AC 2007-203: THE USE OF COOPERATIVE EDUCATION IN CURRICULAR REFORM: THE ABET FEEDBACK CYCLE REALIZED

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As an Associate Professor Cheryl Cates has worked with cooperative education students for 16 years. Cates holds a Master of Business Administration degree and a Bachelor of Arts Degree and has co-authored Learning Outcomes, the Educational Value of Cooperative Education, as well as chapters for the Handbook for Research in Cooperative Education and Internships and the International Handbook for Cooperative Education. In 2004 Cates became principle investigator on a grant from the United Stated Department of Education's Fund for the Improvement of Postsecondary Education to Develop a Corporate Feedback System for Use in Curricular Reform.

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Born in Finland, Kettil Cedercreutz started his career in the United States as an Engineering Technology faculty member at the University of Cincinnati, OMI College of Applied Science (CAS). Since the fall of 2001, Cedercreutz is the Associate Provost and Director of UC's cooperative education program offered by the Division of Professional Practice. Cedercreutz holds a Master's degree in Manufacturing Engineering and Industrial Management from Helsinki University of Technology. He has conducted pedagogic studies at the Center of Pedagogic Training for Lecturers at Institutes of Technology, Tampere and graduate studies in Computers in Manufacturing at Helsinki University of Technology. Cedercreutz is the co-principle investigator on the FIPSE grant, "Developing a Corporate Feedback System for Use in Curricular Reform".

THE USE OF COOPERATIVE EDUCATION IN CURRICULAR REFORM: THE ABET FEEDBACK CYCLE REALIZED

Abstract – The University of Cincinnati has been awarded a US Department of Education Fund for the Improvement of Postsecondary Education [FIPSE] grant to be used for the Development of a Corporate Feedback System for Use in Curricular Reform. The duration of the grant is three years during which the University is scheduled to receive a total of \$ 555,133 (57%). The matching contribution of the University of Cincinnati will be \$421,396 (43%). Including matching funds the University of Cincinnati will be investing \$ 0.976 M in industry integrated curriculum development. The objective of the grant is to build a closed loop system that measures student performance while on co-op and directs this feedback into curricular development. This project develops methodologies to use assessment data of student work term performance in curricular development, thereby continuously aligning experiential- or cooperative-education based curricula with industrial needs. The proposed three-year project would focus on: a) identifying curricular activities exhibiting a strong correlation with student co-op work performance; b) designing and implementing processes allowing the systematic use of employer assessment in curriculum design; c) evaluating the impact of changes in curricular design upon student work performance; d) piloting and contrasting projects in both different academic fields and at different colleges; and e) developing a set of best practices to be used for further refinement and dissemination of the process. Initial collaborators include University of Cincinnati (UC) academic units as follows: the Department of Architecture (College of Design, Architecture, Art, and Planning); the Department of Civil and Environmental Engineering (College of Engineering); the Department of Civil and Construction Management (College of Applied Science); the College of Business Administration; and the Division of Professional Practice. The assessment data will be analyzed by the UC Evaluation Services Center. The Evaluation and Assessment Center for Mathematics and Science Education at Miami University will act as the external evaluator for the project. Schools accredited by, or subscribing to, the attributes of the Accreditation Council for Cooperative Education will act as a reference group, ensuring a transferable end process. The ultimate goal of the project is to move schools engaged in cooperative education to a new era of market alignment. The objective is to build feedback structures that keep the schools abreast of a rapidly-changing environment. The inclusion of a wide array of programs and a large, diverse reference group caters to building a process that can be effectively utilized in schools engaged in cooperative education within a diverse set of academic fields and educational levels. The Grant was filed by Cheryl Cates as PI and Kettil Cedercreutz as co-PI in a joint effort with the Accreditation Council for Cooperative Education. The three year pilot program will involve the

Departments of Architecture (Prof. Anton Harfmann, College of Design, Art, Architecture and Planning) , Civil Engineering (Prof. Richard Miller, College of Engineering), Construction Management (Prof. Benjamin Uwakweh, College of Applied Science) and the College of Business (Prof. Marianne Lewis, College of Business). Project Liaisons from the Accreditation Council for Cooperative Education (ACCE) include Professional Practice Executive Director Tom Akins from the Georgia Institute of Technology and Dr. Luther Epting from Mississippi State University.

The UC (FIPSE) Project

The Fund for the Improvement of Postsecondary Education (FIPSE) is administered by an office of the U.S. Department of Education with the purpose of supporting solutions that are meaningful and lasting to problems in postsecondary education. FIPSE awards grants for innovative educational reform ideas then shares the proven lessons with the larger educational community. FIPSE grants fund initiatives that have potential for national significance in resolving problems in postsecondary education. FIPSE grants are comprehensive and action oriented in that they focus on innovative ideas rather than basic research and they address a variety of problems at a wide range of institutions. FIPSE is bold in its resolve to support unproven as well as proven ideas. The University of Cincinnati was awarded a FIPSE grant in 2004 to develop a corporate feedback system for use in curricular reform.

With this funding the University of Cincinnati is embarking on the second century of cooperative education by creating a vibrant new partnership with faculty interested in curricular reform. Using over 200,000 data points produced annually through co-op employer evaluations we are able to create a feedback loop that shows the impact of teaching through student co-op performance. This information is being used in curricular reform projects around campus to both illuminate areas for reform and to measure the impact of changes on co-op student performance. Using aggregated data from employer assessments of cooperative education student work performance to measure curricular effectiveness forms a cornerstone of outcomes based assessment at the University of Cincinnati. One problem is that results may get buried in both measurement and statistical uncertainty. Enrollment numbers of a single work term may be too small to provide high measurement certainty. University of Cincinnati research shows that the situation can be alleviated by applying Six Sigma Process Stability Analysis (PSA) to data covering multiple academic years of pedagogically stable programs. Stable programs are in this context defined as mature offerings, having relatively small annual fluctuations in curricular offerings. The stability of a process allows the aggregation of statistically relevant data over a sustained period of time to look at student skill development as a function of the curriculum. This presentation focuses on demonstrating the effectiveness of a methodology relying on comparing means and standard deviations of student work term performance indicators. The results are communicated through Mean Standard Deviation Matrixes (MSDM's) or Delta Mean Standard Deviation Matrixes (ΔMSDM's).

The problem of matching curricular content with industrial needs has been, both nationally and internationally, approached on a variety of levels. Accountability concerns have created a focus on practical learning outcomes deemed important by industry. The Accreditation Board for Engineering and Technology (ABET) 2000 Criteria, developed in the late 1990's, strongly emphasize an understanding of market needs. Measurement, feedback and continuous improvement form corner stones of the ABET 2000 philosophy. The thinking behind the criteria is largely based on the logistic concepts developed by Dr. E. Deming that revolutionized the manufacture of consumer goods during the last quarter of the 20^{th} century. The establishment of ABET 2000 criteria constitutes a major step in the market orientation of the educational industry. The interaction between academia and industry inherent in cooperative education forms an asset that has a strong influence on the competitiveness and wealth of a community.

The methodology covered in this paper is developed within the framework of the research project *"Developing a Corporate Feedback System for use in Curricular Reform"*. The ultimate objective of the project is to move schools engaged in cooperative education to a novel era of market alignment. The project focuses on building feedback structures that keep schools abreast with a rapidly-changing environment through the use of co-op work performance data for continuous curriculum improvement. The budget of this FIPSE project is presented in table 1.

Table 1. Project Budget

Year	FIPSE	UC	Total
04/05	$253,356 *[81%]*	$59,132 *[19%]*	$312,488
05/06	$178,175 *[54%]*	$154,418 *[46%]*	$332,593
06/07	$123,602 *[37%]*	$207,846 *[64%]*	$331,448
Total:	$555,133 *[57%]*	$421,396 *[43%]*	$976,529

Examination of the Literature

Continuous improvement and total quality management has been used in business and industry for years with more than three fourths of the corporations in the United States actively engaged in some sort of program to increase effectiveness, efficiency, employee involvement, cost savings, or customer satisfaction (Hiam, 1993). Whereas many areas of the academy, particularly the business and administrative functions, have already adopted the practices of total quality management faculties have been resistant to the concept except when it comes to their own research. "Faculty members naturally and instinctively used continuous quality improvement techniques of the highest order to produce a tremendous outpouring in basic and applied research" according to Lawrence in his preface

(Ruben, 1995). Therefore if faculties are able to apply quality management techniques to their research it stands to reason that those same individuals would be able to apply the same techniques to their teaching. With the public dismay over rising tuition, frustration over the lack of jobs for graduates who have not been adequately prepared for the workforce, calls for increased faculty productivity and accountability, and accusations of waste, duplication and inefficiency in the academy faculty should be focused with equally as much rigor on the teaching side of the equation. Granted the scholarly aspects of the faculty role are typically more glamorous and hold greater opportunities for notoriety and respect from ones peers. Still a university is producing college graduates every year as its primary product. Every year business and industry hires, or chooses not to hire, those graduates.

Yet in many colleges and universities today the external focus can be found only in the attempts to recruit new students with the conviction that the student is the customer. While this is true, the student is the customer / client but also the product. The student enters the university as one person and, assuming all goes as planned, leave as a changed individual who will now be employed by industry. Faculties are uncomfortable with the concept of "student as customer" or "employer as customer" but this is no different that the health care industry that struggles with the concept of "patient as customer". One way to remove concern is to focus not on "customer control" but rather on awareness and responsiveness to the customer. The collection of information, along with subsequent analysis and use of information is critical to the quality mindset and can also focus faculty on the concept of awareness and responsiveness rather than control. (Ruben, 1995)

Faculty are adept at collecting and synthesizing information in their respective fields yet few have devoted their expertise towards understanding the customer, either student or employer. Those who may have devoted their energy towards this goal for personal improvement in their own classroom may not have communicated their findings to the outside world due to lack of reward or even subtle ridicule from their fellow faculty members. While it may be that faculty members are continuously improving their classroom performance their work is largely unpublished as publications are reserved for discipline-specific journals or texts. (Ruben, 1995)

Even within the field of quality management, quality is not regarded as occurring naturally but rather is viewed as a process that requires commitment, resources, and time as part of a continuous process of improvement. If the primary product of the academy is the graduates yet the commitment of the members of the academy is to the creation of knowledge within the diverse fields, clearly there is a dynamic tension that has contributed to the current demands for more accountability. The quality approach has been successful in other organizations that have followed the teachings of Walter Shewhart, W. Edwards, Deming, and Joseph Juran. (Lewis and Smith, 1994) Shewhart developed statistical process control techniques to prevent variability in the manufacturing process and Deming applied those approaches to revolutionize the Japanese auto industry. Perhaps it is time to bring those concepts into the educational process and utilize the power of cooperative education data to bring about this evolution.

Grubb and Lazerson (2005) state “Higher education is now the clearest embodiment of the American dream of getting ahead, especially getting ahead through one’s own labor…vocationalism is now so deeply embedded in American higher education that in cannot be wished away and that reforms need to focus on ways to integrate vocational purposes with broader civic, intellectual, and moral goals.” With the core principle of Total Quality Management being customer focused and meeting customer needs, higher education must begin to focus efforts on this important stakeholder group – the potential employer of its graduates.

Co-op at the University of Cincinnati

The structure of the UC co-op program is based upon full-time, alternating quarters of study and co-op starting in the sophomore year and extending over three years. This format makes the realization of a bachelor’s degree at UC a five-year endeavor. Students must complete a minimum of four co-op quarters, although the majority of students complete six co-op quarters. Students are also required to remain with an employer for a minimum of two quarters in order to provide a realistic depth of experience with that particular employer.

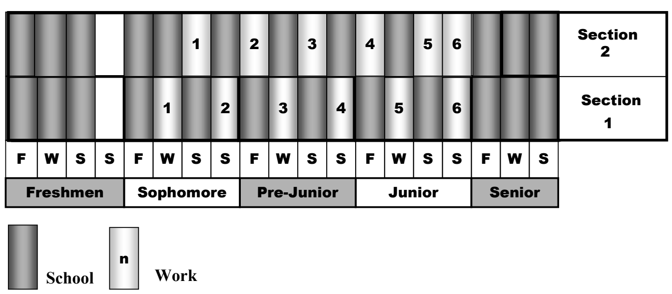

Figure 1. structure of typical UC co-op curriculum

Figure 1 shows a typical alternating University of Cincinnati co-op curriculum. Every co-op work quarter is evaluated through a three-party assessment process: by the student, by the employer, and by the faculty member. This alternation paces the development of the student’s frame of reference with the advancement of the curriculum. Employers are able to assign co-ops to significant positions due to the alternating structure, as these positions can be filled by students on a year-round basis.

The Division of Professional Practice (PP) at the University of Cincinnati (UC) is the centralized unit for the administration of all programs of cooperative education. Faculty and staff in Professional Practice work with about 3,600 co-op students annually and are responsible for programs of cooperative education in four colleges: Applied Science (a mandatory co-op program); Business (an optional co-op program); Design, Architecture, Art, and Planning (a mandatory co-op program); and Engineering (a mandatory co-op program).

The Cincinnati co-op model is based on alternating sections organized by quarter. (Figure 1). The students enrolled in a specific major are divided into two sections. While one section is in school, the other is on a work assignment and vice versa. This alternating schedule is made possible through the University commitment to offer all sophomore, pre-junior and junior courses twice during each academic year.

Co-op students are assigned to a Professional Practice (co-op) faculty adviser by discipline area. This faculty adviser is accountable for all aspects of the cooperative education program for their assigned disciplines. Students are required to meet with their faculty adviser both prior to and after each work assignment. The Professional Practice (co-op) faculty adviser plays an important role as a liaison of the University with industry and observes industrial changes that seem to be of significant interest to the colleges. The close relationship with the adviser helps the student to prepare for the work term, and gives the institution valuable feedback about the match between student aspirations and employer needs.

Gradually Filtering Assessment Process

The complete feedback cycle (Figure 2) will be based upon an assessment process with a gradually-sharpening focus and consequently more accurate resolution. The feedback cycle will be repeated twice, the goal of the first cycle being the establishment of parameters for the project. The second cycle will focus on creating a system that will be transferable to other institutions during a dissemination process.

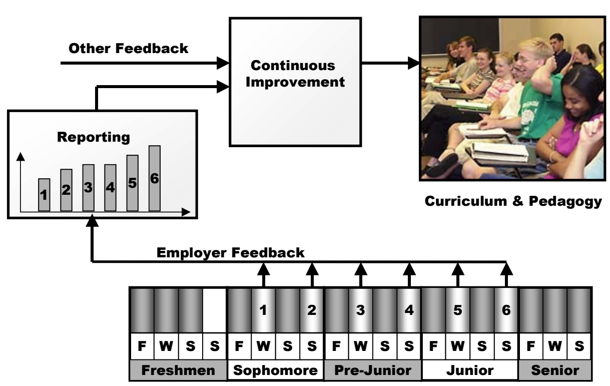

Figure 2. Schematic view of Feedback Structure

Assessment data will be gathered using three different methodologies. Figure 3, gives an overview of how these methodologies (qualitative instruments, quantitative instruments and focus groups) are linked together to form an organic whole.

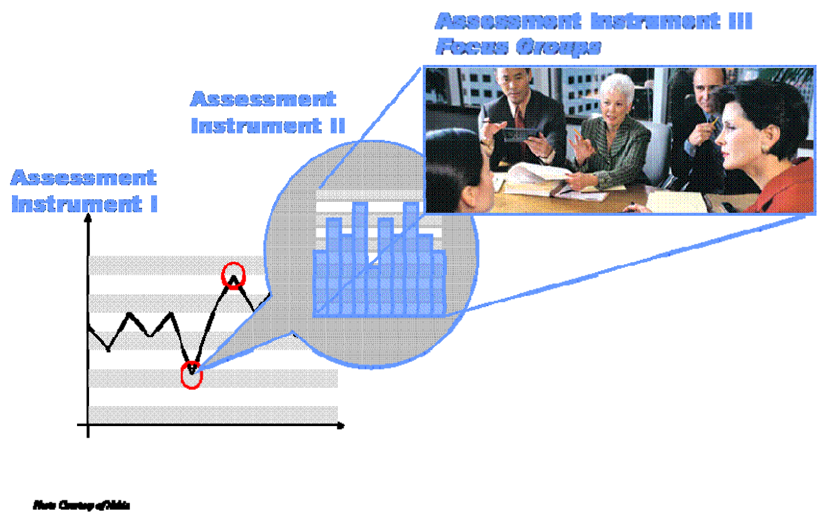

Figure 3. levels of assessment in UC / FIPSE project

The assessment instruments are characterized as follows:

The assessment instrument used in the three party assessments by employers to evaluate students is defined as ***Assessment Instrument I.*** The instrument is well established, has a long history of application, providing a wealth of longitudinal data.

Assessment Instrument II is quantitative in nature, focusing on specific problem areas indicated by Assessment Instrument I. Assessment Instrument II allows the research team to examine details of curricular performance. Being a tool with tailored programmatically-oriented questions, the instrument will allow detailed assessment of specific curricular aspects under scrutiny. Assessment Instrument II will be designed as an integral but flexible part of Assessment Instrument I

Assessment Instrument III is specified as a qualitative tool designed to refine and clarify questions raised through Assessment Instruments I and II The focus group approach will help the research team identify underlying needs and solutions.

Applying Statistical Analysis Principles

Process stability analysis can be applied to any set of quantitative data as long as the data is statistically and measurement technically reliable. We will below focus on demonstrating the validity of the principle in the context of Assessment Instrument I as defined in the above presented FIPSE project.

The data for the Process Stability Analysis (PSA) is gathered through Assessment Instrument I the quantitative questions of which are listed in table 2. The instrument has been developed to measure 11 parameters and 40 sub parameters related to student work term performance. The instrument was developed in the mid 1990's and has since been used by Professional Practice Faculty as an instructional tool. The development of the instrument did rely heavily on the criteria expressed by a variety of accreditation agencies. The instrument has been kept general, as it is used to assess students enrolled in 40 majors and 4 colleges.

The instrument has been statistically validated by analyzing five majors over a period of three years (academic year 01/02, 02/03, and 03/04). The base data covered 1,500 work term assessments yielding approximately 70,000 individual quantitative performance records. The instrument has a Cronbach Coefficient Alpha larger than 0.82 for all constructs. The high Cronbach alpha coefficient supports a high reliability of the instrument.

Process stability analysis is a corner stone in the development of modern manufacturing and service industry. Dr. Edward Deming is often credited for creating the adaptive revolution of modern industry. Just on Time, Lean Manufacturing and Six Sigma literature give a good picture of the continuous improvement approach applied to various industries. Various kinds of Mean Standard Deviation Matrixes are a set of several tools covered in the above literature used to trigger continuous improvement in the production of goods and services. In our case we are attempting to apply the same principle on the measurement of student learning. The standard deviation/mean matrix in figure 4 gives a snapshot of the stability of a process; in our case of an educational process at a given point in a curriculum.

Table 2. Assessment Instrument I:
Grading Scale; 1=Unsatisfactory; 2=Poor; 3=Satisfactory; 4=Good; and 5=Excellent

	CATEGORY	Question	Coding	
			CCode	Abbreviation
A	COMMUNICATION	Speaks with clarity and confidence	A1	Speaking
		Writes clearly and concisely	A2	Writing
		Makes effective presentations	A3	Presenting
		Exhibits good listening and questioning skills	A4	Listening
B	CONCEPTUAL AND ALYTICAL ABILITY	Evaluates situations effectively	B1	Evaluates Situations
		Solves problems/makes decisions	B2	Problem Solving
		Demonstrates original and creative thinking	B3	Creative Thinking
		Identifies and suggests new ideas	B4	Idea Generation
C	LEARNING/THEORY AND PRACTICE	Learns new material quickly	C1	Learning
		Accesses and applies specialized knowledge	C2	Appl. Spec. Knwldg
		Applies classroom learning to work situations	C3	Appl. Classrm Lrnng
D	PROFESSIONAL QUALITIES	Assumes responsibility/accountable for actions	D1	Accountability
		Exhibits self-confidence	D2	Self Confidence
		Possesses honesty/integrity/personal ethics	D3	Integrity
		Shows initiative/is self-motivated	D4	Self Motivation
		Demonstrates a positive attitude toward change	D5	Positive Attitude
E	TEAMWORK	Works effectively with others	E1	Works with Others
		Understands and contributes to the organization's goals	E2	Goal orientation
		Demonstrates flexibility/adaptability	E3	Flexibility
		Functions well on multidisciplinary team	E4	Multidisciplinary Team Fct
F	LEADERSHIP	Gives direction, guidance and training	F1	Gives Direction
		Motivates others to succeed	F2	Motivates Others
		Manages conflict effectively	F3	Conflict Management
G	TECHNOLOGY	Uses technology, tools, instruments and information	G1	Use of Technology
		Understands complex systems and their interrelationships	G2	Systems Understanding
		Understands the technology of the discipline	G3	Underst. of Tchnlgy
H	DESIGN AND EXPERIMENTAL SKILLS	Displays ability to design a component, system or process	H1	Comp. Design Ability
		Demonstrates ability to design and conduct experiments	H2	Experiment Design Ability
		Analyzes and interprets data efficiently	H3	Data Analysis Ability
I	WORK CULTURE	Understands and works within the culture of the group	I1	Work Culture Und.
		Respects diversity	I2	Respects Diversity
		Recognizes political and social implications of actions	I3	Rec. Political Impl.
J	ORGANIZATION PLANNING	Manages projects and/or other resources effectively	J1	Project Management
		Sets goals and prioritizes	J2	Goal Setting
		Manages several tasks at once	J3	Task Management
		Allocates time to meet deadlines	J4	Time Allocation
K	EVALUATION OF WORK HABITS	Professional attitude toward work assigned	K1	Professional Attitude
		Quality of work produced	K2	Work Quality
		Volume of work produced	K3	Work Volume
		Attendance	K4	Attendance
		Punctuality	K5	Punctuality

The scores of a population with regards to the questions are plotted out in a standard deviation mean matrix. A low standard deviation of a student performance score indicates high process stability. A low standard deviation indicates that the variation in student performance is small. A high standard division of student performance suggests the absence of a stable educational process. Students seem in this case to be left to their own devices, some learn and some do not. The matrix is visual and simple to read. Scores in the upper left hand corner are good; the lower right hand corner needs to be avoided.

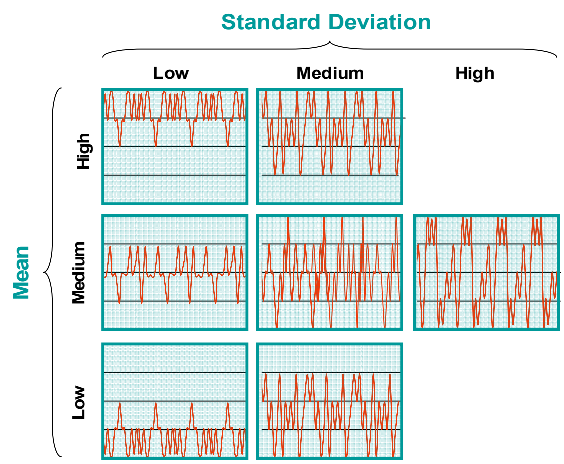

Figure 4. Standard Deviation / Mean Matrix

The matrix gives a good picture of were the educational process is stable and where further improvements could be applied. Six Sigma and Lean Manufacturing literature typically encourage process developers to initially focus on controlling the standard deviation of a particular process outcome. Only after the control of a process has been obtained, can the means of process outcomes be affected.

MSM matrixes are drawn using absolute or relative values. In the latter case we speak about Delta Mean Standard Deviation Matrixes or for short ΔMSM's. ΔMSM's are a valuable instrument especially in before/after studies. Figure 5 shows the principle of a ΔMSM.

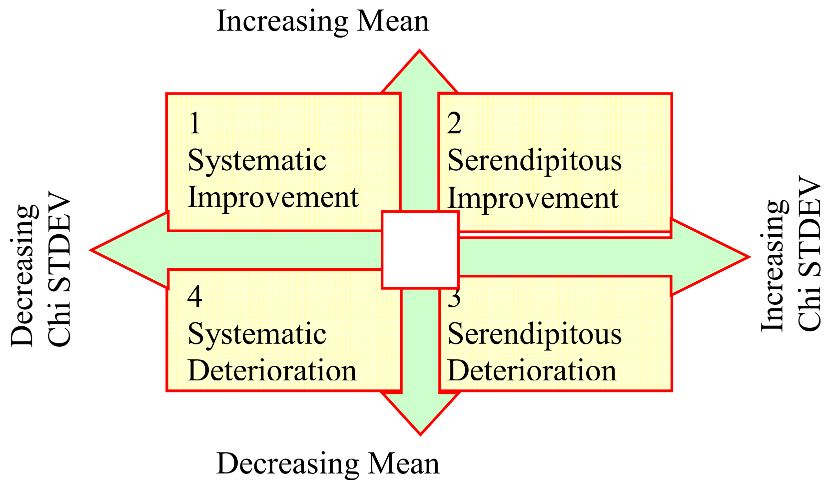

Figure 5. delta mean standard deviation matrix

A ΔMSM matrix gives valuable information about the effectiveness of educational process. Let us assume that we compare the performance of sophomores and seniors. In an ideal case our results get plotted in quadrant 1 (figure 5). Whenever the mean of student performance increases and the standard deviation decreases the educational program is doing what it is supposed to do. The average of student performance goes up, and the students exhibit this behavior coherently as a group.

When both the mean and the standard deviation increases learning is occurring, but some students exhibit more learning than others. This can be seen in quadrant 2. It is seems obvious to hypothesize that the learning is not well supported by the curriculum. The curriculum provides opportunity for learning, but it seems to be out of reach for some individuals.

Quadrants three and four are more problematic. Whenever the mean decreases and the standard deviation increases students are serendipitously starting to exhibit deterioration in behavior. Whenever the means are decreasing and the standard deviation increasing, the program is systematically contributing to the deterioration of student behavior. Fortunately very few programs exhibit these kinds of anomalies.

When analyzing data using a MSDM or ΔMSDM one must make sure that the uncertainty of the data is within acceptable bounds. In this paper central parameters have been calculated using statistical processing detailed in table 3. Statistical data uncertainty has been calculated using expression 7. Standard Deviation values presented in all tables have been calculated using Chi Square Correction expression 8. The correction is made, with a confidence level of 95%, for the lower limit of the Standard Deviation. The use of the lower limit is motivated by the authors aim to reduce unnecessary alarms caused by high standard deviation values.

Table 3. Statistical formulae and definitions

Explanation		Constant or Expression	Nr
Recorded Grade	=	X	(1)
Total Number of Students	=	N	(2)
Returned Assessments	=	N	(3)
Chi Square Function	=	χ	(4)
Population Mean	=	m = $(X_1 + X_2 + X_3 + \ldots X_n) / n$	(5)
Population Standard Deviation	=	s = $[\Sigma (X - m)]^{½} / [n - 1]^{½}$	(6)
Statistical Uncertainty of Mean (Assuming 95 % confidence)	=	$\pm 1.96 [(N – n) / (N – 1)]^{½} s / n^{½}$	(7)
Statistical Uncertainty of St. Dev. (Assuming 95 % confidence)	≥	$[(n - 1) s^2 / (\chi_{0.05})^2]^{½}$	(8)
Statistical Uncertainty of St. Dev (Assuming 95 % confidence)	≤	$[(n - 1) s^2 / (\chi_{0.95})^2]^{½}$	(9)

Application of the Theory to a Specific Program

This section of the paper focuses on applying the above theory to one program offered by the College of Engineering (further referred to as Engineering Program A). The program is an analytically oriented five year Engineering Program, relying on mandatory cooperative education. The relationship between curricular effectiveness and work performance is strong, as the attrition of students mostly occurs before the students enter the co-op phase and as the completion of co-op is an absolute graduation requirement.

Figure 6 shows a statistically significant increase work performance over the progression of the curriculum. The analysis will be further pursued through the help of both MSDM and ΔMSDM matrixes. The analysis will be based on the summary data presented in table 4. The table is an aggregate of 497 individual assessor returns.

Table 4. Summary of Base data for Process Stability Analysis of Engineering program A.

	MEAN				CHI STD				ENTRY		EXIT		CHANGE	
	So	PJr	Jr	S	So	PJr	Jr	S	Ch	Me	Ch	Me	St	Mea
A1	3.9	4.0	4.2	4.2	0.5	0.6	0.6	0.6	0.6	4.0	0.6	4.2	0.0	0.26
A2	3.7	3.9	4.1	4.1	0.6	0.6	0.6	0.5	0.6	3.8	0.6	4.1	-	0.31
A3	3.7	3.9	4.1	4.2	0.5	0.6	0.6	0.5	0.5	3.8	0.6	4.1	0.0	0.35
A4	4.1	4.1	4.3	4.3	0.6	0.7	0.6	0.6	0.7	4.1	0.6	4.3	-	0.19
B1	3.8	3.8	4.1	4.3	0.5	0.6	0.6	0.6	0.6	3.8	0.6	4.2	0.0	0.37
B2	3.6	3.8	4.2	4.1	0.5	0.6	0.6	0.6	0.6	3.7	0.6	4.2	0.0	0.43
B3	3.8	3.8	4.1	4.1	0.6	0.6	0.6	0.6	0.6	3.8	0.6	4.1	0.0	0.26
B4	3.7	3.8	4.1	4.2	0.6	0.7	0.6	0.6	0.6	3.7	0.6	4.2	0.0	0.44
C1	4.3	4.2	4.4	4.5	0.5	0.7	0.6	0.5	0.6	4.2	0.5	4.4	-	0.20
C2	3.8	3.8	4.1	4.2	0.6	0.6	0.6	0.6	0.6	3.8	0.6	4.1	-	0.34
C3	3.7	3.7	4.0	4.2	0.6	0.6	0.6	0.5	0.6	3.7	0.6	4.1	-	0.39
D1	4.0	4.1	4.3	4.5	0.6	0.6	0.6	0.5	0.6	4.1	0.5	4.4	-	0.34
D2	4.0	4.0	4.3	4.4	0.7	0.7	0.6	0.6	0.7	4.0	0.6	4.3	-	0.33
D3	4.4	4.4	4.6	4.5	0.6	0.6	0.5	0.5	0.6	4.4	0.5	4.5	-	0.16
D4	4.0	4.1	4.3	4.3	0.7	0.8	0.7	0.6	0.7	4.1	0.7	4.3	-	0.24
D5	4.1	4.2	4.3	4.4	0.7	0.6	0.6	0.6	0.6	4.1	0.6	4.3	-	0.18
E1	4.3	4.3	4.5	4.5	0.6	0.6	0.5	0.5	0.6	4.3	0.5	4.5	-	0.19
E2	3.9	4.1	4.2	4.3	0.6	0.7	0.6	0.6	0.6	4.0	0.6	4.3	-	0.27
E3	4.0	4.2	4.4	4.3	0.6	0.6	0.6	0.6	0.6	4.1	0.6	4.4	-	0.25
E4	4.0	4.2	4.3	4.4	0.6	0.6	0.6	0.6	0.6	4.1	0.6	4.3	-	0.26
F1	3.6	3.7	4.0	4.0	0.6	0.6	0.7	0.6	0.6	3.7	0.6	4.0	0.0	0.30
F2	3.7	3.6	3.8	4.0	0.6	0.6	0.6	0.6	0.6	3.7	0.6	3.9	0.0	0.21
F3	3.7	3.6	3.9	4.0	0.5	0.7	0.7	0.7	0.6	3.7	0.7	3.9	0.0	0.24
G1	4.0	4.2	4.4	4.4	0.6	0.6	0.6	0.5	0.6	4.1	0.5	4.4	-	0.30
G2	3.7	3.8	4.1	4.1	0.6	0.6	0.6	0.6	0.6	3.8	0.6	4.1	-	0.31
G3	3.7	3.9	4.2	4.2	0.6	0.7	0.6	0.6	0.6	3.8	0.6	4.2	-	0.40
H1	3.5	3.9	4.2	4.0	0.5	0.6	0.6	0.5	0.6	3.7	0.6	4.1	0.0	0.43
H2	3.6	3.7	4.2	4.2	0.5	0.6	0.5	0.4	0.5	3.7	0.4	4.2	-	0.54
H3	3.8	3.9	4.3	4.2	0.6	0.6	0.6	0.6	0.6	3.8	0.6	4.2	0.0	0.37
I1	4.2	4.1	4.3	4.3	0.6	0.6	0.6	0.5	0.6	4.1	0.6	4.3	-	0.19
I2	4.1	4.2	4.4	4.3	0.6	0.6	0.5	0.6	0.6	4.1	0.5	4.4	-	0.25
I3	3.8	4.0	4.1	4.2	0.6	0.7	0.7	0.6	0.6	3.9	0.7	4.2	0.0	0.26
J1	3.8	3.9	4.1	4.3	0.6	0.7	0.7	0.6	0.6	3.9	0.6	4.2	0.0	0.32
J2	3.7	3.8	4.0	4.1	0.6	0.7	0.7	0.7	0.6	3.8	0.7	4.1	0.0	0.32
J3	3.8	3.9	4.2	4.3	0.7	0.8	0.7	0.6	0.7	3.8	0.6	4.3	-	0.41
J4	4.0	3.9	4.2	4.2	0.6	0.7	0.7	0.6	0.7	3.9	0.6	4.2	-	0.29
K1	4.2	4.2	4.5	4.4	0.6	0.7	0.6	0.5	0.6	4.2	0.5	4.4	-	0.23
K2	4.0	4.1	4.3	4.3	0.5	0.6	0.7	0.6	0.6	4.0	0.6	4.3	0.0	0.27
K3	4.0	4.0	4.2	4.3	0.7	0.7	0.7	0.6	0.7	4.0	0.6	4.3	-	0.26
K4	4.5	4.4	4.6	4.5	0.5	0.6	0.5	0.6	0.6	4.4	0.5	4.6	-	0.12
K5	4.3	4.2	4.5	4.3	0.7	0.7	0.6	0.7	0.7	4.3	0.7	4.4	-	0.14
Avr:	3.9	4.0	4.2	4.3	0.6	0.6	0.6	0.6	0.6	4.0	0.6	4.2	-	0.29

Figure 6 shows the MSDM of the Exit Level student performance. The red boundary ovals are drawn for the purpose of clarity. The entry level performance profile is presented in figure 7.

Figure 6. Exit Level Performance MSDM

The MSDM indicates that “Integrity” (D3), “Ability to working with others” (E1) “Attendance” (K4) are the definite strong suits of the exit population. “Sets Goal” (J3)”Gives Direction” (F1), “Motivates Others” (F2) and “Conflict Management” (F3) represent the least stable characteristics of the curriculum. The weakness of “Project Management “(J1) could indicate that the curriculum lacks in project oriented pedagogy at this level. “Punctuality” (K5) is an outlier. The average of K5 is relatively good, but the individual diversity is bothersome. Some engineers are punctual others are not. Surprisingly their attendance score is coherently good. The ability to design experiments is another outlier, having a very high uniformity in performance, but not a very high score. Figure 7 contrasts the exit level profile (red dotted line) with the entry level profile. The difference is remarkable. Blue solid line represents boundary oval for entry population. The red dotted line represents the boundary oval for the exit level.

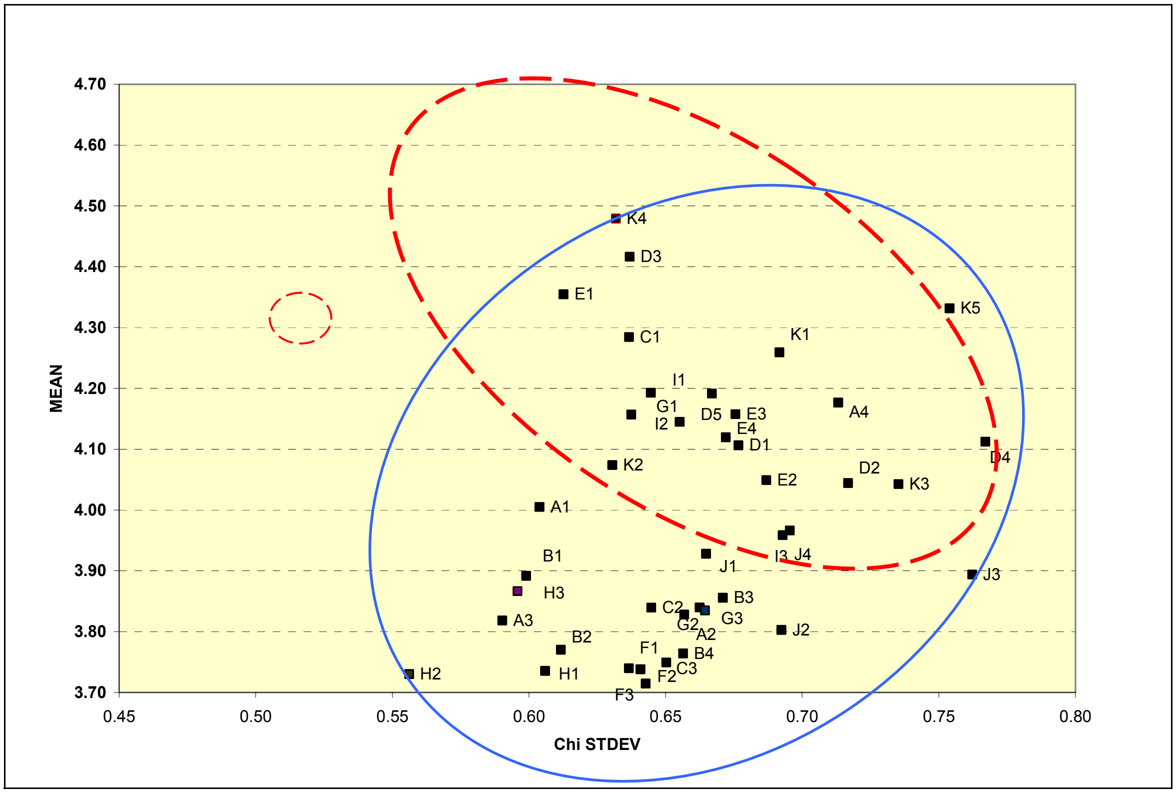

Figure 7. Entry Level Performance MSDM

The comparison of the exit and entry level behavior can be alleviated by drawing ovals around the populations. Figure 8 shows a remarkable difference in behavior between the two populations. The student performance average is less a 4.0 on 50% of measured parameters. This cluster of "mutual ignorance" (comparably low average score and low standard deviation) is completely lacking in the exit profile. The exit boundary curve is higher with a concentration of 10 points having an average of above 4.4 and a standard deviation of less than 0.6.

Figure 8 gives a picture of behavioral change through out the progression of the curriculum. The average of every single parameter increases between 0.12 and 0.54 units. 65 % of the parameters exhibit a declining standard deviation and an increasing mean. The strongest learning is demonstrated in the students "Ability to design experiments" (H2) and in "Component design ability" (H2). The average of writing skills (A2) and speaking skills (A1) increase in the same order of magnitude. Still the writing seems to be covered in the curriculum

(STDEV decreases), where as the students seem to be left for their own devises with regards to the development of their oral expression (STDEV Increases). Professional attitude (K1) exhibits the biggest coherence with regards to the development of the student cohort, where as conflict management (F3) seems to be the trait least systematically covered in the curriculum.

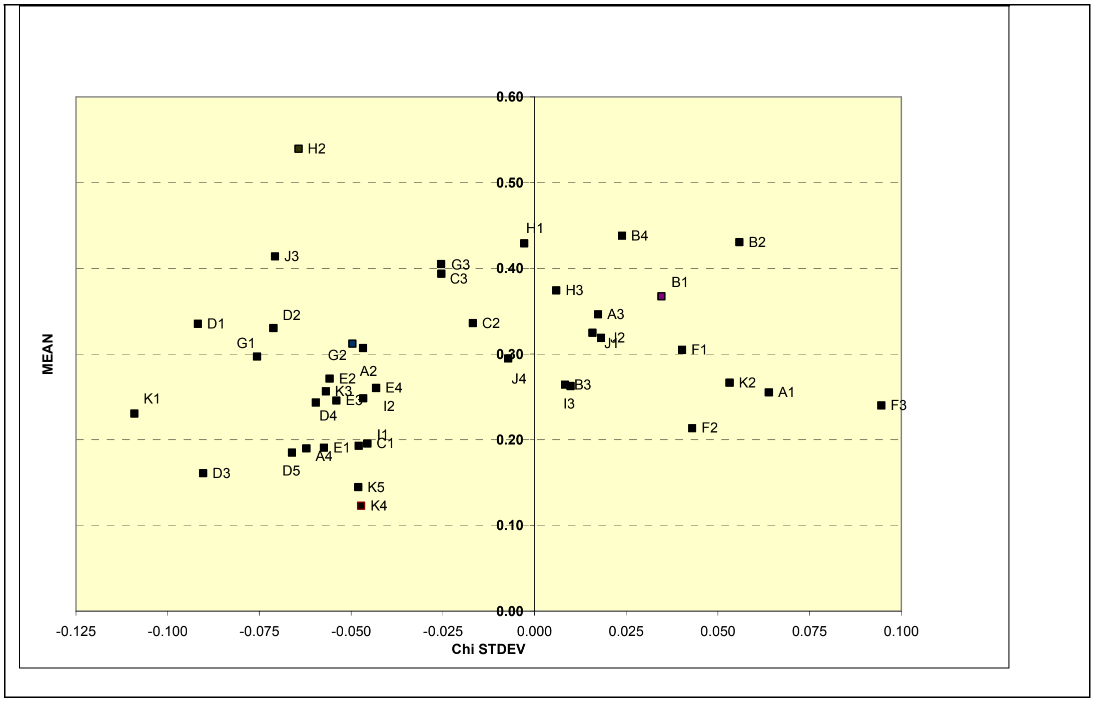

Figure 8. Entry vs Exit ΔMSDM

Conclusions and Acknowledgements

The above presentation covers a six sigma process stability analysis as applied on one specific engineering major. The methodology is still in its infancy and many steps need to be taken until we can harness the MDSM's and ΔMDSM's to alleviate employment oriented education of professionals. Still the methodology offers some quite exiting perspectives. Still we have to realize that we are far from there yet. The mathematical measurement certainty of the instrument as well as of the methodology needs to be more thoroughly analyzed. The hermeneutics ramifications of the system need to be well understood. The instrument is a tool with which a variety of employer constituencies express their opinion of how well a student is pursuing different aspects of his work. It is obvious that, let us say when comparing accountants and engineers, we compare individuals in two very different communities, each with their very specific value system. It is intuitively obvious that the word project does not have the same connotation in an engineering context versus an accounting context.

The methodology of using Six Sigma Process Stability Analysis in the Assessment of Education Curricula is novel in a Cooperative Education context, and has been made possible by a Fund for the Improvement of Postsecondary Education (FIPSE) grant having the title "Developing a Corporate Feedback System for use in Curricular Reform". Initial project collaborators include UC academic units as follows: the Department of Civil and Environmental Engineering (College of Engineering); the Department of Civil and Construction Management (College of Applied Science); the Department of Architecture (College of Design, Architecture, Art, and Planning); the College of Business Administration; and the Division of Professional Practice and the UC Evaluation Services Center. A member of the Evaluation and Assessment Center for Mathematics and Science Education at Miami University acts as the external evaluator for the project. Universities subscribing to the Accreditation Council for Cooperative Education serve as the Dissemination group for the Project.

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