E2020 SCHOLARS: ADVANCING THE VISION AT IOWA STATE UNIVERSITY

1 Project Objectives and Plans

Iowa State University 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 is a recognized leader in many areas of science and technology. The College of Engineering, with 220 faculty, offers 11 undergraduate engineering degree programs in aerospace, agricultural, chemical, civil, computer, construction, electrical, industrial, materials, mechanical, and software engineering. The vision of the College of Engineering has been expressed by our dean as the "2050 Challenge" [55]:

> What fundamental, society-changing challenges must be met today so that globally there will still be prosperous nations in 2050? How do we provide clean water, universal access to information, health care, and robust economies for 9 1/2 billion people? How do we restore our crumbling infrastructure? How do we sustain our agriculture and manufacturing? How do we reverse global warming while developing nonpolluting, renewable energy sources?… The organizations that have the will, the intellectual capacity, the vision, and the social mandate to meet the 2050 Challenge are universities—this is particularly true for universities with colleges of engineering. Indeed, … it is within the collective abilities of universities, and colleges of engineering in particular, to meet the challenges.

It is within this context that the College of Engineering has embraced the National Academy of Engineering's 2004 report on the vision of the Engineer of 2020 [43]. Consider these excerpts from the report:

> By 2020 we aspire to engineers who will assume leadership positions from which they can serve as positive influences in the making of public policy and in the administration of government and industry.
>
> …
>
> We aspire to an engineering profession that will rapidly embrace the potentialities offered by creativity, invention, and cross-disciplinary fertilization to create and accommodate new fields of endeavor, including those that require openness to interdisciplinary efforts with nonengineering disciplines such as science, social science, and business.
>
> …
>
> We should reconstitute engineering curricula and related educational programs to prepare today's engineers for the careers of the future, with due recognition of the rapid pace of change in the world.

Taken together, the college and national visions have led us to identify a set of student development and learning opportunities to be integrated into our curricular and co-curricular activities:

- Leadership development, including teamwork, communication, and service;
- Global awareness and understanding, including cultural adaptability;
- Systems-thinking, including interdisciplinary engineering design; and
- Innovation, including creativity and entrepreneurship.

We refer to these as E2020 learning outcomes, and hence this project is identified as the E2020 Scholars Program. We propose to implement a scholarship program for engineering students that promotes student engagement and development centered on these outcomes.

This proposal answers three primary questions:

- What are the project goals?
- How will the project goals be accomplished?
- Why will the project succeed?

What are the project goals?
The E2020 Scholars Program will pursue the goals of the S-STEM program through fulfilling the following four objectives, as paired with the S-STEM goals:

O1. Improved educational opportunities for students: **To provide opportunities of the Engineering Leadership Program to greater numbers of students and to create learning outcomes consistent with the NAE's vision of the engineer of 2020 (E2020).**
O2. Increased retention of students to degree achievement: **To engage students in new learning opportunities through cohorts and communities focusing on E2020.**
O3. Improved student support programs at institutions of higher education: **To involve greater numbers of students in the Engineering Leadership Program and use E2020 scholarships in coordination with new programs being developed in the NSF STEP grant.**
O4. Increased numbers of well-educated and skilled employees in technical areas of national need: **To use the E2020 focus in coordination with the NSF STEP grant to prepare more graduates to fulfill the NAE and college vision.**

How will the project goals be accomplished?
The E2020 Scholars Program will be integrated with two highly successful programs in the College of Engineering: the Engineering Scholarship Program and the Engineering Leadership Program. These programs are described in section 2. In addition, the opportunities for students will be enhanced by developing and/or framing new learning experiences based on the E2020 vision.

Why will the project succeed?
The E2020 Scholars Program will fit within a powerful framework of programs, services, and initiatives in the College of Engineering. Because of that framework, there is significant return-on-investment of NSF scholarship funding. NSF scholarship funds will enable more students to participate, and will facilitate enhancements that affect all participants.

2 Project Significance and Rationale

The synergy between the S-STEM program goals and the E2020 Scholars Program is outlined in the preceding section. In this section, we summarize information on the demographics of students in the College of Engineering and enrollment statistics for Iowa State as a whole. Also, in presenting the rationale for the scholarships in the project, this section describes the foundation for project success.

Enrollment and graduation data are maintained by ISU's Office of Institutional Research. Table 1 provides Fall 2007 enrollment data for the university, and Table 2 provides comparable data for the College of Engineering. Table 3 lists the number of engineering graduates over the past several years. Similar data for each engineering major are included as tables under Supplemental Documents. These tables are also available at the Iowa State website under the headings of Enrollment Statistics (http://www.iastate.edu/~registrar/stats/) and Fact Book (http://www.iastate.edu/~inst_res_info/FB07files/students07.html).

TABLE 1. Fall 2007 Iowa State University Enrollment (ISU Office of Institutional Research)

	Freshmen		Sophomores		Juniors		Seniors		Total Undergraduates		Graduate Students	
	M	W	M	W	M	W	M	W	M	W	M	W
Total by Gender	3,054	2,264	2,382	1,895	2,751	2,016	3,570	2,681	11,944	9,060	2,787	1,877
Total by Year		5,318		4,277		4,767		6,251		21,004		4,664
Total enrollment of 26,160 students also includes 492 professional students.												

TABLE 2. Fall 2007 Engineering Enrollment (Iowa State University Office of Institutional Research)

	Freshmen		Sophomores		Juniors		Seniors		Total Undergraduates		Graduate Students	
	M	W	M	W	M	W	M	W	M	W	M	W
Total by Gender	1,162	182	783	145	832	107	1,141	228	3,935	665	776	171
Total by Year		1,344		928		939		1,369		4,600		947
Totals by Race/Ethnicity and Residence												
Native American	African American		Asian American		Hispanic		Resident		Non-resident		International	
12	101		155		120		3001		1599		255	

TABLE 3. Number of B.S. Degrees in Engineering for Iowa State University (American Society for Engineering Education)

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
2006	33	38	15	4	62	742	38	788	144	932

Iowa State University maintains extensive retention data in concert with its goal of continually assessing the effectiveness of its learning communities. The average retention rates over the past ten years are: 1-year, 84.2%; 2-year, 75.9%; 3-year, 72.2%; and 4-year, 70.2%. The average 6-year graduation rate is 66.3%. In 2005, the first-year retention rate for learning community students was 87.2%, whereas for non-learning community students, it was 79.6%. As of Fall 2005, 76% of first-year, full-time students in engineering participated in learning communities (575 students) including students who participated in the Freshman Honors Program (165). Most engineering learning communities have seen anywhere from a 5-15 percentage point retention increase among their first-time, first-year students. Refer to the Supplemental Documents for complete tabular data.

The framework of the proposed E2020 Scholars Program is presented here, with related information provided in subsequent sections. The E2020 Scholars Program will be implemented within the Engineering Scholarship Program currently in place and managed in the same manner as scholarships for the Engineering Leadership Program. Each of these programs are summarized below.

2.1 Engineering Scholarship Program

The College of Engineering administers a merit-based scholarship program that complements the University's scholarship program handled by the Office of Student Financial Aid (http://www.financialaid.iastate.edu/). The college program is managed by a program director (Haugli) and assistant, who work closely with the Associate Dean for Academic and Student Affairs, the director of Enrollment Services in the college, and each of the academic departments, as well as the university financial aid office. The program provides an incentive for students to excel in their studies by rewarding them based on their performance. The scholarship plan is formulated as an "award grid," which delineates categories that students fall into as rows and columns, and places award amounts in cells. An incoming student qualifies for a specific amount of financial support by achieving specified merit or other eligibility criteria set by the college and university. For example, a typical scholarship would be $200 for residents in the top 30% (of all engineering students), $500 for residents in the top 20%, and $1,000 for residents in the top 10%. Non-residents and under-represented students receive higher amounts. Grid-based awards are renewed annually based on student performance for up to four years. For sophomores, juniors, and seniors, the Scholarships and Awards Committee may choose to replace a grid-defined scholarship with a larger donor-specified scholarship for any student. These engineering scholarships are in addition to university-level scholarships. The award grid is reviewed annually by key stakeholders to ensure a holistic, strategic approach to recruiting and retaining students. This program is designed to provide a predictable, base-level scholarship for all qualifying engineering students. The goals are to enhance recruitment, increase retention, and decrease the financial burden on students who are excelling in classes. Last year, the college distributed over $1.7 million in engineering scholarships to undergraduate students.

At this time, the grid-based award system is able to fund and continue students who start with a merit-based scholarship as freshmen. "Continue" means that as long as students remain in the top 30% (3.25 grade point average or higher), they will receive a merit-based scholarship for up to four years. Scholarship funds are not available to bring upper-division students onto the award grid if they did not start with a freshman scholarship. The university has launched a new capital campaign and scholarship funding is a priority for the College of Engineering. About $2 million per year is needed to fully fund the award grid, and a goal for the campaign is to begin building an endowment to support this outcome.

The scholarship director prepares detailed reports with tables and graphs to describe, monitor, and analyze how funds are allocated. Two graphs (from among many) are included as samples under Supplemental Documents to reflect the types of analysis that we conduct to manage the Engineering Scholarship Program. The pie charts on analysis of funding sources compare funds based on type of account (College vs. Department, Expendable vs. Endowed, and Designated vs. Undesignated (for a specific use by a donor)). The bar graph on awards by department shows the distribution of funds to students across majors. Review of the data and visuals has contributed to effective decision-making over the years.

Finally, Table 4 provides a snapshot of the Engineering Scholarship Program during the past year (2006-2007).

The Engineering Scholarship Program provides a robust infrastructure for managing a diverse array of scholarship funds.

TABLE 4. Engineering Scholarship Program Statistics (2006-2007)

Total Engineering Scholarship Funds Awarded:	**Averages**:
Freshman:	Resident: $1,081
All Students (309 residents, 185 non-residents, 494 total): $474,800	Non-resident: $2,330
Women (59 residents, 29 non-residents, 88 total): $143,350	
Minorities (3 residents, 13 non-residents, 16 total): $23,350	**Analysis of Funding Sources:**
Sophomores:	College Funds:
All Students (120 residents, 81 non-residents, 201 total): $322,859	Undesignated: 37.54%, $656,570
Women (29 residents, 26 non-residents, 55 total): $117,486	Designated: 32.83%, $575,950
Minorities (2 residents, 7 non-residents, 9 total): $24,823	Department Funds:
Juniors:	Undesignated: 2.99%, $ 52,250
All Students (155 residents, 80 non-residents, 235 total): $547,354	Designated Funds: 26.54%, $464,217
Women (42 residents, 28 non-residents, 70 total): $198,592	
Minorities (6 residents, 9 non-residents, 15 total): $48,746	**Analysis of Accounts (Approximate):**
Seniors:	Corporate Expendable: 50
All Students (165 residents, 57 non-residents, 222 total): $403,974	Private or Endowed: 272
Women (36 residents, 8 non-residents, 44 total): $65,680	Need-Based: 105
Minorities (3 residents, 2 non-residents): $9,500	Merit-Based: 217
Engineering Summary:	**Largest & Typical Scholarships:**
All Students (749 residents, 403 non-residents, 1152 total): $1,748,987	Private: James McIlrath Leadership Scholarship, $9,500
Women (166 residents, 91 non-residents, 257 total): $ 525,108	Merit Grid:
Minorities (14 residents, 31 non-residents, 45 total): $106,419	Past grids: Top 1% non-residents, $7,500; Top 1% residents, $5,000
	Grid for 2007-2008: Engineering Stacked on University to Yield:
	Residents:
	Top 10%: $3,000
	Top 20%: $2,250
	Top 30%: $1,500
	Non-Residents:
	Top 10%: $9,000
	Top 20%: $8,000
	Top 30%: $6,500

2.2 Engineering Leadership Program

In response to the *Engineer of 2020* [43] and the College's vision with the "2050 Challenge" [55], the College of Engineering at Iowa State has partnered with the 3M Corporation to launch a new leadership program to prepare students for life-long leadership roles in industry as well as public service. The program complements the engineering skills and knowledge students acquire during their academic careers to prepare them better for leadership and collaborative roles in their professional careers. Objectives for the leadership initiative include:

- Instill among students the desire and ability to work in leadership and collaborative roles in their professional careers;
- Encourage innovative thinking, leadership development, team building, and peer mentoring among high-ability students;
- Enable students to tailor a program of study to match professional and life-long learning goals; and
- Enhance students' academic experiences by offering interdisciplinary and experiential learning opportunities.

The Engineering Leadership Program (ELP) began in Spring 2006 under a program director (Athreya) and assistant as well as a team of student directors. The first cohort of 17 student scholars was selected for Fall 2006. The second cohort of 15 students started in Fall 2007. With additional corporate and private donor scholarship funding, a cohort of 10 upper-division students also began in Fall 2007. Various aspects of the ELP are described at the program website [46], and several items are included as Supplemental Documents, including an Annual Report to 3M [42], [53], [54], [56]. In addition, letters of support from 3M and Rockwell Collins reflect the strength of this program. The ELP is one of several programs emerging nationwide

[47],[48],[49],[50],[52]. Dr. Athreya participated in a panel at the "National Engineering Leadership Workshop" at NSF in September 2007.

The ELP is a student-led and student-centered program offering scholarships and opportunities to assist undergraduate engineering students in developing leadership skills. The following curricular and co-curricular activities are introduced so that students take incremental steps to acquire and internalize leadership:

- Semester 1: The Basics of Leadership
  Build awareness and learn the fundamentals, responsibilities, and benefits of organizational leadership. The Leadership Seminar introduces leadership theory and skills for freshmen scholars, and creates a support network among ELP students.
- Semester 2: Taking on Responsibility
  Aspects of the leadership model are emphasized through courses, service learning projects, and mentoring.
- Semesters 3-8: Maturing as Leaders
  Advanced experiential learning is accomplished through leadership practice, advanced coursework, and leadership learning projects.

The ELP combines academic programming with experiential learning to develop the leadership skills students will employ as professional engineers. The program is designed to build a community of leaders by facilitating dynamic partnerships and collaborations among students, faculty, alumni, employers, and civic and community leaders. The components of the program include: scholarships, curriculum development, a leadership learning community, leadership learning experiences for students, service learning, and mentoring.

The first-year experience is devoted to community building and leadership development through a set of structured shared activities. The early part of the first-year experience focuses on introducing scholars to theories of leadership and critical leadership skills. Each scholar is then challenged to take on an active leadership role, applying the theories and skills learned in the previous semester to a small service learning project. Current program elements include a leadership retreat, a leadership seminar class throughout the first year, a service learning project, a common reading experience, networking and skills development events, and weekly reflection journals. Additionally, the ELP has been instrumental in creating curricular opportunities that are open to all engineering students. For example, a new course—Science, Technology, and Public Policy—has been developed through the Department of Political Science in partnership with ELP. The course examines the development of science and technology policy in the United States, including the dynamics of the impact of government-university-industry relations on technological advancement, and the impact of science and technology on global politics.

To select a fall cohort of scholars, ELP is marketed to hundreds of incoming engineering students to encourage application to the program. Prospective students and their parents learn about the opportunity during recruiting events such as Breakfast with the Dean and Scholar's Day, and also via the ELP website. As part of the 2007 ELP scholarship application process, applicants received comprehensive information about the program in a pre-application form. In 2007, there were more than 110 applicants from which 15 3M Scholars were chosen. The applicants represented 11 states, with approximately half coming from Iowa high schools. The pool was 23% female, which is above the 16% female enrollment in engineering at ISU. The 2007 3M Scholar group is 53% male and 47% female, and nearly all majors are represented. Scholars are guaranteed a minimum of $2,500 annually for four years. If a student qualifies for a

larger award based on the award grid for the Engineering Scholarship Program, the larger award is used as the base amount and supplemented.

ELP is using Iowa State's eDoc electronic portfolio system to help the college and students track progress toward fulfilling program outcomes. The electronic portfolio allows students to collect and present evidence demonstrating academic and professional competencies. It also allows students to interact and collaborate with their peers in a professional and scholarly manner. ELP scholars utilize eDoc to record individual information about their leadership experiences. Students may input their own reflections and track what they have learned. Ultimately it serves as a resource to help ELP scholars develop their personal leadership portfolios. At the center of this outcomes-based approach for the ELP is a leadership learning model. The leadership model is being employed to meet specific learning outcomes as well as leadership goals leveraging the diverse, integrated curricular and co-curricular environment. The model was developed to recognize several parallels between the competencies and characteristics of social leaders and abilities identified in the outcomes statements defined by ABET [44]. Several of the ABET outcome statements (specifically, d, f, g, h, and i) are incorporated into the ELP leadership model along with three additional outcome statements focused on diversity of thought, influence and visionary leadership. These three additional statements are that students will demonstrate (1) an ability to create a vision, articulate it, and inspire others to share and implement it; (2) an ability to effectively influence and innovate to deliver results; and (3) recognition of the need for actively encouraging diversity and an ability to create an inclusive environment. Each outcome is associated with a set of core competencies that is defined using a set of key actions. Competencies are important for students to understand what the outcomes mean in terms of behavior, and for the college to collect data to evaluate the effectiveness of its programs. For example, Engineering Career Services has been measuring ABET-aligned competencies demonstrated by students in the engineering workplace since 2001. Students and their supervisors use an OPAL™ (On-line Performance and Learning) survey that measures their demonstration of workplace competencies [45].

The leadership model uses the acronym *LEAD* and the following OPAL competencies:

Leadership Characteristics	**Engaging Others**
Initiative Analysis and Judgment Integrity Communication Energy and Drive	Building a Successful Team Developing Abilities of Others Coaching Teamwork Leading Through Vision and Values
Awareness and Growth	**Demonstrating Excellence**
Engineering Knowledge General Knowledge Continuous Learning Cultural Adaptability	Quality Orientation Customer Focus Innovation Professional Impact Planning

The Engineering Leadership Program provides new educational opportunities for students that are consistent with a national vision for engineering education.

2.3 Proposed E2020 Scholarship Program

The proposed E2020 Scholars Program will provide four-year scholarships at $2,500 per year using the ELP award model. This amount has proven effective in attracting students into a special program, and it provides a competitive base amount (exceeding the average award in

engineering) for a student's financial aid package. Of the proposal budget, we are requesting 85% for scholarships and 15% for administrative and student services, resulting in $510,000 for scholarships over four years. This scholarship budget will support up to 23 new E2020 scholarship awards per year, split between incoming freshmen students and transfer students. An estimated 85 students will be supported during the project. The College of Engineering will commit to continuing support for the students already in the E2020 Scholars Program at the end of the NSF project. The distribution of E2020 scholarship awards is shown in Table 5.

TABLE 5. Distribution of E2020 Scholarship Awards to Incoming and Transfer Cohorts

		Freshmen	Sophomores	Juniors	Seniors	Transfer Year 1	Transfer Year 2	Transfer Year 3	Total
Year 2	Number	11				12			23
	Cost	$27,500				$30,000			$57,500
Year 3	Number	11	11			12	12		46
	Cost	$27,500	$27,500			$30,000	$30,000		$115,000
Year 4	Number	11	11	11		11	12	6*	62
	Cost	$27,500	$27,500	$27,500		$27,500	$30,000	$15,000	$155,000
Year 5	Number	11	11	11	11	12	11	6*	73
	Cost	$27,500	$27,500	$27,500	$27,500	$30,000	$27,500	$15,000	$182,500
*Assumes half of transfer students graduate after two years.									

After Year 5, three cohorts that start as freshmen will continue in the program, as do two cohorts that started as transfer students. The scholarship cost to fulfill these commitments is estimated at $225,000. These will be funded based on the College's commitment to sustain and expand the Engineering Leadership Program.

The E2020 Scholars Program will enable the College of Engineering to expand its leadership program in a forward-looking partnership between academia, industry, and government.

3 Current Programs and Services

The preceding section described the Engineering Scholarship Program and the Engineering Leadership Program, which are the anchors and enablers for the proposed E2020 project. These programs would not be successful without key programs and services provided on campus, including:

- Office of Student Financial Aid
- Office of Admissions
- Engineering Enrollment Services and Precollegiate Programs
- Engineering Student Services
- Engineering Career Services
- Engineering International Programs and Services
- Departmental Academic Advising Offices
- Engineering Communications and Marketing
- Student Learning Task Force (engineering faculty committee)
- Learning Communities Task Team (engineering faculty/staff committee)

These units and their professional staff collaborate to support students in many ways, some of which are posted through the College website (www.engineering.iastate.edu). These services contribute to quality educational programs, through internships and co-ops, study abroad, student-centered advising, learning communities, etc.

Two campus-wide programs are notable with respect to the goals of the E2020 Scholars Program and its related infrastructure in the college: Learning Communities and the Admissions Partnership Program. Learning communities at Iowa State are a highly successful partnership between Academic Affairs and Student Affairs. Student involvement in learning communities at ISU has increased steadily since they began as a grassroots 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 are available on campus
- 51% of first-year students are enrolled in a learning community
- 90%, vs. 82%, one-year retention rate for fall 2004 learning community students vs. non-learning community students
- 76%, vs. 62%, six-year graduation rate for learning community students vs. non-learning community students
- Top-25 national rating by *U.S. News and World Report*
- Overall student satisfaction and engagement is higher for learning community students
- Learning community students report high levels of engagement on the National Survey of Student Engagement benchmarks.

Learning communities at ISU have already proven to be sustainable, as some of the existing learning communities have been in place for nearly a decade. To a large extent, there is an institutionalized learning community culture at Iowa State. Learning community success at ISU is well-documented in online reports (http://www.iastate.edu/~learncommunity/reports.html); see also [16]. ISU has benefited from and continues to contribute to the body of work on learning communities [1] [2][3][4][5][6][7][8][9][10].

ISU started the Admissions Partnership Program (www.admissions.iastate.edu/partnership) in 2006 to make it more convenient for community college students to transfer to Iowa State. Through the Admissions Partnership Program, community college students who plan to pursue a bachelor's degree at ISU will receive the following special benefits to promote academic success at both schools—before they enroll in ISU coursework:

- Mentoring and guidance from the community college partner 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.

The two programs cited above are important elements in furthering the goals the E2020 Scholars Program through faculty/staff engagement, connections to the academic departments through representation on the committees, and advice from team members. The Student Learning Task Force (SLTF) will provide guidance in the development, implementation, and assessment of the E2020 learning outcomes. Dr. Steve Mickelson, Associate Professor of Agricultural and Biosystems Engineering and the college's Director of Assessment, chairs the SLTF. SLTF members work with faculty in their departments to review curricular outcomes and program objectives. The Learning Communities Task Team (LCTT) is comprised of coordinators of each of the learning communities in the college. It is chaired by Dr. Paul Castleberry, Engineering Student Services. The LCTT develops and shares best practices in relation to the program components (refer to the matrix in Supplemental Docs).

Finally, in 2007, Iowa State was awarded an NSF STEP grant in partnership with Des Moines Area Community College (DMACC). The project, titled SEEC—Student Enrollment and Engagement through Connections—has the following objectives:

- Increase in graduates (degrees) per year by the College of Engineering of 120 (15% increase compared to baseline)
- Increase in the number of minority graduates by 20% and women graduates by 30% in the College of Engineering
- Total College of Engineering undergraduate enrollment of 4,800-4,900 students
- Learning Village: to enhance the LC model at Iowa State by improving programming and availability, and to create a LC model that spans DMACC and ISU
- Connected Curriculum: to redesign the first-year engineering curriculum to enable flexibility and commonality across learning communities, and to make selected engineering gateway courses available to DMACC students via distance education
- Student-centered Advising: to develop and enhance academic advising and mentoring programs for pre-college, community college, and university students
- 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.

Clearly, there is a synergistic relationship between the SEEC project and the proposed E2020 Scholarship Program. The Engineer of 2020 vision has a broad appeal to attract students into engineering, as evidenced in the Engineering Leadership Program, resulting in an added draw for SEEC recruitment and retention. In addition, the E2020 scholarships will be used to recruit students. In SEEC, there is only $35,000 budgeted for scholarships in years 2-5 as part of a "Talent in Every County" (TEC) scholarship program to support the Coordinated Networking objective. Conversely, the SEEC project objectives will enhance the programs and services available to students receiving E2020 scholarships, especially transfer students. Four PIs for the proposed project are also SEEC project PIs in charge of specific objectives.

4 Project Management Plan

The project team consists of Principal Investigators in engineering and education, as well as Senior Personnel in key programs. The team is exceptionally qualified to achieve the project objectives (qualifications are given in biographical sketches). The team will be led by Rover and coordinated by Bruning, and all team members will have shared responsibility for project outcomes. Rover is an engineering faculty member (electrical and computer) and associate dean for academic and student affairs; most units involved in the project report through her. Bruning is an administrator and education researcher whose expertise is in STEM recruitment, financial aid/scholarships, student development and serving under-represented populations. Mickelson is an engineering faculty member (agriculture and biosystems), director of assessment in the college, and provides expertise in mentoring, learning communities, student learning, and use of e-portfolios. He is a primary liaison to faculty representatives from each department through the Student Learning Task Force. Athreya is an engineering faculty member (materials) and directs the Engineering Leadership Program from which the E2020 Scholars Program will be modeled. Shelley is a statistics and political science faculty member and is an expert in program evaluation. Senior personnel lead robust operations and are committed to serving less privileged students and broadening participation in STEM. Table 6 summarizes team member roles.

Student selection criteria are listed in section 5. In addition, renewal of a scholarship from year to year will be based on annual evaluation of the student's e-portfolio and satisfactory participation in the learning community. Students who lose eligibility for the E2020 award will remain eligible for other engineering scholarships. The cohort coordinator and selection committee will determine whether to replace the scholar with an incoming student, a transfer student, or a current student. This is consistent with ELP's procedures. Scholarship funds are distributed to students through financial aid credits applied to a student's tuition bill.

Scholarship program outcomes will be evaluated as described in section 8. Program outcomes will be disseminated through the SEEC project and its various approaches (web, workshop, conferences, networking, etc.).

The project budget includes both administrative and student services costs, as described in the budget justification.

TABLE 6. Team Member Roles

Rover	Project management and reporting. Liaison to administration.	Haugli	Scholarship fund management. Liaison to ISU Financial Aid Office.
Bruning	Coordination of recruitment and selection for the program. Oversight of cohort. Liaison to ISU Admissions Office.	Castleberry	Coordination of cohort learning community participation. Student records mgmt. Liaison to department coordinators.
Mickelson	Coordination and assessment of student learning experiences in the program. Liaison to faculty.	Other	Academic and Student Affairs staff will assist with transfer recruitment; interact with department advisors; facilitate experiential and international learning opportunities.
Athreya	Integration of E2020 into ELP. Support for scholar selection and mentoring. Liaison to industry partners.		
Shelley	Project evaluation, data management, and report preparation.		

5 Student Selection Process and Criteria

Consistent with the requirements of the S-STEM program, the E2020 Scholars Program will provide scholarships to students who: (1) are citizens of the U.S. (or whose status satisfies S-STEM eligibility); (2) are pursuing engineering degrees; (3) demonstrate academic potential or ability; (4) demonstrate financial need as defined by the U.S. Department of Education rules for need-based federal financial aid; and (5) are part of a cohort. Iowa State uses the Free Application for Federal Student Aid (FAFSA) to determine eligibility for need-based financial aid, and the Office of Student Financial Aid makes the calculation. To be considered, all students must demonstrate need (based on FAFSA). Freshman should have 3.0 GPA on a 4.0 scale or rank in the top 30% of their class; and scores of ACT-Math above 24 (SAT1-Math above 560) and ACT-English above 21 (SAT1-Verbal above 520). Any high school senior who demonstrates potential in ways that go beyond GPA, class ranking or test scores may apply. Transfer students who have completed 24 transferable semester hours at a community college with at least a 3.00 grade point average on a 4.0 scale will be considered. Transfer students or continuing students must achieve a cumulative GPA above 2.75. Students will belong to the Engineering Leadership Program or another engineering learning community and will be members of a cohort associated with an E2020 attribute, as described in section 6. Students will also be evaluated and selected based on answers to questions related to the "Engineer of 2020" vision on the application form. Applications will be processed using the same procedures for

ELP, using a selection committee specifically for E2020. As in ELP, the selection committee will consider a broad set of factors to create diverse cohorts. Applications are typically due in February, with selections made by March, and a May 1 deadline for student acceptance of scholarship and admission. The E2020 scholarship will be advertised through University venues, the Engineering Scholarship Program and engineering recruiting events/media, and targeted invitations to select students. Cohort assignments will be based on information provided on the application as well as the student's self-identified interest in the four E2020 attributes leadership (including teamwork, communications and service), global understanding (including cultural adaptability), systems-thinking (including interdisciplinary engineering design), and innovation (including creativity and entrepreneurship).

6 Enhanced Student Programs and Services

The College of Engineering and Iowa State offer comprehensive student support programs and services as described in sections 2 and 3. Programs serve students across the full range of grades K-16. Short synopses of each unit in the college are given in a Supplemental Document. Current students take advantage of opportunities. For example, 83% of students graduate with internship/coop experience and 25% with international experience. We continually invest in developing, improving, and adapting these opportunities, of which the Engineering Leadership Program is a prime example.

The key adaptation of current programs for the E2020 Scholars Program is the extension of the Engineering Leadership Program to select and mentor new cohorts of students based on E2020 learning outcomes. Also, E2020 scholarships will be added to the Engineering Scholarship Program and managed by the director. Some E2020 scholars may merge directly into the ELP, with leadership development and related attributes of teamwork, communication, and service as their focus. However, three other attribute sets will be defined for development and assessment: global understanding (including cultural adaptability); systems-thinking (including interdisciplinary engineering design); and innovation (including creativity and entrepreneurship). To support student development of these attributes, we will define models similar to the ELP leadership model involving outcomes, competencies, and actions. Students will belong to a "community of practice" associated with an E2020 attribute within the learning community environment, and they will document their progress on these outcomes through the use of e-Doc portfolios. Faculty and peer mentors will work with these students, just as in ELP. For all practical purposes, this will leverage the ELP approach and its established infrastructure.

7 Quality Education Programs

All undergraduate B.S. programs in engineering at Iowa State (except software engineering, which is new this year and has not yet been evaluated) are ABET-accredited, the national professional standard for quality in undergraduate engineering programs. Iowa State's programs are fourth on the *U.S. News & World Report* ranking of best undergraduate engineering programs among public universities in the region. The undergraduate program in agricultural engineering ranks second in the country. The student experience in engineering at Iowa State receives high scores on the National Survey of Student Engagement. Iowa State's learning communities are consistently ranked by *U.S. News & World Report* as among the top 25 programs in the nation. For the third consecutive year, Iowa State is ranked among the top U.S. universities by *Washington Monthly* magazine. Iowa State ranks 21 out of 242 ranked national universities in *Washington Monthly*'s 2007 ranking. The rankings are based on schools' commitment to: recruiting and graduating poorer students, supporting "scientific and humanistic study that is key to our national strength," and fostering an ethic of giving back to the country,

through military or civilian service. **This latter ranking is relevant to the goals of the proposed E2020 Scholarship Program.**

Iowa State engineering students are actively recruited by hundreds of companies and government agencies. More than 300 companies participate in the College of Engineering's annual fall career fair, the largest event of its kind in the nation. Another 250 participate in our spring career event. In addition, nearly 5,000 job interviews are conducted annually on campus. Most of our graduates have engineering work experience as interns or coop students prior to their commencement, and almost all have immediate success in starting their careers. Graduates not only pursue career opportunities within engineering, but also go on to careers in medicine, law, business, academia, the public sector, and the military. The average annual starting salary for graduates is $54,200, and there is a 96% placement rate (job/military/graduate school) six months after graduation.

Hallmarks of engineering education at Iowa State that contribute to quality are itemized in a letter to constituents, included as a Supplemental Document, and summarized below:

- An *excellent and broad education* to prepare graduates to meet the challenges of the 21st century;
- Wide-ranging *employment opportunities* for our students and graduates;
- Serving students and the public through *leadership in engineering education*;
- An *innovative learning environment* to stimulate excellence and enable all members of our community to pursue scholarly work; and
- Being a *destination of choice* for engineering study regionally, nationally, and globally.

8 Assessment and Evaluation

Project evaluation and outcomes assessment will be led by Dr. Mack Shelley, a University Professor in the Department of Statistics and the Department of Political Science, in collaboration with the Research Institute for Studies in Education (RISE) at Iowa State University. 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. Project evaluation will focus on the S-STEM program goals, as follows:

O1. Improved educational opportunities for students: What is the effect of ELP related programming and enhancements for the E2020 Scholarship Program? To what extent do students demonstrate progress on E2020 learning outcomes?

O2. Increased retention of students to degree achievement: Do scholarship support, E2020 relevance to students, and learning community engagement increase retention?

O3. Improved student support programs at institutions of higher education: What is the benefit of extending ELP to greater numbers of students and of complementary NSF STEP grant activities?

O4. Increased numbers of well-educated and skilled employees in technical areas of national need: What is the result of the E2020 focus and the concurrent goal of the NSF STEP grant to increase the number of engineering graduates?

The project activities and assessment 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 retention or non-retention, or graduation/non-graduation), hierarchical linear models, and structural equation models. Throughout these analyses, the central concern is whether there is a statistically

significant main effect of project participation. Potentially confounding variables will be accounted for as covariates. Evaluation will be undertaken by organizing key evaluation questions in a manner that allows for many models of evaluation or methods of data collection. The evaluation effort will be based on the a-e-i-o-u framework [36], which has been shown to be particularly useful in education-related evaluation research. 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?
- 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, based on data collected from interviews with key personnel, focus groups made up of those most affected by the project, and 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 program. Answering questions related to organizational context and unanticipated outcomes can provide additional evaluation information about how the study fits into the broad objectives of the program and the likely broader effects that the program may have. Our evaluation instruments, methods, and findings will be directed toward fulfilling these objectives.

Program evaluation will be both formative and summative. The primary purpose of formative evaluation will be to provide data and interpretations leading to successful midcourse enhancements in program implementation and to ascertain whether the measurement instruments provide adequate reliability and validity. Summative evaluation methods will be employed to determine the longer-term impact of program implementation on students, faculty, departments, and institutions of higher education. The primary objective of both the formative and summative evaluation efforts will be to measure the effect of program implementation on student outcomes. Both quantitative and qualitative data will be collected, using validated sample survey instruments, institutional data on student achievement and growth, focus groups, individual interviews, and document analysis.

Analysis of quantitative data will be 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 15 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 [28],[30],[33],[34] 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 [26][27][31][32] is appropriate when causal interpretations are desired, measuring both the direct and indirect effects of exogenous variables (typically, demographic traits) on endogenous (dependent, often behavioral outcome) 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. 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 [33], and establishes the statistical foundation for growth curve analysis of sustained student outcomes over time. The qualitative data collected will be analyzed using Atlas.ti, which provides the basis for sophisticated analysis of textual information and making meaning of complex semi-structured 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, individual interviews, observation, and focus group sessions of students, faculty, and staff.

9 Results from Prior NSF Support

"VIE: Vertical Integration of Computer, Electrical, and Mechanical Engineering Education (Planning Grant)," Department Level Reform Program, Grant No. 0431924, 8/04-7/06, $99,986, PIs: **Rover**, Mina, Dickerson, **Shelley**, Flugrad. This project piloted a new curricula model to improve student learning through vertical integration of educational activities using a new program structure called a learning stream, a basic element designed specifically to integrate subject matter across courses. A traditional course sequence is replaced with an integrated stream sequence that creates tighter connections across content from the courses and laboratories. The project is an example of curriculum integration, as described by Froyd and Ohland [37]. The process for assessing the VIE program utilized a mixed methodology that triangulated understanding of how the program impacted student learning. The following prominent themes emerged through the analysis of focus group notes: (1) Continuity in the course structure promoted student learning. (2) Intense course structure promoted a deep understanding of the material. (3) Small class structure promoted accountability, interaction, and flexibility. (4) Course structure may promote opportunities after completion of the classes. Presentations were made at the 35th and 36th ASEE/IEEE Frontiers in Education Conferences in 2005 and 2006 [38],[39]. Additional assessment results are published in a final report [40]. www.eng.iastate.edu/vie/ is the website for the project.

The relationship of the VIE project to this proposal is reflected in an excerpt from the "Statement on Integrative Learning" [41]: "It is important for educators to work together to build knowledge about integrative learning in its many varieties, and about how it is best encouraged and assessed. Developing students' capacities for integrative learning is central to personal success, social responsibility, and civic engagement in today's global society. Students face a rapidly-changing and ever-more-interconnected world, in which integrative learning becomes not just a benefit, but a necessity."

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