Using Analytics to Create Real Solutions for Real Problems

Essays and Reflections from the SoLAR Flare Practitioner's Conference

Purdue University
West Lafayette, Indiana
October 1-3, 2012

Matthew D. Pistilli, Editor

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The Five Component Analytic Model

John Campbell and Matthew D. Pistilli

This model, which is referenced by many of the authors in this volume, was developed as means for institutions to have a set of guidelines to consider when investigating the application of analytics on their campuses. This is one approach to the process; there are many others in existence. To that end, this model is fluid. Readers should feel free to adopt and adapt this model in a manner that fits their needs and processes. The spirit of the model, however, wherein campuses gather, predict, act and monitor student behavior and outcome should remain intact in order for the greatest positive effect to be had.

Component 1: Gather

Gathering data is at the heart of analytics, and can be considered a part of the other components as well. Multiple real-time data sources must be tapped in an effort to correlate current behavior/actions with known data about students. Reflecting on the conceptual models, Astin's input-environment-output model is an appropriate lens for considering data to gather and process.

Things to consider:

On what issue(s) ***do you plan to*** focus and why?

What data is important to gather?

How will you know if you have the "right" data? The "best" data?

What data is ***currently*** collected?

How is this data used? By whom? If not, why not?

Who owns the data?

What protocols exist or must be established for using the data?

From whom must permission be granted for us of the data?

What ***additional*** data needs to be collected?

Who owns the data?

How "easily" can it be procured?

Who are the stakeholders?

What are the challenges associated with gathering/assembling data?

What is necessary to be able to access necessary pieces of information?

What are the funding implications for data collection/assembly?

How sustainable is your data collection plan?

Component 2: Predict

Collecting data is only useful if something is done with it. Data should be used to predict student success using, at a minimum, a university-wide model (what can be predicted for all students, regardless of the course for which analytics is being implemented?). Models that could be implemented and augmented at the course-level are ideal, as they allow for the greatest amount of specificity.

Things to consider:

How do you ***identify*** the problem?

How do you avoid over analyzing the problem?

Who are the stakeholders?

What makes a good model?

What is currently being predicted with regard to students?

Anything specific to student success?
What?

Who has the ***expertise necessary*** to "crunch the numbers" and predict outcomes? Are they willing to participate?

Who are the stakeholders?

What are the challenges with predicting information about students on your campus?

What are the funding implications associated with predicting student risk/success?

What is necessary to be able to access necessary pieces of information?

How will ongoing analysis of the prediction model be conducted?
How sustainable is that plan?

To extent are you dealing with correlative information as com
pared to algorithms that outright predict behavior?
Does this distinction matter to the decision makers and stakeholders?

Component 3: Act

Once data has been gathered and predictions made, action must be taken. The goal of the action should be to encourage students to continue good academic behaviors and create new or revise unsuccessful behaviors in an effort to improve their understanding of material and overall standing in the course. This is your real opportunity to achieve desired outcomes and alter the environmental landscape to which students have become accustomed.

Things to consider:

On what issue(s) ***will you focus*** and how will you make that determination?

What is/are the most appropriate forms of action from an institutional standpoint?

What do you ***want students to do***?

What are the offices/services available to students?
What is the impact on staff/offices across campus if struggling students are directed to them?

How will action be taken? What will faculty need to do?

How will the actions be assessed?

How will you know what does/doesn't work?

What are alternatives for making the actions happen?

How often will action be expected to be taken?
Who will take it?
Who will initiate contact?

What are the challenges with acting on predictive information and getting students assistance?

What are the funding implications for acting on predictive information?

Who are the stakeholders?

What is your overall timeline/calendar for action?

How do you craft a message?

Component 4: Monitor

Monitoring change in behavior and course outcomes is central to ensuring that appropriate data was gathered and necessary actions taken based on accurate predictions. This is both a formative and summative activity, as some portions of the other components can be augmented without waiting for the next cycle to begin. Those outcomes that constitute success need to be well defined to ensure progress is being made toward them.

Things to consider:

How will success be measured?

What methods and tools will be used to measure success?

How is reporting on student success currently accomplished/ achieved?

What information would you want in daily/weekly/monthly reports on your solution? In what forms?

Who should receive information and on what basis?

Who are the stakeholders?

Who else needs to be involved in the monitoring of your efforts?

What are the challenges associated with monitoring the solution?

What are the funding implications for monitoring?

What are the time constraints/issues?

How quickly can/will your institution/faculty respond to issues that arise that impact the solution?

Component 5: Refine

Refining the data collected, prediction model, and actions taken after careful monitoring and review of outcomes is necessary to ensure that the right pieces are being taken into account and correct action taken. Refining can be done in a wholesale manner or done so that just simple/small tweaks are made.

Things to consider:

What did you learn from the analytics effort?

Did you realize the goal of the effort?

How will success be measured?

What methods and tools will be used to measure success?

If not, does the process and/or the goal need to be altered for the future?

If so, how does this goal/involvement in the project help meet institutional goals?

Who else needs to be involved from across the institution to help accomplish the goal?

Who from across the institution needs to be informed about the progress and outcomes of the project?

What did you learn from the other institutions in the analytics project that can be applied to your effort?

How will all of these lessons be used to help improve the project for the future?

John and Matt welcome your feedback and questions regarding the model. Please contact them at mdpistilli@purdue.edu.

Thought Papers and Solution Proposals

The First-Year Experience Thirty Years Later: It is Time for an Evidence-Based, Intentional Plan

John N. Gardner and Andrew K. Koch

Introduction

This paper is about the first-year experience as a collective unit of analysis and action. In particular, the authors of this paper are concerned that after more than thirty years of concerted effort, first-year student success rates remain, in aggregate, relatively unchanged. These lackluster performance rates have negative implications for students, institutions, and the nation of which they are a part. But we will address this in greater depth a bit later in this concept paper. First, we must define our terms.

We use the phrase "first-year experience" to describe a multiplicity of intentional efforts used by contemporary U.S. colleges and universities (and a growing number outside the US) to enhance the academic and personal success of first-year students. The first-year experience is both cultural- and time-specific – that is, it varies by institutional context at any point in time, and it varies within a specific institution over the course of time. Because of this, the expression has been used by many American educators in ways that were not intended by John Gardner, one of the authors of this concept paper and the developer of the phrase (Upcraft & Gardner, 1989). For example, a search of the body of scholarship on higher education would reveal that the phrase "first-year

experience" is widely used to describe a particular initiative in the curriculum or co-curriculum, most notably the first-year seminar.

In short, there is much ambiguity associated with a definition for "the first-year experience." But we are using this concept to describe the entirety of an educational institution's approach to the beginning postsecondary education experience: everything it does with and for new students, both intentionally and unintentionally.

What is the problem/challenge and how do we know it's an issue?

As we mentioned at the start of this paper, after more than thirty years of concerted effort, first-year student success rates remain, in aggregate, relatively unchanged. This is a glass-half-empty / glass-half-full issue. During the very same period, the United States expanded college access rates like few if any other nations on the globe. We believe this to be highly beneficial. However, this expanded access has not been matched with increased student success – and access without success is, in our opinion, a very empty promise.

In the 2012 edition of its annual report, National Collegiate Retention and Persistence to Degree Rates, ACT noted that first-to-second year degree rates across all higher education institutions in the United States was 66.5%. In other words, more than a third of all first-year students did not return to the college at which they began their studies the subsequent year (ACT, 2012). This is by no means a one-year trend. ACT has conducted its retention and completion analysis since 1983, and first-to-second year retention rates have

remained relatively flat over the near thirty year period examined for the study (ACT, 2012). In short, in the latter 20th and early 21st centuries, the first college year is the stage in American higher education during which the largest proportion of dropout occurs.

In our view, the retention issue is, sadly, compounded in part by the very efforts that institutions undertake to combat student departure. Specifically, the lack of improvement in first-to-second year retention rates is occurring at a time when institutions are expending great effort and resources to improve student retention. We believe this can be partly explained by the piecemeal programmatic approach institutions frequently employ to address their retention issues.

We believe that one of the main thrusts of what has come to be called "the first-year experience movement" is misguided. Yes, we did write “misguided.” This is a strong word and a strong assertion, but we have equally strong evidence to support our claim. Our work over the past decade has led us to conclude that colleges and universities focus heavily on student success programs, but rarely do they have a comprehensive plan to guide those programs. In the absence of a plan, redundancies and gaps occur, and retention stagnates. In short, a program or a set of balkanized programs do not a successful plan make.

Since the early 1980s – when fear of declining enrollments led higher education administrators to first focus on retention – educators have been

hunting for the silver bullet – the "program" that would yield miraculous student -saving and money-making retention results. This search for the ideal program also became subsumed under the language of "best practices." The idea was very simple: there are best practices out there, they can be identified and replicated with minimal thought given to context, and these best practices should yield the same results everywhere.

We hate to disappoint you, but we need to tell you that there is no silver bullet. Retention improvements that result from one-shot programs have generally been short-lived and, when taken together, have failed to move both the institutional and the national retention statistics in a positive direction.

Our experiences working with hundreds of postsecondary institutions to create action plans for first-year student success – a process called Foundations of Excellence® (FoE) in the First College Year – has led us to conclude that programs compete for resources, attention, and even students. They are frequently disconnected, and this competition and lack of coordination create conditions that are antithetical to what is needed to provide students with a coherent and seamless learning environment – the kind of environment that allows students to best learn and grow.

Who comprises the population most directly affected by this issue?

According to the U.S. National Center for Education Statistics, in 2009, there were over 17.5 millions undergraduate students enrolled in a U.S. postsecondary education institution. Nearly 3.5 million of these postsecondary

participants were new first-year students, and over half of these new first-year students enroll in community colleges (U.S. Department of Education, National Center for Educational Statistics, 2012). With a third of the 3.5 million first-year students not returning to the college or university at which they started their studies the previous year, and a subset of these students not returning to any college at all, it is easy to see that first year of college failure numbers begin to add up to an alarmingly large total.

A scan of contemporary demographic data shows that an increasing number of students enrolling in postsecondary education in the United States come from low-income and/or first generation student classifications. The Western Interstate Commission for Higher Education's 2008 report, Knocking at the College Door: Projections of High School Graduates by State and Race/ Ethnicity,1992 to 2022, points out the steadily changing racial profile of today's high school graduates. The report notes that the nation as a whole and "more and more states are closing in on 'majority-minority' status relative to public high school graduating classes, in which the number of graduates who are not White non-Hispanic exceeds the number of graduates who are" (Western Interstate Commission for Higher Education [WICHE], 2008, p. xiv).

As racial diversity increases, so does the age range of the students who enroll in higher education – either as new beginning students or as students who return to higher education after stopping out in previous years. This is particularly true but by no means exclusive to community colleges. Increased

degree production among adult students is a core component of national completion agenda goals. Whether focused on Lumina Foundation's goal of having sixty percent of the adult population in the United States with a postsecondary credential by 2025, or the Obama administration's goal of being "first in the world" in degree attainment, or comparable efforts from entities as varied as the states and the National Governors Association, adult "non-traditional" student enrollment and success in higher education is a key to realizing national higher education policy goals (WICHE, 2012).

One thing is clear from these demographic trends –higher education's newest participants will be increasingly drawn from the very same populations that have historically fared the worst in postsecondary education, if and when they enter at all. This mixture is a recipe for disaster unless institutions make some drastic modifications to how they teach and support their newest students. The patchwork of programs that has yielded no increase in retention rates over the past three decades must be replaced by something else. Institutions must do better.

What are the existing exemplars for addressing this issue?

But there is hope. We have worked with institutions and seen results that lead us to believe that there is an alternative to the retention program chaos and lackluster performance we have described. Drawing on our experiences with the aforementioned Foundations of Excellence process, we recommend that institutions move beyond individual programs and, instead, focus on creating an

integrated, evidence-based plan that coordinates efforts to improve first-year student performance.

We have seen the benefits on retention and institutional revenue that a plan of this nature can yield. External evaluation of the first-year action plans created by FoE participating institutions shows significant increases in first-to-second year IPEDS retention rates – increases of 5.62 percentage points (8.2 percent) over four years – for the institutions that report implementing their plans to a high degree (Drake, 2010). It merits mentioning that the overwhelming majority of the institutions involved in FoE have not been highly selective institutions. They are mainly non-selective and at best moderately selective two-year and four-year institutions. These are precisely the kind of institutions where it is most difficult to "move the needle." Yet the needle has moved fairly substantially here. This should give hope to other institutions.

What are the barriers for the population in achieving success?

These research findings tell us two things. First, institutions need a plan for improving success – a plan that makes the sum of the parts greater than the individual pieces. Second, institutions must implement their plans to a high degree to realize the benefits they seek.

The second point merits repetition. Institutions must implement their plans to a high degree to realize the benefits they desire. This may seem obvious, but our experience with higher education institutions has led us to believe that faculty and staff would much rather study an issue than act on it. It is not

infrequent for an institution to go through a FoE self-study process – the most comprehensive review of the first-year experience that the institution had ever conducted – and come out of the process with recommendations that call for "further study." This "paralysis via analysis" does nothing to improve the institution, and offers even less support for the students that the institutions are trying to serve.

We want to be clear that we are not calling for random forms of action. We are calling on institutions to draw on evidence to both create and then implement a coordinated plan for improving the first-year experience – and we are encouraging institutions to not let gaps in data or evidence prevent them from acting when the weight of the evidence that they collected suggests that action is merited.

The simple fact is that many colleges and universities were not created to serve the majority of the students who make up their contemporary enrollments. In recognition of the need to do 'something about retention," institutions have added programs in well-intentioned albeit less-than-strategic manners. To more aptly serve the students that they currently enroll, postsecondary institutions need much more than programs – they need an intentional, evidence-based plan that makes the sum of their programmatic parts greater than the individual pieces. *What happens if we do nothing?*

Of course, institutions can choose to do nothing. They can leave their first-year experience as it is and hope for the best. But they should not expect to

improve performance by doing nothing. In fact, with the demographic changes described earlier in this paper, doing nothing will surely lead to increases in first year failure and attrition rates over time.

These first year failure rates and the failure to graduate that is correlated with first year attrition take a toll on institutions as well as the people and broader society they are supposed to serve. Sandy Baum, Jennifer Ma, and Kathleen Payea point out in Education Pays 2010: The Benefits of Higher Education for Individuals and Society that median earnings, lifetime earnings, lifetime tax payments, job satisfaction, sense of work as being fulfilling, pension plan coverage, health insurance coverage, and a host of other measurable variables are all significantly higher for college degree completers when compared to people who either only finished high school or who did not complete high school at all (Baum, et al., 2010). Equally important is what is lower – college graduates have lower rates of smoking, lower levels of unemployment, shorter periods of unemployment if they do lose a job, and use less public assistance. When compared to those who do not attend college, college graduates are healthier, are more involved in their communities, and vote with greater frequency (Baum, et al., 2010).

In our view, given the increasing call for institutional accountability from legislatures and the public-at-large, the personal benefits associated with completing a college degree, and twenty-first century societal and workforce needs, it is an imperative for institutions to act and act now to transform and

reform the first college year. Failure to do so threatens public perceptions and support of higher education, and, in time, it could even threaten institutional and faculty autonomy.

In summation, the time for intentional and highly coordinated action on improving institutional and student performance in the first college year is at hand. For the health of the institution, its students, and the nation of which they are all a part, disconnected programs are no longer an acceptable option. Simply stated, it is time for an evidence-based, intentional plan.

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Planning for the Next Thirty Years: A Possible Analytic Solution to Address the First-Year Experience

Andrew K. Koch, John N. Gardner, Doug Beatty, Farshid Marbouti, Joel McGee, Maria Andersen, Chris Millet, Jim Murray, & Stephanie Teasley

This paper details the manner in which a group of higher education professionals conducted an exercise to create a preliminary framework to improve institutional and student performance during the first-year experience with an analytics solution. The planning effort occurring on October 1-2, 2012 as part of the 2012 SoLAR Flare gathering at Purdue University. The exercise was guided by Dr. John Gardner, President of the John N. Gardner Institute for Excellence in Undergraduate Education and involved the following participants:

Maria Andersen	Director of Learning and Research	Instructure, Inc.
Doug Beatty	Director of Analytics	George Fox University
Farshid Marbouti	Graduate Research Assistant, School of Engineering Education	Purdue University
Joel McGee	Director, Academic Success Center	Texas A&M University
Chris Millet	Asst. Director, Education Technology Services	Pennsylvania State University
Jim Murray	Business. Systems Director, Academic Advising	Indiana University
Stephanie Teasley	Research Professor, School of Information	University of Michigan

The participants read a concept paper created for this meeting before coming to this SoLAR Flare session and used it to guide the group's discussion. As defined in the paper and for purposes of this document, the phrase first-year experience "describes the entirety of a higher education institution's approach to the beginning postsecondary education experience: everything it does with and for new students, both intentionally and unintentionally" (Gardner and Koch,

2012). With a definition that broad, it should come as no surprise that the group struggled a bit as it initially worked to carry out its charge. In short, it would have been easier to apply analytics to a specific portion of or problem within the first-year experience rather than address the first college year as a collective whole. However, after much discussion, the team felt that it wanted to attempt to create a preliminary structure for what could later become a comprehensive analytics solution that addresses the entirety of the first-year experience.

To guide its effort, the team made use of a five component analytic model created by Campbell and Pistilli (2012). In this model, analytic solutions can be initiated and continuously refined by using five progressive steps. These steps include: 1) Gather; 2) Predict/Inform; 3) Act; 4) Monitor; and 5) Refine.

As part of the gather component of the Campbell and Pistilli model the group recommended tapping into multiple real-time data sources to correlate current behavior and actions with known data about students. The working group felt that the following types of data could all be collected to the degree that they existed at a given institution:

- pre-enrollment data drawn from admissions data systems (e.g., demographics, high school grade point average, standardized test scores, visa status, veteran status, marital status, etc.);
- information on involvement drawn from campus life data sources (e.g., student activities, sports, social organizations, common interests, social media, etc.);
- academic progression data drawn from the student information and course management systems (e.g. cumulative grade averages, learning management system usage data, , faculty contact, etc.);
- health and well-being information drawn from the health center (e.g., physical, mental, etc.);

- financial status/aid data drawn from the financial aid and billing / bursar department (e.g., merit and/or grant aid, work status, basic financial status, insurance status, number of residential addresses, etc.); and,
- academic support lab usage data (e.g., library, internet tools, tutoring lab usage, etc.).

The group then recommended using data from these sources to predict student performance. Specifically, the team recommended dividing the predication effort into three foci: 1) student performance; 2) scholastic resilience; and, 3) engagement. The group felt that student performance could be predicted through analysis of attendance patterns, grades on tests and quizzes, and timeliness of completion of assignments. Scholastic resilience could be predicted by considering financial data, housing stability, the degree to which students reported support from family and friends, and student willingness to seek help as measured by use of help resources on campus. Finally, engagement could be predicted by analyzing student participation in optional activities such as student organizations, attendance at orientation, enrollment in an elective first -year seminar and/or a learning community, and the degree to which students reported interacting with professors both inside and outside of class.

With these predictive models established, the group then proposed acting on three distinct pillars that connect for student success. The three pillars of action are not hierarchical; they should occur simultaneously and some pillars may receive analytic data and take action on a more frequent basis than others. The three pillars of action include:

1) The Executive – The first pillar involves institutions acting by informing executive-level members of the institutional community about the progress of the college or university's first-year students. This information process should include the chief academic officer and his/her staff on a regular basis as well as the chief executive officer, trustees/regents, and legislators as appropriate.
2) The Operational – The second pillar of action involves operational faculty and staff – those who teach and support first-year students. These persons should receive data to both inform and shape the manner in which they support students. For example, advisors could use the data mined from this analytic solution to reach out to first-year students displaying signs of difficulty across courses. A specific faculty member could use data collected from the course management system associated with her course to reach out to students who were not engaged in manners predicted with success in the course she teaches.
3) The Student – The student pillar of action involves giving students timely feedback on performance with suggestions about how that performance could be maintained or improved. This performance is not limited to academic performance, but the academic emphasis should be a primary focus.

The degree to which these three pillars of action help improve student success during the first college year should be monitored. This monitoring aspect constitutes the fourth component of analytic solutions according to Campbell and Pistilli's model. In this fourth stage, positive changes in behavior and course outcomes for first-year students that connect with actions that the institution took in the third stage of this analytic effort let institutions know that appropriate data was gathered and fitting actions were conducted.

Outcomes that deviate from predictions require the institution to further refine its model. In this fifth component of analytics, the institution should consider other data sources and/or new uses of existing data sources to create better first-year experience outcomes for its students and the institution at large. These new and/or modified applications of data should be added to the existing analytic solution to further refine the effort.

As pointed out in the concept paper on the first-year experience read by meeting participants in advance of the exercise, the first-year experience needs improvement. Retention rates and the graduation rates have remained flat for over three decades. To remain viable in both the economic and democratic senses, the United States must have more students succeed in the first year of college and subsequently complete degrees and/or certificates than it has done in the last decades of the twentieth and first decades of the twenty-first centuries.

We believe that analytic solutions can be a part of the overall effort to improve the first-year experience and advance the nation's college completion

agenda. However, analytic efforts are hard as this exercise showed. They must be well-defined, applied in local context, and administered in a continuous quality improvement context. This continuous improvement effort must apply data to action and then use additional data to iteratively promote excellence in the first college year and beyond.

To the extent possible, we hope that the description of the efforts taken by the first-year experience-focused group at SoLAR Flare 2012 can inform your institution's first-year experience-focused analytic effort. Ultimately, you are the local experts – you know best the data sources and the potential partners at your institution. Where you find merit, we encourage you to consider this paper as you act to apply analytics to improve the first-year experience at your institution. In so doing, you will be thinking globally while acting locally to increase student learning and success and thereby boost retention and completion rates.

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A Call to Action: Why High Enrollment, High-Risk, Gateway Courses Require an Intentional Institutional Improvement Effort

Andrew K. Koch

The Issue Defined – Introductory Course Failure Rates in Context

This concept paper is about improving institutional and student performance in high enrollment, undergraduate, foundation-level courses that typically enroll first- and second-year students – a.k.a. gateway courses. The paper outlines how and why high failure rates in gateway courses are an issue and explains why the issue merits intentionally coordinated effort on the institutional level. The content of this paper is drawn from both my direct experience garnered by working with an array of four-year and two-year postsecondary institutions on the topic as well as research and data from other practitioners and scholars investigating the gateway course success issue.

In the work that my Gardner Institute colleagues and I have undertaken with nearly 250 U.S. postsecondary institutions to date, we have frequently encountered high enrollment gateway courses with failure rates near or above fifty percent. It is not uncommon to find some with failure rates that exceed seventy-five percent. Lack of success in gateway courses can result in diverted if not extinguished dreams for hundreds of thousands of students every year. According to the U.S. National Center for Education Statistics, in 2009, there were over 17.5 million undergraduate students enrolled in a U.S. postsecondary education institution (U.S. Department of Education, National Center for

Education Statistics [NCES], 2012). Nearly 3.5 million of these postsecondary participants were new first-year students – the kinds of students who often make up the majority of the enrollment in gateway courses. With potentially scores of high enrollment, high failure rate gateway courses at each of the more than 4,500 postsecondary institutions in the United States (Center for Excellence in Higher Education, 2007), and 3.5 million (or more) students enrolled in these kinds of courses across those institutions in any given year, it is easy to see that the course failure numbers begin to add up to an alarmingly large total.

Concern over performance in gateway courses stems back at least to the mid-1980s and early 1990s when Deanna Martin and her colleagues at the University of Missouri – Kansas City (UMKC) initiated an intervention called Supplemental Instruction (SI) to address high failure rates in high-risk courses for students in UMKC's medical school (Martin & Arendale, 1993). Supplemental Instruction has become a widely adopted initiative at colleges and universities across the United States. Yet despite this, failure rates in gateway courses in subjects such as math, chemistry, and biology remain unacceptably high. As Cliff Adelman reported in his 1999 publication *Answers in the Tool Box,* and his 2006 follow-up work, *The Toolbox Revisited*, students with twenty percent or more of their grades in the D,F,W,I category were the least likely to finish a degree. In addition, the higher the proportion of such grades, the more resources were wasted (in the form of both students' and institutions' monies) on duplicate instruction (Adelman, 1999; Adelman, 2006).

The fact that future success in higher education pursuits is directly correlated with success in gateway courses – students have to succeed in gateway courses to be able to move on to further study – means that failure in one or more gateway course can have a significant deleterious impact on a person's ability to live and work in, and make contributions to, the contemporary global economy and society. Sandy Baum, Jennifer Ma, and Kathleen Payea point out in *Education Pays 2010*: *The Benefits of Higher Education for Individuals and Society* how median earnings, lifetime earnings, lifetime tax payments, job satisfaction, sense of work as being fulfilling, pension plan coverage, health insurance coverage, and a host of other measurable variables are all significantly higher for college degree completers when compared to people who either only finished high school or who did not complete high school at all (Baum, et al., 2010). Equally important is what is lower – college graduates have lower rates of smoking, lower levels of unemployment, shorter periods of unemployment if they do lose a job, and use less public assistance. When compared to those who do not attend college, college graduates are healthier, are more involved in their communities, and vote with greater frequency (Baum, et al., 2010).

Successfully completing gateway courses and subsequently completing programs of study is not merely a matter of individual concern. Nowhere is this more apparent than in the STEM (Science, Technology, Engineering, and Math) fields. Recent reports published by the National Academies and the National

Science Board provide evidence that the number of native-born U.S. graduates in the STEM fields will fall far short of the trained professionals needed to replace the large number of projected retirees over the next twenty years (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2007; National Science Board, 2003). In short, if left unaltered, the sink-or-swim methods historically employed by many institutions in gateway courses may very well result in the nation sinking along with its failing undergraduates.

In summation, the strong correlation between gateway course success and degree completion and the correlation between degree completion and better economic and social conditions make improving gateway course success an institutional and national imperative. The time is right for much needed institutional effort and action to improve the manner in which students enroll, are supported, and progress through gateway courses. This paper suggests some ways in which institutions could structure efforts of this nature.

The Characteristics Associated with and a Definition for Improved Gateway Course Success

While I am advocating for improving student and institutional performance in high failure rate gateway courses, it is important to note that I am not advocating for "giving everyone an A" or some other form of passing grade. That form of strategy only serves to decrease expectations and diminish subsequent performance – for students, institutions, and society as a whole. No

one wants to drive on a bridge, fly in a plane, receive medical treatment from, and/or be governed by students who did not successfully complete the coursework requisite for future employment and/or participation in our democratic republic. Thus, maintaining high expectations and academic standards is a maxim for efforts to improve gateway course performance and success. In short, institutions have to improve gateway course performance by actually getting better – not by watering down standards.

My working definition for improved success in gateway courses is admittedly simple – institutions and their students will have successfully addressed the gateway course failure issue when all students who have the capacity and will to succeed in a gateway course are met with a coordinated institutional system that allows them to do so. This definition does not reward lackluster effort, poor attendance, or other bad behavior by students. However, it also does not allow institutions to use these behaviors as a smokescreen for tolerating poor institutional performance that may contribute to alarmingly high failure rates in gateway courses. This dynamic is succinctly summarized by the Columbia University's Teaching Center's website, which explains:

A surprisingly large proportion of students do not attend class regularly, fail to attend help sessions, and do not take advantage of extra-credit opportunities. But other factors are also at work. These include a failure to develop instructional strategies that will actively engage our students and address their confusions and misconceptions. Effective instruction can raise

achievement levels even among students with uneven preparation (Columbia University Graduate School of Arts & Sciences Teaching Center, n.d.).

While I admit that my proposed definition for success is simple, I also must admit that writing verbiage about efforts to "develop instructional strategies that will actively engage our students and address their confusions and misconceptions" is easier than doing so on an institutional level. Intentional and coordinated action will require institutions to revisit (and in some cases completely scrap) approaches that may have existed for decades if not longer. Change will not necessarily be easy – but as the next section reveals, failing to make these changes will mean that higher education institutions will be least capably serving the students who are in the greatest need of support.

Faces in the Crowd – the Students Most Directly Affected by the High Failure Rate Issue

As referenced earlier in this paper, the students most likely to participate in high enrollment gateway courses are first- and second-year students – often in that order. However, this does not mean that these are the only students to enroll in gateway courses. There are many students with "junior" or "senior" standing at four-year institutions who enroll in foundation-level courses. But first- and second-year students are the primary populations that these courses serve.

It is important to note that I include developmental education courses under the overall gateway course umbrella. While successful completion of developmental education courses does not, by definition, result in the rewarding

of college credit – and, as pointed out in the recently released report *Remediation: Higher Education's Bridge to Nowhere* (Complete College America, 2012), as currently offered at many institutions, it is far from certain that students who enroll in developmental education courses will ever complete them let alone obtain a degree – the courses are the requisite for enrolling in a gateway course for the students who need them. This is particularly true for an increasing number of students who start college at America's community colleges. Thus, developmental education courses are, in fact, a gateway unto themselves – they function as a stepping stone to future gateway course enrollment and success. Because of this, they cannot be left out of the gateway course success improvement discussion.

A scan of the demographics shows that an increasing number of students enrolling in gateway courses come disproportionately from low-income and first generation student classifications. This has little if anything to do with the courses themselves, but is rather a reflection of who is coming to college in the twenty-first century. The Western Interstate Commission for Higher Education's 2008 report, *Knocking at the College Door: Projections of High School Graduates by State and Race/Ethnicity, 1992 to 2022*, points out the steadily changing racial profile of today's high school graduates. The report notes that the nation as a whole and "more and more states are closing in on 'majority-minority' status relative to public high school graduating classes, in which the

number of graduates who are not White non-Hispanic exceeds the number of graduates who are" ([WICHE], p. *xiv*).

As racial diversity increases, so does the age range of the students who enroll in higher education – either as new beginning students or as students who return to higher education after stopping out in previous years. Increased degree production among adult students is a core component of national completion agenda goals. Whether focused on Lumina Foundation's goal of having sixty percent of the adult population in the United States with a postsecondary credential by 2025, or the Obama administration's goal of being "first in the world" in degree attainment, or comparable efforts from entities as varied as the states and the National Governors Association, adult "non-traditional" student enrollment and success in higher education – including gateway courses – is key to realizing national higher education policy goals (WICHE, 2012).

One thing is clear from these demographic trends and the profile of who enrolls in high failure rate gateway courses – higher education's newest participants (first-year students) will be increasingly drawn from the very same populations that have historically fared the worst in postsecondary education. This mixture is a recipe for disaster unless institutions make some drastic modifications to how they teach and support their newest students who enroll in their gateway courses. Fortunately, colleges and universities have some arrows in their quivers on which to draw – ammunition that can help higher education

institutions hit the target of greater success in gateway courses if the strategies are used in more intentionally coordinated manners and at greater scale.

Tools for Addressing the Gateway Course Failure Issue

In our years of working to improve undergraduate student success in postsecondary education in the United States, my Gardner Institute colleagues and I have come across a variety of promising practices for addressing gateway course failure issues. These include, but are not limited to: early warning systems; learning analytics; curriculum redesign; academic help labs and services such as Supplemental Instruction; and summer bridge programs. According to Barefoot, Griffin, and Koch, early warning systems are used by institutions to monitor student academic performance and guide appropriate intervention. Often affiliated with gateway courses, "early warning/academic alert systems take on many different forms across and even within institutions. Some rely heavily on technology, others on direct human observation and actions, and still others on a combination of human and technological monitoring and intervention" (2012, p. 25). In addition, "early warning/academic alert support may also vary within an institution across student classification levels (class standing) and by student subpopulations" (2012, p. 25). Some limitations with early warning systems have to do with the degree to which monitored behaviors are physically observed by faculty and/or other staff – because they can only act on what they see – and the frequency with which warnings occur.

Often, early alert programs do not occur as early as their names imply – they may rely on mid-term grades, and these grades may account for as much of half a course grade. Thus, interventions may occur when it is too late to make meaningful changes in student performance and the grades they earn. Arkansas State University hosts the National Clearinghouse for Early Alert Initiatives in Higher Education with a website, listserv, and other resources dedicated to providing "a collective forum for higher education where faculty and professionals can join discussion of and access research on early alert strategies" (National Clearinghouse for early Alert Initiatives in Higher Education, 2010).

Learner analytics is one of the newest and most promising forms of early warning / early intervention tools. Learner analytics tools can mitigate the aforementioned issues associated with early warning systems due to their ability to provide more timely feedback and their ability to do so with great granularity. An example of this is Boise State University's Student Success Monitoring System – a tool that draws on data from the institution's student information system, learning management system, and a variety of other sources on a routine basis to monitor performance and guide intervention in twenty-eight gateway courses (Chacon, Spicer & Valbuena, 2012). Purdue University's Signals project

is another innovative and successful form of learner analytics that is making a difference in gateway course success. When compared to a sample that controlled for the volunteer effect, students in courses with Signals earn more A

and B grades, fewer D or F grades, make greater use of help resources, and graduate sooner (Pistilli, Arnold, & Bethune, 2012). With support from the Bill & Melinda Gates Foundation, EDUCAUSE has placed great focus on promoting and researching analytics, most recently devoting an entire issue of its bi-monthly publication to analytics efforts.

Curriculum redesign is another practice used for improving student learning and, ultimately, success in gateway courses. Focused on improving the manner in which technology and other teaching tools/approaches can be applied to improve course performance, curriculum redesign has been shown to improve outcomes and decrease the costs associated with doing so – thereby showing that improvements in gateway course performance do not require additional resources and may very well generate resources through costs savings . A major contributor to course redesign work is the National Center for Academic Transformation, led by Dr. Carol Twigg (see: http://www.thencat.org/index.html for more information).

Academic help labs and services such as tutoring are tried and tested forms of gateway course support. One of the most researched and more widely disseminated forms of academic help is the previously mentioned Supplemental Instruction (SI) program. Supplemental Instruction targets traditionally difficult academic courses – those that typically have a thirty percent or higher rate of D or F final course grades – and provides regularly-scheduled review sessions in which students share class notes, discuss readings, refine organizational tools,

and prepare for tests. SI sessions are facilitated by "SI leaders" – students who have previously succeeded in the course and who attend all lectures, take notes, and act as models and guides for the students currently enrolled in the class. The University of Missouri – Kansas City (UMKC) developed and led the dissemination of SI. UMKC continues to provide leadership for the SI effort through its International Center for Supplemental Instruction (see: http:// www.umkc.edu/asm/si/index.shtml). Research shows that involvement in Supplemental Instruction can positively alter student final grades in gateway courses anywhere from a half to a full letter grade (Stone & Jacobs, 2008).

Summer bridge programs also can have a positive effect on gateway course preparation and success particularly for low-income and first-generation college students who lack the cultural capital necessary for success in higher education. Existing on an increasing scale since the passage of the Higher Education Act of 1965, bridge programs – sometimes called academic boot or boost camps – generally occur over one-to-six weeks in the summer preceding the first fall of enrollment for new first-year students. The programs help students acquire the knowledge and skills needed for college success – particularly success in gateway courses (Bradley, 2012). Research ties participation in summer bridge programs to higher passage rates in foundation/ gateway-level courses (Barnett, Bork, Mayer, Prelow, Wathington & Weiss, 2012) and increases persistence rates (Garcia, 1991). An example of a summer bridge program to help students succeed in gateway courses and college in

general can be found at the New Community College, a part of the City University of New York. In addition to an overview of the College and participation in community development experiences, New Community College's summer bridge program includes an intensive introductions to college reading, writing and mathematics – introductions that are offered to help pave the way to success in the courses that the students take during their first semester (The City University of New York, n.d.).

I have provided a few specific examples of programs and/or initiatives that are associated with improving success in gateway courses. It must be noted that this is by no means an exhaustive overview. Efforts such as placement testing, registration policies – especially those that prevent registration too far into an academic term – prerequisite policies, approaches to faculty selection and development, etc., all have an impact on success in gateway courses. However, it is beyond the scope of this paper to provide an in-depth summary of all efforts that can decrease failure rates in gateway courses. It suffices to write that institutions have many promising practices on which to draw to be more responsible for and intentional about improving student learning and success in high enrollment, gateway courses. It is up to each institution to determine which practices make the most sense in their unique context.

The Way to Greater Success – Making the Sum of the Parts Greater Than the Individual Pieces

After providing a review of several programs, I am going to tell you that I do not like it when institutions focus on programs. Now before you accuse me

of throwing the baby out with the bath water, please allow me to further refine/ qualify my previous statement. Programs are, in and of themselves, necessary and good. However, they are not sufficient.

In our experiences working with hundreds of postsecondary institutions to create action plans for first-year student success – a process called Foundations of Excellence (FoE) – my Gardner Institute colleagues and I have come to the conclusion that all too often programs compete for resources, attention, and even students. They are frequently disconnected, and this competition and lack of coordination create conditions that are antithetical to what is needed to provide students with a coherent and seamless learning environment – the kind of environment that allows students to best learn and grow.

Drawing on my experiences with FoE, I recommend that institutions move beyond programs and focus on integrated and coordinated efforts to address gateway course improvement. For example, drawing on the evidence that, in many cases, they already have, institutions could create a comprehensive plan for gateway course improvement. Such an effort could focus on one-to-three high-risk gateway courses at first and then expand to other courses over time. It would bring together people and programs to create an intentionally connected gateway course success plan for each of the high risk courses – a plan that the institutions would both create *and* execute. In conjunction with an effort of this nature, faculty selection and development efforts could be intentionally

linked with analytics initiatives, academic help lab offerings, and course redesign efforts to create a seamless process that was owned and understood by students, faculty, and staff alike.

My Gardner Institute colleagues and I have seen the benefits on retention and institutional revenue that a plan of this nature can yield. External evaluation of the first-year action plans created by FoE participating institutions shows significant increases in first-to-second year IPEDS retention rates – increases of 5.62 percentage points (8.2 percent) over four years – for the institutions that report implementing their plans to a high degree (Drake, 2010). This tells us two things: 1) institutions need a plan for improving success – a plan that makes the sum of the parts greater than the individual pieces; and 2) institutions must implement their plans to a high degree to realize the benefits they seek.

The Implications of Action and Inaction for Higher Education Institutions and the Nation at Large

Of course, institutions can choose to do nothing. They can leave their gateway course efforts as they are and hope for the best. But they should not expect to improve performance by doing nothing. In fact, with the demographic changes described earlier in this paper, doing nothing would surely lead to increases in failure rates over time.

In my view, given the increasing call for institutional accountability from legislatures and the public-at-large, and the twenty-first century societal and

workforce needs previously addressed in this concept paper, it is an imperative for institutions to act and act now to transform and reform their efforts in gateway courses. Failure to do so threatens public perceptions and support of higher education, and it could even threaten institutional and faculty autonomy.

In summation, the time for action on improving institutional and student performance in gateway courses is now. For the health of the institution, its students, and the nation of which they are all a part, high failure in gateway courses is no longer an acceptable option.

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Taking Action: A Proposal for an Analytic Solution to Increase Gateway Course Success

Andrew K. Koch, Victor Borden, Mikel Berger, Ben Brautigam, Michael Culbertson, Lee Rynearson, George Siemens, and Chi Wang

Introduction

As part of the 2012 SoLAR Flare gathering at Purdue University (October 1-3, 2012), colleagues from higher education institutions and technology service organizations participated in an exercise to develop a learning analytics application to improve college student performance college gateway courses. Defined as high enrollment, high failure rate courses taken by primarily first- and second-year college students, these gateway courses are critical to overall student success in college. This paper summarizes the activities of the group, including the conceptual frameworks that guided discussions and the proposed features of the analytics solution. The exercise was guided by Andrew K. Koch, Executive Vice President of the John N. Gardner Institute for Excellence in Undergraduate Education. Other group members included:

Mikel Berger	Partner	DelMar Information Technologies
Victor Borden	Professor and Senior Advisor	Indiana University
Ben Brautigam	Manager of Advanced Learning Projects	Pennsylvania State University
Michael Culbertson	Graduate Research Assistant	University of Illinois
Lee Rynearson	Graduate Assistant	Purdue University
George Siemens	Professor & Associate Director, Technology Enhanced Knowledge Research Institute	Athabasca University
Chi Wang	Business Analyst	McGraw-Hill Education Digital

Prior to attending the meeting, the group read "A call to action: Why high enrollment, high-risk, gateway courses require an intentional institutional improvement effort" – a concept paper specifically created by Koch (2012) for the purpose of defining issues and setting the context associated with unacceptably high failure rates in gateway courses across colleges and universities in the United States. For the sake of brevity, the content in that paper will not be recounted here. However, that concept paper should be viewed as necessary reading for anyone considering the solution described in this summary.

The Approach

With a topic as broad as improving institutional and student success in gateway courses, it should come as no surprise that the group decided to focus its efforts on a subcomponent of the overall gateway course failure issue. After considerable discussion, the team decided to create an analytic solution that targeted instructors. Specifically, the group decided to provide timely support to gateway course instructors through the development of an analytic solution that would provide:

- Actionable data regarding student behaviors related to successful completion of a gateway course;
- Interpretive guidance for instructors once the data is provided;
- A roster of context-specific suggested supports and/or interventions that instructors could apply to intervene with students in jeopardy of not succeeding in the course; and,
- Tracking mechanism(s) that took into account the actions taken by instructors and the actions' impact on student success.

To guide its effort, the team made use of a five component analytic model created by Campbell and Pistilli (2012). In this model, analytic solutions can be initiated and continuously refined by using five progressive steps. These steps include: 1) Gather; 2) Predict; 3) Act; 4) Monitor; and, 5) Refine.

The team also decided to draw on Chickering and Gamson's "Seven principles for good practice in undergraduate education" (1987) to further structure its work. The group decided to focus on four of the seven principles – feeling that these four principles could be best addressed by a data-based analytic solution for instructors. All seven of Chickering and Gamson's principles follow, with the four principles on which the group decided to focus being highlighted in bold, italicized font.

1. ***Encourages contact between students and faculty***
2. ***Develops reciprocity and cooperation among students***
3. Encourages active learning
4. ***Gives prompt feedback***
5. ***Emphasizes time on task***
6. Communicates high expectations
7. Respects diverse talents and ways of learning

With the Campbell and Pistilli model and Chickering and Gamson's principles providing theoretical frameworks, the group set out on its task. Specifically, the group worked to address how all four of the Chickening and Gamson's principles would be considered and advanced during each of the five components of analytics that are part of the Campbell and Pistilli model.

Table 1 illustrates how the group proposed addressing the gathering of data for an instructor-focused analytic solution – gathering data is the first component in Campbell and Pistilli's model. The first column depicts how data about contact between instructors and their students would be gathered. This aspect of the work would involve data collected from office hour logs, the frequency of emails between the instruction and student, and the frequency of participation in faculty-/instructor-led chats that are part of the course management system. The second column in Table 1 shows how data for developing cooperation and reciprocity among and between students would be gathered.

Table 1.

Data Elements to Gather By Four Specific Chickering and Gamson Principles of Effective Practice in Undergraduate Education

Encourages Instructor & Student Contact	**Develops Cooperation Among Students**	**Gives Prompt Feedback**	**Emphasizes Time on Task**
Office hours logs	Chat participation – student-to-student	Timeliness of Feedback (How quickly?)	Log-in frequency for students
Frequency of Email	Social learning platform involvement (Mixable, etc.)	Timing of Feedback (When did it occur during term?)	Time per log-in
Chat participation – instructor-to-student	Clicker data	Frequency of Feedback (How often?)	Activity when
			Frequency of

Data elements to be considered for this aspect of the model include the frequency of involvement in student-to-student chats that are part of the course

management system, the rate of participation in social learning environments such as Mixable, and the frequency of involvement and accuracy of responses from classroom clicker data. The third column shows
how the group wanted to gather data on prompt feedback from instructors to their students. Here the speed of provision of feedback on quizzes and exams, the timing of the feedback, and the frequency of the feedback are all data that could be gathered from the course management system as well as from electronic grade books.

Finally, the group felt that gathering data on how time on task was emphasized by instructors also had merit. This data would come in the form of the frequency with which students logged into the course management system, the duration of student visits within the
course management system, the form of activity that students undertook while they were logged into the course management system, and the frequency with which students completed assignments in the course management system.

The group then recommended that instructors use data from these sources to predict and understand student performance – thereby entering the second component of the Campbell and Pistilli (2012) model. Specifically, the team recommended having instructors predict aggregate student performance levels on each of the four Chickering and Gamson (1987) principles considered in the model. These aggregate predications would serve a benchmark that could be used for purposes of monitoring and, where merited, intervening. Individual

scores for each student on each of the four Chickering and Gamson (1987) principles would be derived using the data elements identified in Table 1. These scores would be juxtaposed with the corresponding instructor-predicted aggregate score to see where students fell below, met, or exceeded each score. The group proposed visualizing the data associated with these comparisons through the use of a spider or web chart – a chart that displays multivariate data in the form of a two-dimensional chart of three or more quantitative variables represented on axes starting from the same point (Tauge, 2005, 437). An example of what a spider chart of this nature might look like for students earning an A and a C in the courses follows in Figure 1.

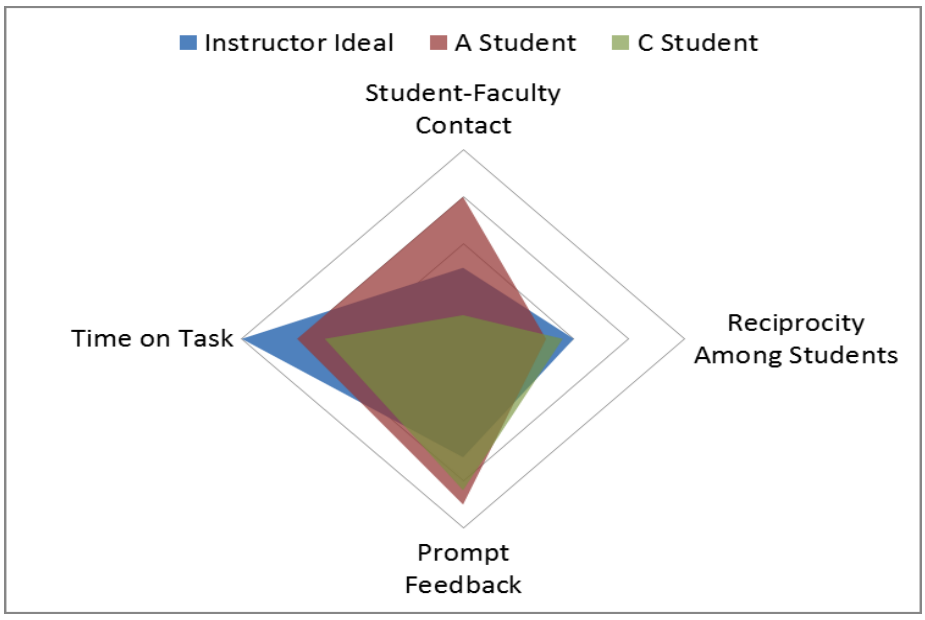

Figure 1: Example spider chart showing instructor predicted and actual student performance on each of the four Chickering and Gamson (1987) principles considered for the proposed analytic solution

With the gathering and prediction components modeled, the group proposed moving to action – the third component of the Campbell and Pistilli

(2012) analytic process. The group proposed using the same action method for guiding intervention with instructors based on all four principles. The method included:

- Providing feedback to instructors on student scores on all four principles; and,
- Including suggested actions / interventions for instructors for students who did not perform as predicted so the instructors, in turn, can reach out to the students to intervene.

It merits noting that the suggested actions in the second element of this component should be based on existing resources / efforts whenever possible. In other words, suggested interventions should not require faculty to draw on resources that do not yet exist at the institution.

The effort would be monitored – the fourth component of the Campbell and Pistilli (2012) model – via an examination of the interventions that instructors selected to determine what (if any) changes occurred in student performance on assignments and final course grades in connection with the actions / interventions. Activities that occurred within each of the four Chickering and Gamson (1987) principles would be analyzed to see what worked or did not work within each principle. Over time, a tool would be created for advisors or key administrators that allows for examination and analysis across for students across courses – to see if there are practices than span disciplines and/or instructors.

The monitoring of data would lead into the fifth component of the Campbell and Pistilli analytic model – the refine component. Where the data and

outcomes suggest, the proposed instructor analytic solution would be recalibrated. At the very least, each year the norms that were established for each of the four principles should be recalibrated using the findings from the previous year's work. Over time, those working with the proposed solution should consider the addition of other Chickering and Gamson (1987) principles as well as other theoretical and data components – components coming from outside of Chickering and Gamson's work.

As pointed out in the Koch (2012) concept paper that created as advance reading for the SoLAR Flare 2012 meeting, decreasing student failure rates in gateway courses is absolutely necessary for the nation to realize its Completion Agenda goals. Retention rates and the graduation rates that are ultimately attained have remained relatively flat for the last four decades. To remain viable in both the economic and democratic senses, the United States must have more students succeed in college and subsequently complete degrees and/or certificates than it has done in the last decades of the twentieth and first decades of the twenty-first centuries – and the first step toward succeeding in college is succeeding in gateway courses.

We believe that analytic solutions can be a part of the overall effort to improve student success and advance the nation's college completion agenda. But, as this exercise showed, analytic efforts are hard. They must be well-defined and applied in local context – which is why the proposed gateway course effort is narrowly focused on instructors and four principles of Chickering and

Gamson's (1987) work. The proposed solution, like predictive analytic solutions of any type, must be administered as a continuous quality improvement effort – an effort that applies data to action and then uses additional data to continuously promote excellence in the gateway courses and beyond.

To the extent possible, we hope that the description of the efforts taken by the gateway course-focused group at SoLAR Flare 2012 can inform your institution's predictive analytic efforts. Ultimately, you are the local experts – you know best the data sources and the potential partners at your institution. Where you find merit, we encourage you to consider this paper as you act to apply analytics to improve the experience in gateway courses at your institution. In so doing, you will be thinking globally while you act locally to increase student learning and success.

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Improving Accessibility and Success Rates for First-Generation and Low-Income Students

James E. Willis, III and Viktoria A. Strunk,

Nontraditional students face a dearth of challenges beginning with accessibility to higher education and continuing through successful completion of a program. One of the difficulties in educational research of so-called "nontraditional" students is articulating the characteristics that define what might classify a student as nontraditional. Levin's (2007) nuanced definition of "traditional" student is helpful here as a point of distinction: "They are viewed as students who have continued their education from high school to college or university, thus their age at college entry is seventeen, eighteen, or nineteen. They are also viewed as full-time students … [other characteristics] include high school completion, second or next generation of postsecondary education attendance within a family, and English as a first language" (p. 6). The Advisory Committee on Student Financial Assistance (2012) cites such characteristics as age ("typically 25 and older"), demography ("socioeconomic status, ethnicity, and first-generation and employment status") and "at-risk characteristics" including "delays enrollment into postsecondary education, attends part-time, is financially independent of parents, works full-time while enrolled, has dependents other than a spouse, is a single parent, [and] lacks a standard high school diploma" (p. 13). Of importance here, too, is the chosen lexicon of terminology like "at-risk" in terms of research perception and student

intervention efficacy; instead, more descriptive terms like "first-generation" or "low-income" tend to be more helpful. Engle's (2007) research in first-generation students yields important distinctions in this terminology: "First-generation students are disproportionately overrepresented in the most disadvantaged groups relative to participation in higher education. Demographically, first-generation students are more likely to be female, older, Black or Hispanic, have dependent children, and come from low-income families than students whose parents have college degrees" (p. 25). While the focus herein is on students who meet the criteria of first-generation and low-income, there are numerous other characteristics that may signify nontraditional status.

Recent literature indicates a drastic increase over the past four decades in the number of students classified as nontraditional. Schuetze and Slowey (2002) attribute fundamental changes in society to this increase, noting that "the change from an elite to a mass system of higher education occurred in the last decade of the twentieth century in virtually all developed societies. It is now acknowledged that this expansion is in the process of transforming fundamentally the very nature of higher education in terms of structure, purpose, social and economic role" (p. 309). Levin (2007) positions this significant change specifically indicating that 25 percent of students in 1970 were classified as nontraditional, whereas by 1999 that number had risen to 73 percent (p. 23). The Center for Postsecondary and Economic Success (2011) recently published data points that

reflect this changing trend: "Today's typical college student is no longer an 18-year-old recent high-school graduate who enrolls full-time and has limited work and family obligations. Students today are older, more diverse and have more work and family obligations to balance" (p. 1). For example, The Center for Postsecondary and Economic Success (2011) states that 36 percent of undergraduates in 2008 were age 25 or older and 40 percent of undergraduates were classified as low-income; this is defined as "family income was less than 200 percent of the Federal Poverty Line" (p. 1). The make-up of today's nontraditional student begs the question of *how* colleges and universities are meeting the needs of the nontraditional student. The Advisory Committee on Student Financial Assistance (2012) offers numerous suggestions including "consistent life coaching for at-risk students … use of faculty as student mentors … student services, such as the library, tutoring, and instructional support, should be available 24/7 in a variety of formats, including in-person, online, by phone, email, or chat" (p. 75-76).

In the plethora of challenges facing today's nontraditional student, perhaps the definition of success would be to define the obstacles to accessibility of collegiate education, identify the major root causes of attrition, and develop actionable plans to help individual students overcome educational barriers. In a key foundational model, Metzner and Bean (1987) identified "background and defining variables" including "age, hours enrolled, educational goals, high school performance, ethnicity, and gender" and analyzed how they fit within a

system of "academic variables, environmental variables, and social variables" (p. 17). In terms of access of first-generation and low-income students to undergraduate education, Engle (2007) identifies "…lower levels of academic preparation, lower educational aspirations, less encouragement and support to attend college, particularly from parents, less knowledge about the college application process, and few resources to pay for college" (p. 28) as leading factors. Accessibility is often directly tied to financial means because "although federal need-based grant aid still plays an important role in access for low-income students, current evidence suggests that merit-based grant programs do not adequately serve this population" (St. John, Musoba, Simmons, & Chung, 2002, p. 3). Indeed, as the Advisory Committee on Student Financial Assistance (2002) posits, "… this year alone due to record-high financial barriers, nearly one-half of all college-qualified, low- and moderate-income high school graduates – over 400,000 students fully prepared to attend a four-year college – will be unable to do so, and 170,000 of these students will attend no college at all" (p. v). The development of specialized programs to help nontraditional students is critical for any measure of success. The Advisory Committee on Student Financial Assistance (2012) offers a number of potential points of improvement from the national to the institutional level, including "… creating better structures for lifelong learning among our general population, initiating more effective workforce credentialing, testing new technologies and methods for use in our education system, promoting educational opportunities across the

country, and bringing people with new perspectives and diverse skills into the academy as both learners and institutional partners" (p. 67-79).

The academic barriers present in the lives of nontraditional students may be multifaceted and complex. The major question for research into accessibility and success models of higher education for nontraditional students centers on the difficulty of helping students who face multiple barriers (such as full-time employment while a student, caring for dependents, financial pressures, etc.). Choy (2002) elucidates one of the major difficulties of nontraditional students: "Two-thirds of highly nontraditional students perceived their primary role to be that of an employee, suggesting that school did not have first claim on their time and energy" (p. 19). These same students were also inclined to report "…that working has a negative effect on their grades" (Choy, 2002, p. 9). In a study conducted on academic services provided to nontraditional students, Keith (2007) found, "Although older students are profiled as vulnerable, barriers that the literature indicates may thwart attainment of nontraditional students were rarely reflected in increased use of services. In all of the models tested, only three variables were significant – age, employment status, and stress from increased tuition" (p. 1127).

Helping nontraditional students achieve success requires a number of considerations. The Advisory Committee on Student Financial Assistance (2012) puts forth suggestions for individual student success models including "provid [ing] students with a variety of options including online learning, low- or no –

cost education…assistance with prior learning assessment to complete their credentials…aligning their mission to serving nontraditional students…in-person and hybrid programs in multiple locations…counsel[ing] students to attend a traditional institution if that is the best route for them to complete a degree… [and to] use courses, tests, and trial periods to help students determine the best institution to serve their needs" (p. 74). More specifically, students matriculating into proprietary schools often state that they had already attended a college or university but had dropped out because they felt like a number, almost as though their instructors did not even know who they were in the auditorium-style classrooms. Borden (2004) classifies this trait as "swirling" but what it really defines is that students, in this case nontraditional students, are themselves identifying what has not worked for them in the past and are trying, through their own determination, to belong to an environment that will support them and all the characteristics that make them unique. The academic setting may consider a threefold plan to help nontraditional students achieve success:

Utilize smaller focus groups with similar cohorts for individualized attention

These groups need to be developed from day one of new student orientation so that the students feel the connection that they need to succeed. Ekman, Garth, & Noonan (2004) bring this out specifically: "The success enjoyed by these [studied] institutions in educating students from the bottom socioeconomic quintile is directly proportional to the knowledge they develop

about each one. If a college does not really know the student, how can the student know that the school believes in him or her?" (p. 120).

Utilize direct intervention with advisors, which includes a decreased academic load, at least in the beginning of the program

The students will be able to communicate with the advisor if they are able to take on more credits with their busy lifestyles; in turn, advisors will be better prepared to help. Schlossberg's (1989) work in "mattering" indicates that "many adult learners felt they mattered to an advisor or to an institution. This feeling kept them engaged in their learning" (p. 11). The focus should be retention and what works best for the student. Here, Schlossberg (1989) concludes that "the creation of environments that clearly indicate to all students that they matter will urge them to greater involvement … institutions that focus on mattering and greater student involvement will be more successful in creating campuses where students are motivated to learn, where their retention is high, and ultimately, where their institutional loyalty for the short- and long-term future is ensured" (p. 14). Gone are the days of teacher-centered education, at least with nontraditional students. As Rendón (1994) articulates, "old ideas, practices, and conventions that have nothing to do with today's students die hard in the academy. But die they must. And they must be replaced with new policies and practices that are tailored to a new student majority that bears little resemblance to the student of days gone by" (p. 45).

Keep students enrolled to prevent stopping out (taking off an academic term or more) and/or dropping out

Stratton, O'Toole, and Wetzel (2005) demonstrate, "From an individual perspective, students who drop out lose because they do not receive the substantial financial reward, the earnings differential, that college graduates receive. From a social perspective, these individuals fail to repay, in terms of tax revenue, the financial subsidy implicit in the low-cost tuition they may receive from taxpayers" (p. 22).

In addition, addressing financial aid concerns expeditiously is important to help nontraditional students achieve success. Hart (2003) points out the unique financial needs of nontraditional students: "Many would argue that the basic system is again the root cause; the financial system was designed and implemented for more traditional students who are dependent on their parents' resources, have not been part of the workforce, go to college full-time, and graduate as soon as possible" (p. 105).

Though a staggering majority of all undergraduates today meet "nontraditional" descriptive characteristics, there are nuances that need to be examined in order to fully understand resilience in the lack of sweeping, institutional changes. Recent research by Johnson and Nussbaum (2012) examined different types of coping mechanisms in a model that incorporated "task-oriented, emotion-oriented, avoidance-oriented coping" (p. 45). This research demonstrated that "traditional students may be disadvantaged in

comparison to nontraditional students in the sense that they may not be as developmentally prepared, or self-regulating, to cope with the stressors of college and, therefore, may benefit from instruction, resources, and services geared towards fostering adaptive coping strategy use" (p. 52). Whereas there may be academic preparation, financial aid, and other concerns for nontraditional students, this recent study suggests that nontraditional students may actually be better equipped to cope with hardships in the collegiate experience. Sheard's (2009) work on hardiness in educational settings demonstrates the importance of "commitment" because it is "the only hardiness attitude significantly correlated with, and predictive of, academic achievement" (p. 199). Chao and Good (2004) approach the barriers of nontraditional students with a qualitative design that argues for the value in specialized counseling to address five specific criteria for obtaining a college education: "Life transition, career development, financial investment, motivation, [and] support systems" (p. 8). What bind these together is a sense of "hopefulness" that "motivated their efforts related to financial concerns, career development, relationships, and life transitions. Indeed, hopefulness provided the self-efficacy and resilience for them to believe they could overcome their difficulties in these five areas" (p. 8). Rendón's (1994) research in student validation also helps demonstrate how "enabling, confirming and supportive process initiated by in- and out-of-class agents that foster academic and interpersonal development" contributes to the coping mechanisms of

nontraditional students (p. 44).

The greater implications to addressing the needs of nontraditional students in terms of higher education can be examined in terms of the sheer number of students who are, in fact, "nontraditional." Choy (2002) sums the findings in a major study:

> The "traditional" student is not typical. Fully three-quarters of all postsecondary students in 1999-2000 had at least one nontraditional characteristic. The most highly nontraditional students (those with four or more nontraditional characteristics) were concentrated in public 2-year institutions, with two-thirds enrolled in this type of institution…Among beginning postsecondary students seeking bachelor's and associate's degrees, nontraditional students were much more likely than traditional students to leave without earning any degree. They were most at risk of dropping out in their first year. Compared with their traditional counterparts, nontraditional beginning students who left their first institution were more likely to leave postsecondary education altogether… (p. 19).

As a society, the success of nontraditional students in higher education cannot be stressed enough: from a financial, sociological, and educated society perspective, it is critical to meet the needs of first generation and low-income students (St. John, Musoba, Simmons, & Chung, 2002, 1-2; 21-22).

Student success models for nontraditional students are vital in their evolution with an ever-changing society. Cabrera, Nora, and Castaneda's (1993) modeling demonstrates "an integrative framework in understanding the interplay among individual, institutional, and environmental variables in the college process" (p. 136). De Vito (2009) recently argued for a tripartite approach of "accessibility, affordability, and accountability" (p. 5). This approach was

developed, in part, by work done earlier by Zemke and Zemke (1995) who demonstrated that nontraditional student "adult learning is problem centered" and "adult learners are motivated by appeals to personal growth or gain" (p. 42-43). In a similar argument, Schuetze and Slowey (2002) suggest that nontraditional students may become "lifelong learners" (p. 321). Of the suggested institutional changes, perhaps the most applicable deals with reshaping the context of skills and education: "For the skills and qualifications that have been acquired in informal and non-formal learning settings – at the workplace, through the media, in community activities or everyday-life learning – to be recognized, it is necessary to develop procedures for their assessment, recognition and certification. With respect to the admission to higher education this means more procedures for the assessment and recognition of experiential learning, especially that based on vocational education and work experience" (p. 323). The implications on an individual student level ought to be brought out specifically: students becoming lifelong learners certainly have the transformative ability to help develop a better-educated society.

The composition of the current undergraduate population is nontraditional. Schuetze and Slowey (2002) summarize this succinctly: "As a part of the process of expansion and heterogenization, new groups of students who, for a complex range of social, economic and cultural reasons were traditionally excluded from or under-represented in higher education, have come to participate in increasing numbers" (p. 324). The potential for institutions to

programmatically address the needs of nontraditional students is both strategically sound and responsible to propagate the ethos of twenty-first century education.

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An Adaptable Model for Improving Accessibility and Success Rates for First-Generation and Low-Income Students

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Introduction

As evidenced by leading educational research, today's nontraditional student constitutes the majority of the college student population (Choy, 2002). Higher education institutions have an ethical, intellectual, and financial responsibility to consider and meet the unique needs of nontraditional students. Often such a mandate is met with words of agreement, but implementing institutional measures to assess and address these needs are a completely different challenge altogether (Watson, 2009; Brock, 2010). There are numerous demographic and socio-economic variables that may qualify a student as nontraditional (Giancola, Munz, & Trares, 2008). For the purposes of this analysis, "nontraditional" refers to individuals who are first-generation and low-income students. Refining the analysis based on these two groups helps focus the educational model to more directly address the needs of this student population. Furthermore, it is important to highlight that nontraditional students often have needs as unique as the individuals themselves and therefore it is unfair to generalize about a "one-size-fits-all" model of assessing and tackling their educational obstacles (Kasworm, 2008). Patience, innovation, and creativity are needed institutionally to drive the model of educational success.

In the age of "big data" and predictive analytics, modeling is a powerful tool to identify and examine the early warning signs of educational obstacles in the nontraditional student population (Campbell, DeBlois, & Oblinger, 2007). There are four central themes that drive our proposed model: (1) the importance of formalized student advising, (2) early detection of obstacles along with subsequent interventions, (3) individualized attention to specific obstacles, and (4) identifying educational obstacles by which an institution may enact change as well as personal obstacles which an institution has very little – if any – control, save that of perhaps supportive counseling.

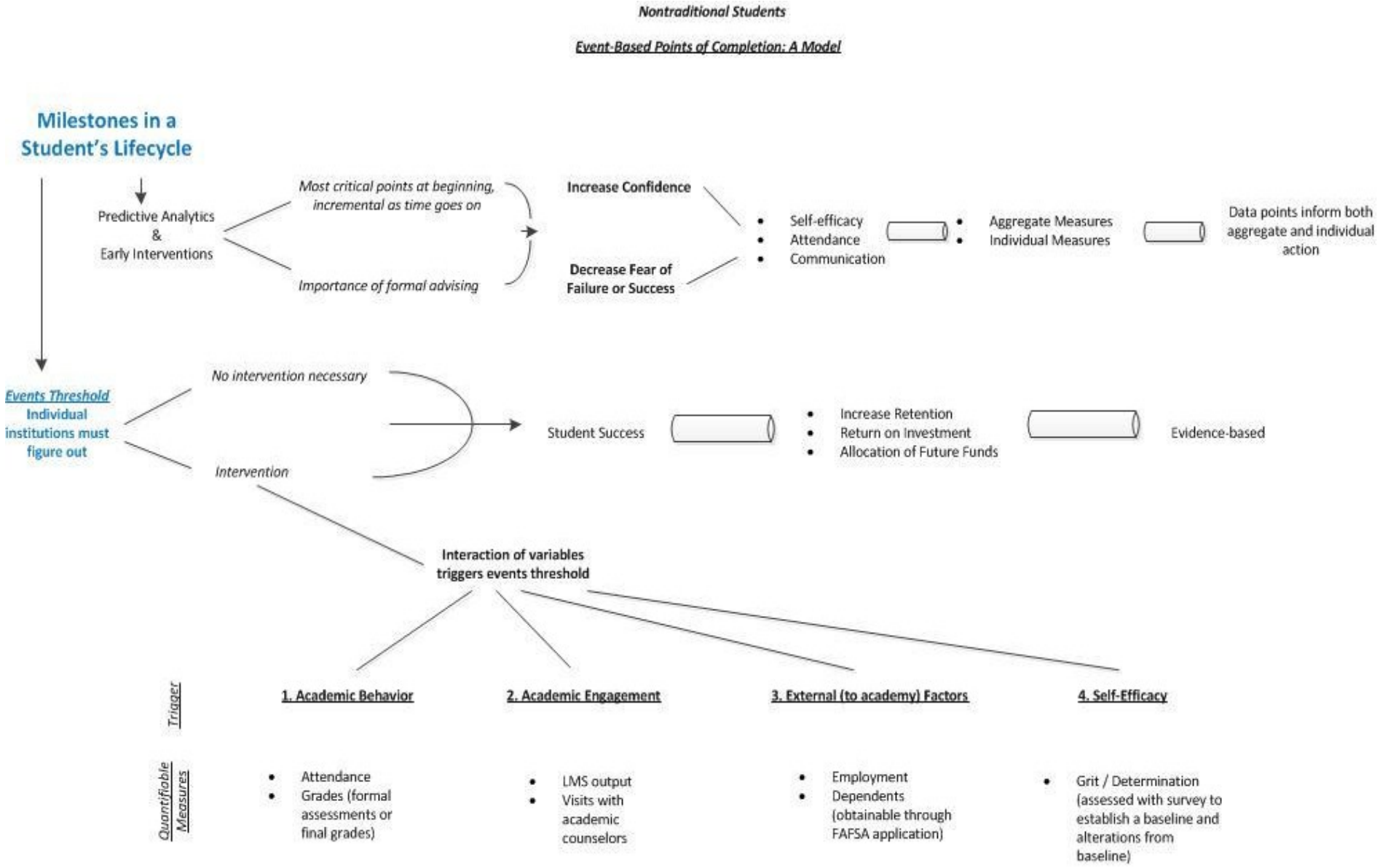
Actionable Change: Themes to a Model

These four central themes driving a model of educational success are useful only in terms of what actionable intelligence they produce. The unique obstacles facing a first-generation and low-income student indicate that any analytical model should be adaptable and malleable according to the needs of a given institution (Pascarella, Pierson, Wolniak, & Terenzini, 2004) and that serve different actionable outcomes based on student cohort characteristics. The proposed model takes into consideration the variety of educational environments including large research and mid-size universities, small liberal arts colleges, career-oriented colleges, online schools, and community colleges. Additionally, this proposed model is not intended to solve the complex, multivariate challenges of nontraditional students, but rather it aspires to help schools think

through some of the problems and then deal with both aggregate and individual data points. The model's key feature is *adaptability*.

While this may be open to interpretation, it is meant to highlight how a collegiate institution might function more efficiently to help the population of nontraditional students. The efficaciousness of this analytical model rests with several key measures taken from the interplay of aggregate and individual data. These measures are quantifiable and important to all institutions of higher education. They take into account student retention across multiple cohorts (Cabrera, Nora, & Castañeda, 1993), return on investment (Stewart & Carpenter-Hubin, 2000-2001), and clarity for the allocation of future funding for student intervention programs (Hagedorn, 2005).

At this point it becomes possible to describe an analytical model to address student success in first-generation and low-income populations. The model's adaptability, aspirations for student success, and measures of key indicators provide a framework within which to describe how aggregate and individual data points become critical interlocutors of scalable change. Figure 1 on the following page is a visual representation of a working model that is both action-based with respect to the target population and adaptable to different educational institutions.



* Note: individual factors must be set by institution according to population of traditional/nontraditional students

Factors might include a designation of low, medium, or high.

An Events-Based Model: Discussion

Nontraditional Students: A Model of Events-Based Points of Completion, is both action-based with respect to the target population and adaptable to different educational institutions. It is premised on the idea that there are milestones in every student's life cycle from admissions to matriculation to graduation at which different interventions can support student success. Identifying, predicting, and acting upon the most critical milestones, typically at the beginning of the student life cycle, will determine success or failure (Calcagno, Crosta, Bailey, & Jenkins, 2007). In terms of the student life cycle, "success" is defined as completion of the academic program in order to fulfill the necessary requirements for graduation; conversely, "failure" is defined as a prolonged or permanent interruption in a course of study that leads to a student dropping out and not achieving their educational goals. Critical milestones and their metrics must be determined and applied by the individual institution. They may be purposely vague such as evaluating if students are able to obtain materials for class, or highly targeted like a measurement of the first grades assessed in a given class. The critical measurements are theorized to become more refined and tightly-spaced as the student navigates through the curriculum naturally flowing with a formal advising system whereby students receive the institutional support needed to progress.

The "top-level" features of this model are meant to engage the less quantifiable, but still critical components for increasing self-confidence and

decreasing the fear of failure (or in some students, the fear of success). These psychological components might be assessed with the metrics of self-efficacy, attendance records, and communication with faculty and staff. The amalgamation of these top-level features is important in aggregate measures and individual measures alike. The data points, working together in a qualitative and quantitative interplay, paint a more complete picture of how schools might begin to fill out what the critical measures of an events' threshold for triggering intervention might be. Specifically, if a school suggests that a study skills preparatory course might greatly benefit its students, this model might usefully measure the outcomes of the course. Through measures of self-efficacy (independent studying and skill-based confidence), attendance records, and measures of student interactions with faculty and staff, an institution might assess if a study skills course increases student confidence and decreases fear of failure (or success). Data points in the aggregate including grades and attendance and an individual's qualitative perceptions of efficacy can lead to actionable outcomes. In this case the data would be used to justify the decision to continue or discontinue the study skills course.

With these top-level metrics in place, an events' threshold can be established to make data-driven decisions on whether or not to intervene in an individual student's life cycle. An institution's determination of whether an intervention is necessary or not will determine, even in a *post hoc* analysis, a student's success or failure. To examine this a bit further, if a school elects not to

intervene on a certain data point, perhaps with grades of D or F on students' first college quizzes, a strong correlation may be seen after the fact when student dropout rates are analyzed. Conversely, the institution that decides to offer tutoring to students with D or F grades on their first college quiz may measure a correlation between higher retention and student success in later courses. As central as the intervention component is to the model, the measurements that may assess its efficaciousness tend to be a bit broader. Schools may put in measures of retention against a control group to assess the effectiveness of certain intervention programs. Likewise, a return on investment for a specific technology, such as a predictive analytics component tied into a learning management system, might be used in terms of student success through a program. Because these metrics are evidence-based, the examination of retention and return on investment may also drive administrative conversations about future allocation of funds for specific programs.

It may be argued that an educational model is only worth as much as its actionable items where the interaction of variables triggers the event threshold that indicates a need for intervention and that offers a range of potentially effective interventions. Here are some suggestions to help guide an institution to determine the interactions of certain key triggers common amongst first-generation and low-income students. The measures of these triggers are specifically quantifiable. While there may be many other possible triggers, the

ones offered in this model are those which may be easiest to quantify and, therefore, equip a school for intervention:

1. *Academic behavior*. A student's behavior can be quantified with attendance records, which tend to be binary in nature (a student is either in attendance or not), but can be captured as frequency/percentage of attendance. It is also possible to quantify and evaluate a student's grades, preferably as early in a semester as possible and often. While final grades may be good fodder for research, the actionable items for retention and student success need to be assessed early in the semester for students to seek or be offered help.
2. *Academic engagement*. A student's engagement in a given class may be quantified with the help of a learning management system (LMS). Engagement could include metrics on student discussion posts and use of other LMS course related resources and features. Additionally, it is possible to quantify types and frequencies of visits with academic counselors which may help identify students who are having multiple difficulties (frequency of visits) or students who are isolated (infrequency of visits). It is important to consider how the inverse may also indicate what should be actionable. In this case infrequent visits may indicate mastery rather than disengagement.
3. *External (non-academic) factors*. Nontraditional students typically have multiple commitments outside of their schoolwork including those

pertaining to employment and family. In terms of what is quantifiable, employment records may be gathered during orientation and number of dependents may be gathered from students' Free Application for Federal Student Aid (FAFSA) form. This type of data may assess students' outside commitments and, thus, what competes for their time.

4. *Self-efficacy*. Nontraditional students often have a determination to succeed that may be less pronounced in other student groups. While more difficult to quantify than other aforementioned measures, it is possible to develop a survey to assess a "grit" factor, or a personal determination to succeed in college. Once a baseline grit factor is determined, further quantifications of deviance from this baseline may indicate need for intervention.

The purpose of describing these four factors is to begin an institutional conversation to determine what can be measured in terms of actionable analytics. Each of the chosen factors might include a low, medium, or high indicator depending upon institutional characteristics like typical demography, curriculum structure, and scheduling considerations. Such indicators will also allow for some flexibility within the model, especially as differing institutions think about how their own internal culture might have divergent priorities.

Implications and Conclusion

The model presented is flexible and specialized enough to describe some of the unique needs of nontraditional students, but also generalizable enough to suggest how institutions may begin to form plans for actionable intelligence. Although it is impossible to fully portray the individual needs of nontraditional students, institutions should consider how aggregate data of students might help shape programs and interventions. Further, institutions should attempt to put into place quantifiable measures that can assess actionable change on the parts of individual students and entire cohorts. The proposed model takes the challenge of addressing the needs of nontraditional students by establishing a triggering system based on early indicators. This provides a way for institutions to turn seemingly disparate information into quantifiable metrics.

The sustained thesis in this educational model is adaptability to continuous change, variable refinement, and production of actionable metrics. The purpose of this model is twofold. In the broad sense, it may help institutions begin productive conversations to address the needs of first-generation and low-income students. In an ambitious sense this educational model provides a way forward to develop a methodology for assessing various forms of data to enact systemic change for better serving the growing nontraditional student population. In either case, the model can serve as a discussion base for the many contributors on campus and beyond that must coordinate to support student success.

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College Completion: A Case for Addressing Issues Surrounding Degree Attainment Rates in American Higher Education

Matthew D. Pistilli and Brent M. Drake

In 2009, a confluence of events and data releases focused attention on the need for a more highly-educated workplace. The United States had just sworn in a new president who was saddled with an economy that was in the throes of the worst recession since the Great Depression. Unemployment was at 7.8% and climbing (it would later top out at 10.0% in October of the same year) (U.S. Bureau of Labor Statistics, 2012). The Organization for Economic Co-Operation and Development [OECD] released its yearly *Education at a Glance* report, which placed the United States 18th among the 25 OECD countries with regard to college going rates of 20-29 year olds (OECD, 2009, Chart C1.1). Further, the OECD indicated that the United States' graduation rate ranked 16th among OECD nations (Chart A3.2). Further, Bowen, Chingos, and McPherson published *Crossing the Finish Line*, in which they asserted that the attainment rate for American students "is both too low and stagnant" (2009, p. 223). They also posited that not only did the overall graduation rate matter, but the time it took to graduate was equally as important (Bowen et al., 2009, p. 224). In short, multiple pieces of data pointed to the same thing: the United States was lagging in both college-going and college-completion rates, and a faltering economy forced businesses to reexamine their workforce needs. Further, more attention needed to be placed on getting students to complete a degree or credentialing program, and

to do so in a timely manner.

One month into his presidency, Barak Obama, in his address to a joint session of Congress, asserted that "by 2020, America will once again have the highest proportion of college graduates in the world … every American will need to get more than a high school diploma." Earlier in the same speech, he asserted that "right now, three-quarters of the fastest-growing occupations require more than a high school diploma. And yet, just over half of our citizens have that level of education. We have one of the highest high school dropout rates of any industrialized nation. And half of the students who begin college never finish" (2009). Around the same time, Lumina Foundation for Education announced its "Big Goal," wherein they were to work "to increase the proportion of Americans with high-quality degrees and credentials to 60 percent by the year 2025" (Lumina Foundation, 2009, p. 1). More recently, in July, 2012, Lorrain Woellert of Bloomberg indicated that roughly three million jobs are going unfilled due to the need for a more highly skilled workforce (p. 1). Compounding the issue is the fact that nearly 30% of undergraduates who take loans to finance their education drop out before completing their degree – and these students are more than four times as likely to default on their loans than their peers who took loans and graduated from college (Mui & Khimm, 2012). These facts clearly indicate a growing need to address the completion rate for students in higher education.

But what is success? In the end, the goal is to have more students com-

plete college than are currently doing so. Lumina Foundation for Education has staked a mark at 60% of all adults should hold some form of a collegiately-granted credential by 2025. President Obama's goal is to see 10 million more graduates from community colleges and universities by 2020 – a number that is two million greater than what is projected given current trends. Obama's plan further calls for every American to have *at least* one year of higher education and/or advanced training. Complete College America, a not-for-profit organization headed by Stan Jones (former Indiana State Representative and Indiana Commissioner for Higher Education) focuses less on hitting a specific number and more on increasing the number of students who complete their degrees in a timely manner. His suggestions are more programmatic and structural in nature: devising procedures and policies to help students navigate through courses more efficiently, creating structure through block schedules, working with individual states who, in turn, work with their state-funded institutions to impact student success.

Over the last six years there have been moderate gains in completion rates. However, for students who begin at four-year institutions the six-year graduation rate still only stands at 58.3% (a gain of 2.9 percentage points), and for students who begin at two-year institutions the 150% completion rate is only 29.9% (a gain of 0.6 percentage points) (National Center for Education Statistics, 2012). Additionally, success, in whatever form, has to ensure that all students are impacted by any reforms that are made. This includes students attend-

ing full-time and part-time at four-year, two-year, and for-profit institutions. Of particular note, however, are specific populations most at risk for not completing their degrees, which are illustrated in the following table.

	Attending Full-Time			Attending Part-Time		
Population	**1-year certificate in 1.5 years**	**2-year degree in 3 years**	**4-year degree in 4 years**	**1-year certificate in 1.5 years**	**2-year degree in 3 years**	**4-year degree in 4 years**
Hispanics	18.5%	11.1%	46.5%	9.1%	2.6%	16.7%
Older (25+ at entry)	30.2%	14.4%	27.0%	11.3%	4.6%	10.6%
Low-income (Pell grant eligible)	23.1%	11.8%	45.2%	10.9%	4.3%	17.3%
All students	27.8%	18.8%	60.6%	12.2%	7.8%	24.3%

Jones (2011) indicates that of those who do graduate, certificates that should take one year to complete take 3.3 years for full-time students compared to 4.4 years for part-time students. Two-year associate degrees, on average require 3.8 years and 5 years, respectively, to complete. Four-year bachelor degrees fare slightly better, with full-time students taking only 4.7 years to complete and part-time students requiring 5.6 years. Jones (2011) continues, by noting that giving full-time community college an extra year or four-year college students two extra years to complete their degrees only increases each by about 4.9%. Other populations at risk of not completing a degree include African-Americans, of whom only 42% graduate with a four-year degree within six years and only 11% complete an associate's degree within three years. (IPEDS, 2007);

first-generation students, of whom only 52% remained enrolled in a four-year degree program three years after starting one (Choy, 2001); and, minority women, of whom only 22 percent of African-Americans and 13 percent of Hispanics earning a four-year degree by age 26 (white women didn't fare much better, having only 36% completing within the same timeframe) (Bowen, Chingos, & McPherson, 2009, p. 8).

Barriers for these, and truly, all student populations do exist – some of which are within the power of a given institution to manage, others which need to be acknowledged by an institution in an effort to work with students facing them. For example, at the point of entry there is an issue with students who are "undermatched" to institutions. That is students ending up at a less selective institution than one they appear to be qualified for. Students who wind up "undermatched" graduate at rates that are 15 percentage points lower than their similarly qualified peers (Bowen et al., 2009). Bowen and his colleagues (2009) also point out that an articulation problem appears to exist for students starting at two-year institutions, as students who start in two-year colleges are far less likely to ever obtain a bachelor's degree.

Furthermore, once a student is enrolled at an institution a common barrier can be full-time attendance; as indicated by Jones' research (2011), students who attend college full-time complete their degrees at rates demonstrably higher than their part-time counterparts. However, students attending part-time often do so because they need to work, have familial responsibilities, or simply can't afford

to attend full-time. Additionally, analysis at an individual institution level has indicated that even among full-time students even attempting enough credit hours for on-time completion let alone earning enough is not a common practice (Drake, 2012).

Students entering college in need of remediation present another significant challenge. Currently only 4 in 10 remedial students at community colleges complete their remedial courses, only 1 in 10 remedial students graduate from community colleges in three years, and only a third of remedial students earn bachelor's degrees in six-years (Complete College America, 2012). Beyond remediation courses, student success in gateway courses as well as repeats of said courses delay students' on-time completion (Drake, 2012). Also, the frequency and timing of students changing of majors impacts their completion and time to degree (Drake, 2012; Foraker, 2012).

Other barriers include working more than 20 hours a week (regardless of schedule), simply being a minority, first-generation, or low-income student, or falling behind in completed credits in the first year of college (Astin & Oseguera, 2005). Finally, 40 years of higher education literature indicates the importance of students' motivational factors such as commitment, integration, and engagement at their institutions (Reason, 2009). The challenge is determining which barriers can be directly addressed through programming and intervention by an institution, and then taking said action to address them.

Because inaction also is a form of action, there exists the opportunity for

us to do nothing. However, Bowen et al. note that "As is increasingly recognized, the United States can no longer claim that it is "first-in-class" in terms of a continuing progress in building human capital…in the United States only 56 percent of entering students finished college, an outcome that placed the country second to the bottom of the rank-ordering of countries by completion rate." (2009, p. 4). Further, the economy that so badly needs skilled, college-educated workers will continue to falter and the United States' presence as the strongest economy in the world will no longer be so. To that end, and more pointedly, Baum, Ma and Payea indicate that college completion is highly correlated, and nigh on a prerequisite for, having a higher median income and overall lifetime earnings, greater satisfaction with jobs and doing fulfilling work, and obtaining quality health care and retirement benefits (2010).

The implications for increasing completion and graduation rates for higher education are many, at both the individual institution level and the national level. First, students will progress through degree programs faster, possibly without having to repeat courses. If less students have to repeat courses, then more students who haven't taken a given course will be able to get into that course, meaning less sections of that same course will need to be offered. That frees up faculty/instructors on campuses to teach other courses *as well as* frees up classroom space, of which there often is precious little. The cost savings to institutions from this is enormous.

Second, getting more students through to graduation means that more

students from all populations will graduate. Thus, more minority students, low-income students, and first-generation students will earn degrees, which, in turn, will begin to close the gap in earnings and earning potential between these populations and their white, affluent, second-generation or later peers.

Finally, institutions that succeed in raising their graduation/completion rates and shortening the time to degree will have created, as Hrabowski and Seuss (2010) noted, "a climate that encourages (1) asking good questions, (2) being honest about both strengths and challenges, and (3) developing innovative problem-solving strategies and initiatives that address particular issues, including programs that connect students to faculty, staff, and each other" (p. 60). In creating this climate, all students will have a better chance of succeeding, and the institution will have done a great deal to better itself.

In an era of accountability and transparency, it is imperative that institutions work to improve them. Completion agendas must be created and institutionalized. As pointed out in *The Completion Agenda: A Call to Action* from the American Association of Community Colleges, "completion should be made a part of [an] institution's strategic plan" (p. 3). They continue, noting that institutions have "a responsibility to increase completion rates" (p. 3). Complete College America (2011) advocates that "colleges and universities must make graduation, not head counts, their measure of success." Between the resources made available and emphases placed on graduation rates, the very great potential exists for higher education to stem the tide of people leaving college with no credential

or degree. The application of analytics to existing data can only aid us in that effort.

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A Learning Analytics Methodology for Impacting the College Completion Agenda in Higher Education

Brent M. Drake, Matthew D. Pistilli, William Cooper, Shane Dawson, Ken Guan, Y. Lakshmi Malroutu, Glenda Morgan, Stephanie Oetting, Andrea Pluckebaum, & Charles Thornburgh

Introduction

In 2009, a confluence of events and data releases focused attention on the need for a more highly-educated workplace. The United States had just sworn in a new president who was saddled with an economy that was in the throes of the worst recession since the Great Depression. Unemployment was at 7.8% and climbing (it would later top out at 10.0% in October of the same year) (U.S. Bureau of Labor Statistics, 2012). The Organization for Economic Co-Operation and Development [OECD] released its yearly *Education at a Glance* report, which placed the United States 18th among the 25 OECD countries with regard to college going rates of 20-29 year olds (OECD, 2009, Chart C1.1). Further, the OECD indicated that the United States' graduation rate ranked 16th among OECD nations (Chart A3.2). Further, Bowen, Chingos, and McPherson published *Crossing the Finish Line*, in which they asserted that the attainment rate for American students "is both too low and stagnant" (p. 223). They also posited that not only did the overall graduation rate matter, but the time it took to graduate was equally as important (p. 224). In short, multiple pieces of data pointed to the same thing: the United States was lagging in both college-going and college-completion rates, and a faltering economy forced businesses to

reexamine their workforce needs. Further, more attention needed to be placed on getting students to complete a degree or credentialing program, and to do so in a timely manner.

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Jones (2011) indicates that of those who do graduate, certificates that should take one year to complete take 3.3 years for full-time students compared to 4.4 years for part-time students. Two-year associate degrees, on average require 3.8 years and 5 years, respectively, to complete. Four-year bachelor degrees fare slightly better, with full-time students taking only 4.7 years to complete and part-time students requiring 5.6 years. Jones (2011) continues, by noting that giving full-time community college an extra year or four-year college students two extra years to complete their degrees only increases each by about 4.9%. Other populations at risk of not completing a degree include African-Americans, of whom only 42% graduate with a four-year degree within six years and only 11% complete an associate's degree within three years. (IPEDS, 2007); first-generation students, of whom only 52% remained enrolled in a four-year degree program three years after starting one (Choy, 2001); and, minority women, of whom only 22 percent of African-Americans and 13 percent of Hispanics earning a four-year degree by age 26 (white women didn't fare much

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The challenge is determining which barriers can be directly addressed through programming and intervention by an institution, and then taking said action to address them. Solving this challenge requires expanding access and completion effectiveness. The authors believe that data can help institutions to match and guide students to completion of an appropriate credential. As such this paper is an overview of a process (figure 1) that can assist institutions in

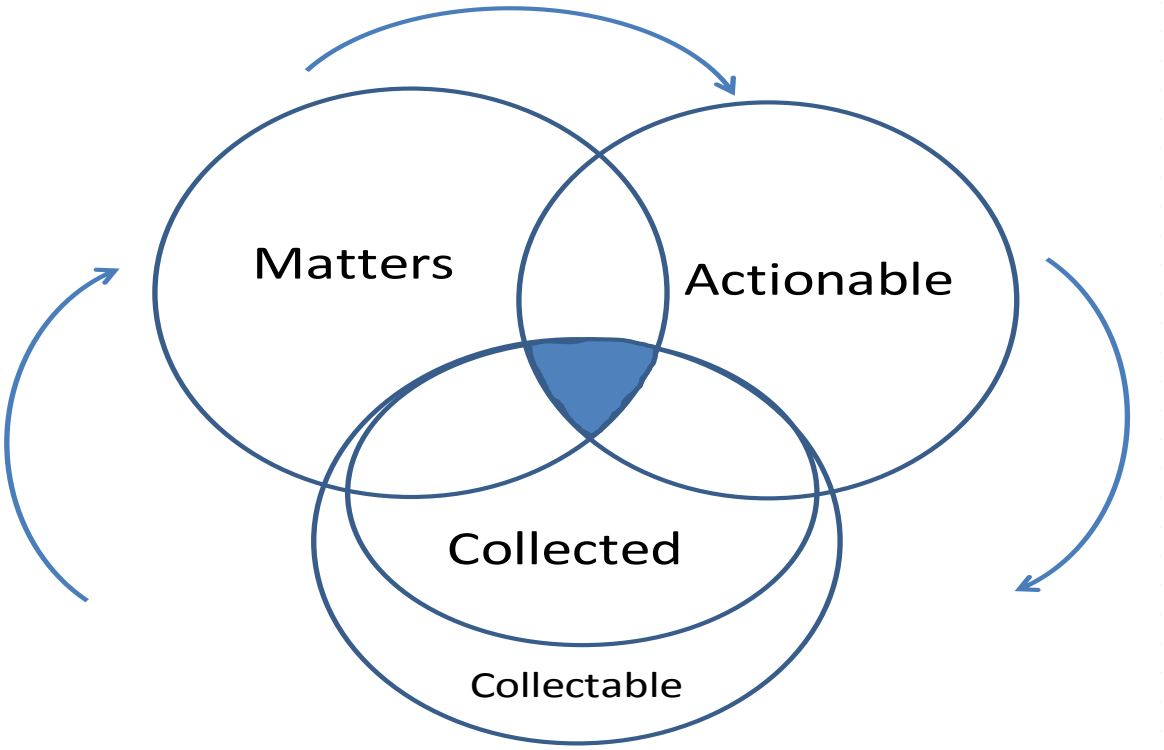

Figure 1. Process for addressing data analytic questions

developing data analytic methods to address student completion at their institution.

The Process

As indicated in figure one the process is cyclical in nature, moving through the stages of what data are collectable and collected by your institution, conducting initial analyses to determine what of the data matters, focusing on the subset of data that are actionable and reexamining the process to determine how your models can be refined and additional data points added. The goal of the analytical process is for the user to determine what data are collected at their institution, that matter in relation to college completion, and allow for action at the institution.

The first step in the process is a thorough examination of what data are collectable by your institution to inform your students' completion rates. This

involves both a close examination of all the data points that are actually collected at your institution as well as those data that are identified within the literature as relevant. Relevant data likely available at institutions tend to cluster among five broadly defined data themes: incoming, selection, learning, performance, and administrative

Incoming data are those elements typically held within the enrollment management offices such as admissions, financial aid, and the registrar. These elements include standardized test scores, high school transcript information, location, extracurricular information, income factors, institutional placement exams, parental education, cognitive assessments, and key demographic markers such as gender and race. Selection data elements pertain to the students' choice of institution including academic interest profiles, admissions essays focusing on leadership and participation in areas of interest, recommendations from professionals, career exploration batteries, past subject data, and sequence of previous courses. Learning elements focus on what is occurring in your institution's classrooms including course outcomes, detailed activity data within the course, attendance data, assessments of learning objectives, instructor demographics, class sizes, advising demographics, course modality, and instructional design models. Performance data are focused on how students are proceeding at your institution. They included summative course grades, and formative gradebook data, assessments of learning objectives, types of classroom assessments, student satisfaction, teacher evaluations, retention, and graduation.

Finally, administrative data are focused primarily on campus system metrics such as use of campus resources, use of and quality of academic advising, use of academic technologies, course withdrawals, add/drop rates, course retake behavior, majors, change of majors, timing of major changes, and student course loads.

Almost all of these elements have the potential to be highly related to student completion rates at your institution, so to make the task of gathering elements more feasible one should focus on what elements the institution has readily available, what of those items can be accessed with the lowest efforts, and finally what elements you may need to focus on trying to gather in the future.

Once you have identified what of the potential collectable data are actually collected and readily accessible at your institution you must conduct correlational analysis to determine which of the data points are related to your metrics of student success. This will allow you to ascertain which of the elements truly matter. While there are a myriad of ways to broadly define student success at an institution, we recommend focusing on those data elements that predict: 1. Course completion, 2. Term to term retention, and 3. Graduation. Additionally, it is necessary to examine the differentiation of the correlates by key demographic subgroups on your campus.

After you have determined which of the data elements truly matter via their prediction of student success at your institution the next step is to identify

the subset of correlates that are readily actionable at your institution. Those actions must be linked and holistic and fit within your institution's environment and mission. You need to focus on what is doable, cost effective, and indicates the best combination of potential risk and impact. For instance while student pre-entry measures of academic ability are highly predictive of student success at institutions it serves little purpose to focus efforts on increasing entering students' academic profile if you work at an open access institution.

Once you have determined what actions you will take at your institution based on the correlates of student success you must continue to holistically review the process and the implications of your actionable steps. One should focus on how well recommendations were enacted, the impact on aforementioned student success metrics, and any road blocks that occurred in implementation efforts. This continual evaluation of your efforts will help you identify revisions to your initial correlational models. This will lead you to examine what additional data you can collect, that relates to and better predicts student success at your institution, and that you can take actionable steps upon.

Conclusion

In an era of accountability and transparency, it is imperative that institutions work to improve their students' success. Completion agendas must be created and institutionalized. Complete College America (2011) advocates that "colleges and universities must make graduation, not head counts, their measure of success." Between the resources made available and the emphasis

placed on graduation rates, the very great potential exists for higher education to stem the tide of people leaving college with no credential or degree. The application of analytics to existing data can only aid us in that effort.

Institutions that succeed in examining and enacting methods that increase their students' success and ultimate graduation will create what Hrabowski and Seuss (2010) describe as, "a climate that encourages (1) asking good questions, (2) being honest about both strengths and challenges, and (3) developing innovative problem-solving strategies and initiatives that address particular issues, including programs that connect students to faculty, staff, and each other" (p. 60). In creating this climate, all students will have a better chance of succeeding, and the institution will have done a great deal to better itself.

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Supplemental Materials

Overview of Supplemental Materials

Two additional papers were written for the SoLAR Flare conference at Purdue University, and both were thoroughly investigated and discussed during the event. However, as of the time when this volume was being assembled, final potential solutions had not yet been drafted into a form that would be suitable for publication. Given that the goal of the conference was to create dialogue around a topic that could be addressed and mitigated (to some extent), the organizers felt it prudent to include in this document both papers with the intent of having the reader utilize them – and potentially the other thought papers – as foundations for exercises with colleagues and other interested parties.

To that end, the following two papers focus on the needs of and challenges facing student veterans on our college campuses and increasing success of college women majoring in science, technology, engineering or math (STEM). Using the analytic model outlined on pages XX-XX, we suggest that readers take these papers as a starting point for determining how one might begin to address these concerns using analytics. Further, we challenge those developing a solution to put them into practice, and to report on the results.

Following these two papers are the biographies for the editor of the volume, as well as for those authoring the thought papers for which the solutions were developed. Finally, a roster of institutional affiliation for those contributing to the solution papers is also included.

Student Service Members and Veterans on Campus

Stacie F. Hitt

More than 2 million service members have been deployed in Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) since 2001 (U.S. Armed Forces Surveillance Center, 2011). Since 2009, when the Post 9/11 GI Bill went into effect, more than 1.3 million veterans have accessed U.S. Department of Veterans Affairs (VA) education benefits of all types, representing an investment by U.S. taxpayers of $18.8 billion in military veterans' education (U.S. Department of Veterans Affairs, 2012). Due to the military drawdowns, which began in September 2010, and general force reductions, the number of student service members and veterans on campuses throughout the country is expected to increase substantially in the coming years (Steele, Salcedo, & Coley, 2010).

The challenge

Only 4% of Vietnam era veterans completed a college degree before their GI Bill benefits expired, despite the fact that more of them used GI Bill benefits than veterans of either World War II or Korean War eras (Card & Lemieux, 2000; Horan, 1990). While the Vietnam era GI Bill and its subsequent amendments provided some tuition assistance for those who paid into the programs during their service, the amounts were insufficient to cover the costs of a college education and veterans needed additional resources to finish school (Boulton, 2008). These issues have largely been addressed in the newest iteration of the GI Bill and other tuition assistance programs, but as many as 70% of OIF and OEF student veterans report moderate to major non-financial challenges in the transition from military service to education (Steele, Salcedo & Coley, 2010). Universities and colleges may not be well informed or equipped to address the unique needs and expectations of these highly capable students, unintentionally contributing to poor completion rates. In light of anticipated increased enrollment of student service members and veterans, the postsecondary community has an important opportunity to understand the non-financial barriers to postsecondary success and to take appropriate actions

that are effective, but do not overburden already strained resources.

Defining success

Student veterans are no more homogenous than any other student group, but a few general assumptions may help define success metrics. Compared to civilian students, student veterans are older and more likely to be first-generation, transfer students, and distance learners (National Survey of Student Engagement, 2010). Although they are also more likely to be enrolled part-time than their civilian counterparts, the number of student veterans who are enrolled full-time is noteworthy in light of their many other commitments. For these reasons, degree completion may not be an appropriate measure of success. Many students return to or

Table 1. Age, gender, and academic status of first year civilian and veteran students

	Civilian (n = 362,000)[a]	Veteran – combat (n = 4,840)[a]	Veteran – non-combat (n = 6,160)[a]
< 24 years old ≥ 24 years old	94% 6%	64% 36%	21% 79%
Male	35%	70%	85%
Dependents	32%	62%	
Transfer	9%	28%	45%
Full-time	95%	83%	77%

(U.S. DoE, 2011; IAVA, 2012; NSSE, 2010[a])

enter postsecondary education seeking certifications, licensure, or other training that can expedite their pathway to meaningful employment (U.S. Department of Veterans Affairs, 2012). For this group of students, success might be defined as attainment of academic goals within the eligibility period of their education benefits, i.e. not a customary cohort graduation rate.

Among the group of student veterans, who are seeking a postsecondary degree, indicators of academic success should be similar to those of civilian students. Do student veterans remain enrolled for three consecutive semesters? Are their course add/drop patterns or other measures of persistence similar to civilian students? How do change rates of academic major compare? And, of course, how do grade point averages of the two groups compare within the same academic major or program of study?

Each institution must also define measures of its own success. Measures of student veteran engagement with the larger campus community, satisfaction with campus supports, academic and otherwise, and utilization of resources can all be indicators of how successfully an institution is supporting all its students.

Who are student service members and veterans?

Student veterans comprise approximately 4% of undergraduate enrollment (U.S. Department of Education, 2011). The majority of student combat veterans are less than 24 years of age. Student veterans are predominantly white, but the proportions of under-represented groups are larger in the veteran population than in the civilian population (U.S. Department of Defense, 2010). They are more likely to be male and one quarter to nearly half are transfer students, having earned academic credits prior to or during military service. Most student veterans are full-time students. Student veterans report working more hours per week than civilian students and are more likely to spend time caring for dependents, but they report studying as many hours per week as civilian students (National Survey of Student Engagement, 2010)..

While images of veterans with amputations are pervasive in the media, there were only 1,621 service-related amputations during the period from 2001 to 2010 (U.S. Department of Defense, 2011). However, in this same period there have been more than 170,000 estimated cases of traumatic brain injury (TBI) as a result of military service (Fischer, 2010). Incidence estimates of post-traumatic stress disorder (PTSD) among combat veterans range from 7.6 to 18.2% (Seal, et al, 2009; Vasterling, et al, 2010). Lifetime risk of developing PTSD among the general population is estimated to be as high as 8.7% (Kessler, et al, 2005). The effects of TBI, PTSD, and other hidden disabilities, such as sensory deficits, are likely to have a greater impact on academic success than visible injuries, such as amputations.

With respect to use of campus resources, the evidence is mixed. Senior student veterans

in one study reported feeling less supported by their campus than their civilian peers (NSSE, 2010). Other work suggests student veterans are engaged in their campuses and generally satisfied with their interactions with faculty and staff (Iraq and Afghanistan Veterans of America, 2012; Whiteman & Hitt, 2010).

Exemplars

The term, "veteran-friendly," is frequently used to describe institutions that exemplify supportive polices, programs, and services for student veterans. Unfortunately, the term has many definitions and is often a self-attribution. For purposes of this discussion, a *standards* approach to determining "veteran competency" might be more informative.

The Council for Advancement of Standards in Higher Education (CAS) is among the forerunners in assimilating disparate qualitative and quantitative evidence and recommendations generated by various stakeholders, academic researchers, and special interest groups. Recently, CAS proposed benchmarks by which institutions can assess their programs and services for student service members and veterans (CAS, 2011). The first priority is to identify military students on campus. All subsequent coordination and facilitation flows from documenting and tracking these students.

While individual institutions need not aspire to excellence in all standards, there are some noteworthy examples of institutional veteran competence. The Minnesota State Colleges and Universities System (http://www.mnscu.edu/military/transfer.html) is an outstanding example of consistent, transparent, efficient, but rigorous awarding of academic credit for military training and experience. A collaboration between the University of Wisconsin System and Wisconsin Technical College System offers a veterans' transition portal that places the full range of supportive educational opportunities and resources literally at the fingertips of veterans as well as active duty service members, who may be investigating post-deployment educational options from anywhere in the world (http://www.veterans.wisconsin.edu/). Embracing campus diversity includes supporting students with hidden and visible disability. The University of

Arizona's Disabled Veterans Reintegration and Education Project (http://drc.arizona.edu/about/veterans-reintegration-education) provides support specifically to student veterans, whereas the University of Illinois has long been a benchmark institution for successful integration of all disabled students, including veterans, into all aspects of academic and extracurricular life (http://www.disability.illinois.edu/). One of the schools that most fully exemplifies a holistic approach to student veterans is the University of Maryland (http://thestamp.umd.edu/student_involvement/veteran_student_life), which has a well-established tradition of commitment from its leadership, faculty, and the larger community.

Barriers

Failure to accurately and reliably identify and track student veterans limits the ability to monitor their academic behaviors, such as preferred courses of study, change of degree objective/switching majors, and use of support services, and is a barrier to tracking academic progress and degree completion.

The population is difficult to define. Not all military students are veterans. Many are service members, who are subject to involuntary training and mobilizations that do not correspond with academic calendars. Student service members can experience multiple activations, deployments, and returns during their postsecondary careers.

- Current software packages have limited functionality to add the necessary data fields.
- A clear path of action (What do we do with the data now?) is not always apparent.

If we do nothing

Failure to recognize and respond to the challenges will result in economic and intellectual losses for society and financial, employment and, possibly, emotional harm for military veterans and families. The investment in human and intellectual capital may not reach its predicted potential.

Implications

- Decisions about allocating scarce academic resources (time, money, people) must be based on evidence. Whether the question is about academic policy adjustments or supportive programing, campus leaders can be guided by a growing body of research.
- Compared to the experiences of student veterans in previous eras, there is much to be encouraged about in 2012, but we can do more.
- Creating sustainable policies, programs, and services for student veterans will benefit all students.

The take-away: Schools need to maximize what they do well and be realistic about what can be achieved. Data will help demonstrate successes, point to growth areas, and clarify decisions about what ought to be jettisoned in frequently austere resource environments.

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Increasing the Success of College Women in STEM

Matthew D. Pistilli, Rebecca Lindell, and Aaron Goldner

University administrators across the country are working to address the issue of first to second year persistence for men and women in the science, technology, engineering or math (STEM) disciplines. Furthermore, many are working to increase the presence and success of historically underrepresented and underserved students, including women. These efforts have been rewarded, as female students are attending, and continue to enroll at, colleges at unprecedented levels – to the extent that for 3 decades they have represented over half of all students in college (Carnevale & Fry, 2000; Keup, 2005-2006; National Center for Educational Statistics [NCES], 2003, 2005, 2007; National Science Foundation [NSF], 2007; Rendón & Hope, 1996). Keup also indicated "that we appear to have achieved a degree of success with respect to increasing access to postsecondary institutions overall, and significant gains" in success for women (2005-2006, p. 62).

While an increase in access is positive, Keup (2005-2006) continued, indicating that "retention statistics paint a relatively somber picture" with regard to students who actually persist through four (or more) years of college to achieve a degree (p. 62). Additionally, Harvey (2002) stated that the higher rates of attendance for this population do not always translate into higher graduation rates.

While the retention and success of women as a population has received a great

deal of attention in recent years, a subset of this population has been the subject of scrutiny and study: women majoring in a STEM field. Bystydzienski and Bird (2006) noted that efforts to increase participation and success of women in STEM fields while still in college has not been without challenges and has lacked urgency and speed: men still tend to be enrolled in STEM majors at higher rates than women (Adelman, 1998; Burke, 2007; NSF, 2007), tend to persist at higher rates in STEM majors than women (Burke, 2007), and have lower likelihood of changing majors (Seymour, 1995). Burke and Mattis (2007) echo this, indicating that while women and minorities are talented and have the capacity to major and work in STEM fields, they "have historically been underrepresented in STEM education and occupations" (p. x). A 2007 NSF report revealed that in 2004 (the most recent year data were available), only 42% of all STEM majors were women (an increase from 37% in 1994) while 57.2% of all undergraduates in college were women. The same report also indicated that 50.3% of all bachelor's degrees in STEM majors awarded were to women, and while this is encouraging, those women represent only 16.29% of all bachelor's degrees awarded and only 28.10% of all women receiving bachelor's degrees.

The question, then, becomes how to best serve women majoring in STEM fields so that they succeed on campuses and in majors where they fail to have equal representation in the classroom. According to Rypsi, Malcom and Kim (2009), the "retention of female students in STEM disciplines is most fragile during the first year [of college]" (p. 119). They continue, indicating that

the situation that currently exists, where there are far fewer women than men who enter, are retained to, and ultimately graduate from STEM fields need to be addressed (p. 133).

Some refer to this phenomena of students leaving STEM fields as a "leaky pipeline" (Astin & Astin, 1992; Blickenstaff, 2005; De Weld, Laursen, & Thiry, 2007; Dean & Fleckenstein, 2007; Potočnik, 2009; Watson & Froyd, 2007; Zimpher, 2009). The leaky pipeline is a situation whereby students, particularly women and minorities, have an interest in a STEM field in secondary education, and somewhere between high school, completing college, and either entering graduate school or the workforce, they "leak" out of college altogether or into other, non-STEM, majors. This creates issues for the workforce and for the academy because the leaks mean that there will continue to be a disparity between the number of women and the number of men in STEM fields.

Explanations for the leaky pipeline are varied. However, several reasons are generally mentioned as contributing to the leaks, academic preparation in high school notwithstanding. The prominent reasons include 1) a "chilly climate" for women in STEM classrooms and majors, where faculty and students fail to fully welcome them or appreciate what they bring to the academic discussion (Hall & Sandler, 1982, 1984; Hanson, 1997; Seymour & Hewitt, 1997), 2) a lack of female role models for women studying STEM fields (Dryburgh, 1999; Etzkowitz, Kemelgor, Uzzi, & Neushatz, 2000; Ferreira, 2002;

Hanson, 1997; McCormick & McCormick, 1991); and 3) a lack of equal representation, or critical mass, in the classroom (Etzkowitz, Kemelgor, Neuschatz, Uzzi, & Alonzo, 1994; Hanson, 1997; Hathaway, Sharp, & Davis, 2001; Oakes, 1990; Seymour & Hewitt, 1997).

Seymour and Hewitt (1997) set out to better understand the general decline of students majoring in the sciences, and the specific concern that students in the sciences were predominantly white men. They indicated that little research existed about the reasons for this general decline and enrollment disparity, except to note that women's enrollment and "persistence rates are significantly lower than that of their male peers" (1997, p. 234). As a result, they embarked on a three-year study designed to "discover, and to establish the relative importance of, the factors with greatest bearing upon the decisions of undergraduates at four-year colleges and universities to switch from science, mathematics and engineering majors into disciplines which are not science-based" (p. 13).

Experiences of gate-keeping by instructors (wherein teachers and professors made a priori judgments about who could and could not handle the coursework and counseled or directed students based on those judgments) and prejudice in high school persisted into college, were two factors Seymour and Hewitt (1997) determined had impacts on women's decisions to study a STEM major. Seymour and Hewitt also found that the women in the study noted that there was an issue of self-confidence and self-perception that played into

whether they, or their peers, persisted in STEM majors. In short, some of the lack of persistence for women in STEM majors stemmed from prejudicial behavior on the part of instructors and from the students' own perception of their abilities to complete the coursework associated with a STEM major.

Seymour and Hewitt also indicated that sheer interest in a STEM field played a major role in female students' decisions to remain in a STEM field. Broadly, women left STEM fields either because another major offered more interest (46.2% of women interviewed) or because the lifestyle associated with a given major was more appealing than that associated with their original chosen STEM major (37.6%). Campus climate also played a large role in students' decisions to stay STEM majors. In many instances, female students reported negative, antagonistic, or even rude interactions with male students in classes, and in most cases the women used this as motivation to do well and out-perform their peers. However, it also became a relatively easy reason for women to leave STEM majors when other factors, such as ability, allure of other majors, or personal interests, became more prominent.

In summary, Seymour and Hewitt (1997) noted that there are distinct things that can aid in women's success in STEM majors and that ultimately lead to women graduating from a STEM major. Students indicated that it was important for them to feel as though they "belonged" (p. 256). Further, role models and mentors, particularly among their student peers, seemed to provide guidance and counsel to students that helped them feel less alone and more

integrated into the major and college. Heuristic knowledge learned from other students helped the women in STEM majors "survive" (p. 257), as did the building of support networks and opportunities for interacting with successful women in the field. In addition, female role models from outside of academia, particularly those with families, helped students understand that success in a STEM field in college and beyond was realistic and achievable. Programs such as Women in Science, Women in Engineering, freshmen interest groups, and other academic-based programs that incorporate mentoring and camaraderie are highly beneficial and should be replicated where possible. Additionally, the teaching of individual coping skills, such as confidence in one's abilities, assertiveness, persistence in asking for help from faculty, and learning how to work while in the minority seemed to be things that those interviewed indicated were helpful to them.

Generally, Seymour and Hewitt (1997) indicate that "programs for women [that] seek to address attrition solely by reconciling the relatively few women who use them to a learning environment which is inherently opposed to the needs of female [science, math, and engineering] students as a whole, are doomed from their inception" (p. 314). They continue, indicating that those "who are serious about making the education they offer as available to their daughters as to their sons are, we posit, facing the prospect of dismantling a large part of its traditional pedagogical structure, along with the assumptions and practices which support it" (p. 314).

Seymour and Hewitt (1997) describe programs that would create conditions under which women would succeed in STEM fields. In particular, they suggest that opportunities for mentoring and role modeling be broadened on campuses where they exist and created where they do not. To that end, several studies indicate that programs such as these are highly effective in helping to enhance the success and retention of women to STEM majors. Allen (1999) described a learning community program at the University of Wisconsin-Madison that works to create a smaller, homogenous community in which "women can develop their self-confidence and allow them to learn more effectively" at a coeducational institution that enrolls over 25,000 undergraduates (p. 267).

A program similar to that described by Allen (1999) is detailed by Hathaway, Sharp and Davis (2001). Hathaway et al. described a program at a large, Midwestern, public research institution, and noted that the program they evaluated, like many others, was created in part to "counteract factors that contribute to lower retention of women in science and engineering fields," like low levels of self-confidence, competition in classes for grades, non-collaborative classroom environments, and a lack of peer groups for women (Hathaway et al., 2001, p. 108). A study of the program indicated that female science majors in a learning community were retained to major and to degree completion at rates statistically significantly higher than their non-participating peers of both genders.

Rypsi et al. (2009) provided several examples of programs that can help alleviate both the chilly climate often perceived by women in STEM fields and the lonely academic experienced by many women. They advocated a classroom that "emphasizes connection, respects and supports personal experience as a source of knowledge, and encourages student-induced work patterns (p. 123). Further, they suggested developing learning communities, in particular ones that have a residential and course component where the courses are made up entirely of women. They also suggested creating "curricular opportunities for students to engage with research and scholarship on areas of gender, race and ethnicity… courses [that] provide women students an opportunity to place themselves at the center of the production of knowledge" (Rypsi et al., 2009, p. 128). The placing of women at the "center of the production of knowledge" is key for them, because it allows students to realize themselves as competent and able scientists and engineers. Mentoring programs and annual symposia on the success of women in the STEM fields are also put forth as experiences that can help to retain women to the disciplines.

The implications for higher education and student success are many. Increasing achievement rates for women in STEM fields results in more women in academia and the corporate world, thereby creating a more balanced workforce, and, potentially, reducing the aforementioned chilly climate for women in this careers. improving the climate in colleges and universities for women, will improve the experiences for all students, thereby increasing the

ability for collaboration and learning to occur, and reducing the current meritocracy that rules the halls of education.

However, if we do nothing, women will continue to lag behind men in both academia and the workplace. In an interview with *The Chronicle of Higher Education*, Cheryl Geisler indicated that "in the last four years, we're seeing 27 percent of new hires in science and engineering are women. It was 25 percent earlier in the decade, so it's just been creeping up" (Wilson, 2012). She continues, indicating that at this rate, it will be 2050 before 50 percent of new hires in science and engineering faculty positions are women, and another 40 years before there's a true 50/50 split for men and women in the academe. Beyond that, Phoebe Leboy, then-president of the Association for Women in Science, noted in an interview with Marla Vacek Broadfoot that "When diversity is lost in any discipline – whether in terms of racial diversity, ethnic diversity, or gender diversity – a certain amount of intellectual content is lost as well" (2008).

This point is illustrated further in *Beyond Bias and Barriers* (2007), wherein the National Academy of Sciences notes "that the United States will have to aggressively pursue the innovative capacity of all of its people – women and men – in order to maintain its scientific and engineering leadership amid increasing economic and educational globalization" (p. 1). In the end, the authors of Beyond Bias and Barriers conclude that "the current situation is untenable and unacceptable. We must unite to ensure that all of our nation's people are welcomed and encouraged to excel in science and engineering at our

colleges and universities" (p. 243).

These authors couldn't agree more.

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Biographies

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Matthew D. Pistilli, PhD, is a Research Scientist for Teaching and Learning Technologies, part of Information Technology at Purdue within Purdue University. For over 12 years, Matt has focused on creating and assessing conditions and environments that positively affect college student success. Over his career, he has worked with summer bridge programs, residence life, learning communities, orientation programming, supplemental instruction, and low-income student scholarship and support programming, and has presented numerous times on these topics. After studying the impact of learning communities on women in STEM majors for his doctoral dissertation, Matt began examining the intersection of technology and student success.

Currently, Matt is the principal investigator and project director for an initiative funded by the Bill & Melinda Gates Foundation looking at the process for building capacity for using analytics at eight institutions around the United States in an effort impact student success and expand the use of Course Signals and analytic technology at Purdue University. He has published on academic and learning analytics, learning communities, college seniors, and low-income student success programming, and has co-edited two annotated bibliographies – one on the first-year experience in American higher education, and a forthcoming volume on the various transitions students face while in college.

Contributing Authors

John P. Campbell, Ph.D., is Associate Provost for Information Technology and Chief Information Officer. In this role, John is responsible for providing institution-wide leadership to the University'Âs technology infrastructure. John's efforts focus on leading the institution'Âs strategic and resource planning as well as service delivery. Prior to his appointment at WVU, he was the Associate Vice President for Academic Technologies at Purdue University. His responsibilities focused on the support, empowerment, and enhancement of faculty efforts in research and teaching/learning. During the past ten years, John has examined methods to use academic analytics to identify students at risk within courses. He was the founder of the Signals project which has been featured on NBC and in the Chronicle of Higher Education. The Signals project has also been awarded the 2012 Noel-Levitz Retention Award, the 2011 Digital Educational Achievement Award, and the 2011 Campus Technology Innovators Award for Teaching and Learning. His doctorate was earned at Purdue University in Higher Education Administration.

Brent M. Drake, Ph.D., currently serves as the Assistant Vice Provost and Director of Enrollment Management Analysis and Reporting at Purdue University where he provides institutional research related to the recruitment, access, enrollment, retention, and completion of higher education students. He has been a member of Enrollment Management since 2003. Prior to this appointment he served as the assessment coordinator for the Lily Endowment retention initiatives at Purdue University. Brent earned all three of his degrees from Purdue University. His B.A. was earned in 1995 in athletic training, M.S. in 1997 in Sports Psychology, and Ph.D. in 2009 in Educational Psychology, with an emphasis in both motivational theory and psychometrics.

Brent presents and publishes on a number of topics in higher education including motivational models related to student success, retention enhancing programs, enrollment modeling, and various enrollment management topics such as recruitment, enrollment trends, and student success efforts. Brent also serves as a continuing lecturer in the Purdue department of Educational Studies where he teaches motivation theory, measurement theory, and research methods in higher education.

John Gardner is a professor and higher education change agent whose principal interest is calling more attention to the importance of the first year of college and improving assessment of the entirety of the beginning college experience. Toward this end, he has led a 30-year international reform movement to persuade colleges to change their approaches to working with their first-year students. He is the founder of two national centers, The National Resource Center for the First -Year Experience and Students in Transition at the University of South Carolina,

and the John N. Gardner Institute for Excellence in Undergraduate Education (formerly the Policy Center on the First Year of College) based in Brevard, North Carolina.

Aaron Goldner is a PhD candidate at Purdue University studying climate dynamics and global climate modeling. Aaron received his bachelors degree from Oregon State University where he studied Earth and Environmental Science. While at Oregon State, Aaron worked in Dr. Edward Brook's ice core laboratory where he used a gas chromatograph to take methane out of ice cores to explore changes in methane concentrations during the late Holocene.

In graduate school, Aaron has focused on using complex computational models to understand how large scale forcings within global climate models can shift precipitation and global temperature patterns in past and present climate. More specifically, his research has focused on two projects, 1) how El Niño cycles effect precipitation over the continental United States, and 2) how changing height and albedo over Antarctica changes global temperature. In the future, Aaron is interested in exploring how to use his background in climate research and teaching to work within the policy arena to better inform the public about relevant issues involving climate change and education reform.

Stacie F. Hitt, R.N., Ph.D., is the director of Operation Diploma, the education and employment initiative of the Military Family Research Institute at Purdue University. As such, she is actively involved in generating and sharing evidence of promising practices that support student service members and veterans in achieving their academic and career goals. She was faculty and served in various academic leadership positions for nearly 20 years prior to joining MFRI.

After earning bachelor's and master's degrees from the University of Wisconsin-Madison, she received her Ph.D. from the University of Pittsburgh. Her career includes service as associate dean for academic programs at the University of Texas Medical Branch, where she oversaw creation of an alternative degree completion program for non-traditional students. She also served as director of accelerated health programs at Waynesburg University, and managed global research projects for private industry. Her research has been presented internationally and published in journals such as the Archives of Pediatric and Adolescent Medicine and Drugs: Education, Prevention, and Policy.

Andrew (Drew) K. Koch, Ph.D., is Executive Vice President of the John N. Gardner Institute for Excellence in Undergraduate Education. During more than two decades of his career, Koch has garnered substantive experience with undergraduate education administration, strategic planning, fund raising, and enrollment management and a host of other efforts designed to enhance student access to and success in college. Koch is also the author of more than a dozen publica-

tions pertaining to student success, including the second, third, and fourth editions of *The First-Year Experience in American Higher Education: An Annotated Bibliography*. He has served on several boards and commissions, including the Indiana College Access and Success Network; the Directorate Board for the American College Personnel Association Commission on Admissions, Orientation, and the First-Year Experience; the Advisory Board for the National Resource Center for the First Year Experience and Students in Transition; the National Advisory Board for the Military Family Research Institute, and the editorial review board of the *Journal of the First-Year Experience and Students in Transition*.

Rebecca Lindell, PhD, is with the Department of Physics at Purdue University, and previously served as a physics faculty member at Southern Illinois University Edwardsville. With over 15 yrs experience in the field of Physics Education Research, Rebecca brings to Purdue expertise for assessing college students understanding of physics and astronomy, specifically in the area of concept inventory development and critique. As part of her dissertation, she created the Lunar Phases Concept Inventory, which was used as model concept inventory in the development of other astronomy concept inventories. In addition to her research efforts, Rebecca is an award winning curriculum developer and has received national recognition for her redesign of her introductory astronomy course. She has redesigned or assisted in the redesign of numerous physics courses at every level. Based on her expertise, Professor Andrew Hirsch recruited her to the Purdue University Department of Physics to assist with the redesign of PHYS 172: Modern Mechanics, the introductory physics course at the University.

James Willis, III, Ph.D., completed his bachelor of arts in theology from Roanoke College in the beautiful Blue Ridge mountains of Virginia. He then went on to complete a *master litterae* in divinity from the University of St. Andrews in Fife, Scotland, and a doctor of philosophy degree in comparative religion at King's College London. His previous experience includes collegiate administration, teaching, and research. He recently joined Purdue University as an Educational Assessment Specialist in the Academic Technologies department of Information Technology at Purdue.

Viktoria Strunk, Ed.D., has a bachelor of science degree in Speech Pathology and Audiology, a master of arts in teaching with concentrations in English and communications, a cognate from Louisville Bible College in counseling, and an education doctorate in leadership education from Spalding University. She has over 24 years of experience in education, having served as a Writing Assessment Coordinator, English Professor, and Administrator.

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