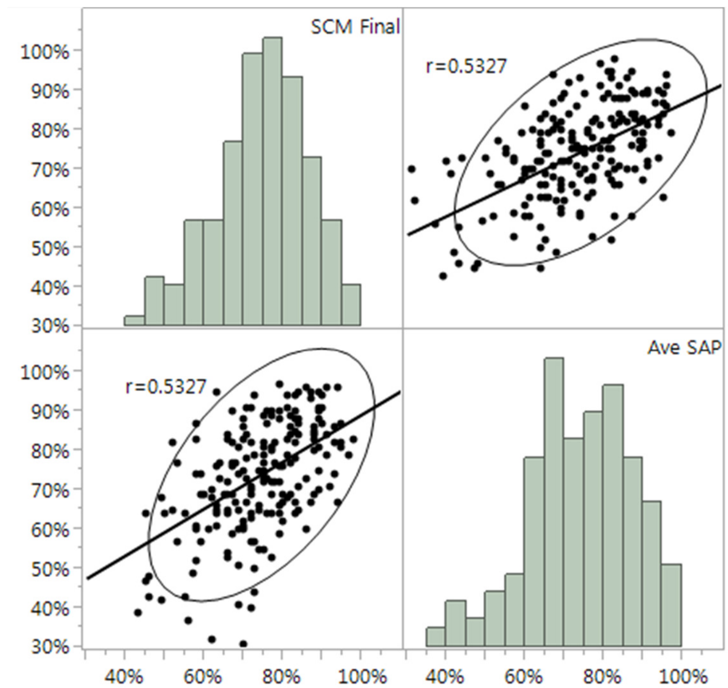


Figure B1. All Students: Correlation SCM to SAP

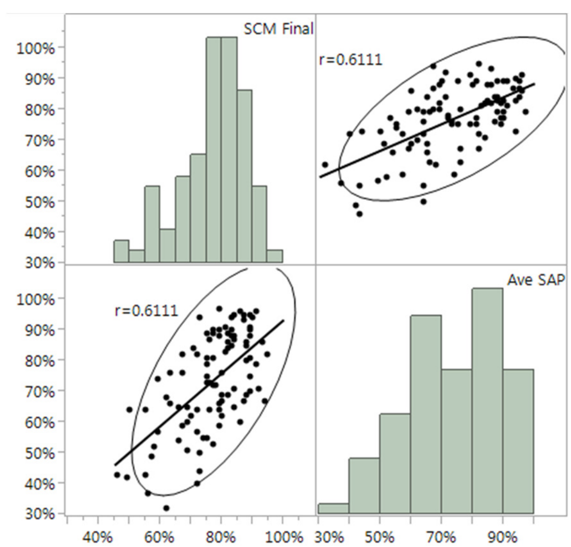


Figure B2. DE Correlation

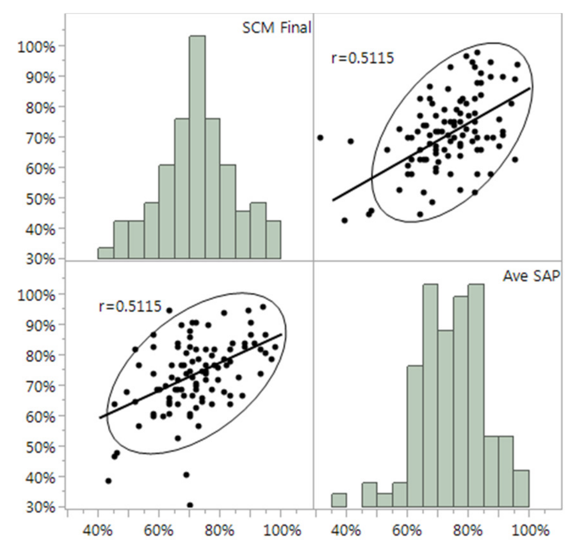


Figure B3. FTF Correlation