SEEC: STEM STUDENT ENROLLMENT AND ENGAGEMENT THROUGH CONNECTIONS

Project Summary

Iowa State University (ISU) and Des Moines Area Community College (DMACC) are partnering on the STEM Student Enrollment and Engagement through Connections (SEEC) project to increase the number of students graduating with a bachelor's degree in engineering at ISU and the number of students in STEM areas of study at DMACC, including increasing the number of transfers from DMACC to ISU in engineering. Retention at DMACC and ISU will be increased by a new learning community model, called a learning village or meta-community. First-year and gateway engineering courses will be reviewed to better engage students, to provide flexibility, and to support transfer students. The ACCESS program makes gateway courses available through distance education. Working with DMACC and the STEM Pathway project, student-centered advising will be coordinated to broaden the diversity of students enrolled in engineering and to make students aware of the various paths to successfully completing an engineering degree, including transfer from a community college. ISU Extension will partner on the project to develop the STEM TEC (Talent in Every County) initiative.

Intellectual Merit

The goal of the SEEC Project is to increase the number of engineering graduates at Iowa State University by 120 per year. The percentage of women and minority graduates will approach 20% and 10%, respectively. The objectives of the project are:

- To enhance the Learning Community (LC) model at ISU by improving programming and availability; and to create a LC model that spans DMACC and ISU. (**Learning Village**)
- To redesign the first-year engineering curriculum to enable flexibility and commonality across LCs; and to make selected engineering gateway courses available to DMACC students via distance education. (**Connected Curriculum**)
- To develop and enhance academic advising and mentoring programs for pre-college, community college, and university students. (**Student-centered Advising**)
- To establish a recruiting and outreach network across Iowa and with alumni using ISU Extension, DMACC, and involving parents and teachers; to tap into diverse communities of students; and to improve the awareness and understanding of engineering among those who influence student choices. (**Coordinated Networking**)
- To evaluate project effectiveness and improve project activities. (**Evaluation**)
- To share best practices on campus in other areas of STEM, with other community colleges in Iowa, with other institutions in the Big 12 consortium, and at national meetings. (**Dissemination**)

The objectives of the SEEC project will be achieved through a set of recruitment, retention, and engagement activities. These activities include the application of proven, research-based practices, alignment with national recommendations, institutional and SEEC team strengths, and expert evaluation. Two education research projects of direct relevance to the advising and networking objectives are underway by members of the SEEC team, and we plan to incorporate results from that work into this project.

Broader Impacts

The proposed activities strengthen the partnership between ISU and DMACC and advance the learning environment of each school. The SEEC project purposefully includes both proven and emerging strategies to increase enrollment and degree production and enhance student diversity. The emerging strategies, e.g., coordinated networking, are aligned with new national initiatives (such as the NAE's Public Understanding of Engineering program); and thus provide an opportunity to discover approaches that are effective. They are also informed by new research. This is critical at a time when many approaches have been ineffective at substantially increasing the participation of underrepresented groups in engineering and STEM fields. The SEEC project expects to create awareness and interest in engineering across Iowa, with a special emphasis on attracting women, minority, and rural students onto the path of engineering study. This includes educating parents on the value of an engineering career. The learning village and networking methods will be applicable to other community colleges and universities in Iowa and around the nation. The project will sponsor a regional forum among Big 12 institutions to share best practices.

SEEC: STEM STUDENT ENROLLMENT AND ENGAGEMENT THROUGH CONNECTIONS

1 Introduction

The STEM Student Enrollment and Engagement through Connections (SEEC) project, pronounced "seek", does what its name implies – seeks students and connections. The goal is to increase the number of engineering graduates at Iowa State University by 120 per year. The means to that end are connections rooted in community: learning communities, community colleges, and Iowa communities. The proposed project is collaborative between Iowa State University (ISU) and Des Moines Area Community College (DMACC). The cornerstone of SEEC is the success of learning communities for recruitment and retention, and the project will build upon Iowa State's established learning community infrastructure, leadership and expertise. Retention at DMACC and ISU will be increased by a new learning community model, called a learning village or meta-community. First-year and gateway engineering courses will be reviewed to better engage students, to provide flexibility, and to support transfer students. Working with DMACC and the STEM Pathway project, student-centered advising will be coordinated to broaden the diversity of students enrolled in engineering and to make students aware of the various paths to successfully completing an engineering degree, including transfer from a community college. Students will be advised on the range of STEM disciplines. Interestingly, in this day and age of high tech communications, we propose a recruiting approach using one of the oldest services of a land-grant institution. With ISU Extension, we will seek to improve the public awareness and understanding of engineering, especially among students and their parents. The methods of the project will serve ISU and DMACC in several contexts and will also be adaptable to other institutions.

Iowa State University, chartered in 1858, became the nation's first land-grant institution, and was named Iowa State University of Science and Technology in 1959. Today, Iowa State is a broad-based public university of international stature with more than 26,000 students from all 50 states and nearly 120 other nations. Iowa State, a Carnegie Doctoral/Research-Extensive university, has led the development of several fields of study that are central to the land-grant movement, including engineering, agriculture, family and consumer sciences, and veterinary medicine. Today, Iowa State is a recognized leader in many areas of science and technology, including plant and animal genomics, materials sciences, analytical chemistry, behavioral studies, physics, computer science, and many areas of engineering, with new initiatives in food safety and food security, human/computer interaction, combinatorial chemistry, and bioeconomy.

Des Moines Area Community College is a publicly supported two-year institution serving the Des Moines metropolitan area and surrounding counties and enrolling over 16,000 students in credit courses. It is Iowa's largest two-year college. Approximately twenty-five percent of the state's population resides within the area served by DMACC's six campuses, including all or major portions of Audubon, Boone, Carroll, Dallas, Guthrie, Jasper, Madison, Marion, Polk, Story and Warren counties and parts of adjacent counties. College transfer curricula meet the requirements of four-year colleges and universities. In 2005, DMACC began delivering technical education at its new Story County Career Academy – Hunziker Center in Ames, seven minutes from the Iowa State University campus.

About 60% of new undergraduate transfer students to ISU are from Iowa area community colleges, of which over one-third are from Des Moines Area Community College campuses. The missions of ISU and DMACC are included in the Supplemental section.

This proposal is organized around three primary questions:
- What are the SEEC project goals?
- How will the project goals be accomplished?
- Why will the project succeed?

2   Project Goals

What are the project goals?
There are six main objectives of the SEEC Project:
- O1. **Learning Village**. To enhance the Learning Community (LC) model at Iowa State University by improving programming and availability; and to create a LC model that spans DMACC and ISU.
- O2. **Connected Curriculum**. To redesign the first-year engineering curriculum to enable flexibility and commonality across LCs; and to make selected engineering gateway courses available to DMACC students via distance education.
- O3. **Student-centered Advising**. To develop and enhance academic advising and mentoring programs for pre-college, community college, and university students.
- O4. **Coordinated Networking**. To establish a recruiting and outreach network across Iowa and with alumni using ISU Extension, DMACC, and involving parents and teachers; to tap into diverse communities of students; and to improve the awareness and understanding of engineering among those who influence student choices.
- O5. **Evaluation**. To evaluate project effectiveness and improve project activities.
- O6. **Dissemination**. To share best practices on campus in other areas of STEM, with other community colleges in Iowa, with other institutions in the Big 12 consortium, and at national meetings.

Each of the objectives O1 – O4 is related to recruitment and retention, and hence to increasing the number of graduates in engineering and other STEM fields. The recruitment and retention methods in the SEEC Project represent a combination of both proven and new approaches. The objectives are tied to recommended practices of effective recruitment, retention, and engagement, including: inclusiveness, engaged faculty, mentoring, peer support, experiential learning, student development, community involvement, relevant curricula, pre-college student/adult relationships, encouragement to consider engineering, and the influence of parents, peers, teachers/counselors, and the media.

The goal of the SEEC Project is to increase the number of engineering graduates at Iowa State University by 120 per year. As a baseline for the project, we will use an average of the ASEE 2001-2005 degree data, as shown in Table 1. The ASEE 2005 degree data represents a peak, resulting from peak enrollments in 2001 and 2002. The additional graduates represent an increase of about 15% of total engineering degrees awarded at Iowa State compared to the baseline. Enrollment and graduation data are maintained by ISU's Office of Institutional Research.

TABLE 1. Number of B.S. Degrees in Engineering for Iowa State University (ASEE)

Year	African-American	Asian-American	Hispanic	Native-American	Foreign	Caucasian	Other	Men	Women	Total
2001	6	28	9	0	93	555	0	574	117	691
2002	12	31	11	1	68	594	0	607	110	717
2003	9	27	8	1	94	711	0	696	154	850
2004	11	23	14	1	89	668	0	662	144	806
2005	18	32	24	1	83	672	38	741	127	868
Avg.	11	28	13	1	85	640	8	656	130	786

More specifically, the numerical goals of SEEC are as follows:
- Increase in graduates (degrees) per year: 120 (15% increase compared to baseline)
- Total graduates per year: approximately 910
  This total would place ISU back in the ASEE top 10 list of schools by degrees awarded. ISU is currently 12th (refer to the table provided as Supplemental). Our goal is to stay in the top 10.
- Increase in diversity of graduates per year: minority graduates by minimum of 10 (20% increase) and women graduates by a minimum of 40 (32% increase)
- Total undergraduate enrollment at the levels of 2001-2002: 4800-4900 undergraduate students

Of the 910 total graduates, we will aim for a minimum of 175 women and 75 minority graduates. These represent the following percentages of total graduates. The number of minority graduates is set rather aggressively at the 2005 total, representing both a peak degree production and a minority degree production 20-25 greater than preceding years.

Percentage of women in 2005 graduates:	14.6%	Minority students in 2005 graduates:	8.6%
Percentage of women in baseline data:	16.6%	Minority students in baseline data:	6.8%
Percentage of women in SEEC graduates:	19%	Minority students in SEEC graduates:	8.2%

These are achievable goals within the five years of the SEEC Project. We expect the project to create a positive trend in diversity that continues, such that female graduates will reach 25% within five years after the project, and minority graduates, 12%. With the number of Hispanic high school graduates in Iowa more than tripling by 2012, there is the potential for even greater strides in the number and percentage of minority graduates.

The increase in the number of graduates per year will result from several sources, as shown in Figure 1. For example, the project goal is an increase of 110 new first-year students as part of the Fall 2008 enrollment. These new students then flow through the retention path through to graduation, with some losses along the way. However, the retention path has higher capacity due to the SEEC project, and thus there are increases in the graduating class due to student retention. The third source of additional graduating students is transfer students from community colleges (here, DMACC), shown as entering during the 2nd and 3rd year of the class (this is a simplification since transfer patterns vary). Note that there are also increases in recruitment and retention at DMACC, and these are not shown; the increases are supporting bachelor's degree production in engineering and STEM fields at ISU (or elsewhere).

An estimate of the number of additional graduates *during each year of the SEEC Project* is also shown (in parentheses after "Graduates"). Since most new first-year students will not graduate until the end of the project, these increases in graduates reflect higher numbers of 2nd through 4th year retained students and transfer students resulting from project activities.

The Fall 2006 new student enrollment in engineering at Iowa State is 1320 students, an increase of almost 125 compared to 2005. Of these new students, 65% are residents and 34% non-residents; 17% are transfers, and 81% new freshmen. For additional background on enrollment data and graduation rates at Iowa State, see the Supplemental section; these are also available at the Iowa State website under Enrollment Statistics and Fact Book (refer to the Index). The total number of DMACC students enrolled at ISU in Fall 2006 is approximately 890, with 250 being in STEM majors, including 66 in engineering majors. 94 new transfers from DMACC were admitted in fall 2006 in STEM majors, and of these, 23 in engineering.

3   Project Strategy

How will the project goals be accomplished?
The objectives of the SEEC project will be achieved through a set of recruitment, retention, and engagement activities associated with developing the community, curriculum, advising, and networking components of the project. Both recruitment and retention goals are supported by project components related to objectives O1-O3 (community, curriculum, and advising). Primarily recruitment goals are supported by the networking component of objective O4.

Key project activities and their rationale are described in this section. The activities are:
Community
- A1. Build a learning village or meta-community that involves all engineering majors, special interests, lower- and upper-level years, and DMACC pre-engineering students.
- A2. Enhance student engagement and measure results through NSSE (National Survey on Student Engagement, in which ISU participates); enhance student-faculty interaction.
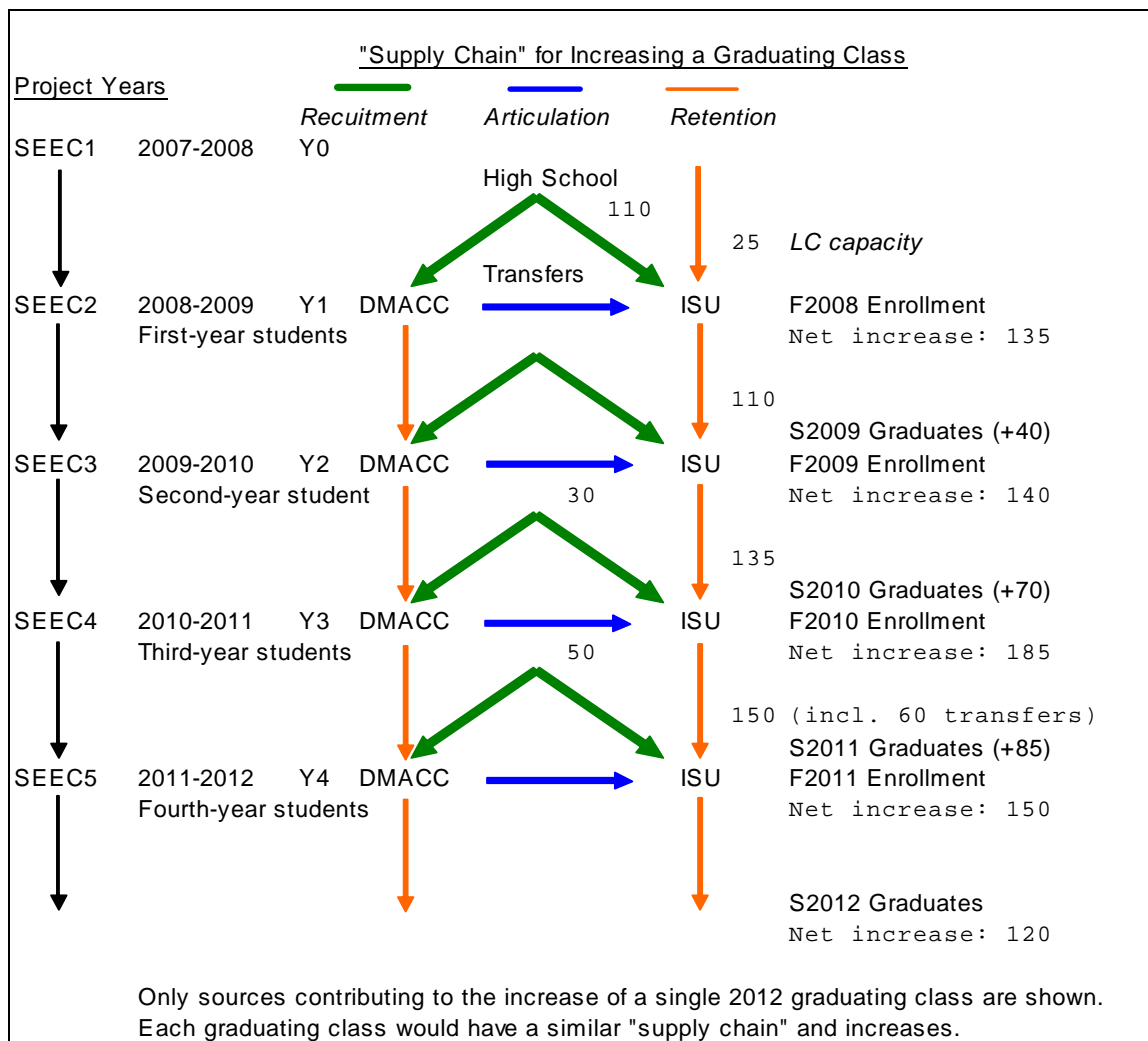
"Supply Chain" for Increasing a Graduating Class

Project Years

| | | | Recuitment | Articulation | Retention | |

SEEC1   2007-2008   Y0

High School   110

25   *LC capacity*

SEEC2   2008-2009   Y1   DMACC   Transfers   ISU   F2008 Enrollment
First-year students   Net increase: 135

110

SEEC3   2009-2010   Y2   DMACC   ISU   S2009 Graduates (+40)
Second-year student   30   F2009 Enrollment
Net increase: 140

135

SEEC4   2010-2011   Y3   DMACC   ISU   S2010 Graduates (+70)
Third-year students   50   F2010 Enrollment
Net increase: 185

150 (incl. 60 transfers)
S2011 Graduates (+85)

SEEC5   2011-2012   Y4   DMACC   ISU   F2011 Enrollment
Fourth-year students   Net increase: 150

S2012 Graduates
Net increase: 120

Only sources contributing to the increase of a single 2012 graduating class are shown.
Each graduating class would have a similar "supply chain" and increases.

Figure 1. Flowchart Illustrating the Increase in Number of Graduates for a Single Class (all numbers are estimates based on institutional data, trends, and expected project outcomes)

Curriculum

A3. Apply outcomes-based design to first-year engineering courses and identify multiple tracks to achieve outcomes that fit within the learning village.

A4. Implement interdisciplinary service-learning projects and undergraduate research projects as part of LC programming for 2nd and 3rd year students.

A5. Develop and implement the ACCESS program, Academic Courses for Colleges in Engineering Study and Scholarships, a new College of Engineering distance education program to offer selected gateway courses in engineering to community college students at community college tuition rates.

Advising

A6. Implement the Admissions Partnership Program with DMACC.

A7. Define options and paths for success and satisfaction in engineering and communicate to student, parent, and high school audiences; use best practices for diversity and STEM recruiting and advising. Use and adapt resources from Laanan's "STEM Pathway" dissemination project. Use results from Bruning's "Views" Gender in Science and Engineering project.

Networking

A8. Collaborate with ISU Extension to implement programs to improve awareness, understanding, and interest in engineering in every county in Iowa. Establish a parent network to encourage student interest.

A9. Collaborate with ISU Extension and Admissions on diversity recruiting across Iowa, seeking at least one new female student from every county and one new minority student from minority-populated counties (i.e., STEM TEC Recruitment – Talent in Every County). Offer scholarships through Extension in coordination with College of Engineering scholarship program.

A10. Develop recruiting kits for use by various stakeholders, including Extension, Admissions and alumni (PERK, Personal Engineering Recruiting Kit; or PRKS, Personal Recruiting Kit for STEM).

Evaluation

A11. Apply quantitative and qualitative evaluation methods, both formative and summative.

A12. Create and use internal and external advisory groups.

Dissemination

A13. Coordinate activities and share practices with related efforts on the ISU and DMACC campuses. Transition results to other STEM disciplines and community college partnerships.

A14. Create an active network of Big 12 institutions to advance STEM recruiting and retention in the central United States. Organize regional forums on best practices in STEM involving the Big 12, including sharing project outcomes among institutions having NSF STEP grants.

A15. Document and publish project results, and participate in national meetings.

DMACC has developed a plan to partner with ISU to achieve the project's objectives and increase the overall and specific demographic percentages for enrollment, retention, and transfer to Iowa State for engineering study.

3.1 Learning Village

Currently, the College of Engineering (COE) at ISU administers ten undergraduate degree-granting programs. Of these programs, nine have learning community (LC) initiatives. These engineering programs include Aerospace, Agricultural, Chemical, Civil (new), Computer, Construction, Electrical, Industrial, and Mechanical. All of these LCs have course linkages for freshmen students during the first semester, with several continuing into the second semester. Only three LCs continue into the sophomore year and one into the junior year. Three LCs also provide an opportunity for freshmen and sophomore students to interact with each other in an LC environment. Four additional LCs cut across all of the engineering programs. These include the Leadership through Engineering Academic Diversity (LEAD) LC for multicultural students, the Undeclared Engineering LC (CLUE), the Women in Science and Engineering (WiSE) LC, and the Engineering Transfer LC. All multidisciplinary LCs (except the Transfer LC) are freshmen LCs with an option for a living community component. Several general LC objectives are common to program development and ongoing assessment:

- To build community for entering first-year students within each curricula;
- To increase the retention of first-year students in each curricula;
- To increase recruitment of students in each program, especially underrepresented students (women and minorities);
- To enhance learning and team skills using collaborative, learning-based educational methodology in the learning community courses;
- To improve problem solving skills by solving engineering problems related to each curricula.

A matrix of engineering learning communities and their program elements is included in the Supplemental section along with a color brochure used for recruiting consistent with the University's new adventure theme.

As of Fall 2005, 76% of first year, full-time students in engineering participated in LCs (575 students) including students who participated in the Freshman Honors Program (165). The LC model has been proven to be an effective retention and student engagement program. Five years of assessment data (1998-2003) for ISU LCs has shown that retention after the first year is over 8 percent higher, on average, for learning community participants than that for non-learning community students. Five SEEC Project team members have successfully implemented LCs in their programs. Most of these programs have seen anywhere from a 5-15 percent retention increase in their first-time,

first-year students. Others have had success at the sophomore and junior levels with LC links that have increased upper-level retention even further. Detailed LC retention statistics are included as tables in the Supplemental section.

Although the COE at ISU has experienced impressive retention of first-time, first-year students due to LC experiences, it is important for the COE to enhance the LC model to improve retention of engineering students by increasing availability of LCs for all freshmen students interested in an LC and to increase the diversity of LC programs to encourage more and better participation in LCs at all class levels. Our approach is to build a learning village, i.e., a collection of connected learning communities, and to promote cross-community interactions, similar to cross-functional organizations. The learning village is a kind of meta-community, in which the students help to create the connectedness. The learning village will consist of LCs in each major as well as special interest LCs. Students may be members of more than one LC. An LC will be generalized to provide programming for multiple years, not just the first year. Possible extended programming includes discipline-specific integrated course clusters in major LCs; gateway courses at the sophomore level (added benefit of transitioning transfer students into engineering); an interdisciplinary LC or team project across LCs; shared seminars between LCs, e.g., on professional topics (career, work-balance, effective communication, personal analysis, etc.); study abroad LC; leadership LC; and any number of experiential learning LCs, including service learning. A goal is to set up the village so that LCs are not competing for students, and instead, there is some synergy in the organization. Peer mentoring is vital to any LC, and will have added value in this dynamic environment. Student engagement will increase due to increased interaction with faculty, professionals in the engineering field, and with other engineering students at various class levels.

The implementation plan for the learning village will focus first on increasing enrollment numbers in existing LCs within the COE. Second, academic programs without LCs will be strongly encouraged through incentives to start LCs. Third, as the village starts to take shape, programming will be modified to make LCs available to more students at the sophomore and junior years. Statistics between years 2 and 3 show that a sophomore level LC can have a significant impact on retention. In particular, we expect to incorporate service learning in the 2nd year; ISU's new Service Learning website will serve as a guide (http://www.celt.iastate.edu/ServiceLearning/). Service learning projects are becoming widely used in engineering education, so there is a wealth of information, including research and examples [37]. They provide a real-world application as well as a context for engineering, which increases engagement for all students and often has special appeal to women and minority students [40]. In the development of the learning village, service learning will also help to create a "community feel" through helping others. Finally, the village concept will incorporate best practices for recruitment and retention of underrepresented groups, creating an environment of diverse communities of students and faculty. ISU PIs have experience with various LC programming and, working with the COE Learning Community Task Team (LCTT, a group of LC coordinators and academic advisers), will explore the "design space" in developing a model for the learning village.

DMACC Collaboration
Students from DMACC and ISU will participate in an LC that spans or bridges pre-engineering with engineering, e.g., a 2nd year Service Learning LC, to engage students in creative and socially-relevant problem-solving through distance and face-to-face teamwork environments. The course will also be linked to an engineering orientation/career development required course so as to help students in starting a professional portfolio related to workplace competencies. Faculty from both DMACC and ISU will coordinate in-class and out-of-class activities so students become acquainted with ISU students and faculty. DMACC students will form a cohort, and interact with an ISU cohort. The LEAD and WiSE LCs will also invite DMACC students to events. We expect to disseminate and expand this effort through other community colleges, e.g., via the Iowa Department of Education Equity Leadership Team, which represents community colleges, the three Regents institutions, and a few high schools, and focuses on gender/racial equity in community college degree programs; a SEEC team member represents ISU in this group (Karen Zunkel). We expect the joint learning communities will improve retention and transfer rates, will serve as an enticement for enrollment at DMACC, and ultimately lay the groundwork for a smooth transition to the university.

3.2   Connected Curriculum

An objective of the SEEC project is to create a connected learning environment in engineering for all students. This need has been stated by many organizations, including the National Academy of Engineering, the American Society for Engineering Education, the National Science Foundation, the Boyer Commission on Educating Undergraduates in Research Universities, among others. In such an environment, college students see connections across courses and disciplines, pre-college students see connections to engineering, undergraduates see connections to research and practice, and students and teachers at all levels benefit from the interaction and mentoring that takes place in the process of discovery. The need is expressed in the following statement by Bordogna [36]:

"Most curricula require students to learn in unconnected pieces – separate courses whose relationship to each other and to the engineering process are not explained until late in a baccalaureate education, if ever. Further, an engineering education is usually described in terms of a curriculum designed to present to students the set of topics engineers "need to know," leading to the conclusion that an engineering education is a collection of courses. The content of the courses may be valuable, but this view of engineering education appears to ignore the need for connections and for integration – which should be at the core of an engineering education."

The SEEC project will create a connected learning environment, and by doing so, increase the number of engineering graduates at Iowa State through strategic recruitment and retention practices in partnership with DMACC.

We will apply an outcomes-based approach in the redesign of the first-year engineering problem-solving courses. Currently, the COE has two sets of courses. Some departments within the college have their own particular first-year engineering courses. In addition, there is a college-wide first-year engineering course that is used primarily by undeclared and transfer students. Not having a uniform first-year requirement has been one of the hurdles for incoming transfer students. We will define a set of baseline outcomes for the courses to be followed by department-specific versions of the courses and to give the courses uniformity in the joint ISU-DMACC learning community. In addition, a structured approach will help DMACC strengthen its pre-engineering curriculum to prepare students for successful transfer to ISU. Our plan is to utilize the LCTT and work with the DMACC group to improve our requirements for transfer students.

In addition to first-year course equivalencies, we have proposed a new program to make available selected "critical path" first- and second-year engineering gateway courses, i.e., engineering courses that serve as entry points into engineering programs of study and that are not typically taught at a community college. Often, these courses must be taken first to continue with other courses in the program, and thus making them available early allows transfer students to make immediate progress. The new program, called ACCESS, Academic Courses for Colleges in Engineering Study and Scholarships, will be developed and offered through Engineering Distance Education (http://www.ede.iastate.edu/) under the direction of SEEC team member Loren Zachary, Assistant Dean and Director of EDE. DMACC students who take an ACCESS course and later transfer into an engineering degree program at ISU will receive a scholarship equivalent to the difference in tuition between ISU and DMACC for the course(s) taken, creating both an academic and financial benefit and providing greater access to engineering study.

DMACC Collaboration

Curriculum improvements will optimize the quality of education at DMACC and provide the greatest benefit to students transferring on to ISU. The commonality between coursework and the university credit via articulation agreement provides a clear benefit to DMACC students and will help to assure success after transfer to ISU. At DMACC, three courses have proven to be valid indicators of student intention to articulate to a four-year institution to study engineering. These courses are trigonometry, pre-calculus, and calculus, hereafter referred to as pre-engineering courses. These courses serve as a valid baseline for illustrating the need for the proposed SEEC project. The data indicates a modest percentage transferring to ISU with particularly low numbers for enrollment and transfer among women and minorities. This proposal is aimed at increasing both overall and under-represented enrollment in pre-engineering coursework and transfer to ISU. The project team may stipulate other courses, new or modified, as the focus of this project for a joint learning community and articulation. The intent and results

would be to best serve pre-engineering students and ensure credit articulation, leading to an increase in the number of students transferring to engineering programs at ISU.

3.3   Student-Centered Advising

ISU and DMACC will work together on a highly focused student-centered recruiting/advising strategy that reaches out to inform students, parents, and high school teachers/counselors of the options and paths for success and satisfaction in engineering. We plan to create an advising network that is informative, supportive, and encouraging of individuals from all backgrounds to consider STEM fields. These activities revolve around implementing the Admissions Partnership Program between ISU and DMACC and applying the STEM Pathway dissemination project.

Admissions Partnership Program (APP). ISU and DMACC started the Admissions Partnership Program (http://www.admissions.iastate.edu/partnership) in 2006 to make it more convenient for DMACC students to transfer to Iowa State. Through the APP, DMACC students who plan to pursue a bachelor's degree at ISU will receive special benefits to promote academic success at both schools – before they enroll in ISU coursework:
- Mentoring and guidance from DMACC and ISU
- Opportunities to live in ISU housing
- Access to career resources at ISU
- ISU student pricing for athletic and cultural events
- Opportunities to participate in early orientation and registration at ISU
- Guaranteed acceptance into a bachelor's program at ISU, provided all college and program requirements are met at the time of transfer

Students who want to be a part of APP must enroll at DMACC as a degree-seeking student. Following admission to DMACC, students will work with their DMACC educational advisors to complete and submit an application form. A student who is accepted into the program by ISU:
1. Meets with his or her DMACC educational advisor each semester prior to registration;
2. Consults with an assigned ISU academic advisor each semester;
3. Follows a course of study at DMACC that will meet ISU entrance requirements and fulfill college and program requirements for his or her intended major;
4. Submits an "Intent to Enroll" form and pays an application fee to ISU, one semester prior to transferring to Iowa State.

STEM Pathway Dissemination Project. This NSF-sponsored project under SEEC PI Frankie Laanan has the following objectives (www.pathway2stemdegree.org):
- to develop media presentations in the form of educational videos that educate the public and college students about the pathway to a STEM baccalaureate degree from two-year colleges;
- develop a STEM Pathway: Transfer Student Guide (TSG) for prospective students attending two-year colleges that educates students about the transfer process; and
- to develop a website that will be used to disseminate educational resources to educators (two- and four-year institutions), academic counselors/advisors, Transfer Center coordinators, students in two-year colleges, business and industry, researchers, policymakers, and the public.

The dissemination project provides resources for a diverse audience as a means to increase understanding of the factors that influence students' self-concept, educational aspirations, and academic preparation to pursue a pre-STEM emphasis in the community college and to be ready to pursue a STEM bachelor's degree. Resources under development include videos, a guidebook, and a website. The videos include: Pathway to a STEM Bachelor's Degree; Research on Gender & Ethnicity in Science & Engineering; Recruiting and Retaining Women and Minorities in Pre-STEM Majors; and Community College and University Partnerships. ISU and DMACC will incorporate these resources in recruiting and advising students, including training of and use by ISU Extension in the STEM TEC initiative.

DMACC Collaboration

The student support services and mentoring associated with these activities are essential to effectively recruit, retain, and transfer underrepresented students to a four-year engineering degree program. DMACC will provide the tutoring, study skills training, and counseling that are often needed. DMACC will deliver an information program, including instructor visits, to central Iowa high schools, explaining the different fields and opportunities in engineering. The requisites for academic success and benefits of the ISU/DMACC partnership will also be presented.

3.4   Coordinated Networking

Three emerging areas of thought have informed the development of the SEEC recruiting (and outreach) plan. First, one of the highest priorities for the National Academy of Engineering has become improving the public awareness and understanding of engineering. This is embodied in the PUE program, Public Understanding of Engineering (http://www.nae.edu/nae/pubundcom.nsf/weblinks/naew-5rcrcx?opendocument), comprised of three projects: Developing Effective Messages to Improve Public Understanding of Engineering; Raising Public Awareness of Engineering; and National Engineers Week. The PUE program is using print and electronic media, public and private forums, and strategic communications to develop messages promoting a more positive public image of engineering. The report states that significant improvements require coordinated efforts and consistent messages.

Second, also via the National Academy of Engineering, in the Summer 2006 issue of the *The Bridge*, Jacquelyn Sullivan authors "A Call for K-16 Engineering Education" (http://www.nae.edu/NAE/ bridgecom.nsf/weblinks/MKEZ-6QDLB3?OpenDocument). Her observations include: "only 3 percent of U.S. adults perceive engineering as creative"; "only 2 percent of U.S. college-bound eleventh-grade female students indicate an interest in majoring in engineering"; "mid-teen girls… have personally experienced little encouragement to consider engineering, and do not understand what engineering is about"; "the people who influence today's teenage girls are, in rank order, parents, peers, teachers/counselors, and the media." All of these observations reinforce the need for the PUE program and parents as a target audience. She recommends that teaching-based community service by engineering students is a means to "spread the word about the value of engineering to students, teachers, and parents."

Third, the connections in a "recruiting network" are inspired by the principles of social networking and information dissemination, for example, as presented in M. Gladwell's *The Tipping Point* and A.-L. Barabasi's *Linked*. It is important to identify hubs and make connections. Consider terms from *The Tipping Point*, specifically Connectors, Mavens, and Salesmen. These are special roles people play in social epidemics to spread ideas. A Maven has lots of information and wants to share it; mavens provide the message. A Connector knows lots of people in different worlds (i.e., social circles); connectors spread the message. A Salesman is persuasive; salesmen sell the message. The coordinated networking of the SEEC project will fulfill these roles among engineering faculty, staff and students, ISU Extension, Admissions, alumni, parents, etc. An important piece of the networking process will be packaging the message to recruit students into engineering at ISU. We propose to develop a set of informational and marketing materials referred to as an "ISU PERK," or Personal Engineering Recruiting Kit. Staff will use the kits, and kits will be available to COE alumni and other stakeholders interested in talking about ISU engineering to prospective students and their parents. A kit might be specialized for particular events or specific groups. Early feedback from the Engineering College Industrial Advisory Council indicates enthusiasm for helping with the recruiting effort.

Elements of the recruiting plan are illustrated in Figure 2, annotating a map of the counties of Iowa showing undergraduate enrollment at ISU in fall 2005 per county. We will partner with DMACC to recruit in central Iowa and with other community colleges elsewhere in the state. DMACC is located in counties with relatively high percentages and numbers of African-American and Latino students. Of the 99 counties, 36 had no female students enrolled in engineering at Iowa State during 2003-2005. Twenty counties had only one female student enrolled. Over this three year period, only Linn, Polk, Scott, and Story counties totaled fifteen or more female enrollees in engineering. Thus there is a significant opportunity to expand the pool of under-represented students through public awareness (assuming sufficient preparation). We propose to use the DMACC and ISU Extension networks to
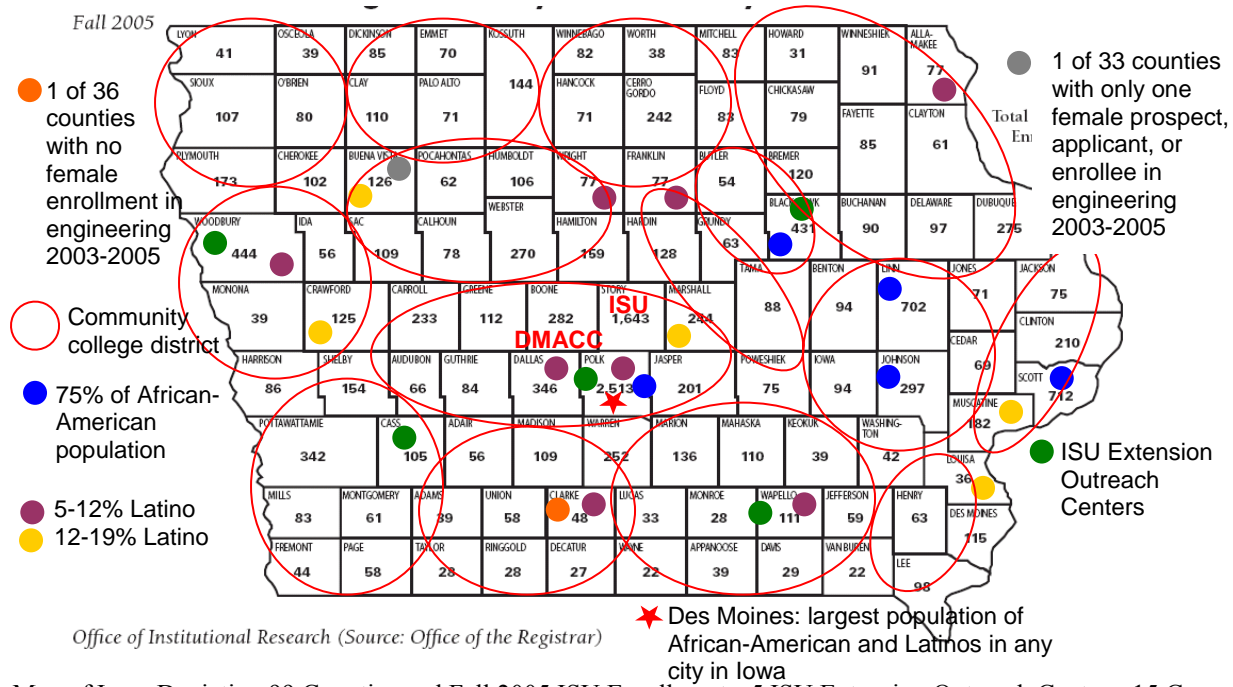
Figure 2. Map of Iowa Depicting 99 Counties and Fall 2005 ISU Enrollments, 5 ISU Extension Outreach Centers, 15 Community College Districts (approximate), 13 Counties with Significant Latino Populations, 5 Counties with Significant African-American Population, and 2 Counties (of 51) with Low Awareness/Interest in Engineering by Women.

implement a new recruitment effort called "STEM TEC – Talent in Every County". STEM TEC will partner with Extension offices in each of the 99 counties and with the five Extension Outreach Centers. The goal is to enroll at least one new female student from every county and one new minority student from minority-populated counties. SEEC scholarships will be through Extension in coordination with the current College of Engineering scholarship program. With ISU Extension, we will also identify counties that need to improve high school preparation for college-level STEM.

3.5 Dissemination Plan

Activities and outcomes of the SEEC project will be shared within ISU and DMACC, with other colleges in Iowa, with other land-grant institutions and the extension community, with the network of Big 12 institutions, with universities and colleges interested in learning communities, and with the engineering education profession. Within ISU, SEEC team members will inform others through their participation on related ISU committees (e.g., Articulation Coordination Council, Retention Task Force). An internal advisory board with members from across campus will also be well-informed. A project website will be maintained. Results will be presented at national meetings on engineering and STEM education, on higher education, and at professional meetings on recruiting and advising. Every other year of the project, ISU will host (or sponsor at the annual ASEE conference) a meeting of Big 12 institutions to share best practices on STEM recruiting and retention, including participation by current NSF STEP projects at the University of Nebraska, Kansas State University, the University of Oklahoma, and Texas A&M University. This coalition of schools, as shown in Figure 3, has the potential to dramatically impact the image of engineering in the central United States.
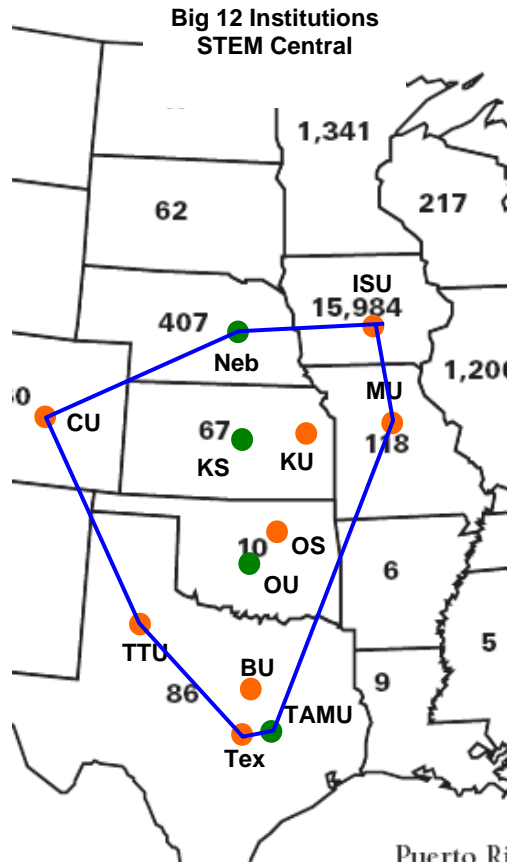

Figure 3. Central U.S. Network of Big 12 Universities; STEP Projects in Green.

4   Project Success

Why will the project succeed?
The SEEC project will achieve its goals through the application of proven, research-based practices, alignment with national recommendations, institutional and SEEC team strengths, and expert evaluation. In addition, related activities at ISU are synergistic with the SEEC project objectives and will indirectly contribute to successful outcomes.

4.1   Institutional Strengths

Learning Communities
Learning communities at Iowa State are a highly successful partnership between Academic Affairs and Student Affairs. Nationally, the history of learning communities can be traced to an experimental educational program in the 1920s (the Meiklejohn Experimental College at the University of Washington). Learning communities can now be found at four to five hundred colleges and universities across the nation [10]. According to Smith, "Learning communities are a broad structural innovation that can address a variety of issues from student retention to curriculum coherence, from faculty vitality to building a greater sense of community within our colleges." Learning communities usually involve purposive groupings of students and coordinated scheduling. In addition, they may involve coordinated approaches to learning and an emphasis on connecting material across disciplinary boundaries. Student involvement in learning communities at ISU has steadily increased since they began as a grass roots effort in 1994, with the first learning community implemented in the fall of 1995. As of 2006, the following highlights are reported for ISU learning communities:
- 57 learning communities on campus
- 51% of first-year students in a LC
- 90% vs. 82%: one-year retention for fall 2004 LC students vs. non-LC students
- 76% vs. 62%: six-year graduation rates for LC students vs. non-LC students
- Top 25 national rating by U.S. News and World Report
- Overall student satisfaction and engagement is higher for LC students.
- LC students report high levels of engagement on the NSSE benchmarks (National Survey of Student Engagement).

Learning communities at ISU have already proven to be sustainable, as some of the existing LCs have been in place for nearly a decade. To a large extent, there is an institutionalized learning community culture at Iowa State, evidenced in part through the 2005-2010 strategic plan (see Supplemental section). Learning community success at ISU is well-documented in online reports (http://www.iastate.edu/ ~learncommunity/reports.html); see also [35]. ISU has benefited from and continues to contribute to the body of work on LCs. [1] [2][3][4][5][6][7][8][9][10]

Articulation Agreements
Public institutions in the state of Iowa have a long history of voluntary articulation. Statewide articulation agreements are available online (http://www.admissions.iastate.edu/equiv/pdf/lacts_1.pdf). ISU Admissions maintains equivalency guides with all 15 Iowa Community Colleges, as well as 12 Illinois schools, 12 Minnesota schools, and selected institutions in Missouri, Kansas, and Nebraska (see http://www.admissions.iastate.edu/equiv/). A comprehensive list of agreements between ISU and each Iowa Community College is available online (http://www.admissions.iastate.edu/equiv/pdf/lacts_2.pdf). The College of Engineering maintains a list of transfer plans for each community college (http://www.eng.iastate.edu/transfer/transfer-guides/community-colleges/). Efforts to promote and enhance articulation continue within ISU as well. The Articulation Coordination Committee (ACC), chaired by the Associate Provost for Academic Programs, works to improve articulation and student recruitment efforts. Action items include a pilot on-site registration, dual enrollment agreements, academic partnerships with selected community colleges, and making transfer plans more accessible to prospective transfer students via the Web.

ISU Extension
ISU was founded on the ideals that higher education should be accessible to all and that the university should teach liberal and practical subjects. These ideals are integral to the land-grant university, created by the Morrill Act

passed by Congress in 1862. Iowa was the first state to accept the law's provisions. ISU subsequently pioneered the idea of Extension – extending the university's knowledge to people throughout the state. ISU Extension is a vital part of the university's engagement with the public and has a presence throughout the state (http://www.extension.iastate.edu/).

Program for Women in Science and Engineering (PWSE)

The mission of the Program for Women in Science and Engineering is to encourage women and girls of all ethnic backgrounds to pursue careers in STEM fields, thereby enriching those professions through the full participation of women. The PWSE Director is a member of the SEEC team. PWSE collaborates with colleges and departments across the university to provide programs giving women the opportunity for exploration, professional development, and success in STEM fields. The mission of PWSE is in congruence with the university's mission to increase the diversity of the institution, by increasing the number of women in degree programs where they are traditionally under-represented. (http://www.pwse.iastate.edu/)

4.2   Evaluation Plan

Project evaluation and outcomes assessment will be coordinated through the Research Institute for Studies in Education (RISE) at Iowa State University. Assessment will be led by Dr. Mack Shelley, a senior faculty member holding a joint appointment between the Department of Statistics and the Department of Educational Leadership and Policy Studies serving as Director of RISE. He and other RISE staff have extensive experience with the evaluation of learning communities, course redesign (particularly of mathematics and English curriculum), program evaluation, advanced data analysis, and grants implementation.

The SEEC activities and research questions will be investigated using methods appropriate for experimental and quasi-experimental studies, including analysis of variance, analysis of covariance, logistic regression (for dichotomous outcomes such as student graduation/nongraduation or passing/not passing), hierarchical linear models, and structural equation models. Throughout these analyses, the central concern is whether there is a statistically significant main effect of SEEC participation. Potentially confounding variables will be accounted for as covariates.

Accurate and reliable measurement of expected student outcomes is essential to successful evaluation of the SEEC project at Des Moines Area Community College (DMACC) and Iowa State University (ISU). Student recruitment and retention results following SEEC implementation will be compared against the historical record for the two institutions. In particular, we will examine student persistence within major, within disciplinary area, and within the institution from semester to semester, as well as the impact on persistence of student participation in learning communities, and the impact on student performance (measured by grade point average). Student engagement will be measured by surveys validated for use in this evaluation, and to the extent possible including results from students who participated in the widely-used National Survey of Student Engagement. Changes in student diversity will be measured by tracking student movement from DMACC to ISU and comparing student distribution across categories of gender and ethnicity before and after SEEC implementation.

Evaluation will be undertaken by organizing key evaluation questions in a manner that allows for many models of evaluation or methods of data collection. A framework shown to be particularly useful in assessing education evaluation research that will be used in the present evaluation effort is the a-e-I-o-u approach [95]. This approach organizes evaluation questions into five areas:

(a)ccountability
- Did the project team do what it said it was going to do?
- Were the activities related to the goals and objectives of the project actually completed?

(e)ffectiveness
- How well did the activities meet the objectives of the project?
- Were the objectives accomplished, in light of the attitudes, opinions, and knowledge of the participants?

(I)mpact
- What changes have occurred as a result of the project?
    - New methods
    - Changes in the curriculum

- o Policy innovations
- How are these changes related to the stated expected outcomes of the project?
- How have individual and group attitudes been changed?
- How have individual and group behavior been affected?
- What forms of institutional change have occurred?

(o)rganizational context
- Which structures, policies, or events affected the project?
  - o Based on data collected from interviews with key personnel, focus groups made up of those most affected by the project, or analysis of documents.
- What helped to achieve the goals and objectives of the project?
- What made it difficult to achieve project goals and objectives?

(u)nanticipated outcomes
- What happened that was not planned for or expected?

Addressing the first three components—accountability, effectiveness, and impact—is particularly important for ascertaining the success of the project. Answering questions related to organizational context and unanticipated outcomes can provide additional evaluation information about how the study fits into broad objectives and the likely broader effects that the work may have. Our evaluation instruments, methods, and findings will be directed toward fulfilling these objectives.

Assessment will be both formative and summative. The primary purpose of formative assessment will be to provide data and interpretations leading to successful midcourse enhancements in program implementation and to ascertain whether measurement instruments are providing adequate reliability and validity. Summative assessment methods will be employed to determine the longer-term impact of program implementation on students, faculty, and their academic institutions (Des Moines Area Community College and Iowa State University). The primary objective of both formative and summative assessment efforts will be to measure the effect of SEEC implementation on student outcomes. Both quantitative and qualitative data will be collected, using validated sample survey instruments, collection of institutional data on student and faculty achievement and growth, focus groups, and individual interviews.

A major objective for the project is to inform stakeholders about college/career paths and about how to use new ISU Extension materials to inform students and parents about engineering and STEM, in pursuit of the National Academy of Engineering's Public Understanding of Engineering program goal to improve public understanding of engineering. County extension staff who participate in the informational and instructional sessions at the annual extension conference will be given a survey to assess their understanding of how best to communicate to parents, students, teachers, counselors, the general public, elected representatives, policymakers at all levels of government, and opinion leaders in Iowa the critical societal roles played by engineers and the technologies they create, and the career potential of engineering. Emphasis in the survey will be placed on how engineering has made change and progress possible over time and the impacts of engineering on quality of life and economic prosperity. The survey will emphasize the usefulness extension staff see of reaching these various audiences with coordinated, consistent, and effective communication through print and electronic media, public and private forums, and strategic communications vehicles.

Based on the responses from extension staff and experience of the investigators, we will construct appropriate instruments for each audience element and conduct pilot tests of the effectiveness of the messages transmitted and the knowledge tapped by these instruments. Rigorous tests will be conducted to evaluate the validity and reliability of these survey instruments, in conjunction with focus group data that will provide essential contextual information to buttress the quantitative findings from the questionnaire data. Additional pilot tests and focus groups will be conducted with members of the engineering community to evaluate the content and appropriateness of the instruments. These evaluation efforts will be informed by the previous work by Davis and Gibbin [94]. Evaluations among members of the engineering community of the choices available for delivering the highest-impact message, particularly through the mass media, will be concentrated on representatives of the coalition of more than 75 engineering, professional, and technical societies and more than 50 corporations and government agencies that cooperate annually for National Engineers Week. Particular emphasis will be placed on the most effective methods for attracting women and young people generally into the engineering profession through contacts with groups and

individuals taking part in Introduce a Girl to Engineering Day, New Faces of Engineering, DiscoverE, and similar activities directed to expanding participation in the engineering profession. Reactions from multiple group and individuals will be obtained regarding the utility of websites such as Celebration of Women in Engineering, EngineerGirl!, Greatest Engineering Achievements of the 20th Century, Technically Speaking, television productions available through the ResearchChannel, and selected print publications such as Engineering as a Social Enterprise.

Analysis of quantitative data is conducted using advanced general statistical software, including the Statistical Analysis System (SAS, version 9.0 or later), the Statistical Package for the Social Sciences (SPSS, version 12 or later), and advanced specialized statistical software, including Hierarchical Linear Models (HLM, version 5.04 or later) and Structural Equation Model (SEM) LInear Structural RELations (LISREL, version 8.50 or later), and Analysis of Moment Structures (AMOS, version 5.0 or later). HLM [50],[85],[88],[89] is appropriate for the analysis of data measured on different levels—for example, both student-specific achievement variables and variables measuring the effectiveness of the instructors or mentors with whom they interact. SEM data analysis [48][49][86][87] is appropriate when causal interpretations are desired, measuring both the direct and indirect effects of exogenous variables (typically, demographic variables) on endogenous (dependent, often behavioral outcomes) variables and the effects of some endogenous variables on other endogenous variables. HLM can be used to analyze student performance using individual student demographic, attitudinal, behavioral, and outcome data at one level and contextual characteristics (e.g., class size or level, degree of implementation of LC or metacommunity, or instructor/mentor differences). HLM enables researchers to explain how individual student differences (Level 1) and differences in learning environment context (Level 2) contribute to explaining variance in student outcome measures. Moreover, researchers also can examine the direct effects of environment-level factors on the average outcome (the intercept) and the indirect effects of environment-level factors on the individual characteristics and outcomes (that is, the slopes). In addition, HLM enables researchers to investigate how much the second-level variables amplify or reduce the effects of the first-level variables ([88].

The qualitative data collected will be analyzed using appropriate software packages, notably Atlas.ti and Nvivo, which provide the basis for the sophisticated analysis of textual information. The emergent content of the qualitative data will be central to providing the context for understanding and interpreting the meaningfulness of the quantitative data. Qualitative data will be collected through document analysis (of, for example, relevant course syllabi, student handbooks, etc.), individual interviews, and focus group sessions of students, faculty, and staff.

The proposed SEEC project plan has been improved based on reviews from a prior STEP proposal submission. The Learning Village and Evaluation plans received very positive comments and have been fine-tuned based on project revisions. The collaboration with DMACC is significantly enhanced due to new agreements and proposed activities. The ACCESS program with DMACC and the STEM TEC initiative with ISU Extension are novel additions. Teaming up with Extension to develop a recruiting network and public awareness campaign about engineering is a new and promising approach. We have also strengthened the research background for the project.

4.3 Management Plan

The project team at ISU and DMACC has been assembled with the broader vision of the SEEC project in mind. The ISU team consists of PIs in engineering and education, as well as Senior Personnel in selected areas. The team is exceptionally qualified to achieve the project objectives. The PI and senior personnel qualifications are given in their biographical sketches. The PIs have excellent track records as effective and innovative teachers and engineering education researchers. The team will be led by the PI (Rover), however, all team members will have shared responsibility for project outcomes. Team members have responsibilities for the objectives (where L refers to Leader, C to Contributor), as shown below. Laanan provides expertise from the STEM Pathway project on community college aspects of several objectives. Bruning brings expertise from the Gender in Science and Engineering research project on girls' views of engineering. Zunkel will provide guidance on monitoring the effect the project on other STEM majors and transitioning project activities into other areas. The new SEEC project coordinator will share duties on several objectives as shown. Rover, the new coordinator, and a budget assistant will administer the project budget.

Member	O1 – Learning Village	O2 – Curr.	O3 – Advising	O4 - Networking	O5 – Eval.	O6 – Dissem.
Rover	Project Management					L
Bruning				L	C	
Laanan	L – comm.college		L– comm.college	L– comm. college		L– comm. college
Mickelson	L	L				
Shelley					L	
Goodwin	C		L	C		
Knight	L – diversity	L– diversity		L– diversity		
Mina	C	C				
Zachary		L– EDE				
Zunkel	C			C		C
new	L		C	L	C	C

Expenditures related to project objectives and activities are summarized in the budget justification. Milestones associated with the project activities are denoted in the chart below.

Year.Semester	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15
1.1 (fall 07)	*		**	*	**	*	**	**	**	*	*	*	*	*	*
1.2 (spring 08)	*		**	*	**	*	**	*	**	**	*	*	*	**	*
2.1 (fall 08)	**	*	*	*	**	*	**	**	*	**	**	*	*		*
2.2	**		*	**	**	*	**	*	*	**		*	*		*
3.1 (fall 09)	*	*	*		*	*	**	**	**	*	**	*	*	*	*
3.2	*		*	**	*	*		*	**	*		*	*	**	*
4.1 (fall 10)	**	*			*	*	*		*		**	*	*		*
4.2	**			**	*	*		*				*	*		*
5.1 (fall 11)	*	*			*	*	*		*		**	*	*	*	*
5.2 (spring 12)	*			*	*	*		*			**	*	*	**	*

The following activities will occur annually: mid-year and year-end outcomes analysis within the SEEC team; External Advisory Group meeting during fall and/or spring semesters, coordinated with the Engineering College Industrial Advisory Council (ECIAC) meeting; Internal Advisory Group, involving representatives from academic affairs and student affairs units, other colleges, and Extension, at end of fall and spring semesters; quarterly joint DMACC / ISU team meetings; ISU Extension Annual Conference in fall semester; and other conferences. During years 1, 3, and 5, there will be a Big 12 forum. In Year 3, there will be a formal project review with NSF.

A Sharepoint intranet webspace will be set up to support project management at ISU and DMACC, including meeting agendas, project documents, discussion postings, calendar, team information, etc. We expect most of the project activities to develop infrastructure that will continue to be used (courses, curricula, practices, resources, tools, etc.) beyond the end of the grant period. Staffing will need to be fully supported by the unit budget, and that will be accomplished through fiscal planning. The learning village and peer mentoring require funding, however, with LCs as a strategic priority of the university, support is likely.

The DMACC team will be led by Dr. Harry McMaken, Math and Engineering faculty, and Dr. Kim Linduska, Executive Vice President, Academic Affairs, whose full qualifications are given in their biographical sketches. DMACC's complete work plan is given in the Supplemental Docs section. Excerpts are included in this proposal.

4.4   Related Activities that Enhance Success

There are a number of activities that are synergistic with the SEEC project, and will positively reinforce SEEC objectives in the short or long term. For example, the College of Engineering and ISU offer effective pre-college outreach programs, such as PWSE's Taking the Road Less Travelled and the COE-hosted First Lego League Iowa championship. Such pipeline activities are essential. The COE has two new programs aligned with "Engineer of 2020" priorities, the Engineering Leadership Program and the Minor in Engineering Studies (for non-engineering majors). These programs influence the image of engineering. The COE will fill 50 new faculty positions in interdisciplinary research and education clusters. ISU Admissions also has intensified its marketing and recruiting efforts out-of-state, internationally, and with other community colleges. SEEC outcomes will be transferable.

References

[1] Angelo, T. A. (1997). The campus as learning community. *AAHE Bulletin, May* 3-6.

[2] The Boyer Commission on Educating Undergraduates in the Research University. (1998). *Reinventing undergraduate education: a blueprint for America's research universities.* Stony Brook, NY: State University of New York at Stony Brook for the Carnegie Foundation for the Advancement of Teaching.

[3] Cross, K. P. (1998). Why learning communities? Why now? *About Campus, July/August,* p. 4-11.

[4] Huba, M. (2000). Focus on learning: A newsletter of the Office of the Vice Provost for Undergraduate Programs at Iowa State University, Vol. 1, No. 1.

[5] Lenning, O.T. & Ebbers, L.H. (1999). *The powerful potential of learning communities: improving education for the future.* ASHE-ERIC Higher Education Report Volume 26, Smith, B.L. (2001). The challenge of learning communities as a growing national movement, *Association of American Colleges and Universities Peer Review 4*(1). Available: http://www.aacu-edu.org/peerreview/pr-fa01feature1.cfm (accessed 01/02/02).

[6] No. 6. Washington, D.C.: The George Washington University, Graduate School of Education and Human Development.

[7] Tinto, V. (2000). What have we learned about the impact of learning communities on students? *Assessment Update, 12*(2), 1-2,12.

[8] Tinto, V., Goodsell-Love, A., and Russo, P. (1993). Building community. *Liberal Education, Fall,* p. 17-21.

[9] U.S. Department of Labor, Bureau of Labor Statistics. http://www.bls.gov/blshome.htm, January 7, 2001.

[10] Smith, B.L. (2001). The challenge of learning communities as a growing national movement, *Association of American Colleges and Universities Peer Review 4*(1). Available: http://www.aacu-edu.org/peerreview/pr-fa01feature1.cfm (accessed 01/02/02).

[11] American Association for the Advancement of Science. 1989. Science for all Americans: Project 2061. New York: Oxford University Press.

[12] American Association for the Advancement of Science. 1990. The liberal art of science: Agenda for action. Washington, DC: American Association for the advancement of Science.

[13] Angelo, T. and K. Cross. 1993. Classroom assessment techniques: a handbook for college teachers.

[14] Brown, T. L. and J. P. Lassoie. 1998. Entry-level competency and skill requirements of foresters: What do employers want?. Journal of Forestry. Vol. 96, No. 2. pp. 8-14.

[15] Chuska, K. R. 1995. Improving classroom questions.

[16] Costa, A. L., and Kallick, B. (2000). Discovering & exploring habits of mind. Alexandria, VA: Association for Supervision and Curriculum Development.

[17] Gardiner, L. 1994. Redesigning higher education: Producing dramatic gains in student learning. Vol. 23, No. 7. Washington, DC: The George Washington University, Graduate School of Education and Human Development. (ASHE-ERIC Higher Education Report).

[18] Gough, P. B. 1987. The key to improving schools: an interview with William Glasser. Phi Delta Kappan, 68, 656-662.

[19] Jungst, S. E., B. L. Licklider, & J. A. Wiersema. 2003. Providing support for faculty who wish to shift to a learning-centered paradigm in their higher education classrooms. Journal of scholarship of teaching and learning. Vol. 3, No. 3, pp. 69-81.

[20] Jungst, S. E., J. R. Thompson, and G. J. Atchison. 2003. Academic controversy: fostering constructive conflict in natural resources education. Journal of Natural Resource Life Science Education. Vol. 32, pp. 36-42.

[21] Leamnson, R. 2000. Learning as a biological brain change. Change: The magazine of higher learning. 32(6), 34-40.

[22] Marzano, R. J. and D. J. Pickering. 1997. Dimensions of learning

[23] Marzano, R. J., D. J. Pickering, J. E. Pollock. 2001. Classroom instruction that works. Association for Supervision and Curriculum Development.

[24] Nastasi, B. K., and D. H. Clements. 1991. Research on cooperative learning: implications for practice. School Psychology Review Vol 20, No. 1:110-131.

[25] National Research Council. 1995. National science education standards. Washington, DC: National Academy Press.

[26] National Research Council. 1996. From analysis to action: undergraduate education in science, mathematics, engineering, and technology. Washington, DC: National Academy Press.

[27] National Research Council. 2001. How people learn: brain, mind, experience, and school. National Academy Press. Washington D.C. 374pp.

[28] National Science Foundation. 1996. Shaping the future: New expectations for undergraduate education in science, mathematics, engineering, and technology. Report on the Review of Undergraduate Education. Washington, DC: National Science Foundation Directorate for Education and Human Resources.

[29] Salvin, R. E. 1990. Cooperative learning: theory, research, and practice. Englewood, NJ: Prentice Hall

[30] Wiggins, G. and J. McTighe. 1998. Understanding by design. Association for Supervision and Curriculum Development. Alexandria, VA.

[31] The Seven Principles of Good Practice in Undergraduate Education: http://learningcommons.evergreen.edu/pdf/fall1987.pdf

[32] Zunkel, K.A. (2002) Relationships among learning community participation, student self-efficacy, confidence, outcome expectations and commitment. Iowa State University

[33] C. Gandhi (1999) A longitudinal evaluation of factors associated with retaining women in science and engineering. Iowa State University

[34] http://learningcommons.evergreen.edu/pdf/PeerReview2001.pdf

[35] Samantha Beres, "Bonuses abound in learning communities," Inside Iowa State, January 28, 2005, http://www.iastate.edu/Inside/2005/0128/learncomm.shtml.

[36] J. Bordogna, "Next Generation Engineering: Innovation Through Integration," Keynote Address, NSF Engineering Education Innovator's Conference, April 8, 1997, www.nsf.gov/od/lpa/forum/bordogna/jb-eeic.htm

[37] Ward, H. and Zlotkowski, E. (eds.) Acting Locally: Concepts and Models for Service-Learning in Environmental Studies, American Association for Higher Education, Washington, DC, 1999.

[38] Goodman Research Group, Inc. (2002). Final Report of the Women's Experiences in College Engineering (WECE) Project. Cambridge, MA: Goodman Research Group, Inc. (www.grginc.com)

[39] Seymour, E. & Hewitt, N.M. (1997). Talking About Leaving: Why Undergraduates Leave the Sciences. Boulder, CO: Westview Press. (Chapters 5 and 6)

[40] National Council for Research on Women [NCRW]. (2001). Balancing the Equation – Where are Women and Girls in Science, Engineering, and Technology? New York: The National Council for Research on Women. (pp. 46, 65, 83 and 97)

[41] Howe, N., & Strauss, W. (2000). Millennials Rising: The Next Generation. New York: Vintage Books.

[42] Howe, N, & Strauss, W. (2003). Millennials Go to College. Washington, DC: American Association of Registrars in Admissions Officers and LifeCourse Associates.

[43] Howard-Hamilton, M. F. (2003). Meeting the Needs of African American Women. New Directions for Student Services, 104, 19-28; 53-66.

[44] Ginorio, A. & Huston, M. (2001). Si, Se Puede! Yes, We Can: Latinas in School. AAUW Education Foundation. (www.aauw.org)

[45] Eisenhart, M. A. & Finkel, E. (1998). Women's Science. Chicago, IL: The University of Chicago Press. Lave J. & Wenger, E, (1991). Situated learning: Legitimate peripheral participation. Cambridge: Cambridge Press

[46] Aronson E., *The Jigsaw Classroom*, Sage, 1978.

[47] J. Bordogna, "Next Generation Engineering: Innovation Through Integration," Keynote Address, NSF Engineering Education Innovator's Conference, April 8, 1997, www.nsf.gov/od/lpa/forum/bordogna/jb-eeic.htm

[48] Bollen, K.A. (1989). *Structural equations with latent variables*. New York, NY: Wiley.

[49] Bollen, K.A., & Long, J.S. (Eds.). (1993). Testing structural equation models. Newbury Park, CA: Sage.

[50] Bryk, A., & Raudenbush, S. W. (1992). Hierarchical linear models for social and behavioral research: Applications and data analysis methods. Newbury Park, CA: Sage.

[51] J.R. Davis, Interdisciplinary Courses and Team Teaching: New Arrangements for Learning, American Council on Education and Oryx Press, 1995.

[52] Mary Huba and Jann Freed, Learning-Centered Assessment on College Campuses, Allyn & Bacon, 2000.

[53] J.D.McCowan and C.K.Knapper "An Integrated and Comprehensive Approach to Engineering Curricula, Part One: Objectives and General Approach," *International Journal of Engineering Education*, Vol. 18, No. 6, pp. 633-637, 2002.

[54] J.D.McCowan and C.K.Knapper, "An Integrated and Comprehensive Approach to Engineering Curricula, Part Two: Techniques," *International Journal of Engineering Education*, Vol. 18, No. 6, pp. 638-643, 2002.

[55] J.D.McCowan and C.K.Knapper, "An Integrated and Comprehensive Approach to Engineering Curricula, Part Three: Facilities and Staffing, " *International Journal of Engineering Education*, Vol. 18, No. 6, pp. 644-651, 2002.

[56] Project LEA/RN (Learning Enhancement Action/Resource Network), Iowa State University, Feb. 2000, http://www.educ.iastate.edu/ess/learn.htm.

[57] John Seely, Brown and Paul Duguid, *The Social Life of Information*, Harvard Business School Press, 2002.

[58] Stuart Shulman, Lisa Thrane, and Mack Shelley, "eRulemaking," in G. David Garson (Ed.), Handbook of Public Information Systems (2nd edition, revised and expanded). New York, NY: Marcel Dekker-forthcoming.

[59] Mack Shelley, Lisa Thrane, Stuart Shulman, Evette Lang, Sally Beisser, Teresa Larson, and James Mutiti, "Digital Citizenship: Parameters of the Digital Divide," Social Science Computer Review, 22(2)-forthcoming.

[60] Mack C. Shelley, Lisa E. Thrane, and Stuart W. Shulman, "Generational Differences in Informational Technology Use and Political Involvement," submitted to the Social Science Computer Review.

[61] Stuart Shulman, Sally Beisser, Teresa Larson, and Mack Shelley, "Digital Citizenship: Lessons Learned as Service-Learning Meets the Digital Divide," in Proceedings of the Second National Conference on Digital Government Research, May 20-22, 2002 (Digital Government Research Center).

[62] Stuart Shulman, Sally Beisser, and Mack Shelley, "Digital Citizenship: Expanding Information Technology Literacy with a Service-Learning Approach," presented at the Instructional Technology Research Forum, Iowa State University, Ames, IA, October 25, 2001.

[63] Stuart Shulman, Sally Beisser, Teresa Larson, and Mack Shelley, "Digital Citizenship: Lessons Learned as Service-Learning Meets the Digital Divide," presented at the dg.o2002 National Conference on Digital Government Research, Los Angeles, CA, May 19-22, 2002.

[64] Stuart Shulman, Sally Beisser, Teresa Larson, and Mack Shelley, "Digital Citizenship: Lessons Learned as Service-Learning Meets the Digital Divide," presented at the 2002 Annual Meeting of the American Political Science Association, August 29-September 1, 2002, Boston, MA.

[65] Stuart Shulman, Mack C. Shelley, and Lisa Thrane, "Digital Citizenship: Parameters of the Digital Divide," presented at the dg.o2003 National Conference on Digital Government Research, Boston, MA, May 18-21, 2003.

[66] Stuart Shulman, Mack C. Shelley, and Lisa Thrane, "Digital Citizenship: Parameters of the Digital Divide," presented at the First Annual Interdisciplinary Research Institute for Survey Science Workshop, May 27-28, 2003, Ames, IA.

[67] Mack Shelley, Lisa Thrane, Stuart Shulman, Evette Lang, Sally Beisser, Teresa Larson, and James Mutiti, "Digital Citizenship: Parameters of the Digital Divide," presented at the 2003 Joint Statistical Meetings, San Francisco, CA, August 3-7, 2003.

[68] Mack Shelley, Lisa Thrane, and Stuart Shulman, "Parameters of the Digital Divide," invited presentation at the Science and Society seminar series of the Iowa State Institute of Science and Society, September 30, 2003.

[69] Stuart W. Shulman, Sally Beisser, Teresa Larson, Mack C. Shelley, and Lisa Thrane, "Service-Learning and the Digital Divide," presented at the International Conference on Civic Education Research, New Orleans, LA, November 16 -18, 2003.

[70] Mack C Shelley, Lisa Thrane, and Stuart W. Shulman, "Generational Differences in Informational Technology Use & Political Involvement," proposed for presentation at the dg.02004 National Conference on Digital Government Research, May 24-26, 2004, Seattle, WA.

[71] K.A. Smith and Waller, A.A., "Cooperative Learning for New College Teachers," *New Paradigms for College Teaching*, edited by Campbell, W.E. and Smith K.A., pp. 185-209, Interaction Book Co., 1997.

[72] L. Suchman, W. Beeman, M. Pear, B. Fox, and P. Smolensky, "Social Science and System Design: Interdisciplinary Collaborations," *Proc. Of the SIGCHI/GI Conferences on Human Factors in Computing Systems and Graphics Interface*, 1986, Vol. 17, No. SI, pp. 121-123.

[73] Teaching Alone, Teaching Together: Transforming the Structure of Teams for Teaching *by James L. Bess and Associates* Jossey-Bass (A Wiley Company), 2000.

[74] Etienne Wenger, Richard McDermott, and William Snyder, *Cultivating Communities of Practice: A Guide to Managing Knowledge*, Harvard Business School Press, 2002.

[75] K.G. Wilson and Daviss, B., *Redesigning Education*, Holt and Company, 1994.

[76] D. R. Woods, *Problem-based Learning: Helping your students gain the most from PBL*, Waterdown, Canada, 1995. See also http://chemeng.mcmaster.ca/pbl/pbl.htm

[77] Engineering Education Coalitions Websites, http://www.eng.nsf.gov/eec/coalitions.htm

[78] B. J. Winkel and G. Rogers, "Integrated, first-year curriculum in science, engineering, and mathematics at Rose-Hulman Institute of Technology Nature, Evolution, and Evaluation," in *Proc. ASEE Annu. Conf.*, Champaign-Urbana, IL, 1993, pp. 186–191.

[79] J. Morgan, "A freshman engineering experience," presented at the 8th Annual TBEEC Conf. Learning with Technology (TBEEC), Long Beach, CA, Nov. 1996.

[80] R. J. Roedel, D. Evans, M. Kawaki, B. Doak, M. Politano, S. Duerden, M. Green, and J. Kelly, "An integrated, project-based, introductory course in calculus, physics, english, and engineering," presented at the Frontiers in Education (FIE) Conf., Salt Lake City, UT, Nov. 5, 1996.

[81] K. Frair, "An integrated first-year curriculum: The foundation coalition and the University of Alabama," presented at the Frontiers in Education 25th Annual Conf., Atlanta, GA, Nov. 1995.

[82] D. DiBiasio *et al.*, "Evaluation of a spiral curriculum for engineering," presented at the 29th ASEE/IEEE Frontiers in Education Conf., San Juan, Puerto Rico, Nov. 10–13, 1999.

[83] Grant Wiggens and Jay McTighe, *Understanding by Design*, Association for Supervision & Curriculum Development (ASCD), 1998.

[84] M. Jones, "The Renaissance Engineer: A Reality for the 21st Century?", *European Journal of Engineering Education*, Vol. 28, No. 2, pp. 169-178, June 2003.

[85] Heck, R.H., & Thomas, S. L. (2000). An introduction to multilevel modeling techniques. Mahwah, NJ: Lawrence Erlbaum.

[86] Jöreskog, K.G., & Sörbom, D. (1996a). *LISREL 8: User's reference guide.* Chicago, IL: Scientific Software International.

[87] Jöreskog, K.G., & Sörbom, D. (1996b). *LISREL 8: Structural equation modeling with the SIMPLIS command language.* Chicago, IL: Scientific Software International.

[88] Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods.* (2nd Ed.). Sage.

[89] Raudenbush, S. W., Bryk, A. S., & Congdon, R. (2002). *HLM: Hierarchical linear and nonlinear models.* Lincolnwood, IL: Scientific Software International.

[90] Diamond, Robert M, *Designing and Assessing Courses and Curricula: A Practical Guide*, San Francisco: Jossey-Bass, 1998. Dickerson, J. A. (2004). FCModeler: Dynamic Graph Display and Fuzzy Modeling of Metabolic Maps. Genome Exploitation: Data Mining (Stadler Genetics Symposia 23rd Conf). J. P. Gustafson, Plenum Pub Corp.

[91] National Academy of Engineering 2020 Project, http://www.nae.edu/nae/naehome.nsf/weblinks/NAEW-4NHMDH?OpenDocument

[92] Grants for the Vertical Integration of Research and Education in the Mathematical Sciences (VIGRE), VIGRE Awards, Division of Mathematical Sciences, National Science Foundation, http://www.nsf.gov/mps/divisions/dms/research/vigreawards.htm

[93] David Smith and Lang Moore, "The Connected Curriculum Project," *Journal of Online Mathematics and its Applications*, Volume 1, Issue 3 December, 2001.

[94] Davis, L.A., & Gibbin, R.D. (Eds.). (2002). *Raising public awareness of engineering.* Washington, DC: National Academy of Engineering.

[95] Kemis, M., & Walker, D. (2000). The a-e-I-o-u approach to program evaluation. *Journal of College Student Development, 41*(1), 119-122.