The rationale for the text to follow can be found in my paper, “Pasteur’s Quadrant in Higher Education” (Benjamin, 2016). That paper makes the case for use-inspired basic research (UIBR) in higher education. Its title is inspired by Donald Stokes's book titled *Pasteur’s Quadrant: Basic Science and Technological Change* (1997). Stokes uses the narrative of Pasteur's professional life to illustrate his argument. Pasteur was driven to solve the problem of tainted milk killing millions of children. While on the path to succeeding in his mission, he ended up unintentionally inventing the building blocks of microbiology.

“Pasteur’s Quadrant in Higher Education” proposes that higher education follow the path taken by other major policy domains in the United States, such as agriculture, healthcare, and national security. In each of these major policy arenas at a critical historic juncture, a commitment was made to create an integrated, multidisciplinary research program that brought researchers and practitioners together to create new tools for decision-makers to come to better determinations. In attempting to solve real-world issues in these policy arenas, based in part on the value system of science, UIBR stimulated the development of tools of analysis that, in hindsight, were dramatic breakthroughs. Human capital is increasingly recognized as the principal resource of a nation, and the K-16 education system is the formal venue for preserving and enhancing it. It is time to focus on higher education using the UIBR approach.

The premise for CLA+ (Collegiate Learning Assessment) Analytics is based on the assessment my colleagues and I made that it makes immediate sense to introduce the UIBR model to the higher education sector through data mining and other Internet-based tools. This is a different UIBR strategy than the one followed in agriculture, healthcare, and national security policy domains. The ways UIBR was implemented in agriculture, healthcare, and national security policy differed in each case because of the nature and context for these three major policy domains. Congress established the Land Grant University in 1862 for the purpose of improving agriculture, a vital part of the economy. Since World War II, the resources devoted to UIBR in healthcare have been exceeded only by resources provided to national defense. For example, 6000 scientists work at the Bethesda, MD health research facility alone. In addition, significant research grants are awarded by the National Institute of Health to researchers in medical schools and the biological-related sciences throughout the country. Because of the nature of national security policy, it made sense to create and fund Federally Funded Research Development Centers such as the RAND Corporation to assemble a critical mass of researchers from across the hard and social sciences in a single-purpose facility to conduct UIBR. This supplemented the strategies that introduced UIBR to the three major policy domains noted above.

For UIBR on the higher-education sector, the most immediate problem is how to overcome the absence of tight channels of communication across and among academic departments, administrators, and faculty committees. Universities, after all, are aptly characterized as loosely coupled organizations. This is in sharp contrast to the command and control system of the military. The need, therefore, is to create a virtual network that permits and encourages researchers from many academic disciplines, along with administrators and faculty leaders, to share information in a timely fashion and to use that information on demand when they need it. As a first step, my colleagues and I have created a prototype tool called CLA+ Analytics that is designed to provide the virtual infrastructure that allows for collaboration between faculty, who are engaged in formative efforts to improve teaching and learning, and researchers from a number of scientific, empirical-based research fields.

CLA+ Analytics allows leaders and researchers to network horizontally within the institution and across to other institutions to access and share data. In turn, this offers leaders of institutions the ability to access information and carry out analyses in real time that assist them in making better-informed decisions.1 The intent is that, instead of operating in individual silos, economists of education, cognitive scientists, teaching and learning specialists, education measurement specialists, and experts in data analytics can operate in a more integrated way to tackle the daily issues higher education leaders face, as well as mount longer term research programs designed to assist the higher education sector in dealing with its problems.

In today's information-saturated environment, unless research findings can be provided to the intended users in real time, the information may not be useful. Administrators and faculty at colleges and universities need data to assist them in making better decisions when they are in the process of making decisions, not months after the fact. Students need to be able to access their test results along with their transcripts and other supporting documents in real time as well. We have created CAE (Council for Aid to Education) Data Miner, a software tool that can be used to introduce on-demand, use-inspired access to information relevant to higher education decision-makers. This paper describes the CLA+ Analytics tool and how we visualize its use.

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1 Until the late 1960s social science researchers needed to learn FORTRAN to carry out standard statistical tests such as regression and causal modeling analysis on data sets. Because of the complexity of this process, the time and effort involved in statistical corroborating of hypotheses often took as long as, or longer than, other steps in the research process itself. The invention of the Statistical Package for the Social Sciences (SPSS) made the statistical tests much quicker and easier. The researcher could now choose the appropriate statistical package and carry out the tests quickly, in real time. The technological breakthrough of the SPSS (2015) made social research a more robust, more vigorous enterprise. Researchers could spend more time on the actual research itself. New tools such as CAE’s Data Miner give promise of assisting decision-makers in higher education and related stakeholders, such as employers and policymakers, to make better decisions.
Attacking Pasteur’s Quadrant in Higher Education Through CLA+ Analytics

CAE’s Data Miner links CLA+ test results to multiple disciplines through new analytical tools for colleges, students, and employers. The CLA+ test reports will provide information to students and colleges along with opportunities for colleges, systems of colleges, states, and countries to create their own analyses. CLA+ Analytics are to be used in a dynamic, interactive manner by the user.

Three analytic tools will be available for the initial set of deliverables to students and college leaders when they participate in CLA+ testing. The goal is for the first beta test delivery of the tools to be ready for a selected number of schools and students testing in the spring of 2016.

CLA+ CareerConnect—provides certificates and badges to CLA+ students scoring Proficient or better to indicate critical-thinking skills to potential employers

Students who take CLA+ will be offered certificates featuring badges that certify their critical-thinking skills mastery level. Using the results from the standard setting study (Zahner, 2014), students who score at the Proficient, Accomplished, or Advanced mastery levels will be eligible to receive badges certifying their aptitude in critical thinking. To date, about 60% of CLA+ students have been found to be eligible for a badge. These badges allow students to demonstrate their critical-thinking attainment levels to potential employers and graduate school admission officers. Students will also be able to share their CLA+ scores and certificates directly on the CLA+ Analytics jobs board, as well as through social media and their résumés. (See Benjamin, Leveling the Playing Field from College to Career (2016) for a rationale and description of CLA+ CareerConnect.)

CLA+ Education—used to promote growth in teaching and learning aligned with the skills measured by CLA+

- For institutions:
  - A compendium of resources detailing established instructional practices, which promote the skills assessed by CLA+; these resources will focus on feasible practices that can be implemented at the classroom level
  - A variety of practices for institutions to choose from to improve their students’ scores.
- For students:
  - Videos that help students understand their performance level and improve their critical-thinking skills
  - Additional online resources that allow students to understand and improve their test scores
  - Student reports that provide diagnostic information to students, which can be used to improve their writing, analytic, problem-solving, and quantitative reasoning

CLA+ Data Analytics—using the new opportunities provided by the CAE Data Miner

- Provides data to be used across university offices to compare cross-university performance based on key indicators such as size, total costs and fees, selectivity, and per student expenditures organized in a variety of data analyses, including “Big Data” analysis. See an example below in the Appendix following the Flow Chart, Figure 1.
- Provides links to research centers and organizations identified by CAE as preferred providers of data about assessment, teaching and learning practices, and data analytics
How CLA+ Analytics Works

When CLA+ data are placed on the CAE Data Miner, the information needed to complete CLA+ CareerConnect, CLA+ Education, and CLA+ Data Analytics are also computed. Previously, CLA+ reports for each test administration were sent to the Office of Institutional Research, and CLA+ student reports were sent to each student. Now, CLA+ Analytics will be sent to eight to 10 offices at the institution with the information relevant to each office highlighted.

See Figure 1, Possible Destinations of CLA+ Analytics Applications in the University Organization Flow Chart for an illustration of how the specific applications could be accessed by colleagues in offices throughout the institution in real time.

![Possible Destinations of CLA+ Analytics Applications in the University Organization Flow Chart](image)

**KEY:**
1. Career Connect
2. CLA+ Education
3. CLA+ Data Analytics

*Figure 1*
This research assisted in creating a plan for dealing with Nevada's rapid population increase, which placed pressure on the postsecondary education system from 2000 to 2003. As a result, R. Lempert's analysis in Benjamin et. al. (2002; a report for the Regents of the Nevada postsecondary system), a new four-year college was established to absorb the increased demand for postsecondary education. (See the Nevada System of Higher Education's website for more information about the related decisions made following the Regents' deliberations informed by the analysis.)

Achieving the Access Goals of Nevada Higher Education

One of the most pressing issues facing Nevada higher education is contending with the large population increases Nevada expects over the next decade. RAND was asked to explore the possible ramifications of various levels of increased undergraduate enrollment. For this purpose, we employed computer models that project enrollment and other attributes of Nevada's higher-education system into the future, based on Nevada's projected demography and data on the current flows of students through Nevada higher education. Because the future is often highly unpredictable, we consider a wide range of scenarios and report conclusions robust across these scenarios. Such an “exploratory modeling” process can be useful for strategic planning because it reveals the key driving forces and tradeoffs any strategy must address. It can also allow decision-makers to "test drive" choices across key scenarios before committing to action.

The findings of our exploratory modeling exercise strongly suggest that Nevada must make significant changes in its higher-education system to meet its goals in the face of rapid population growth. Accommodating this population growth within the current structure could require heroic increases in the rates at which students enter and progress through existing institutions. Changing the structure of the Nevada higher-education system can meet goals with other, less aggressive changes. These findings confirm the qualitative assessment discussed in the first part of this draft report that the Regents need a strategic plan, a road map giving them stronger decision-making tools and a logic for the management of growth.

### Table 1: Some Goals for Nevada Higher Education

<table>
<thead>
<tr>
<th>Goal</th>
<th>Definition</th>
<th>Current Performance</th>
<th>10 Largest States</th>
<th>WICHE States</th>
<th>All 50 States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access</td>
<td>Enrollment per Population</td>
<td>4.1%</td>
<td>5.1%</td>
<td>4.9%</td>
<td>4.2%</td>
</tr>
<tr>
<td>Attainment (BA)</td>
<td>Annual BA Degrees per Population</td>
<td>0.19%</td>
<td>0.26%</td>
<td>0.36%</td>
<td>0.29%</td>
</tr>
<tr>
<td>Attainment (AA)</td>
<td>Annual AA Degrees per Population</td>
<td>0.08%</td>
<td>0.17%</td>
<td>0.20%</td>
<td>0.17%</td>
</tr>
<tr>
<td>Diversity</td>
<td>Black &amp; Hispanic Enrollment per Population / White Enrollment per Population</td>
<td>0.58</td>
<td>0.89</td>
<td>0.82</td>
<td>0.84</td>
</tr>
</tbody>
</table>

Nevada must set clear goals for its higher-education system to successfully manage its growth. We choose four goals for the modeling exercise (Table 1), based on our discussions with decision-makers and stakeholders throughout the system. These are **Access**, which we define as UCCSN enrollment as a fraction of the Nevada population; **Attainment (BA)**, which we define as the annual number of bachelors degrees awarded as a fraction of the population; **Attainment (AA)**, which we define as the annual number of associate degrees awarded as a fraction of the population; and **Diversity**, which we define as the ratio of the enrollment of Hispanics and African Americans as a fraction of Nevada's Hispanic and African American population to the enrollment of whites as a fraction of Nevada's white population.

All four of these goals relate to Nevada's ability to provide equal opportunity to its citizens. The two Attainment goals are particularly relevant to Nevada's ability to build a vibrant, diversified economy.

At present, Nevada is behind other states for each of these goals. The above table compares Nevada's performance to the averages for the nation, the Western Interstate Commission for Higher Education (WICHE) states, and the nation's ten largest states for each of these goals. Nevada scores a 4.1% on the access goal, compared to 4.9% for the WICHE states; 0.19% and 0.08% on the BA and AA Attainment goals, compared to 0.29% and 0.17% for the national average; and a 0.58 for the Diversity goal, compared to the WICHE score of 0.82. In this report, we will use this mix of WICHE and national benchmarks (shaded gray in the above table) as the goals for Nevada higher education over the next ten years. However, this choice is illustrative. The goals for Nevada education can only be set by its elected leaders.

In addition, these four goals do not exhaust the full set of goals Nevada should use to manage its higher-education system. For instance, quality is an important goal we do not explicitly consider in our modeling exercise. We implicitly assume it stays at least constant across all the scenarios we consider.

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1 The example is supplied by R. Lempert in Benjamin, et al., pp. 19-33. For additional information about the data analytics approach of Lempert and his colleagues see Lempert et al., 2006.
We use a computer simulation model to project the performance of UCCSN, assessed by these goals, from the present through 2010 over a wide range of future scenarios.

The model uses data and projections for Nevada's population to determine the pool of people who need to be served. The model calculates the rate at which individuals enter Nevada higher education and then advance through the system based on data from the various institutions. We project future enrollment and degrees based on various assumptions about how these rates may change in the future and what capacity constraints may affect the systems. From these projects we assess UCCSN's performance according to the various goals. The Appendix describes the model in more detail.

We use this model to create a wide range of plausible future scenarios for Nevada higher education. The model ensures that each future is consistent with the available data and basic “accounting” facts we know for certain hold in the future. For instance, students must either remain in the system, drop out, or graduate. Institutions must have the capacity to support their enrollment.

**Rationale for Development of Scenarios**

We create multiple scenarios because everyone knows that any specific ten-year forecast is likely to be wrong. It is easy to find faulty assumptions behind any such forecast, inviting debates over the “trees” at the expense of the “forest.” As an alternative, we show “maps” of many plausible futures and look for patterns that are robust across all the paths Nevada might take into the future. These maps should help Nevadans focus on key issues that their higher-education system will face.
The first message from our analysis is that with Nevada’s large expected population growth over the next decade, UCCSN must move faster just to stay even.

Figure 3 tracks access to UCCSN through 2010, assuming there is no increase in capacity, so that total enrollment stays constant. This scenario is not likely, but it provides an important comparison to the challenging actions scenarios where Nevada takes aggressive action to improve access, attainment, and diversity.

In the no-capacity growth scenario, access falls from the current 4.1% of the population to 3.2% of the population, reflecting the projected 33% population growth over that period. In order to keep access at its current 4.1%, and assuming all else remains the same, UCCSN must increase its capacity by 2.6% annually over the decade. Even with such aggressive expansion, access to Nevada higher education will still remain below the WICHE-based goal of 4.9%, as well as the national and ten largest states’ averages.

Not surprisingly, Nevada also fares poorly in the other goals in this no-capacity growth scenario.

Here (Figure 4), we show a color-coded scorecard for each of the access, attainment, and diversity goals. In 1999, we label Nevada’s current levels with yellow. In 2010 in the no-capacity growth scenario, Nevada drops significantly in both the access and attainment goals, which we indicate by red color, and makes no improvement in diversity, which we indicate by the yellow.

![Access Goal Over Next Decade](image)

**Figure 4: No Capacity Growth Scenario**

Can Reach Access Goals with Aggressive Increases in Participation

![Map of Access Goal Across Many Scenarios](image)

**Figure 5**
How might Nevada meet access, attainment, and diversity goals over the next decade?

To answer this question, we will use our model to create maps of a wide variety of paths Nevada higher education might take into the future. These maps will help the Regents better understand the options available to them.

We begin by considering the access goal. As one important condition for improving access, Nevada must increase the rate at which its citizens access higher education. Currently, this rate is among the lowest in the nation. There are a number of ways to increase participation rates. At a minimum, additional capacity must be made available.

Figure 5 shows how much Nevada must increase participation rates in order to achieve access rates similar to those of the WICHE average by 2010. We have color coded each scenario to indicate whether Nevada in 2010 has reached the goal (green), made significant improvements short of the goal (turquoise), remained at or near current levels (yellow), or is doing worse (red).

We assume here that additional capacity is made available by growing the current system, rather than making any significant changes in its structure. If participation rates stay the same, access will remain relatively constant at 4.1% in 2010. Participation must grow at roughly 5% per year to achieve the average level of other states. This is an aggressive rate of increase, even more than needed to absorb the doubling of the number of high school graduates expected in Nevada over the next decade. To put this increase in context, we note that during its heyday expansion from 1964 to 1970, California increased the percentage of its residents entering its higher-education system by 4.4% per year.

Next we consider the attainment goal. One of the most effective means to increase the number of Nevadans who leave UCCSN with the skills needed for the new economy is to increase the rates at which students already in the system move through the system and then go on to graduate. The more entering students who eventually leave with a degree, the less capacity the system needs to produce each degree.

Figure 6 shows how much Nevada must increase such advancement and graduation rates from their current levels in order to achieve levels of BA attainment similar to the national average by 2010. As before, we have color-coded each scenario to indicate whether Nevada in 2010 has reached the goal (green), made significant improvements short of the goal (turquoise), remained at current level (yellow), or is doing worse (red).

Nevada must increase these advancement rates by 4% a year in order to meet these BA attainment goals by 2010. To put this increase in a comparative context, we note that from 1964 to 1970, California increased the rate at which students advanced through its public higher-education system at about 1.3% per year. Could Nevada increase advancement rates at a 4% per year level? It would appear to be very difficult to achieve.
It is important to understand whether any particular actions serve one goal or several. Does increasing participation rates also improve attainment? Only a little.

This map, Figure 7, shows the impact of increasing advancement rates on Nevada's BA attainment performance in 2010. Increasing participation rates only have a small impact on Nevada's performance on attainment.

Figure 8 shows similar results for the AA attainment goal. This goal focuses on the performance of the community colleges. We see that Nevada needs significant increases in both advancement and participation rates to meet the goals for AA attainment. The AA attainment goals are harder to reach than the BA attainment goals because Nevada's current AA performance is further from the national average.

(It is important to note, however, that an AA degree is not the only goal of students attending community colleges. For instance, some students attend seeking particular skills that they can gain in one or two classes. Currently available data does not support a computer model with performance measures based on addressing such student needs. If such data were available, it could support a richer view of future community college performance.)
Increasing advancement rates have even less impact on Nevada's access goal. Figure 9 shows the impact of increasing both the advancement rates and the percentage of Nevadans who attend college on Nevada's access goal in 2010. Note that increasing advancement rates can decrease enrollment because students may spend less time in school. This may free up capacity, but only helps access if participation rates also increase.

Comparing Figure 9 with the previous two figures, we see that, all other things being equal, Nevada must increase participation rates by 5% per year and advancement rates at 4% per year in order to meet its access and attainment goals by 2010. This is a very aggressive rate of improvement and success, which is problematic. By comparison, during its 1960s expansion, California's higher-education system only increased participation and advancement rates, respectively, by 4.4% and 1.3% annually.

There are various ways Nevada might ease the task of meeting its access and attainment goals. Figure 10 suggests one possibility—reducing the dropout rate in addition to increasing participation and advancement rates.

This chart shows the impact of increases in participation rate (horizontal axis), increases in advancement rates (vertical axis), and decreases in dropout rates (axis going into the page) on BA attainment in Nevada higher education in 2010. As shown by the scenario with the thick border, if the dropout rate also decreases at 2% per year, Nevada could meet its BA attainment, as well as its AA attainment and access goals by increasing its participation rates by 3% per year and its advancement rates by 2% per year. This is still a significant challenge, but much closer to that met in the past by other states.
Now we consider the diversity goal. Significant improvements in diversity require additional increases in the participation rates of Hispanic and other individuals who currently enroll in college at rates less than whites, above and beyond any increases in the participation rates for the entire population.

Figure 11 shows the impact of increasing, across the board, participation rates and of additional increases in Hispanic participation rates, on Nevada's diversity goal in 2010. This map shows that it will be very difficult for Nevada to reach parity with the other WICHE states in diversity by 2010. Increasing annual Hispanic participation rates by 6% more than general participation rates provides significant improvements, but does not achieve the goals.

Summarizing the information on the previous charts, we see that Nevada can significantly improve its access, attainment, and diversity performance by sustaining large annual improvements in participation, advancement, and dropout rates. However, such large sustained improvement rates could be extremely difficult to achieve. Meeting the access and attainment goals without major changes to the UCCSN system—that is meeting goals only by improving advancement, participation, and dropout rates—may be very challenging.

Here, Figure 12 shows a color-coded scorecard for each of the four access, BA attainment, AA attainment, and diversity goals. The inset map combines the maps on the previous pages with the access goal at the top of each box and the advancement rate goal at the bottom of each box. We also assume that annual Hispanic participation rates increase, and Hispanic dropout rates decrease, at twice the rate of the general population.
The scenario in the lower left-hand corner is the current system with no changes in participation and advancement. As we have seen, it shows no improvement in access, attainment, or diversity. Nonetheless, it requires an average budget increment of $100 million. The scenario in the upper right-hand corner meets both access and attainment goals with 3% annual increases in participation rates and 2% annual improvements in advancement and dropout rates. In this scenario, Nevada reaches in 2010 the access and attainment goals shown in Figure 3 and shows significant improvement in diversity. This scenario requires a budget increment that averages roughly $160 million per year over the coming decade. Depending how the capital costs are financed, this represents a roughly 7% per year increase in the state contribution to higher education. This figure is consistent with recent ten-year forecasts by the Governor’s Office.

![Scenario Map with 3 Four Year Colleges](Image)

The scenarios we have considered up until now all assume that the current structure of UCCSN remains the same. Now we consider the potential impact of adding four-year colleges to the Nevada system. We assume each college would have a capacity of 10,000 students (headcount) and would begin with advancement rates similar to other such institutions nationwide and participation rates about half those of similar institutions nationwide. Currently Nevada universities and community colleges have about half the participation rates of similar institutions in other states.

Figure 13 shows the impact on Nevada’s attainment and diversity goals in 2010 in a scenario where Nevada builds three such four-year colleges over the next decade, all serving the southern portion of the state. We illustrate these two goals, because they are the most difficult to achieve. These new four-year colleges offer significant improvement in Nevada’s performance on these goals. Even if participation and advancement rates remain unchanged (lower left-hand corner), Nevada’s performance improves compared to the scenario with these new colleges. If participation and advancement rates both increase by 2% annually, Nevada’s access reaches parity in AA attainment with the national average and significant improvement in diversity by 2010. With these increases, it will also reach parity in access with WICHE averages and in BA attainment with the national average.

Building three four-year colleges is clearly one of many such options. The best plan will depend on numerous factors, many of which are not treated in the model. The map shows how the AA attainment and diversity goals will vary as participation and advancement rate change. We assume that Hispanic participation rates increase, and Hispanic dropout rates decrease, twice as fast as the rates for the general participation rates, and that increases in participation at the four-year colleges decrease participation at the universities. These scenarios achieve the goals at relatively low additional cost.
Here, Figure 14 compares a color-coded scorecard for each of the four access, attainment, and diversity goals for the scenarios with six new four-year colleges with UCCSN’s current performance.

In the scenario with no changes in advancement and participation rates, UCCSN still achieves significant improvements in access and modest improvements in attainment and diversity. The cost averages $165 million above the current UCCSN budget.

In the scenario where advancement and participation rates improve by 2% annually, UCCSN meets the access, BA attainment, and AA attainment goals, and significantly improves diversity with an average budget increase of roughly $190 million per year over the next decade.

**Conclusion**

These scenarios will not be easy to achieve. They involve significant increases in spending and significant increases in the performance of existing institutions. But for roughly the same costs, these scenarios achieve Nevada’s goals with more realistic increases in the participation and advancement rates of existing Nevada institutions. We have used our computer models to look over a very wide range of scenarios. The message that consistently emerges is the same as that seen in the comparisons here. Nevada higher education faces impressive challenges and meeting these challenges with bold changes may be less challenging than attempting to meet them with incremental changes to the current system.
References


