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Designing Customizable Content Delivery Systems Using Lean-Agile Principles for Improved International Student Success

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Henry Griffith serves as an adjunct instructor in the College of Engineering at Wright State University. He has over 7 years of experience teaching and developing coursework in engineering and mathematics. In addition, he has 10 years experience in applying electromagnetic principles to the design of high frequency components and sensing systems.

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Dr. Ajami received his Ph.D. from Pennsylvania State University in International Business, Strategic Management and Oil Economics.

Currently, Dr. Ajami is the Editor-in-Chief of the Journal of Asia-Pacific Business and serves as an editorial board member of Competitiveness Review, Journal of Global Marketing, Journal of Transnational Management Development, and other leading international, academic business journals.

Dr. Ajami has also co-authored International Business: Theory and Applications, (M. E. Sharpe), third edition 2013. In addition, he is the co-author of The Psychology of Marketing: Cross-Cultural Perspectives (Gower Publishing, 2010), Customer Relationship Management: A Global Perspective (Gower Publishing, 2008), and The Global Enterprise: Entrepreneurship and Value Creation (2007, The Haworth Press). He is also a frequent contributor to a number of books on the subject of International Business. He has had articles published on International Business in the Wall Street Journal, Journal of International Business Studies, Management International Review, Strategic Management Journal, Journal of International Management, and other leading international, academic business journals. Professor Ajami has appeared on national television and radio, including, among others, Nightline, the PBS News Hour, NBC News, CNN, National Public Radio and CBS Radio. Dr. Ajami is a co-founder and principal of Management International Consultants and Advisors (MICA), Luxembourg and New York City.

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Introduction

Increasing economic and technological interdependence has provided global incentive for countries to further investments in engineering education (National Science Board, 2012; Onsomu, Ngware, & Manda, 2010). In certain Middle Eastern nations, domestic capacity for such education lags demand, thereby necessitating that students be supported in their pursuit of such studies abroad (Continuing Expansion for Education in the Middle East, 2013). While such mobilization presents significant opportunities for the host school and its students, institutions are often underprepared to provide sufficient support structures capable of addressing the unique challenges faced by international students (Fischer, 2014). Development of such systems is often hindered by highly volatile enrollment forecasts, as well as a lack of dedicated financial support for such initiatives. The latter challenge is exacerbated for U.S. state-funded institutions, where international education efforts fall outside of the institution's primary mission.

In order to address these challenges and leverage the associated opportunities in educating internationally mobile students, it is essential that U.S. engineering colleges develop dedicated processes and systems which are optimized with respect to the unique needs of the target population. In light of the aforementioned financial and forecasting challenges, these processes must be lean, agile, and effective. One approach for achieving such functionality within the classroom is to leverage and customize existing content delivery systems through the use of supplemental technology-driven processes as well as data-driven optimization of core system parameters. Such customization requires courses which utilize a system framework for content delivery, as opposed to the traditionally rigid and unimodal method often employed in traditional lecture based courses.

The research described herein describes an approach to course redesign conducted in such a framework suitable for meeting the unique needs of international learners. Namely, EGR 1980, a course at Wright State University intended to service underprepared students in their progression through the nationally acclaimed engineering mathematics sequence (Klingbeil, Mercer, Rattan, Raymer, & Reynolds, 2005) is being redesigned in Spring 2014 in order to leverage advancements in the knowledge and learning space theory of assessment and learning (Falmagne, Albert, Doble, Eppstein, & Hu, 2013). This is achieved through utilization of the ALEKS software package, which has found success across a wide array of disciplines, including mathematics (ALEKS Corporation, 2014; Nwaogu). By utilizing a system viewpoint constructed in a lean-agile six sigma framework, the course has been redesigned in order to allow for the level of customization necessary in order to ensure sufficient international student success at minimal cost. This paper begins by briefly reviewing the history of lean-agile process improvement in order to develop the case for its utilization in higher education. Next, the role of the redesigned course in the context of the entire engineering mathematics sequence is discussed, along with the unique demographics of the Spring 2014 cohort which motivated these efforts. Finally, the redesign process is presented along with an observational analysis of preliminary assessment results.

Case for Deployment of Lean-Agile Six Sigma Process Improvements in Higher Education

Increasingly competitive markets have resulted in elevated consumer value expectations across all industries (George, 2002). Through utilization of lean six sigma principles, successful companies have moved beyond first-order cost savings in order to develop sophisticated value propositions which are commensurate with these expectations, thereby ensuring their competitive advantage (P. Atkinson & Nicholls, 2013). These improvements have yielded substantial added value in the form of increased supply chain surplus, allowing for the simultaneous achievement of increased profitability and consumer satisfaction (Chopra & Meindl, 2013). While initiated in large-scale manufacturing and service firms operating within developed countries, recent research has demonstrated successful implementation of these principles in firms of varying size, sectors, and markets (Elewaut, Linenboim, & Scokin, 2003; Enoch, 2013; Golicic & Medland, 2007; Hernández Palomino, de Jesús Espinoza, & Aguilar Arellano, 2013). This latter observation is especially promising, as it expands the business case for broad process improvement implementation regardless of constraints on capital resources.

In spite of the significant value added by lean concepts in the private sector, implementation in public sector institutions has been somewhat sluggish (P. E. Atkinson, 2013). This is especially troubling in light of the increasing pressures on state and local government budgets within the United States, where current funding models for higher education are unsustainable and demand immediate attention (Newfield, 2010). As a result of these pressures, long term initiatives and research has focused on developing modified funding structures based upon student success factors instead of enrollment (Sav, 2013; Sexton, Comunale, & Gara, 2012). However, pragmatic transient responses to these aforementioned pressures are often focused solely on cost elimination. This is problematic since demand for higher education tends to rise in periods of recession, where reduced tax revenue oftentimes serves to stimulate budget reductions and associated cuts (Douglas & University of California, Berkeley, Center for Studies in Higher Education, 2010). In light of these observations, the capacity of lean process improvements to reduce cost while simultaneously improving customer satisfaction furthers the case for their implementation within higher education.

While the above arguments make a strong case for the rapid and broad implementation of lean six sigma process improvement strategies, recent research has suggested that institutions of higher education should proceed with some degree of caution before pursuing large-scale initiatives. Namely, Antony suggests that universities must examine their own internal readiness factors before implementing such improvement processes in order to ensure the success and sustainability of the effort. Readiness factors are defined in this context as the institutional parameters which are necessary in order to maximize the likelihood of success, and include sufficient leadership and vision, management buy-in, alignment with the broad mission of the University, as well as a student-centric focus (Antony, 2014).

While such recommendations may be appropriate for large-scale initiatives, it is intuitive to assume that small scale projects with limited risk may be pursued with less hesitation, and may in fact help advance the achievement of the aforementioned readiness factors required for improvement on a larger scale. For example, Doman describes such an initiative in which lean process improvement was used as both an educational tool and a value-added addition to the grade change process at Oakland University (Doman, 2011). Another similar opportunity for small-scale implementation exists in the course redesign process. For example, Balzer describes the utilization of lean principles to the redesign of a course in leadership. (Balzer, 2010)

Engineering Mathematics Sequence at Wright State University

At Wright State University (WSU), proven processes exist for addressing the significant variation in the mathematical preparation of students intending to enroll in engineering. Namely, through the Engineering Mathematics curriculum redesign, students have been able to accelerate entry into the core program curriculum, which has been demonstrated to improve the likelihood of retention throughout the degree program. While prepared students may complete this sequence in one semester, thereby entering their first semester of engineering coursework, a pathway consisting of an additional preparatory course exists for underprepared students. For purposes of illustration, the various pathways available for students are emphasized in the figure below –

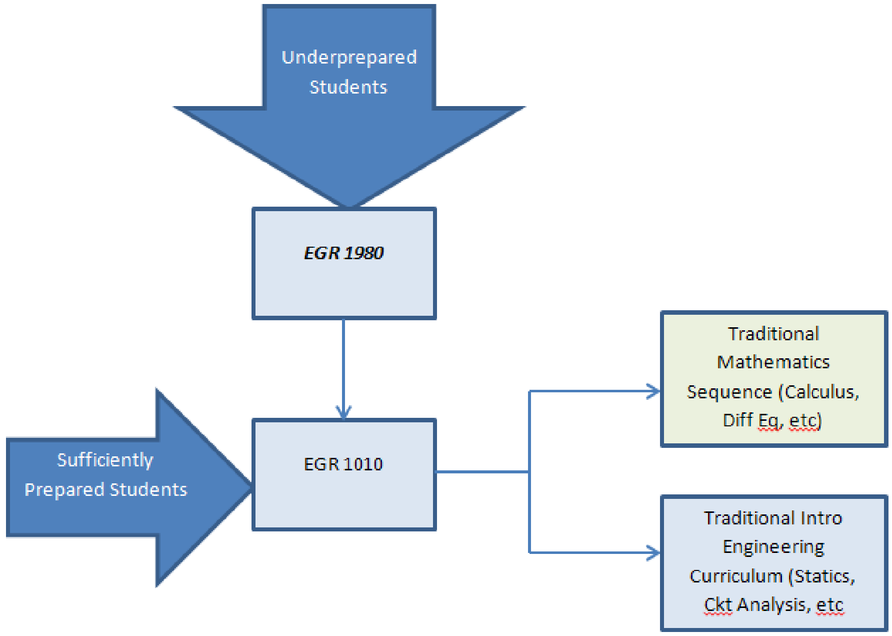

Figure 1: Curriculum Progression for Wright State University Engineering Students

In addition to accelerating their entry into the introductory engineering curriculum, students enrolling along the underprepared pathway receive the additional advantage of being able to retake the math placement exam at the end of the course. Therefore, the natural objective of the EGR 1980 course is two-fold – 1) to prepare students to improve their math placement level, thereby bypassing significant coursework in remedial mathematics, and 2) to prepare students to succeed in the EGR 1010 course, which requires significant application of advanced mathematical principles to basic engineering problems. While these objectives are somewhat complimentary, fulfillment of the first does not necessarily guarantee fulfillment of the second.

In its initial implementation, EGR 1980 employed a similar content delivery structure to that of EGR 1010. Namely, content was delivered in both a standard instructor-led lecture, as well as a student-(either graduate or undergraduate that had previously demonstrated exemplary performance in the course) led recitation (it should be noted that EGR 1010 also contains laboratory experiments as an additional mode of content delivery). In addition, mathematical content was applied to basic engineering problems in order to promote increased student engagement in both courses. However, over the course of implementation of EGR 1980, content delivery began to shift in order to focus more on pure mathematical content for MPL preparation. While such a strategy may be suitable for improving achievement of the prior goal of the course, it ignores the importance of the secondary goal. As EGR 1010 represents the immediate gateway to entering the engineering curriculum for students within this pathway, such an approach poses significant risk of jeopardizing the success of these students.

Over the past year, accelerated growth in the enrollment of internationally mobile undergraduate students has significantly expanded the number of enrollees entering the pathway at the preparatory stage. In Spring 2014 alone, a cohort of 63 internationally mobile students from Kuwait and Saudi Arabia sought to enroll in the preparatory pathway described above. Amongst these students, variation in mathematics preparation as measured according to the math placement level (MPL) was substantial, as is evidenced by the sample histogram presented below –

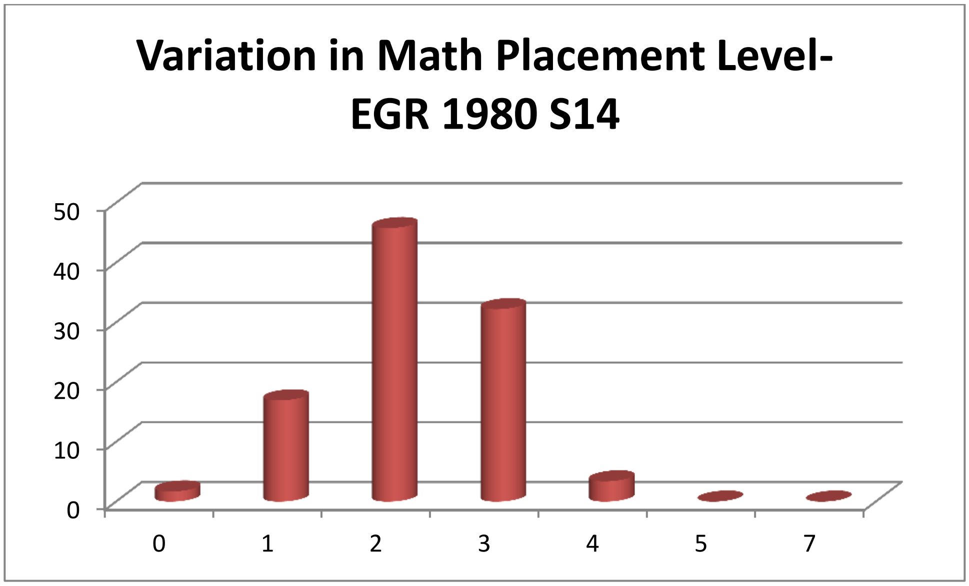

Figure 2: Curriculum Progression for Wright State University Engineering Students

For purposes of emphasizing the value provided by the course though the improvement of math placement scores, consider the scenario for a student scoring at the mode of the above sample (MPL = 2). In the current mathematics program sequence at WSU, such a student would be required to enroll in a developmental mathematics course, thereby leaving them at least 3 semesters removed from a course in mathematics which would count towards their degree. As such courses represent unnecessary steps towards the fulfillment of the ultimate end goal of the customer, it is evident that successful implementation of the EGR 1980 course reflects a unique opportunity to achieve the primary objective of lean process design.

Based upon the unique demographics of this cohort, it is worthwhile to devote some attention towards examining the potential of English language deficiencies to mask true ability on the math placement test. Such a hypothesis is supported by a multitude of research in the literature, including that which suggests that test anxiety is significantly elevated within second language learners (Gardner & MacIntyre, 1993). In order to investigate this claim, a baseline experiment was conducted in which an ungraded assessment was administered on the first day of class containing two distinct types of questions which were identical in mathematical content. Namely, the first type of questions posed prompts using only written English language, including particular words which are specific to the discipline of mathematics. The second type of question prompts contained no written words, relying solely upon the symbolic expressions of mathematics. For purposes of this discussion, the prior set of questions is referred to as a technical assessment, where technical is chosen to reflect the fact that comprehension of the question prompts required understanding of words within the English language which are unique to mathematics. The secondary set of questions is referred to as a symbolic assessment. Student performance on each of the assessment types is demonstrated in the figure below. As may be expected, assessment scores on the symbolic assessment exceeded those observed on the technical assessments.

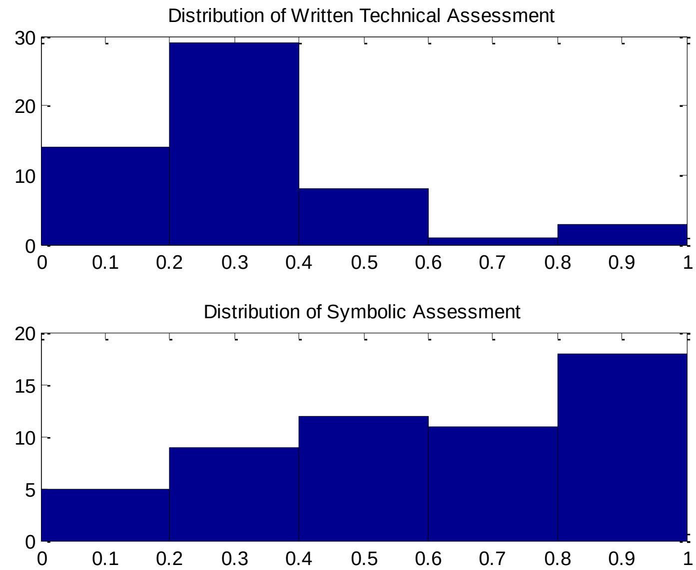

Figure 3: Distributions of Student Performance on the Technical and Symbolic Assessment

For purposes of examining the proposed masking effect of language, it is more beneficial to examine the relationship between the performance of each specific student on both types of assessments. This is demonstrated in the scatter plot presented below. Note that the upper left-hand corner is referred to as the so-called "masking region." Students scoring in this region exhibit symbolic assessment scores which far exceed their technical assessment, suggesting that a lack of language mastery may contribute significantly to their performance on mathematics assessments.

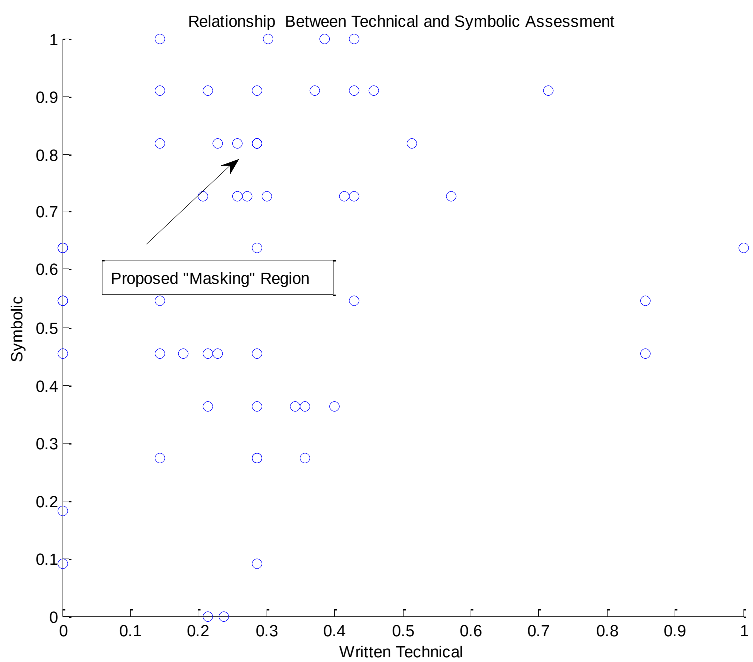

Figure 4: Scatter Plot Demonstrating the Relationship of Technical and Symbolic Performance by Student

At the time of this writing, the authors are conducting additional investigation regarding the proposed masking effect of language deficiencies, including a thorough review of the literature, a more sophisticated data analysis based upon further student course performance, as well as data obtained for a control group of native speakers of English. It is the intent of the authors to publish this research in the future.

Lean-Agile Six Sigma Approach to EGR 1980 Course Redesign

When attempting to employ lean-agile six sigma principles to the redesign of any process, it is essential that practitioners recognize the unique objectives associated with each of the individual principles. Namely, lean seeks to improve process speed through the elimination of non-value added elements, while a focus on agility attempts to develop robust systems which deliver suitable performance under a variety of external conditions. Finally, six sigma principles seek to ensure process effectiveness by identifying and eliminating special cause sources of variability in the process output (George, 2002).

For deployment of such principles within higher education, Antony suggests that the order and focus of implementation is not overtly important. Rather, he suggests that the specific focus of an improvement initiative should be chosen for each project based upon the unique needs of the implementing organization (Antony, 2014). In contrast, most literature on the implementation of such initiatives in the private sector promotes a more rigid and defined approach. For example, George suggests a slight modification of the well-known DMAIC approach used for process tuning. Namely, the DMEDI (Define-Measure-Explore-Development) is suggested as a framework for the design of world class services.

In the design discussed herein, the define phase of the process was driven by two key strategic initiatives within the College of Engineering at WSU – 1) A commitment to improved accessibility for students of all preparation levels, and 2) A commitment towards superior service levels in support of international student success. With this in mind, the choice of ALEKS software as a central component of the redesigned system was a natural fit based upon its aforementioned results in ensuring student success in mathematics. In addition, the ability of the software package to generate significant value added data for specific student performance was viewed as a mechanism to support the ultimate quality improvement goals of the course. Finally, the inherent learning pathway customization associated with knowledge space theory was viewed as a mechanism to enhance agility of the overall system.

While the software offers the capacity to deliver content autonomously, it was decided to retain the in-person delivery of content in lecture in order to maximize system agility with respect to unique student learning styles. The complimentary delivery of content through both lecture and ALEKS channels is hereby referred to as the adaptive mathematics content delivery system. Certain notable aspects of this system are emphasized in the figure below –

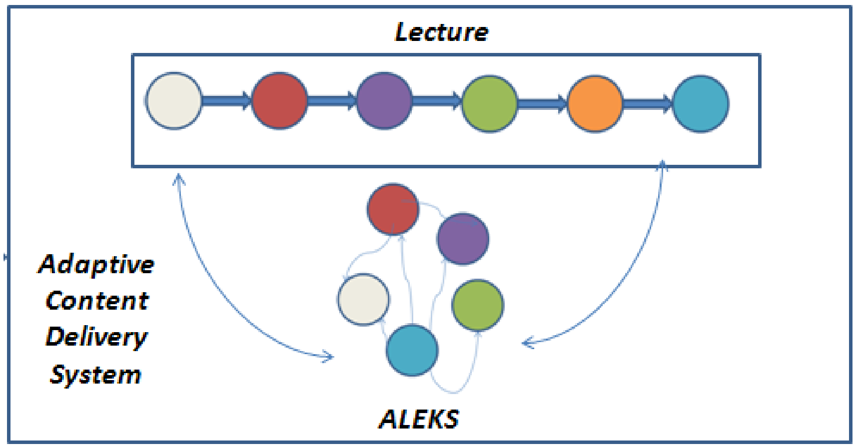

Figure 5: Relationship Between Channel Components with Adaptive Content Delivery System

While the lecture content delivery channel follows through the traditional sequential presentation of material, students' efforts within the ALEKS learning system are directed according to a customized learning pathway. This provides significant value in terms of both feed-back and feed-forward coupling with the lecture channel. In particular, through continuous review of content covered in lecture, ALEKS helps ensure long term retention across the semester. In addition, by introducing some content which has not yet been covered in lecture, ALEKS helps effectively allocate time when introducing new topics within lecture.

While the aforementioned adaptive content delivery system is suitable for achieving the primary goal of MPL improvement within the course, it does not fully address the latter goal of ensuring student success in EGR 1010. This is achieved through dedicated integration of material which presents content from mathematics in the framework of applied engineering problems. Ensuring the inclusion of this channel in the modified delivery system has many advantages, including the capacity to improve student engagement by emphasizing relevance to their future careers. (Woolley, Rose, Orthner, Akos, & Jones-Sanpei, 2013). While this deficiency could easily be addressed through integration of applied content within the core delivery system, it was decided to isolate its delivery within recitation meetings, with only limited review of the associated content provided within lecture as necessary. The purpose of isolating the two types of content delivery is two-fold. Namely, through isolating delivery channels, the system becomes increasingly adaptable, allowing for adjustments in the blend of individual content delivery type. This flexibility can be especially beneficial based upon variations in student preparation. In addition, while the material presented for MPL preparation is largely review, many students may not be familiar with basic engineering systems, such as electrical circuits or mechanics. By presenting this content a small group interactive learning environment, students may leverage the documented benefits associated with participation in interactive learning environments (Jamieson, Fisher, Gilding, Taylor, & Trevitt, 2000). This small group interaction is especially important for newly enrolled international students, as it allows them opportunities to further develop their support networks.

While the aforementioned content and associated delivery channels form a baseline platform suitable for achieving the goals of the course, further customization is possible in order to address the unique needs of specific cohorts. This adaptability is especially valuable for international cohorts, who may benefit substantially from opportunities to improve upon their English language skills and further establish their social support networks. In support of these goals, an online discussion board platform was added to the content delivery system for the Spring 2014 cohort. While several platforms are available to deliver this service, MOOT (www.moot.it) was chosen based predominately upon its ability to deliver content seamlessly across both PC and mobile platforms. The entire customized system is summarized in the figure below –

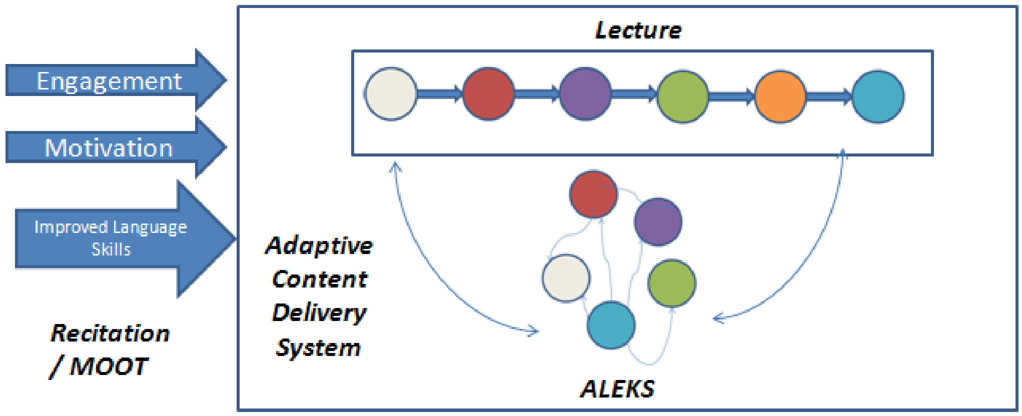

Figure 6: Customized Delivery System for Spring 2014 EGR 1980 Cohort

While the description of process design significantly emphasized the lean and agile aspects of the redesigned course, the capacity of the system to achieve high levels of quality through six sigma process implementation should not be overlooked. Namely, through the ALEKS online platform, significant data is available for purposes of tracking specific student performance over the course of the semester. Information may be extracted from this data in order to yield optimized software parameter settings for each particular student (for example, high levels of variability between subsequent assessments could indicate the need for increased review frequency), thereby further contributing to system adaptability.

Preliminary Results

At the time of preparation of this report, the pilot implementation of the course was currently ongoing, thereby limiting the capacity to present significant results. In addition, as the pilot implementation of the redesigned course consists almost entirely of first semester international students, the capacity to compare the performance of students within this cohort to traditional domestic students is not yet available. However, it should be noted that the authors are currently designing follow-up observational data collections and designed experiments in order to facilitate more detailed analysis in future publications.

In spite of the lack of a complete data set, some interesting insights may be gained through examination of preliminary data obtained thus far. First, it is of interest to examine the perceived accuracy of the comprehension of course material provided in ALEKS as compared to those recorded on the in-class midterm. In order to facilitate this observation, a plot of the so-called error in ALEKS comprehension estimates (calculated as the difference between average ALEKS assessment for a particular topic relative to midterm performance on the same topic) versus an integer topic identifier is provided. As the topic identifiers are assigned based upon the order in which material was presented in the lecture delivery channel, the graph is essentially a time-series plot.

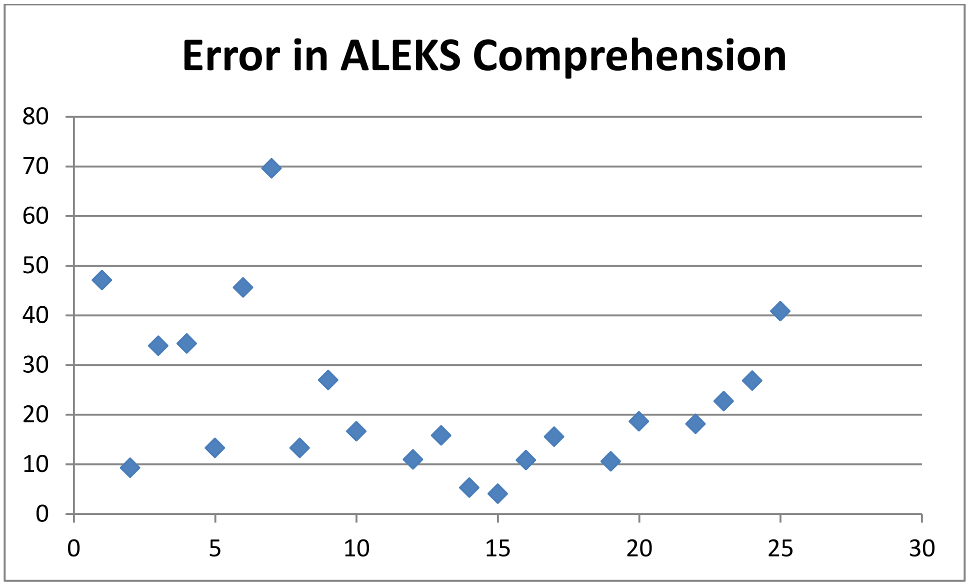

Figure 7: Variability in Error of ALEKS Comprehension Measurements Over Time

Notice that ALEKS appears to overestimate competency in all cases, as may be expected due to the fact that students take ALEKS assessment in their own environment with outside resources and calculators available. However, perhaps more noteworthy is the appearance of a somewhat parabolic trend in the time series data, suggesting that the estimate is most inaccurate for material presented both far and immediately before the exam. This observation seems consistent with what many instructors observe in practice – namely that students perform best on questions related to material that has been presented in lecture recently, assuming that adequate time has passed to allow for appropriate review and content retention. Unfortunately, this may indicate that the periodic review functionality of ALEKS under default parameter settings is not sufficient to ensure long-term content mastery for international students.

Another interesting observation is the variation in student midterm performance as a function of math placement level. This is an especially noteworthy observation, as failure to note a statistically significant dependence in performance may indicate the capacity to expand offerings of the course to students at lower MPL levels without comprising potential student success, thereby improving system agility. A histogram detailing the performance of students at each MPL level is provided below –

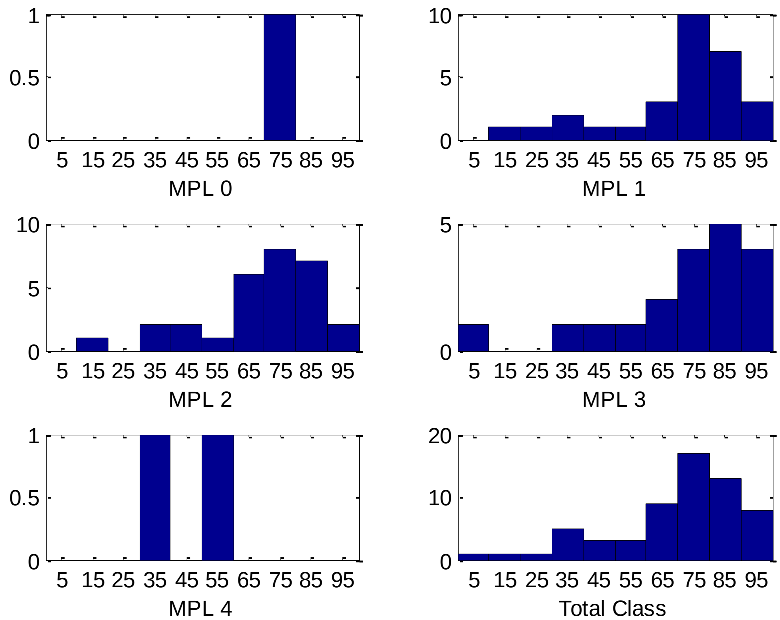

Figure 8: Variability in Midterm Exam Performance for Various MPL Levels

Further investigation is needed in order to draw meaningful conclusions about the effect of MPL. Namely, assessments based upon subsets of course performance data provide limited insight in regards to suggesting policy, particularly when the subset reflects content from the beginning of the course. This investigation is especially important for the current cohorts, as it may serve to provide further evidence towards the aforementioned masking effect. In light of these aforementioned limitations, no formal statistical analysis has yet been conducted.

In addition to examining student exam performance, it is also worthwhile to investigate data regarding student satisfaction with various aspects of the course. In light of this, a survey was designed and deployed in order to gauge student perceptions. Of those responding students, 83% reported that this course was their first time using an online learning system such as ALEKS in their education. On a scale of 1 (very difficult) to 5 (very simple), respondents classified the usability of ALEKS with an average score of 4.02. 54% of responding students were very confident in their ability to master topics in ALEKS even if they had not yet been covered in lecture. Perhaps most importantly, 88% of respondents reported that they would enroll in a course using ALEKS in the future as opposed to an identical course in which ALEKS was not utilized.

Conclusions

An increase in the number of internationally mobile undergraduate students presents significant opportunities for US institutions of higher education. In order to provide maximum value to international students, colleges and universities must attempt to customize systems with respect to the unique needs of the target population. As such efforts are often viewed as falling outside of the mission of US public institutions, it is essential that such efforts be executed at minimal cost. This may be achieved through the deployment of a lean-agile six sigma framework to existing process redesign. One example of such an implementation is the creation of parameterized content delivery systems in the course redesign process.

The research described herein presents a description of such efforts for the purpose of redesigning the preparatory course within the WSU engineering mathematics pathway. Customization of system parameters for an international cohort of over 60 students from Saudi Arabia and Kuwait has produced successful results in the form of improved student satisfaction and performance. Further research is ongoing in an attempt to leverage the significant data capacity of the ALEKS software system in order to provide optimization at the student level, thereby increasing process agility and ensuring optimal effectiveness. In addition, an expansion of the efforts described herein regarding the examination of the effectiveness of mathematics assessments for English learners is also continuing.

References

ALEKS Corporation. (2014). *Mathematics - success stories.* Retrieved 2/14, 2014, from http://www.aleks.com/highered/math/success_stories#case

Antony, J. (2014). Readiness factors for the lean six sigma journey in the higher education sector. *International Journal of Productivity & Performance Management, 6*3(2), 257-264. doi:10.1108/IJPPM-04-2013-0077

Atkinson, P. E. (2013). Implementation of lean culture change and continuous improvement. *Operations Management (1755-1501), 3*9(3), 16-21. Retrieved from http://ezproxy.libraries.wright.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=88397921&site=ehost-live

Atkinson, P., & Nicholls, L. (2013). Demystifying lean culture change' and continuous improvement. (cover story). *Management Services, 5*7(3), 10-15. Retrieved from http://ezproxy.libraries.wright.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=90521885&site=ehost-live

Balzer, W. (2010)*, Lean higher education - increasing the value and performance of university processe*s. New York, New York: Taylor and Francis Group.

Chopra, S., & Meindl, P. (2013). *Supply chain management : Strategy, planning, and operation / sunil chopra, peter meind*l Boston : Pearson, c2013; 5th ed. Retrieved from http://ezproxy.libraries.wright.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=cat01902a&AN=wsu.b3705044&site=eds-live

Continuing Expansion for Education in the Middle East. (2013). Retrieved 3/9, 2014, from http://monitor.icef.com/2013/03/continuing-expansion-for-education-in-the-middle-east/

Doman, M. S. (2011). A new lean paradigm in higher education: A case study. *Quality Assurance in Education: An International Perspective, 1*9(3), 248-262. Retrieved from http://ezproxy.libraries.wright.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ930936&site=eds-live; http://dx.doi.org/10.1108/09684881111158054

Douglass, J. A., & University of California, Berkeley, Center for Studies in,Higher Education. (2010). *Higher education budgets and the global recession: Tracking varied national responses and their consequences. research & occasional paper series: CSHE.4.1*0Center for Studies in Higher Education. Retrieved from http://ezproxy.libraries.wright.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=ED511965&site=eds-live

Elewaut, T., Linenboim, P., & Scokin, D. L. (2003). Chile's lesson in lean banking. *McKinsey Quarterly*, (3), 6-8. Retrieved from http://ezproxy.libraries.wright.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=10462643&site=ehost-live

Enoch, O. (2013). Lean six sigma methodologies and organizational profitability: A review of manufacturing SMEs in nigeria. *American Journal of Industrial and Business Management,* 3(6), 573.

Falmagne, J., Albert, D., Doble, C., Eppstein, D., & Hu, X. (Eds.). (2013). *Knowledge spaces: Applications in educatio*n. New York: Springer Heidelberg.

Fischer, K. (2014, Helping foreign students thrive on U.S. campuses. *The New York Times,*

Gardner, R. C., & MacIntyre, P. D. (1993). On the measurement of affective variables in second language learning. *Language Learning, 4*3(2), 157-194. doi:10.1111/j.1467-1770.1992.tb00714.x

George, M. L. (2002). *Lean six sigma : Combining six sigma quality with lean speed / michael L. georg*e New York : McGraw-Hill, c2002. Retrieved from http://ezproxy.libraries.wright.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=cat01902a&AN=wsu.b2245296&site=eds-live

Golicic, S. L., & Medland, S. (2007). Size might matter: A case study of lean implementation in an SME. *Society for Marketing Advances Proceedings,* , 261-264. Retrieved from http://ezproxy.libraries.wright.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=37325602&site=ehost-live

Hernández Palomino, J., de Jesús Espinoza, J., & Aguilar Arellano, M. (2013). Implementation of lean business strategies: Evidence from mexico. *International Journal of Management & Marketing Research (IJMMR),* 6(2), 67-78. Retrieved from http://ezproxy.libraries.wright.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=90144464&site=ehost-live

Jamieson, P., Fisher, K., Gilding, T., Taylor, P. G., & Trevitt, A. C. F. (2000). Place and space in the design of new learning environments. *Higher Education Research & Development, 1*9(2), 221-236. doi:10.1080/072943600445664

Klingbeil, N., Mercer, R., Rattan, K., Raymer, M., & Reynolds, D. (2005). Work in progress - the WSU model for engineering mathematics education. *Proceedings Frontiers in Education 35th Annual Conference,* , F3C. Retrieved from http://ezproxy.libraries.wright.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=edb&AN=81217210&site=eds-live

National Science Board. (2012). *Science and engineering indicators 201*2. Arlington, VA: National Science Foundation.

Newfield, C. (2010). The end of the american funding model: What comes next*? American Literature, 8*2(3), 611-635. doi:10.1215/00029831-2010-026

Nwaogu, E. *The Effect of ALEKS on Students' Mathematics Achievement in an Online Learning Environment and the Cognitive Complexity of the Initial and Final Assessments,*

Onsomu, E. N., Ngware, M. W., & Manda, D. K. (2010). The impact of skills development on competitiveness: Empirical evidence from a cross-country analysis. *Education Policy Analysis Archives, 1*8(7) Retrieved from http://ezproxy.libraries.wright.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ895614&site=eds-live

Sav, G. T. (2013). Four-stage DEA efficiency evaluations: Financial reforms in public university funding. *International Journal of Economics and Finance,* 5(1), 24-33. doi:http://ccsenet.org/journal/index.php/ijef/issue/archive

Sexton, T. R., Comunale, C. L., & Gara, S. C. (2012). Efficiency-based funding for public four-year colleges and universities. *Education Finance and Policy,* 7(3), 331-359. doi:http://www.mitpressjournals.org/loi/edfp

Woolley, M. E., Rose, R. A., Orthner, D. K., Akos, P. T., & Jones-Sanpei, H. (2013). Advancing academic achievement through career relevance in the middle grades A longitudinal evaluation of CareerStart. *American Educational Research Journal, 5*0(6), 1309-1335.