Oregon Pre-engineering Learning Outcomes Study

Final Report

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Engineering Technology and Industry Council (ETIC)

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Principal Investigator
David T. Conley, Ph.D.

Primary Project Staff
Holly Langan, MPA
Darya Veach, MS
Virginia Farkas, M.Ed.

Educational Policy Improvement Center (EPIC)
Center for Educational Policy Research (CEPR)
Dr. David T. Conley, Chief Executive Officer
720 East 13th Street, Suite 202
Eugene, OR 97401
Phone 541.346.6153 • Toll-free 877.766.2279
http://cepr.uoregon.edu
http://www.epiconline.org

Executive Summary

Oregon postsecondary institutions offer a variety of opportunities to students seeking programs in engineering. Most of these institutions offer pre-engineering coursework to students that will eventually transfer to other Oregon institutions and complete a degree in engineering. However, what is expected of students in the first two years of engineering studies is not explicit and varies by institution. This is due in part to the fact that the community colleges and OUS institutions have not identified a common engineering curriculum in terms of educational learning outcomes expected during those first years of study. Without explicit standards, it is difficult for high schools and postsecondary institutions to communicate expectations to students.

This study undertook a standards development process designed to yield the first set of explicit pre-engineering learning outcomes that could then used to align high school and postsecondary, entry-level engineering courses. The process led to the development of learning outcomes for content knowledge, key cognitive strategies, and teaching practices that reflect the content and intellectual goals of best practice in pre-engineering education.

Once these learning outcomes were developed, instructors provided course reviews to determine alignment to the draft outcomes and to identify the expectations of pre-engineering students in their entry-level courses. Instructors generally found that students in Oregon postsecondary pre-engineering programs enter courses with adequate knowledge and are expected to begin college study in engineering with a basic understanding of course content.

In addition, instructors provide feedback on the importance of the draft learning outcomes for success in their courses as well as for preparation for upper-division engineering studies. Two-thirds of learning outcomes were identified as more or most important for the success in the first two years of engineering programs. Almost 40% of the learning outcomes are more or most important for successful entry into upper-division engineering courses.

EPIC is pleased to provide this report which includes a list of the Oregon Pre-engineering Learning Outcomes as developed by reviewers and Oregon postsecondary educators. Also included are instructors' reviews of the pre-engineering courses they teach along with feedback from follow-up telephone interviews with engineering instructors. Finally, a website has been developed to provide information regarding this study and resources for careers and education in engineering.

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Educational Policy Improvement Center (EPIC)

The Educational Policy Improvement Center, a 501(c)3 nonprofit organization, seeks to help policy makers and policy implementers alike do a better job of using educational policy as a tool to improve schooling and student learning.

EPIC works with federal agencies, state education departments, non-governmental organizations, private foundations, and school districts to support research on a range of issues in the areas of high school-to-college articulation, adequacy funding, large-scale assessment models, and other policy initiatives designed to improve student success.

On this study, EPIC worked in partnership with the Center for Educational Policy Research (CEPR), a University of Oregon research center with expertise in validity studies and high school-college articulation issues.

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ETIC Steering Committee

Jay Bockelman
Dave Krumbein
Gary Naseth
Skip Rochefort
Bruce Schafer
Scott Huff

Institution Liaisons

Dr. William Becker, Portland State University
Jay Bockelman, Oregon Institute of Technology – Portland
Timothy Brower, Oregon Institute of Technology
Bruce Emerson, Central Oregon Community College
John Evans, Columbia Gorge Community College
Greg Fallon, Klamath Community College
Dr. Lori Gates, Tillamook Bay Community College
Sue Goff, Umpqua Community College
Dr. Lonnie Guralnick, Western Oregon University
Dr. Jeff Hayen, Southwestern Oregon Community College
Dr. Tom Herrmann, Eastern Oregon University
Scott Huff, Portland Community College
Ron Jantzi, Chemeketa Community College
Patrick Keefe, Clatsop Community College
David Krumbein, Blue Mountain Community College
Mike Laam, Rogue Community College
Dr. Brett McFarlane, Oregon State University
Niki Schulz, Mt. Hood Community College
Dr. David Strom, University of Oregon
John Sweet, Linn-Benton Community College
Robert Thompson, Lane Community College
Susan Tinker, Treasure Valley Community College
Baldwin van der Bijl, Clackamas Community College
Dr. Peter Wu, Southern Oregon University

Learning Outcomes Consultants
Dr. James R. Barber, University of Michigan – Ann Arbor
Dr. James W. Male, University of Portland
Dr. James W. McCuen, University of Maryland – College Park
Dr. David Strom, University of Oregon
Dr. Solomon Yim, Oregon State University

EPIC Research Staff
Gretchen Bredeson
Genevieve Conley
Duane Jones
Jody Kirtner, MA
Timothy Meredith
Zenia Treto
Dr. Terri Ward

EPIC Consultants
Dr. Carla Bowers
Dr. Michel Kovcholovsky
Kimberley Nies

Oregon Pre-engineering Learning Outcomes Project and EPIC

The Oregon Pre-engineering Learning Outcomes Project was conducted by the Educational Policy Improvement Center (EPIC) with grant funding from the Engineering and Technology Industry Council (ETIC). The study sought to improve student preparation and success in pre-engineering programs through the development of the Oregon Pre-engineering Learning Outcomes, a comprehensive set of standards reflecting student learning, key cognitive strategies, and teaching practices essential to student success in the first two years of postsecondary studies in engineering programs at Oregon community colleges and Oregon University System (OUS) institutions. The learning outcomes are the first research-based standards of their kind developed for the state of Oregon. This study applied the learning outcomes to virtually all 100- and 200- level core-engineering courses to learn what is taught in courses statewide and to highlight alignment and gaps among institutions' programs. These results are intended to assist the OUS in complying with recent legislation that mandates creation of a system of seamless credit transfer based on a common, statewide framework of learning expectations.

Study Objectives and Applications

In 2005, ETIC convened the Oregon Pre-engineering & Applied Sciences (OPAS) Strategic Planning Summit. This meeting of academic and industry minds identified five critical action areas in Oregon science, technology, engineering, and mathematics (STEM) education: motivation, preparation, transfer, retention, and diversity. This study addresses three of the OPAS committee goals as listed in the OPAS Summit Report (Table 1).

Table 1: OPAS Summit Goals and Study Objectives

Summit Goal	OPAS Study Objective
Use a common set of achievement and preparation standards.	Develop Oregon Pre-engineering Learning Outcomes based on best practice research from national and state organizations
Establish coordinated and clearly articulated educational pathways, allowing students to plan and transition among Oregon educational institutions.	Understand the knowledge and skills currently being taught in 100- and 200- level core courses in engineering programs.
Increase the number of Oregonians receiving two-year and four-year degrees in engineering and applied science.	Develop a website that can provide information to students and educators on engineering education and careers.

Potential applications of the study

Identifying learning expectations for the first two years of postsecondary engineering studies improves the preparation of high school students for college studies, provides a reference point for transferring between postsecondary engineering programs, and provides a baseline for upper-division engineering programs.

Improve high school student preparation for engineering by clarifying the knowledge and skills they need to succeed in engineering programs at Oregon postsecondary institutions. With an improved understanding of the content of 100- and 200-level pre-engineering courses, ETIC and OPAS steering committees could develop materials for Oregon high schools that will enable more high school students to enter college prepared to succeed in engineering courses and to provide such information directly to high schools. The findings may influence current efforts to review and revise Oregon K-12 standards and assessments. The timing of the study is well suited to result in a significant impact on high school courses throughout the state. Because this project is the first of its kind to develop research-based standards for the knowledge and skills necessary for the success of all students seeking to study engineering at OUS institutions, it will inform state efforts to move high schools further in the direction of standards-based teaching and learning.

Provide a reference point to postsecondary institutions when reviewing the content and focus of their engineering studies curriculum. Providing a common set of learning outcomes for all Oregon engineering studies may assist the OUS to comply with recent legislation that mandates creation of a system of seamless credit transfer based on a common, statewide framework of learning expectations.

Improve student preparation for upper-division engineering study. Improving transparency of expected learning in lower-division engineering studies may increase student preparation for upper-division courses and define explicitly the foundational skills required for more advanced study in engineering. Increased retention and graduation rates from Oregon engineering programs may be a result of these efforts.

Overview of Methodology

The study began with a review of best practices in pre-engineering standards and applied a modified Delphi approach to develop learning outcomes for pre-engineering courses in Oregon. A criterion-based analysis methodology identified what is taught in 100- and 200-level courses required of students seeking engineering degrees. Instructors' ratings of their own courses were supplemented by trained raters' evaluation of course documents. Engineering instructors were interviewed to further clarify findings.

Specific Research Questions

1. According to best practice research, what are *key learning outcomes* for content knowledge, cognitive skills, and teaching practice expected of students completing the first two years of engineering education?
2. Which learning outcomes are *taught during the first two years* of engineering programs in Oregon universities and community colleges?

Learning Outcomes Development

EPIC researchers developed learning outcomes from research on best practice in engineering education. Researchers reviewed over 100 websites of national organizations, state education departments, and other engineering-related educational organizations for standards containing engineering content knowledge, key cognitive strategies, and teaching practices. Appendix G provides a comprehensive list of these sources. This research culminated in a draft list of 14 topical areas and 88 performance expectations across the three groups of standards.

Distinguished reviewers were recruited to review, edit, and endorse the standards, and EPIC conducted two sequential reviews. Reviewers were unpaid and volunteered about an hour per review.

Recruitment of distinguished engineering educators

Researchers reviewed websites of Oregon postsecondary institutions, national institutions listed as being in the top 20 engineering programs, and national engineering organizations in order to identify potential reviewers to edit and endorse the initial draft of learning outcomes. Individuals were considered distinguished if they met at least one of the following criteria:

- Prestige/status or acknowledged expertise in a field of engineering
- Author of publication/report related to improving undergraduate teaching
- Member of an engineering-related national group/committee/organization
- Recipient of engineering-related awards
- Recommendation by a person who met one of the criteria above

This search resulted in a list of potential reviewers from both Oregon and non-Oregon institutions. Learning Outcomes Development participants included distinguished educators, as shown in Table 2.

Table 2: Institutions Participating in Reviews

Institution	Review 1	Review 2
Oregon State University	X	
Pennsylvania State University – University Park		X
University of Maryland – College Park	X	X
University of Michigan – Ann Arbor	X	X
University of Oregon	X	
University of Portland	X	
University of Southern California		X
Review 1: 25 invited, 7 accepted, 5 completed *Review 2: 7 invited, 4 accepted, 4 completed*		

Study Recruitment and Participation

This study included a variety of participant groups, including consultant reviewers, institutional liaisons, instructors, and paid course raters.

Institutions

Community colleges and Oregon University System (OUS) institutions with undergraduate programs were eligible for participation. This study sought to evaluate all core pre-engineering courses in the institutions shown in Table 3.

Table 3: Oregon Community Colleges and OUS Institutions

Community Colleges (17)	OUS Institutions (7)
Blue Mountain Community College	Eastern Oregon University
Central Oregon Community College	Oregon Institute of Technology*
Chemeketa Community College	Oregon State University
Clackamas Community College	Portland State University
Clatsop Community College	Southern Oregon University
Columbia Gorge Community College	University of Oregon
Klamath Community College	Western Oregon University
Lane Community College	

Linn-Benton Community College	
Mt Hood Community College	
Oregon Coast Community College	
Portland Community College	
Rogue Community College	
Southwestern Oregon Community College	
Tillamook Bay Community College	
Treasure Valley Community College	
Umpqua Community College	

**Oregon Institute of Technology includes both the Klamath Falls and Portland campuses.*

Liaisons

A liaison for each institution was recruited to work with EPIC during the study. The primary role of the liaisons was to be an informed participant at the institution who could confirm and correct the preliminary engineering course and instructor lists. Liaisons were recruited from the 24 community colleges and OUS institutions in Oregon.

As shown in Table 3 above, 17 community colleges and seven OUS sites participated in the study. Each of the campuses for the Oregon Institute of Technology was treated as a separate institution for purposes of tracking pre-engineering course submissions and reviews, bringing the institutional count to 25. On August 7, 2006, letters were sent to deans, associate deans, engineering program directors, and community college presidents explaining the project and requesting their recommendations for liaisons at their institutions. By August 24th many of the institutions had identified a contact. Oregon Coast Community College declined to participate, as they have no courses required for pre-engineering and would counsel any student interested in engineering to transfer after taking basic courses the first year. The campus offered no calculus courses or 200-level science courses that would apply to this study.

Of the final 24 liaisons, 12 were administrators (deans, department chairs, pre-engineering directors etc.) that were not currently teaching 100-200 level courses. Twelve of the liaisons were professors currently teaching 100- and 200-level courses, although many of them also served as engineering transfer coordinators, department chairs, or similar roles. From August through early October liaisons confirmed and corrected the course and instructor lists that had been developed by EPIC from institutional course catalogs and website information.

Instructors

On October 23, 2006, all instructors identified by liaisons (approximately 200 instructors) received an email explaining the goals of the Oregon Pre-engineering and Applied Sciences Study and inviting them to participate. They were given access to a secure online course review tool containing the learning outcomes. EPIC researchers informed instructors that the purpose of reviewing courses was to develop a common list of learning outcomes for pre-engineering studies in both two- and four-year Oregon institutions. Courses relevant to the study were 100- and 200-level courses that are core requirements for a pre-engineering or engineering program. Instructors were asked to submit and review any course considered a pre-requisite to an engineering program at their own institutions or for transfer to another Oregon engineering program. Mathematics, science, and computer science courses were included if required for the engineering program, but not if the course was considered solely a general education requirement.

In addition, instructors electronically submitted course documents to supplement their course reviews. Course documents could include a syllabus, major assignments, exams, or any other document that could provide evidence of course content. Submitting course documents was optional, but encouraged.

Raters

Raters, who were paid content experts, were trained to evaluate course documents submitted by instructors for evidence of the Oregon Pre-engineering Learning Outcomes. The purpose of the external review process was to provide an objective rating of the course to identify whether evidence of each learning outcome statement existed within the documents submitted for the course. Rater course review results were used in combination with instructor course reviews to identify the knowledge and skills necessary in the courses presented.

Eleven professors, representing eleven different institutions of higher education across the United States, were trained to review course documents for this process. All of these external raters have experience teaching undergraduate courses in the subjects for which they were asked to conduct reviews.

Data Collection

Overview

The Oregon Pre-engineering Learning Outcomes Project applied a modified Delphi process and included several data collection processes. The data collection and analysis began with development of learning outcomes. Once the learning outcomes were identified, a review process was implemented to pilot the learning outcomes and establish alignment between the draft outcomes and entry-level courses in Oregon engineering programs. Telephone interviews were conducted with a sample of faculty members to gain additional information on the learning outcomes and to solicit their candid opinions about pre-engineering studies in Oregon.

Learning Outcomes Development

The learning outcomes were developed through several steps that included research on best practices in engineering education, multiple reviews and edits of draft outcomes by distinguished engineering educators, and a final review by OPAS stakeholders.

1. Online Research of Existing Pre-engineering Learning Outcomes

EPIC developed learning outcomes from research on best practice in engineering education. Over 100 websites of national organizations, state education departments, and other engineering-related educational organizations were reviewed for standards for engineering content knowledge, key cognitive strategies, and teaching practices. Primary sources are listed below.

- Center for Mathematics, Science, and Technology (CeMaST)
- Knowledge and Skills for University Success (Physics and Chemistry)
- Project 2061 (American Association for the Advancement of Science)
- Center for Engineering Learning and Teaching (CELT)
- Connections Project (Illinois State University)
- Massachusetts Department of Education Standards
- New York State Standards
- Oregon Skill Sets (Oregon Department of Education)

Standards were synthesized, combining like statements and including only general engineering expectations. Field-specific expectations were not included because this study focused on the pre-engineering curriculum that prepares students to advance to any field of engineering. This research culminated in a draft list of 14 topical areas and 88 performance expectations across three sections: 1) Content Expectations, 2) Key Cognitive Strategies, and 3) Teaching Practices.

2. Review One

The initial review of the learning outcomes was available online from August 21, 2006, through September 4, 2006. Seven distinguished faculty from Oregon and non-Oregon institutions were recruited as unpaid reviewers, and five completed review one (see Table 2 above). Reviewers had the option to edit, delete, or add to the 88 expectations. For each expectation, reviewers were asked to indicate the level of importance for preparing students for engineering programs. Ratings included:

4 - **Most important** for preparing students for engineering programs

3 - **More important** for preparing students for engineering programs

2 - **Less important** for preparing students for engineering programs

1 - **Least important** for preparing students for engineering programs

Reviewers were asked to base the importance rating on their overall opinion of how important they believed each statement was for preparing students to move on to professional engineering programs. In order to reflect best practice in college readiness, reviewers also eliminated statements that were not the equivalent of at least a first-year college course.

The rating was used to reduce the number of outcomes included in the final list. Statements with an average rating of less than 2.5 were not included in Review Two, unless at least one rater had assigned a rating of most important. Additionally, statements were included in Review Two when a concept appeared in multiple best practice sources and there was not clear reviewer agreement on the importance rating.

3. Review Two

Five reviewers agreed to participate in the second review and were sent a token of appreciation, a "Made In Oregon" gift basket, for their efforts. Comments and ratings from the first review were synthesized to create Review Two, resulting in 3 sections, 12 topics, and 73 expectations. Review Two was available online from September 7, 2006, through September 13, 2006. The same criteria for synthesis were applied here as were used in the first review, resulting in a final list of 3 sections, 10 topics, and 63 expectations.

4. Final Learning Outcomes

The synthesis and review process eliminated 25 non-essential or remedial-level learning outcomes. EPIC shared this milestone with OPAS stakeholders in order to receive feedback on the outcome statements before beginning the Oregon course review process. Feedback indicated that the outcomes should better reflect the strong connections between engineering and science, mathematics, and information technology.

EPIC reorganized the learning outcomes, eliminating the topical headings and replacing them with content-based headers. With permission from the College Board, EPIC added content-specific performance expectations based on best practice research in high school Advanced Placement® courses in science, including, biology, chemistry, and physics. Mathematics expectations were further developed by a content expert and consultant experienced in standards development for college readiness. Additionally, computer science expectations were developed through online research of current college expectations and teacher training for information technology education.

The inclusion of topical areas in each of those areas resulted in the addition of 83 content expectations, as listed in Table 4.

Table 4: Number of Learning Outcomes by Section and Topical Area

Section	Topical Area	Number of Learning Outcomes
Content Expectations		**108**
	General Engineering	25
	Mathematics	19
	Biology	14
	Chemistry	15
	Physics	15
	Computer Science	20
Key Cognitive Strategies		**31**
Teaching Practices		**12**
TOTAL NUMBER OF LEARNING OUTCOMES		**151**

The complete list of Oregon Pre-engineering Learning Outcomes is presented in Appendix A, and results from the instructor and rater questions are provided in Appendices B through F.

Oregon pre-engineering course alignment to learning outcomes

Once the draft learning outcomes were developed, EPIC researchers worked with liaisons at each Oregon community college and OUS institution to identify instructors of pre-engineering courses. Instructors were asked to review each course they had taught in the last two years, were currently teaching, or would be teaching in the 2006-2007 academic year. Because the online tool was extensive and required multiple decisions, EPIC allowed an extended period for instructor course reviews. Raters then reviewed submitted course documents to confirm instructor reviews.

Initial pre-engineering course and instructor identification

EPIC researchers reviewed course catalogues and department websites to identify over 700 required100- and 200-level courses in engineering programs at the 24 Oregon institutions. From late August 2006 to October 2006, liaisons used an online tool to confirm the course list and to submit contact information for instructors of each course.

Instructors were given the following guidelines for refining the course lists:

- Algebra courses were not included, as they were viewed as prerequisites to postsecondary study.
- Engineering tech courses (courses required for one- and two-year certificates) were not included, as only courses that contributed to a four-year degree from an engineering program were eligible for review.

- Geography, geology, economics, English, technical report writing, and other courses were not included although they may be required for general education requirements or electives.
- Introduction to Windows and other low-level computing courses were not included, as well as computer gaming courses that were non-major courses.
- Labs were not included as separate courses, but instructors were told to include the lab content in the associated course review.
- Courses titled "Special Topics" at schools were not included.
- Spring courses without an assigned instructor were only included if a past instructor could be reached to complete the review.
- If an institution submitted contact information for more than one instructor for the same course, only one was contacted. If a professor was listed for multiple courses, EPIC staff made every effort to spread the course review load across other available professors.
- Liaisons could participate as both an instructor and liaison for their institutions.

Liaison's final confirmation of courses and instructors resulted in a list of just over 600 coursers across all participating institutions. Instructors received an email invitation to participate in the Oregon Pre-engineering and Applied Sciences Study in mid-October 2006. Liaisons could monitor instructor progress online and were contacted by EPIC staff if there were concerns about participation.

Instructor online course review tool

Instructors logged into a web-based data collection tool to complete a course profile of each course they taught, review the course for evidence of the Oregon Pre-engineering Learning Outcomes, and submit course documents.

For each performance expectation, or learning outcome, instructors were prompted to respond to four questions:

1. How important is each performance expectation in my course?
2. What do students need to know when they enter my class?
3. What do I observe students knowing when they enter my class?
4. How important is the performance expectation in preparing students for further study in engineering programs?

Although responses to each question were optional, instructors were strongly encouraged to respond to all expectations listed in the engineering strand of the content section, key cognitive strategies, and teaching practices. Instructors were also asked to offer any general comments about the learning outcomes and answer open-ended questions about student preparation for postsecondary study in engineering programs. In addition to completing the online course review, faculty had the option to upload accompanying course documents. This could include syllabus, major assignments, exams, or other supporting documents.

In late November 2006, liaisons and instructors requested course review extensions. Several extensions were given to accommodate teaching and grading demands as well as a community college curriculum review that could produce outcomes that would change course content. Participation was slow but steady and required persistent communication between EPIC staff, liaisons, and instructors.

While feedback regarding the goals of the study was overwhelmingly positive, there were several issues identified by instructors during the course review process. Key issues included:

- Survey is too long and complex—making it difficult to complete.
- Instructors of some mathematics or science courses found it difficult to identify engineering-specific outcomes.
- In several specific cases one instructor taught 5-12 courses included in the study.

To assist instructors a few adjustments were made to course review submissions:

- If an instructor taught a series course (e.g., Physics 211, 212, 213), one review could be submitted for all three courses.
- When instructors declined to participate in the four questions of the course review process, they were encouraged to email course documents to EPIC.

The online instructor course review tool was available through January 2007. As listed in Table 5 below, just over half of identified instructors of pre-engineering courses participated in the instructor course reviews, including instructors who chose to email syllabi in lieu of completing the course reviews.

Table 5: Completed Instructor Course Reviews by Course Type

Course Type	Total Expected	Total Completed	Percent Complete
Engineering	274	135	49.3%
Mathematics	109	63	57.8%
Biology	6	3	50.0%
Chemistry	60	28	46.7%
Physics	76	40	52.6%
Computer Science	83	45	54.2%
Totals	**608**	**314**	**51.6%**

Consultant rater review of submitted course documents

Consultant raters provided external validation of what the course documents reflect about the courses. EPIC staff trained paid raters on use of the tool and the criteria for establishing evidence of learning outcomes through the course documents. Using an online rating tool to view PDF files of the submitted course documents, raters indicated if evidence was found for each learning outcome. Between March and May 2007, raters reviewed documents submitted for 216 courses. Table 6 shows the number of courses per content area for which supporting documents were submitted.

Table 6: Number of Courses by Content Area with Documents Submitted for External Review

Content Area	Number of Courses
Engineering	112
Mathematics	43
Biology	4
Chemistry	19
Physics	17
Computer Science	21
Total	**216**

Instructor interviews

Instructor interviews were added to the study to supplement information reported via the online tool and course documents. Primarily instructors of courses under the engineering content area were invited to participate in the interviews, particularly given the feedback from mathematics and science instructors regarding their difficulty in identifying engineering-specific learning outcomes for non-engineering content areas. An additional effort was undertaken to include instructors who were unable to participate in the online course review process.

Under these general criteria for participation, 52 of 71 (73%) invited engineering instructors participated in short phone interviews. This group included instructors who both participated and did not participate in the online course review and document submission process. As shown in Table 7, about two-thirds of interviewees taught courses at OUS institutions.

Table 7: Instructor Interviews Participation by Institution Type

Interview Participation	Community College Participants	OUS Institution	Total Number of Participants
Instructors invited	29 (41%)	42 (59%)	71
Instructors participating	19 (36%)	33 (64%)	52

Interview questions

Telephone interviews were conducted over a three-week period beginning in mid-May 2007 and generally lasted 10-15 minutes. Selected-response items were included to clarify responses from the instructor and reviewer process. Of particular consideration was further identification of the most important learning outcomes for pre-engineering. Responses to open-ended questions were also solicited to record instructor impressions of student preparation for postsecondary study, including:

1. What could students do in high school to be better prepared to succeed in entry-level engineering courses?
2. How can programs in the high school be improved so students enter courses ready to succeed?
3. How do students demonstrate thinking skills (critical thinking, analytic thinking, coping with ambiguous tasks, interpretation, precision & accuracy) in their classes?
4. How do students who don't demonstrate thinking skills perform differently in their classes?
5. Based on their experience and observation, what are the major reasons students do not continue beyond entry-level courses in engineering?

Limitations of the Research Design and Methodology

Although this study provides a strong foundation for the development of pre-engineering learning outcomes, there are limitations to the methodology and the process applied over the course of the study. The draft of learning outcomes developed by reviewers resulted in a strong set of general engineering learning expectations. However, feedback from engineering educators and industry experts resulted in the addition of content-specific standards. While the inclusion of content areas increased the explicit links between general engineering, science, mathematics, and computer science, it also increased the length of the reviews. Instructor fatigue resulted in fewer course review completions and course document submissions. EPIC researchers provided flexibility to instructors to reduce the amount of time required for online reviews. This also resulted in partial responses to the four questions when instructors chose to submit responses for only select outcomes. Instructors also chose to upload or email only their course documents, reducing the ability to provide external validation of instructor self reviews. Refining and reducing the number of standards may increase transparency and successful adoption of the learning outcomes.

Biology instructors submitted no course reviews, and only one course document was received for a biology course. Due to virtually no biology-specific instructor participation, the biology learning outcomes are not included in the following results and discussion. Biology learning outcomes, as developed by the reviewers and best practice research by EPIC, are provided in Appendix A.

Findings & Interpretation

Overview

The draft list of Oregon Pre-engineering Learning Outcomes was developed to identify expectations for both high school students entering pre-engineering programs and postsecondary students preparing for upper-division engineering studies. A review of 100- and 200-level engineering courses in Oregon postsecondary institutions provided a baseline understanding of what is currently taught in the first two years of engineering courses. To assist in this effort, instructors from Oregon community colleges and universities reviewed over 300 pre-engineering courses in which they had teaching experience. The learning outcomes cover content knowledge, key cognitive strategies, and teaching practices. For each performance expectation in the content knowledge and key cognitive strategies sections, instructors responded to four questions:

1. What do students need to know to enter my class?
2. What do I observe that students know?
3. How important is this for students to successfully complete this course?
4. How important is the learning outcome in preparing students for further engineering studies?

Only the last two questions were included for the teaching practices section of the online course review. A synthesis of the reviews provides several general findings on the preparation and expectations of pre-engineering students.

- Virtually all pre-engineering courses require more than a basic understanding of course content.
- Instructors generally find that students enter their courses with adequate knowledge.
- Two-thirds of learning outcomes are more or most important for the success in the first two years of engineering programs.
- Almost 40% of the learning outcomes are more or most important for successful entry into upper-division engineering courses. Responses regarding future studies specifically identified finding all of the teaching practices learning outcomes as important for study beyond the first two years of engineering programs.

Overall, there was little change in the instructors' ratings of the importance of each of the learning outcomes for their course and for ongoing engineering study. This may indicate that the learning outcomes reflect college-level standards and are foundational for general engineering studies. Finally, the overall importance of many of the learning outcomes, across content-specific expectations, may also reflect the cross-disciplinary nature of pre-engineering programs. Additional findings by content area are provided in the next sections of this report.

Findings by Content Area

The following five content areas are discussed below: general engineering, mathematics, chemistry, physics, and computer science.

General Engineering

Instructors submitted reviews for engineering courses from Oregon postsecondary institutions. Course reviews represent an even distribution between community colleges and OUS institutions, with Oregon Institute of Technology (OIT) representing one-half of the submitted OUS courses.

Learning outcome importance

Engineering instructors identified all learning outcomes for engineering content and key cognitive strategies to be important for success in both entry-level courses and advanced engineering coursework. Among the 53 instructors interviewed, the importance of key cognitive strategies was further evidenced by over three-quarters of interviewed instructors identifying student thinking skills as most important to success in their courses. Teaching practices were identified as having a greater level of important overall than course content and key cognitive strategies.

With regard to specific learning outcomes, GE023, *Convert between different unit and measurement systems*, stood out as the most important learning outcome for success in the courses. The following outcomes were relatively less important:

> *GE002: Understand that scientific knowledge used in technology is not a replacement for the trial-and-error method of technology; rather, it provides a means of selecting what trial to undertake next and thus contributes to the efficiency and effectiveness of the trial-and-error process.*
>
> *GE003: Know that technology usually affects society more directly than science because it solves practical problems and serves human needs (and may create new problems and needs). In contrast, science affects society mainly by stimulating and satisfying people's curiosity and occasionally by enlarging or challenging their views of what the world is like.*

GE015: Understand that as the number of parts of a system increases, the number of possible interactions between pairs of parts increases much more rapidly.

Similarly, relative to the other learning outcomes, GE018 (below) was identified most important for preparing students for further study in engineering:

Understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, trigonometry, differential equations, data analysis, and probability,

and GE003 (below) as least important:

Know that technology usually affects society more directly than science because it solves practical problems and serves human needs (and may create new problems and needs). In contrast, science affects society mainly by stimulating and satisfying people's curiosity and occasionally by enlarging or challenging their views of what the world is like.

With key cognitive strategies, the following learning outcomes were identified as skills that are key to course success:

KCS18: Make up and write out simple algorithms for solving problems that take multiple steps.

KCS25: Use tables, charts, and graphs in making arguments and claims in oral and written presentations.

KCS26: Check graphs to see that they do not misrepresent results by using inappropriate scales or by failing to specify the axes clearly.

Learning outcomes KCS12: *Demonstrate problem-solving skills by developing a process for a solution using relationships between words, diagrams, graphs, and mathematical representations* and KCS13: *The student can plan a solution for a given problem by determining the steps necessary to solve, verify the solution, and evaluate whether the proposed solution is reasonable* were noted as most important for preparing students for further study. However, similar to the course content, very little evidence of key cognitive strategies learning outcomes was found among the course documents submitted by instructors, with exception to five learning outcomes (namely KCS10-KCS15) for which evidence was overwhelmingly found. This suggests that although the key cognitive strategies and thinking skills are crucial to course success and preparing students for further study, not much is directly addressed in the entry-level courses.

Teaching practices were found to be most important overall with learning outcome TP004: *Helping and encouraging students to develop their abilities* standing out as a key practice for both helping students succeed in the courses and for preparing students for further study. Interestingly, discussion of these teaching practices was found to be highly evident within the course documents, suggesting that instructors recognize the importance of these practices and convey their methods openly to students.

Observations and expectations

On average, roughly one-third of the instructors expressed that an engineering learning outcome was not taught in his/her course. However, for those who did include the specific learning outcomes, instructors identified that they expect college students to enter their entry-level engineering courses with only a basic understanding of the course material. Instructors further confirmed that they have observed that generally students do indeed enter their classes with adequate knowledge, thereby meeting the expectation. The same pattern was observed for the key cognitive strategies learning outcomes.

The expectation of students only needing a basic understanding of the material implies that instructors plan to build upon this foundational knowledge and will therefore teach this material in their courses. However, this was not found to necessarily be the case. Although external reviewers did find some evidence of the learning outcomes being covered among the engineering courses, little evidence was found overall. Outside of the material identified as not being included in the course, there are a few possible explanations for this. It is possible that the course documents provided by the instructors were not the most descriptive or detailed documents that could have been provided. Or, it is possible that documents themselves should have been sufficient, but the detail provided that would identify the learning outcomes in the documents was insufficient or poorly represented.

Preparation and success

High school was identified as playing a significant role in a student's preparedness for engineering courses in college; however the level of its significance varies among those interviewed. Overall, 50% of the interviewees observed that of the students who seem particularly well prepared to succeed in the instructor's engineering courses, a great deal of their preparation can be attributed to their high school program of study. However, when broken down by the institution at which the instructor teaches, the majority of university instructors agree with this statement, whereas only 37% of community college instructors agree with this, the others observing that students' high school preparedness attributes to their success to a lesser degree.

According to the 53 instructors interviewed, actions that high school students can take to better prepare themselves for college-level engineering courses are to:

- Take more mathematics courses.
- Take responsibility for their own learning.
- Take more science courses, particularly physics or “hands-on” science.
- Improve writing skills.
- Seek challenges and complex problem solving.

Students must increase their mathematics proficiency, particularly with regard to algebra. It was noted that drafting classes should also be taken when available as they help to fine-tune problem-solving skills by requiring students to apply their algebra knowledge. Exposure to calculus would also be helpful. Most importantly, it was expressed that students need to feel comfortable and confident with mathematics and be able to think beyond individual problems to real-world applications.

Instructors also expressed that students can better prepare themselves in high school by taking responsibility for their learning by being self-disciplined enough to look beyond graduation requirements and take the additional courses they need (such as additional mathematics, drafting and physics) to prepare for engineering. Additionally, students need to be self-disciplined in their study habits to perform well in these courses.

Although taking more science courses in general would be helpful, physics was identified specifically and repeatedly as a key discipline for preparing students for engineering. It should be noted that some instructors further clarified that the physics course taken does not need to be calculus based.

When asked how high school programs of study can be improved so that students are better prepared for college engineering courses, the instructors stated that high schools should improve the way in which mathematics is currently being taught. More specifically, students need to better understand how to apply their mathematics skills across varying situations. Mathematics should be more highly integrated into science, drafting, and other course subjects to assist in understanding the applications of mathematics. Students should be taught how to approach problems and become more aware of the process involved in solving problems as opposed to simply being focused on whether the answer is correct. It was also noted that better guidance from high school counselors and instructors would be beneficial to students by steering them towards more appropriate courses and encouraging their studies.

Furthermore, it was the observation of engineering instructors that students do not continue beyond entry-level courses in engineering primarily because they find the engineering program simply too difficult. Students are either unprepared for rigorous coursework, particularly with regard to mathematics, or, in many cases, either lack the self-discipline or are simply unwilling to apply themselves appropriately. However, instructors also pointed out that while the many students may be ill prepared, they are not necessarily unqualified. Many of the students who do not continue on with engineering are perfectly capable of doing the work, but it is possible that they discontinue the program because they do not have realistic expectations and end up being intimidated by the coursework and the amount of time their studies require.

Finally, postsecondary instructors advise high school educators and career counselors to work with local community colleges and industry to provide opportunities for students to see what engineers actually do—students need opportunities to see the exciting aspects of engineering and to connect with people that are passionate about what they do.

Mathematics

Data were collected from 53 mathematics courses from among Oregon postsecondary institutions. All mathematics courses were identified as core courses required for engineering majors. These courses represented both two- and four-year institutions with about two-thirds from community colleges.

Learning outcome importance

Instructors identified all mathematics learning outcomes to be important for success in their entry-level courses, but less important for further engineering coursework. The key cognitive strategies learning outcomes, however, were identified as important for success in the courses as well as further engineering coursework. Interestingly, teaching practices were identified as having a greater level of importance overall than course content and key cognitive strategies for both success in current and future engineering coursework.

With regard to specific learning outcomes, MA006: *Have knowledge of gradient, curl, Jacobian, and Laplacian* stood out as the most important learning outcome for success in the courses and outcome MA016: *Use Newtonians method for approximation* was the least in relative importance. Similarly, relative to the other learning outcomes, the following three were identified as key elements for preparing students for further study in engineering:

MA001: Perform operations on matrices and use them to solve systems of linear equation

MA008: Use differentiation to optimize functions of one variable

MA009: Understand implicit differentiation and its use for related rates problems

Learning outcome MA019: *Use partial fractions and trigonometric substitutions for integration* was rated least important.

With key cognitive strategies, learning outcome KCS27: *Describe, in words, both written and orally, an experiment or derivation he or she has made to an audience of non-experts in a manner that avoids jargon and follows a clear logical path between question, method, solution, and impact* was identified as a key element for course success and learning outcomes. KCS13: *The student can plan a solution for a given problem by determining the steps necessary to solve, verify the solution, and evaluate whether the proposed solution is reasonable* and KCS22: *Determine whether the mathematical solutions are reasonable by reviewing the process and checking against typical values from experience of the everyday world* were noted as most important for preparing students for further study. However, similar to the course content, very little evidence of key cognitive strategies learning outcomes was found among the course documents submitted by instructors, with exception to three learning outcomes, namely KCS14: *The student can determine known and unknown quantities that are relevant to a given problem* and KCS29: *Use and correctly interpret relational terms such as if . . . then . . . and, or, sufficient, necessary, some, every, not, correlates with, and causes* for which evidence was overwhelmingly found. This suggests that although the key cognitive strategies and thinking skills are crucial to course success and preparing students for further study, not much is directly addressed in the entry-level courses.

Teaching practices were found to be most important overall with learning outcome TP004 standing out as a key practice for helping students succeed in the courses. Although still considered important, learning outcomes TP009: *Connecting academic ideas with the way a professional in the field thinks and explains the practical issues of the topics covered* and TP012: *Raising questions consciously that cause students to consider the quality of evidence* were identified as less critical overall for success in current coursework and for helping prepare students for further study. Interestingly, more evidence of these teaching practices was found within the course documents than of course content or key cognitive strategies, suggesting that instructors recognize the importance of these practices and convey their methods more openly to students.

Observations and expectations

On average, roughly one-half of the instructors expressed that a mathematics learning outcome was not taught in his or her course. However, for those who did include the specific learning outcomes, instructors identified that they expect college students to enter their entry-level mathematics courses with only a basic understanding of the course material. Instructors further confirmed they have observed that students generally do enter their classes with adequate knowledge, thereby meeting the expectation. The same pattern was observed for the key cognitive strategies learning outcomes. However, instructors expressed that they expect students to have a more thorough understanding of learning outcomes KCS22: *Determine whether the mathematical solutions are reasonable by reviewing the process and checking against typical values from experience of the everyday world* and KCS31: *Write clear, step-by-step instructions for conducting investigations, operating something, or following a procedure* before they enter the class and that students' knowledge and practice of learning outcomes KCS11: *Apply knowledge and thinking skills to address real life problems and make informed decisions* and KCS17: *Make up and write out simple algorithms for solving problems that take multiple steps* has been observed to be less than adequate in general.

Chemistry

Data were collected from 19 chemistry courses from among Oregon postsecondary institutions. All chemistry courses were identified as core courses required for engineering majors. These courses represented both two- and four-year institutions with about two-thirds from community colleges.

Learning outcome importance

Instructors identified all chemistry learning outcomes to be most important for success in their entry-level courses and important as well for further engineering coursework, although to a slightly lesser degree. Following a similar pattern, the key cognitive strategies learning outcomes were identified as most important for success in the courses and nearly as important for further engineering coursework. However, teaching practices were identified as having a greater level of importance overall than course content and key cognitive strategies for both success in current and particularly for future engineering coursework.

With regard to specific learning outcomes, CH006: *Know the basic subatomic constituents of matter (i.e., proton, neutron, electron)* stood out as a key learning outcome for success in the courses. Learning outcome CH013: *Experimentally measure and calculate limiting reactant and percent yield* was identified as the least in relative importance with regard to the courses, but was identified as a key element for preparing students for further study in engineering along with CH012: *Use stoichiometry to measure or calculate the relationship among mass, moles, and number of particles of reactants and products in a balanced chemical equation* and CH015: *Links chemical concepts to personal observations and experiences and chemically related news items.* Considerable evidence of the chemistry learning outcomes was found within the course documents submitted by instructors. This is a good indication that chemistry instructors are doing a good job of teaching material that is most important and critical for engineering students.

For key cognitive strategies, learning outcomes KCS28: *Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions* and KCS31: *Write clear, step-by-step instructions for conducting investigations, operating something, or following a procedure* were identified as key elements for course success and learning outcomes. The outcomes listed below were noted as most important for preparing students for further study.

> *KCS01: Know why curiosity, honesty, openness, and skepticism are so highly regarded in scientific research and how they are incorporated into the way engineers carry out science.*
>
> *KCS04: Know that there may be ethical issues, such as ignoring contradicting data and selecting only supporting data, when considering claims.*
>
> *KCS13: The student can plan a solution for a given problem by determining the steps necessary to solve, verify the solution, and evaluate whether the proposed solution is reasonable.*

Teaching practices were found to be most important overall with learning outcome TP004: *Helping and encouraging students to develop their abilities* standing out as important. Interestingly, considerable evidence of these teaching practices was found within the course documents, suggesting that instructors recognize the importance of these practices and convey their methods openly to students.

Observations and expectations

Very few of the instructors who participated in this study expressed that a chemistry learning outcome was not taught in his/her course. Instructors identified that they expect students to enter their entry-level chemistry courses with a more than a basic understanding of the chemistry course material, particularly more with regard to learning component CH006: *Know the basic subatomic constituents of matter (i.e., proton, neutron, electron)*. Instructors were nearly evenly split between whether they observe students' knowledge to be adequate with regard to the expected level of knowledge. The same pattern was observed for the key cognitive strategies learning outcomes. However, instructors expressed that they expect students to have a more thorough understanding of learning outcomes KCS02: *The student regards science as an essential way of knowing and learning engineering professions* and KCS27: *Describe, in words, both written and orally, an experiment or derivation he or she has made to an audience of non-experts in a manner that avoids jargon and follows a clear logical path between question, method,* *solution, and impact* and they observe that students' knowledge is indeed adequate for this raised expectation.

Physics

Data were collected from 31 physics courses from among Oregon postsecondary institutions. All physics courses were identified as core courses required for engineering majors. These courses represented both two- and four-year institutions with about two-thirds from community colleges.

Learning outcome importance

Instructors identified all physics learning outcomes to be highly important for success in their entry-level courses, but slightly less important for further engineering coursework. The key cognitive strategies and teaching practices learning outcomes followed an opposite pattern, identified as important for physics courses and even more important for further engineering coursework. Interestingly however, both were identified as less important overall than the physics content.

With regard to specific learning outcomes, PH013: *Describe, using words, diagrams and equations, the forces on and motion of charges in given electric and magnetic fields* stood out as the most important content learning outcome for success in physics courses. Similarly, relative to the other learning outcomes, the following were identified as key elements for preparing students for further study in engineering.

> *PH002: Describe, using words and a free-body diagram, the forces acting on a given object or a system of interacting objects.*
>
> *PH003: Describe, using words, graphs, or equations the motion of a given object or system of interacting objects that results from forces acting upon the object or objects.*
>
> *PH008: Describe, using words, graphs or equations, the change of linear momentum of a given system under different conditions, including before and after an interaction, and any transfer of linear momentum into or out of the system, using the principle of the conservation of linear momentum.*

The physics learning outcomes were found to be highly evident throughout the course documents, their presence supporting the importance of these standards.

For key cognitive strategies, learning outcome KCS12: *Demonstrate problem-solving skills by developing a process for a solution using relationships between words, diagrams, graphs, and mathematical* *representations* was identified as the most important element for course success followed closely by outcomes KCS13: *The student can plan a solution for a given problem by determining the steps necessary to solve, verify the solution, and evaluate whether the proposed solution is reasonable* and KCS14*: The student can determine known and unknown quantities that are relevant to a given problem.*

Similarly, learning outcome KCS03*: Insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position being taken-whether one's own or that of others-can be judged* was noted as a key element for preparing students for further study. Conversely, the following learning outcomes stood out as the least important elements for course success as well as further engineering studies.

> *KCS05: Know what is expected of a professional, such as knowing a professional code of ethics.*
>
> *KCS09: Understand that scientists use methods and knowledge drawn from more than one scientific discipline as they solve problems.*
>
> *KCS21: Be able to estimate how likely it is that some event of interest might have occurred just by chance.*

Evidence of the key cognitive strategies outcomes was found in the course documents, but not overwhelmingly so. However, the degree of evidence found was proportional to the importance indicated, such that the learning outcomes identified as most important were more highly evident than the others, with the least important being least evident. This suggests that the importance of key cognitive strategies and thinking skills most crucial to course success and preparing students for further study are recognized and addressed appropriately in the entry-level courses.

Teaching practices were found to be nearly as important as the physics content, with the following learning outcomes standing out as key practices for helping students succeed in the courses.

> *TP004: Helping and encouraging students to develop their abilities.*
>
> *TP005: Working to develop students' good study habits, self-reliance and responsibility for learning.*
>
> *TP008: Developing goals and pace for the course that are appropriately challenging.*

Outcome TP004: *Helping and encouraging students to develop their abilities* was also identified as the most important practice for preparing students for further study in engineering. The teaching practice learning outcomes were highly evident within the course documents, suggesting that instructors recognize the importance of these practices and convey their methods openly to students.

Observations and expectations

Very few of the instructors who participated in this study expressed that a physics learning outcome was not taught in the course. Instructors identified that they expect college students to enter their entry-level physics courses with less than a basic understanding of the course material. Instructors further confirmed that they have observed that generally students do indeed enter their classes with adequate knowledge, thereby meeting the expectation. The same pattern was observed for the key cognitive strategies learning outcomes. Instructors expressed that they expect students to have a stronger basic understanding of learning outcome KCS29 before they enter the class and have observed that students' knowledge and practice of this skill has been generally observed to be adequate.

Computer Science

Data were collected from 31 computer science courses from among Oregon postsecondary institutions. All computer science courses were identified as core courses required for engineering majors. These courses were fairly evenly distributed between community colleges, universities, and OIT, with roughly one-third of the courses from each.

Learning outcome importance

Instructors identified all computer science learning outcomes to be important for success in their entry-level courses and equally important for further engineering coursework. Similarly, key cognitive strategies and teaching practices learning outcomes were identified as important for success in the courses and equally important for further engineering coursework as well. Interestingly however, teaching practices were identified as having a greater level of importance overall than computer science content and key cognitive strategies for success in both computer science courses and future engineering coursework.

With regard to specific learning outcomes, CS001: *Demonstrate knowledge of and skill regarding the syntax and semantics of a high level programming language, its control structures, and its basic data representations* and CS015: *Implement syntactically correct, logically accurate programs based on logical algorithms/pseudo code* stood out as the most important content learning outcome for success in computer science courses. Similarly, learning outcome CS001 was also identified as a key element for preparing students for further engineering coursework along with outcome CS004: *Demonstrate knowledge of and skill regarding program correctness issues and practices (e.g., testing program results, test data design, loop invariants).* Despite their identified importance however, little evidence of the computer science learning outcomes was found throughout the course documents submitted by instructors.

For key cognitive strategies, learning outcomes KCS13: *The student can plan a solution for a given problem by determining the steps necessary to solve, verify the solution, and evaluate whether the proposed solution is reasonable* and KCS31: *Write clear, step-by-step instructions for conducting investigations, operating something, or following a procedure* were identified as key elements for success in computer science courses. Similarly, the following learning outcomes were noted as most important elements for preparing students for further engineering study.

> *KCS11: Apply knowledge and thinking skills to address real life problems and make informed decisions.*
>
> *KCS13: The student can plan a solution for a given problem by determining the steps necessary to solve, verify the solution, and evaluate whether the proposed solution is reasonable.*
>
> *KCS14: The student can determine known and unknown quantities that are relevant to a given problem.*

Conversely, learning outcomes KCS06: *Sample a wide range of scientific literature at a superficial level so as to build up an approximate framework for interpreting what is found on more detailed reading* and KCS21: *Be able to estimate how likely it is that some event of interest might have occurred just by chance* stood out as the least important elements for course success as well as further engineering studies. Surprisingly, considerably little evidence of the key cognitive strategies learning outcomes was found within the course documents. This suggests that although the key cognitive strategies and thinking skills are crucial to course success and preparing students for further study, not much is directly addressed in the entry-level courses.

Teaching practices were found to be relatively more important than the physics and key cognitive strategies learning outcomes with regard to computer science course and further engineering study success. Learning outcome TP001: *Providing timely and suitable feedback to students* stood out as key practice for helping students succeed in the courses as well as TP004: *Helping and encouraging students to develop their abilities* which was also identified as the most critical element for preparing students for further study in engineering. Although some evidence of the teaching practice learning outcomes was found within the course documents, little evidence was found overall suggesting that instructors may not openly convey their methods to students.

Observations and expectations

Roughly one-quarter to one-half of the instructors who participated in this study expressed that a computer science learning outcome was not taught in the course. Instructors identified that they expect college students to enter their entry-level physics courses with less than a basic understanding of the course material. Instructors further confirmed that they have observed that generally students do indeed enter their classes with adequate knowledge, thereby meeting the expectation. The same pattern was observed for the key cognitive strategies learning outcomes.

Recommendations

Implications of Findings

The Oregon Pre-engineering Learning Outcomes Study is the first of its kind to examine learning expectations in the first two years of Oregon engineering courses. Refinement of existing national and state standards in engineering education and related content areas provide a foundation for the draft outcomes included in this report. As a starting place for standards development, the outcomes reflect a broad scope and general performance expectations.

The outcomes are presented to ETIC as draft outcomes, as EPIC acknowledges that these are only the beginning of additional investigation.

We recommend improving the draft outcomes through additional studies, such as:

1. Additional analysis of alignment between engineering programs at Oregon community colleges and OUS institutions..
2. A "best practices"-style study, including a deeper and broader review of course documents, to find exemplars of Oregon courses that already fully incorporate the learning outcomes.
3. An investigation of vertical alignment between the three primary engineering schools (Oregon State, Oregon Institute of Technology, and Portland State) and other postsecondary institutions in Oregon.
4. Focused studies on each of the subject areas to illuminate the explicit connections between engineering, mathematics, science, and technology courses.

Appendix A: The Oregon Pre-engineering Learning Outcomes

General Engineering

ID	Outcome
GE001	Know that mathematics, creativity, logic, and originality are all needed to improve technology.
GE002	Understand that scientific knowledge used in technology is not a replacement for the trial-and-error method of technology; rather, it provides a means of selecting what trial to undertake next and thus contributes to the efficiency and effectiveness of the trial-and-error process.
GE003	Know that technology usually affects society more directly than science because it solves practical problems and serves human needs (and may create new problems and needs). In contrast, science affects society mainly by stimulating and satisfying people's curiosity and occasionally by enlarging or challenging their views of what the world is like.
GE004	Understand that the professional practice of applying the engineering design process is used in the solution of problems and the advancement of society.
GE005	Identify and explain the steps of the engineering design process (i.e., identify a design problem, propose a solution, construct one or more prototypes and/or models, evaluate design, and revise design).
GE006	Communicate solutions by making an engineering presentation that includes a discussion of how the solution best meets the needs of the initial problem or opportunity.
GE007	Consider cost constraints and how the technology will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it.
GE008	Understand that problem solving begins with specifying system boundaries and subsystems, indicating its relation to other systems, and identifying what its input and its output are expected to be.
GE009	Understand that the basic idea of mathematical modeling is to find a mathematical relationship that behaves in similar ways as the system or processes under investigation.
GE010	Interpret multi-view drawings (orthographic projections) and pictorial (isometric, oblique, perspective) drawings using various techniques.
GE011	Interpret plans, diagrams, and working drawings in the construction of prototypes or models.
GE012	Test the usefulness of a model by comparing its predictions to actual observations in the real world with consideration of alternative solutions.
GE013	Apply statistics, graphs, and equations as useful ways for depicting and analyzing patterns of change and drawing conclusions.
GE014	Recognize that statistical scatter results from uncertainties in measurements and specification ranges of quantities and therefore impacts these quantities along with all calculations using them.
GE015	Understand that as the number of parts of a system increases, the number of possible interactions between pairs of parts increases much more rapidly.
GE016	Understand scientific notation, the concept of a logarithm, logarithmic scales, and the use of units appropriate for the problem at hand.
GE017	Know that representing large numbers in terms of powers of ten makes it easier to think about them and to compare things that are greatly different.
GE018	Understand mathematics and become mathematically confident by communicating and reasoning mathematically, by applying mathematics in real-world settings, and by solving problems through the integrated study of number systems, geometry, algebra, trigonometry, differential equations, data analysis, and probability.
GE019	Make measurements or calculations to collect data and analyze the data using appropriate statistics such as mean, standard deviation, chi-square, linear regression and correlation.
GE020	Construct and use tables and graphs to interpret data sets.
GE021	Solve algebraic equations with several variables including equations with unspecified parameters.
GE022	Measure with accuracy and precision (length, volume, mass, temperature, time, etc.)

ID	Outcome
GE023	Convert between different unit and measurement systems.
GE024	Determine the correct number of significant figures.
GE025	Determine percent error from experimental and accepted values.

Note: All outcomes below that are marked with an asterisk are used with permission by the College Board AP® program.

Chemistry

ID	Outcome
CH001	Use periodic trends to predict the chemical and physical properties of elements.
CH002	Describe and use the periodic trends in electronegativity and metallic character of a given set of elements based upon position in the periodic table.
CH003	Predict whether the bonding in a given substance is primarily covalent, metallic, or ionic, using the periodic table and the arrangement and energies of the elements' outermost electrons.
CH004	Know the basic constituents of matter.
CH005	Predict the shape of molecules (e.g., VSEPR theory, molecular geometry).
CH006	Know the basic subatomic constituents of matter (i.e., proton, neutron, electron).
CH007	Describe the Arrhenius, Bronsted-Lowry, and Lewis acid-base definitions.
CH008	Apply the pH scale to characterize aqueous acid and base solutions.
CH009	Classify and predict products for oxidation-reduction, acid-base and single and double replacement reactions.
CH010	Understand/know oxidation and reducing agents in an oxidation-reduction reaction.
CH011	Measure and calculate the solute concentration of a solution in units (e.g., molarity, mass and volume percentage, mole fraction).
CH012	Use stoichiometry to measure or calculate the relationship among mass, moles, and number of particles of reactants and products in a balanced chemical equation.
CH013	Experimentally measure and calculate limiting reactant and percent yield.
CH014	Understand/know why the chemical equilibrium of a reaction is a dynamic process.
CH015	Links chemical concepts to personal observations and experiences and chemically related news items.

Physics

ID	Outcome
PH001	Describe, using words, graphs, or equations, the linear position, velocity, and acceleration of a given object for motion in one or two dimensions.
PH002	Describe, using words and a free-body diagram, the forces acting on a given object or a system of interacting objects.
PH003	Describe, using words, graphs, or equations the motion of a given object or system of interacting objects that results from forces acting upon the object or objects.
PH004	Describe, using words, diagrams or equations, the linear momentum of a system under different conditions, including before and after an interaction, using the principle of the conservation of linear momentum.
PH005	Describe, using words, graphs or equations, the motion of objects in a given system of interacting objects, using the principle of conservation of energy.
PH006	Describe, using words, graphs or equations, the change of energy within a given system of interacting objects, including the role of work and other forms of energy transfer.
PH007	Describe, using words, graphs or equations, the motion of objects, before and after an interaction, in a given system of interacting objects, using the principles of conservation of energy and momentum.
PH008	Describe, using words, graphs or equations, the change of linear momentum of a given system

	under different conditions, including before and after an interaction, and any transfer of linear momentum into or out of the system, using the principle of the conservation of linear momentum.
PH009	Describe, using words and diagrams, wavelength, amplitude, period, and frequency of a given wave.

ID	Outcome
PH010	Describe, using words, diagrams or equations, constructive and destructive interference using the principle of superposition.
PH011	Describe, using words, diagrams and graphs, amplitude, frequency, and energy of an object undergoing simple harmonic motion.
PH012	Describe, using words, diagrams, or equations, the potential and kinetic energy of a given oscillating system as a function of time.
PH013	Describe, using words, diagrams and equations, the forces on and motion of charges in given electric and magnetic fields.
PH014	Describe, using words and equations, the functional dependence of one variable on another by examining a graph.
PH015	Evaluate, using words or equations, reasonableness of calculated or measured physical parameters.

Mathematics

ID	Outcome
MA001	Perform operations on matrices and use them to solve systems of linear equations.
MA002	Use techniques of Linear Programming for optimization problems.
MA003	Know how to find the characteristic values and vectors associated with a matrix.
MA004	Understand linear dependence and linear independence of a set of vectors.
MA005	Perform and interpret dot or scalar product and cross or vector product.
MA006	Have knowledge of gradient, curl, Jacobian, and Laplacian.
MA007	Can manipulate complex numbers in polar notation.
MA008	Use differentiation to optimize functions of one variable.
MA009	Understand implicit differentiation and its use for related rates problems.
MA010	Use differentials for approximation problems.
MA011	Can use techniques of integration to find arc lengths, areas and volumes.
MA012	Can differentiate and integrate in polar coordinates.
MA013	Evaluate line integrals and surface integrals.
MA014	Determine the convergence or divergence of improper integrals.
MA015	Use L'Hospital's rules for determining certain limits.
MA016	Use Newtonians method for approximation.
MA017	Can expand functions in power series and know some important power series.
MA018	Use partial derivatives to optimize functions of two or more variables.
MA019	Use partial fractions and trigonometric substitutions for integration.

Computer Science

ID	Outcome
CS001	Demonstrate knowledge of and skill regarding the syntax and semantics of a high level programming language, its control structures, and its basic data representations
CS002	Demonstrate knowledge of and skill regarding common data abstraction mechanisms (e.g., data types or classes such as stacks, trees, etc.)
CS003	Know how to properly use classes, instances, methods, and attributes in programs.
CS004	Demonstrate knowledge of and skill regarding program correctness issues and practices (e.g., testing program results, test data design, loop invariants)
CS005	Design, implement, and test programs in languages from two different programming paradigms in a manner appropriate to each paradigm
CS006	Effectively use a variety of computing environments (e.g., single- and multi-user systems and various operating systems)
CS007	Describe the operation of a computer system--CPU & instruction cycle, peripherals, operating system, network components, and applications--indicating their purposes and interactions among them
CS008	Describe how data is represented at the machine level (e.g., character, Boolean, integer, floating point)
CS009	Identify and provide usage examples of the various data structures and files provided by a programming language (e.g., objects, various collections, files)
CS010	Describe the elements (people, hardware, software, etc.) And their interactions within information systems (database systems, the Web, etc.)
CS011	Demonstrate awareness of social issues related to the use of computers in society and principles for making informed decisions regarding them (e.g., security, privacy, intellectual property, limits of computing, rapid change)
CS012	Be familiar with object oriented design principles and properly use them to develop programmatic solutions.
CS013	Recognize and apply computer programming related terminology.
CS014	Demonstrate clear understanding of programming language compilers and the software development process.
CS015	Implement syntactically correct, logically accurate programs based on logical algorithms/pseudo code.
CS016	Construct and implement commonly used algorithms and data structures for solving programming problems.
CS017	Create easily readable and understandable programs by employing appropriate modules and comments.
CS018	Design and implement computer-based solutions to problems in a variety of application areas.*
CS019	Read and understand a large program consisting of several classes and interacting objects.*
CS020	Design an interface.*

Biology

ID	Outcome
BI001	Know the integration of individual structures and biochemical pathways that produce an organism capable of surviving and reproducing in its environment.
BI002	Know the relationship between structure and function from the molecular to the organismal level.
BI003	Know the structure and function of the components of a living system.
BI004	Explain characteristics of living organisms.
BI005	Explain the differences in cell structure and function between prokaryotes and eukaryotes.

ID	Outcome
BI006	Explain how proteins are synthesized in a cell, using the processes of transcription and translation.
BI007	Explain the relationship between feedback mechanisms and the maintenance of homeostasis.
BI008	Explain how materials are moved within cells and across cell membranes.
BI009	Know/Understand the basic chemical principles including the properties of chemical bonds, oxidation and reduction, and the structure and function of the four major classes of biological macromolecules: carbohydrates, lipids, proteins, and nucleic acids.
BI010	Understand/Know the chemical and structural properties of DNA and its role in specifying the characteristics of an organism.
BI011	Explain the relationships among DNA, chromosomes, genes, and alleles.
BI012	Explain how traits are inherited and expressed in organisms.
BI013	Explain why mutations and new gene combinations may have positive, negative, or no effects on the organism.
BI014	Explain the role of mutation, genetic diversity, and natural selection in the adaptive potential of populations.

Key Cognitive Strategies

ID	Outcome
KCS01	Know why curiosity, honesty, openness, and skepticism are so highly regarded in scientific research and how they are incorporated into the way engineers carry out science.*
KCS02	The student regards science as an essential way of knowing and learning engineering professions.
KCS03	Insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position being taken-whether one's own or that of others-can be judged.*
KCS04	Know that there may be ethical issues, such as ignoring contradicting data and selecting only supporting data, when considering claims.
KCS05	Know what is expected of a professional, such as knowing a professional code of ethics.
KCS06	Sample a wide range of scientific literature at a superficial level so as to build up an approximate framework for interpreting what is found on more detailed reading.
KCS07	Show an awareness that from time to time major shifts occur in the scientific view of how the world works, and that such a change is a strength of science and engineering, not a weakness.
KCS08	Suggest alternative ways of explaining data and criticize arguments in which data, explanations, or conclusions are represented as the only ones worth consideration, with no mention of other possibilities.
KCS09	Understand that scientists use methods and knowledge drawn from more than one scientific discipline as they solve problems. *
KCS10	Understand the relationships and common themes that connect mathematics, science, technology, and engineering.
KCS11	Apply knowledge and thinking skills to address real life problems and make informed decisions.
KCS12	Demonstrate problem-solving skills by developing a process for a solution using relationships between words, diagrams, graphs, and mathematical representations.*
KCS13	The student can plan a solution for a given problem by determining the steps necessary to solve, verify the solution, and evaluate whether the proposed solution is reasonable. *
KCS14	The student can determine known and unknown quantities that are relevant to a given problem. *
KCS15	Design a testable scientific hypothesis, refine the hypothesis, and conduct an experiment to confirm or refute the hypothesis.
KCS16	Demonstrate the use of experimental thinking as an inherent part of the problem solving process.
KCS17	Persist in quest for solutions by designing alternative solutions to problems and accepting failure and ambiguity as part of the process.
KCS18	Make up and write out simple algorithms for solving problems that take multiple steps.
KCS19	Understand attributes, purposes, and limitations of scientific models. *

KCS20	Understand that precision in measurement, description, and reporting is an important component of scientific research.*
KCS21	Be able to estimate how likely it is that some event of interest might have occurred just by chance.
KCS22	Determine whether the mathematical solutions are reasonable by reviewing the process and checking against typical values from experience of the everyday world.
KCS23	Trace the source of any large disparity between an estimate and the calculated answer.

ID	Outcome
KCS24	Offers clear, thorough explanations by beginning with simple generalizations and moving toward complexity and specificity.
KCS25	Use tables, charts, and graphs in making arguments and claims in oral and written presentations.*
KCS26	Check graphs to see that they do not misrepresent results by using inappropriate scales or by failing to specify the axes clearly.
KCS27	Describe, in words, both written and orally, an experiment or derivation he or she has made to an audience of non-experts in a manner that avoids jargon and follows a clear logical path between question, method, solution, and impact.*
KCS28	Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.*
KCS29	Use and correctly interpret relational terms such as if . . . then . . ., and, or, sufficient, necessary, some, every, not, correlates with, and causes.*
KCS30	Write scientific analyses with clarity, cohesiveness, and meaning, especially as they present and defend experiments.
KCS31	Write clear, step-by-step instructions for conducting investigations, operating something, or following a procedure.

Teaching Practices

ID	Outcome
TP001	Providing timely and suitable feedback to students.
TP002	Employing announced grading criteria that are consistent with course goals.
TP003	Demonstrating high but appropriate standards in grading.
TP004	Helping and encouraging students to develop their abilities.
TP005	Working to develop students' good study habits, self-reliance and responsibility for learning.
TP006	Ensuring that all students have equal access and opportunity to learn and apply science, technology, and mathematics to engineering.
TP007	Demonstrating an attitude that all students will meet high expectations.
TP008	Developing goals and pace for the course that are appropriately challenging.
TP009	Connecting academic ideas with the way a professional in the field thinks and explains the practical issues of the topics covered.
TP010	Facilitating student engagement in active exploration of the problem, finding materials, and proposing, testing and modifying solutions.
TP011	Including assignments that promote deep understanding of fundamental thought processes.
TP012	Raising questions consciously that cause students to consider the quality of evidence.

Appendix B: Ratings Results - General Engineering Courses

Question 1 - What do students need to know to enter my class? ***(115 courses participating)***

Scale:

1 - No prior student knowledge of content necessary
2 - Basic understanding of content necessary
3 - Thorough understanding of content necessary
4 - Mastery of content necessary
N/A - This expectation is not a part of this course

Question 2 - What I observe students know ***(114 courses participating)***

Scale:

1 - Student knowledge is adequate relative to necessary levels
2 - Student knowledge is less than adequate relative to necessary levels

Question 3 - How important is this for students to successfully complete this course? ***(118 courses participating)***

Scale:

1 - Least Important
2 - Less Important
3 - More Important
4 - Most Important

Question 4 - How important is the PE in preparing students for further engineering studies? ***(57 courses participating)***

Scale:

1 - Least Important
2 - Less Important
3 - More Important
4 - Most Important

General Engineering Outcomes

	Question 1			Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% N/A	% Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
GE001	2.39	0.99	17%	73%	3.05	0.72	3.23	0.79
GE002	2.13	1.02	26%	59%	2.78	0.77	2.86	0.84
GE003	1.95	0.96	30%	60%	2.68	0.74	2.61	0.90
GE004	1.94	0.93	19%	73%	2.89	0.83	3.04	0.87
GE005	1.85	0.97	25%	70%	3.08	0.81	3.24	0.82
GE006	1.75	0.86	33%	61%	2.99	0.88	3.02	0.86
GE007	1.77	0.89	46%	65%	2.97	0.79	2.77	0.94
GE008	1.77	1.00	20%	62%	2.93	0.85	3.09	0.81
GE009	2.11	0.94	35%	59%	3.04	0.81	3.09	0.81
GE010	1.97	0.93	43%	77%	3.13	0.88	2.73	1.03
GE011	2.15	1.00	41%	62%	3.03	0.86	2.86	1.00
GE012	2.00	0.97	50%	53%	3.00	0.78	3.10	0.88
GE013	2.04	0.82	39%	51%	3.14	0.70	3.07	0.75
GE014	1.98	0.85	57%	51%	3.00	0.87	2.85	0.85
GE015	1.76	0.84	48%	61%	2.78	0.88	2.63	0.82
GE016	2.57	1.06	26%	59%	3.07	0.82	3.35	0.62
GE017	2.70	1.10	35%	71%	3.10	0.73	3.08	0.76
GE018	2.45	1.06	22%	63%	3.24	0.78	3.50	0.67
GE019	2.03	0.93	43%	56%	2.97	0.76	2.84	0.83
GE020	2.29	1.07	33%	59%	3.08	0.81	3.16	0.73
GE021	2.69	1.17	34%	64%	3.22	0.80	3.13	0.97
GE022	2.24	1.02	39%	64%	3.27	0.73	3.20	0.81
GE023	2.49	1.09	16%	62%	3.29	0.81	3.37	0.75
GE024	2.53	1.13	28%	54%	3.13	0.86	3.10	0.80
GE025	2.47	1.06	57%	43%	3.13	0.72	2.90	0.84
Total	**2.17**	**1.03**		**62%**	**3.04**	**0.81**	**3.03**	**0.86**

Chemistry Outcomes

	Question 1			Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% N/A	% Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
CH001	1.89	0.78	17%	44%	2.89	0.93	2.54	0.88
CH002	1.88	1.13	18%	50%	3.13	0.99	2.54	1.05
CH003	2.00	1.15	19%	57%	3.14	1.07	2.46	1.13
CH004	2.00	1.00	16%	55%	3.27	0.79	2.77	1.01
CH005	1.60	0.89	21%	60%	3.00	1.00	2.23	1.09
CH006	2.40	1.34	21%	40%	3.20	1.10	2.77	1.09
CH007	1.50	0.58	21%	50%	3.25	0.96	2.23	1.09
CH008	1.83	0.75	20%	67%	2.83	0.98	2.54	1.05
CH009	1.40	0.89	21%	80%	3.20	0.84	2.46	1.13
CH010	1.60	0.89	21%	40%	3.00	1.00	2.46	0.97
CH011	2.17	1.17	20%	67%	3.33	0.82	2.54	1.13
CH012	2.33	1.21	20%	60%	3.40	0.89	2.77	1.17
CH013	1.80	1.10	21%	40%	3.40	0.89	2.54	1.13
CH014	1.83	0.75	20%	50%	3.33	0.82	2.69	1.25
CH015	2.00	0.71	21%	60%	3.20	0.84	2.54	1.05
Total	**1.90**	**0.95**		**50%**	**3.16**	**0.87**	**2.54**	**1.06**

Physics Outcomes

	Question 1			Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% N/A	% with Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
PH001	2.14	1.03	23%	64%	3.00	0.78	3.00	0.89
PH002	2.40	1.24	22%	47%	3.60	0.51	3.29	0.90
PH003	1.83	1.11	24%	50%	3.09	0.83	2.90	1.07
PH004	2.00	1.07	28%	63%	3.71	0.49	2.95	1.05
PH005	2.00	1.00	26%	56%	3.56	0.73	3.10	0.97
PH006	2.21	1.05	22%	43%	3.00	0.88	3.05	0.89
PH007	1.64	0.67	24%	55%	3.00	0.94	2.95	1.05
PH008	1.63	0.74	27%	63%	3.25	0.89	2.95	1.15
PH009	2.57	1.40	27%	71%	2.86	0.69	2.61	1.14
PH010	2.63	1.30	26%	50%	2.71	0.76	2.42	1.12
PH011	1.88	1.36	26%	50%	2.13	0.64	2.39	1.04
PH012	2.29	1.38	28%	71%	2.83	0.98	2.74	1.05
PH013	2.33	1.37	29%	50%	2.20	0.84	2.61	0.98
PH014	2.63	1.15	20%	67%	3.27	0.59	3.05	1.00
PH015	2.05	1.13	17%	35%	3.28	0.89	3.38	0.86
Total	**2.15**	**1.12**		**54%**	**3.10**	**0.83**	**2.91**	**1.03**

Mathematics Outcomes

	Question 1			Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% N/A	% with Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
MA001	2.60	1.04	22%	61%	3.14	0.76	2.82	0.97
MA002	2.25	1.22	37%	55%	3.27	0.65	2.50	0.97
MA003	2.56	1.31	33%	27%	3.00	0.85	2.59	1.01
MA004	2.62	1.26	35%	33%	3.08	0.90	2.55	0.99
MA005	2.85	1.14	34%	69%	3.21	0.70	2.55	0.96
MA006	2.00	1.00	44%	33%	3.33	0.58	2.10	0.94
MA007	2.85	1.28	35%	67%	3.17	0.83	2.35	1.11
MA008	2.79	0.92	30%	56%	2.95	0.78	2.84	1.05
MA009	2.91	0.54	37%	55%	3.18	0.60	2.60	1.07
MA010	2.75	0.46	39%	38%	3.13	0.83	2.36	1.13
MA011	2.53	0.72	31%	65%	2.82	0.81	2.73	1.01
MA012	2.20	1.03	38%	33%	3.11	0.93	2.21	1.05
MA013	2.50	1.08	37%	50%	3.20	0.79	2.37	1.03
MA014	1.40	0.55	43%	60%	2.60	0.55	2.00	0.92
MA015	2.40	0.89	43%	80%	3.20	0.45	1.93	0.92
MA016	2.00	1.13	35%	31%	2.46	0.78	2.33	0.88
MA017	2.50	1.35	38%	30%	2.50	0.85	2.22	0.97
MA018	2.40	1.17	38%	30%	3.00	0.82	2.43	1.01
MA019	2.12	1.05	31%	29%	2.88	0.70	2.48	1.03
Total	**2.50**	**1.07**		**48%**	**3.00**	**0.78**	**2.43**	**1.02**

Computer Science Outcomes

	Question 1			Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% N/A	% with Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
CS001	1.78	0.67	23%	38%	2.56	0.73	2.11	0.90
CS002	1.50	0.84	26%	33%	2.33	0.52	1.89	0.90
CS003	1.00	0.00	29%	0%	2.00	0.00	1.67	0.91
CS004	1.78	1.09	23%	56%	2.44	0.73	1.89	0.90
CS005	1.50	0.58	28%	50%	2.25	0.50	1.72	0.83
CS006	1.43	0.53	25%	43%	2.29	0.95	2.06	0.87
CS007	1.63	1.19	24%	14%	2.63	0.92	2.17	1.20
CS008	1.57	1.13	25%	29%	2.43	0.98	1.94	1.00
CS009	1.33	0.82	24%	50%	2.50	1.05	1.88	0.99
CS010	1.75	0.89	23%	25%	2.63	0.92	2.17	1.04
CS011	1.75	1.22	21%	42%	2.50	0.80	2.17	0.79
CS012	1.14	0.38	25%	71%	2.43	0.98	2.00	0.91
CS013	1.73	1.10	22%	55%	2.45	0.82	2.44	0.92
CS014	1.57	0.79	25%	29%	2.29	0.49	2.11	1.02
CS015	1.63	0.74	24%	25%	2.63	0.52	1.83	0.99
CS016	1.67	0.82	26%	17%	2.60	0.89	2.06	1.00
CS017	1.63	0.92	23%	38%	2.63	0.74	2.22	0.94
CS018	1.25	0.46	24%	43%	2.25	0.46	2.33	0.91
CS019	1.25	0.50	28%	75%	2.00	0.00	1.72	0.83
CS020	1.33	0.52	26%	40%	2.33	1.03	1.61	0.92
Total	**1.56**	**0.84**		**39%**	**2.44**	**0.75**	**2.00**	**0.94**

Key Cognitive Strategies

	Question 1			Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% N/A	% with Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
KCS01	2.22	0.94	25%	67%	2.90	0.67	2.85	0.74
KCS02	2.26	0.92	23%	71%	2.87	0.81	2.98	0.75
KCS03	2.03	0.90	30%	50%	2.79	0.91	2.92	0.83
KCS04	1.77	0.80	33%	69%	2.88	0.98	3.06	0.76
KCS05	1.93	1.01	28%	75%	3.00	0.93	3.24	0.74
KCS06	2.05	0.97	58%	46%	2.89	0.84	2.80	0.83
KCS07	2.07	1.03	51%	65%	2.98	0.89	2.80	0.93
KCS08	1.86	0.83	46%	55%	2.96	0.83	2.89	0.88
KCS09	1.97	0.89	33%	69%	2.83	0.89	2.94	0.81
KCS10	1.99	1.01	23%	66%	2.91	0.88	3.06	0.67
KCS11	2.02	0.93	15%	74%	3.17	0.67	3.06	0.72
KCS12	2.02	1.01	15%	69%	3.15	0.91	3.41	0.70
KCS13	1.99	0.99	13%	69%	3.02	0.90	3.34	0.67
KCS14	2.19	1.00	23%	68%	3.14	0.93	3.28	0.77
KCS15	1.94	0.91	59%	52%	3.21	0.74	2.89	0.83
KCS16	1.95	0.98	37%	63%	2.88	0.92	2.89	0.85
KCS17	1.80	0.92	38%	63%	2.81	0.91	2.96	0.87
KCS18	2.22	0.90	45%	56%	3.22	0.69	2.87	0.81
KCS19	2.08	0.98	45%	52%	3.08	0.74	2.8	0.79
KCS20	2.07	0.99	26%	68%	3.00	0.76	3.11	0.77
KCS21	2.06	0.96	63%	62%	2.94	0.77	2.42	0.81
KCS22	2.09	1.03	31%	69%	3.09	0.74	3.15	0.75
KCS23	2.03	0.99	30%	68%	3.03	0.80	3.04	0.74
KCS24	2.07	0.96	41%	63%	3.02	0.72	2.89	0.75
KCS25	2.26	1.11	37%	65%	3.24	0.78	3.18	0.81
KCS26	2.19	1.04	36%	57%	3.23	0.76	3.08	0.79
KCS27	2.23	1.07	55%	61%	3.08	0.75	2.79	0.81
KCS28	2.05	1.02	54%	62%	3.03	0.80	2.76	0.88
KCS29	2.29	0.99	58%	66%	3.11	0.83	2.69	0.97
KCS30	1.97	0.91	57%	59%	3.08	0.87	2.78	0.99
KCS31	1.93	0.94	42%	63%	2.96	0.95	3.15	0.84
Total	**2.05**	**0.97**		**65%**	**3.01**	**0.84**	**2.98**	**0.82**

Teaching Practices

	Question 1			Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% N/A	% with Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
TP001	N/A				3.67	0.49	3.54	0.54
TP002					3.58	0.66	3.42	0.71
TP003					3.53	0.65	3.35	0.60
TP004					3.74	0.52	3.72	0.50
TP005					3.54	0.60	3.52	0.55
TP006					3.43	0.74	3.36	0.82
TP007					3.62	0.59	3.46	0.62
TP008					3.56	0.57	3.44	0.62
TP009					3.64	0.56	3.43	0.62
TP010					3.42	0.71	3.19	0.68
TP011					3.44	0.73	3.23	0.73
TP012					3.23	0.81	3.15	0.79
Total					**3.53**	**0.65**	**3.4**	**0.67**

Appendix C: Ratings Results - Chemistry Courses

These questions use the same ratings scales as presented in Appendix B.

Chemistry Outcomes

	Question 1		Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
CH001	2.47	1.37	53%	3.72	0.46	3.40	0.70
CH002	2.47	1.33	53%	3.72	0.46	3.44	0.53
CH003	2.53	1.23	65%	3.67	0.59	3.33	0.71
CH004	2.82	1.33	65%	3.67	0.49	3.44	0.53
CH005	2.00	1.31	47%	3.50	0.63	3.11	0.78
CH006	2.87	1.46	67%	3.81	0.40	3.22	0.83
CH007	2.46	1.39	58%	3.57	0.51	2.89	1.05
CH008	2.31	1.38	46%	3.50	0.52	3.00	1.00
CH009	2.40	1.30	47%	3.38	0.50	3.22	0.67
CH010	2.40	1.30	40%	3.56	0.51	3.00	1.00
CH011	2.20	1.26	47%	3.38	0.62	3.44	0.53
CH012	2.43	1.28	43%	3.60	0.51	3.50	0.53
CH013	2.54	1.33	58%	3.36	0.63	3.50	0.53
CH014	2.33	1.37	42%	3.54	0.52	3.13	0.99
CH015	2.63	1.20	63%	3.65	0.49	3.50	0.53
Total	**2.46**	**1.30**		**3.58**	**0.53**	**3.27**	**0.74**

Key Cognitive Strategies

	Question 1		Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% with Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
KCS01	2.64	0.92	45%	3.55	0.52	3.83	0.41
KCS02	3.00	1.07	75%	3.38	0.52	3.57	0.79
KCS03	2.17	1.27	50%	3.50	0.52	3.43	0.79
KCS04	2.31	1.11	69%	3.54	0.88	3.86	0.38
KCS05	2.18	1.33	73%	3.40	0.97	3.50	0.84
KCS06	2.44	1.13	56%	3.33	1.00	3.17	1.33
KCS07	2.38	1.04	69%	3.46	0.88	3.50	0.84
KCS08	2.33	0.98	42%	3.42	0.51	3.43	1.13
KCS09	2.62	1.04	69%	3.23	0.83	3.43	1.13
KCS10	2.69	1.11	67%	3.31	0.85	3.43	1.13
KCS11	2.54	1.13	54%	3.38	0.87	3.43	1.13
KCS12	2.58	1.16	50%	3.75	0.45	3.57	1.13
KCS13	2.58	1.00	50%	3.75	0.45	3.86	0.38
KCS14	2.58	1.00	50%	3.75	0.45	3.57	1.13
KCS15	2.33	1.15	50%	3.42	0.67	3.29	1.25
KCS16	2.46	1.20	23%	3.54	0.66	3.71	0.76
KCS17	2.25	1.22	42%	3.25	0.87	3.14	1.46
KCS18	2.58	1.16	50%	3.67	0.49	3.29	1.11
KCS19	2.46	1.20	54%	3.46	0.88	3.43	1.13
KCS20	2.54	1.13	50%	3.62	0.65	3.71	0.76
KCS21	2.60	1.07	60%	3.50	0.53	3.33	0.82
KCS22	2.45	1.04	45%	3.80	0.42	3.57	0.79
KCS23	2.36	1.12	36%	3.45	0.82	3.57	0.79
KCS24	2.40	0.97	20%	3.50	0.53	3.14	1.07
KCS25	2.45	1.13	36%	3.55	0.52	3.29	1.11
KCS26	1.89	0.93	0%	3.78	0.44	3.43	1.13
KCS27	2.90	0.99	50%	3.80	0.42	3.43	1.13
KCS28	2.73	1.10	73%	3.82	0.40	3.29	1.11
KCS29	2.70	1.16	40%	3.70	0.48	3.17	1.17
KCS30	2.46	1.20	8%	3.77	0.60	3.43	0.79
KCS31	2.73	1.10	36%	3.82	0.40	3.43	1.13
Total	**2.49**	**1.08**		**3.55**	**0.66**	**3.46**	**0.95**

Teaching Practices

	Question 1		Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% with Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
TP001				4.00	0.00	4.00	0.00
TP002				4.00	0.00	4.00	0.00
TP003				4.00	0.00	4.00	0.00
TP004				4.00	0.00	4.00	0.00
TP005				3.83	0.39	4.00	0.00
TP006				3.83	0.39	3.80	0.45
TP007		**N/A**		3.00	0.95	3.60	0.89
TP008				4.00	0.00	4.00	0.00
TP009				3.58	0.67	3.80	0.45
TP010				3.67	0.49	3.80	0.45
TP011				3.75	0.45	3.80	0.45
TP012				3.83	0.39	4.00	0.00
Total				**3.79**	**0.50**	**3.90**	**0.35**

Appendix D: Ratings Results – Physics Courses

These questions use the same ratings scales as presented in Appendix B.

Physics Outcomes

	Question 1		Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
PH001	2.21	0.98	78%	3.39	0.83	3.33	0.59
PH002	1.90	1.08	70%	3.50	0.88	3.53	0.62
PH003	2.14	1.09	70%	3.61	0.79	3.53	0.62
PH004	1.79	1.05	70%	3.33	0.92	3.38	0.81
PH005	1.75	0.97	69%	3.54	0.65	3.47	0.80
PH006	1.68	0.98	69%	3.63	0.63	3.31	0.87
PH007	1.68	0.98	69%	3.48	0.58	3.38	0.81
PH008	1.79	0.99	69%	3.33	0.92	3.53	0.52
PH009	1.55	0.96	76%	3.64	0.49	3.33	0.62
PH010	1.48	0.75	65%	3.43	0.60	3.13	0.64
PH011	1.38	0.74	65%	3.67	0.48	3.31	0.60
PH012	1.48	0.73	71%	3.45	0.74	3.19	0.66
PH013	1.41	0.80	62%	3.77	0.43	3.25	0.68
PH014	2.35	0.94	76%	3.35	0.75	3.31	0.79
PH015	1.96	0.77	58%	3.35	0.63	3.38	0.89
Total	**1.79**	**0.97**		**3.49**	**0.72**	**3.36**	**0.70**

Key Cognitive Strategies

	Question 1		Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% with Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
KCS01	2.11	0.96	67%	2.71	0.92	2.92	0.95
KCS02	2.15	0.99	76%	2.89	1.05	3.15	1.07
KCS03	1.91	0.73	70%	3.14	0.71	3.54	0.52
KCS04	2.00	0.84	69%	2.82	0.73	3.08	0.86
KCS05	1.88	1.25	67%	2.29	0.95	3.00	0.82
KCS06	2.20	0.45	20%	2.50	0.58	2.45	1.13
KCS07	1.89	0.74	59%	2.65	0.79	2.55	0.82
KCS08	1.63	0.62	57%	2.57	0.65	2.75	0.87
KCS09	2.18	0.81	80%	2.27	0.96	2.42	0.79
KCS10	1.89	0.90	60%	2.59	0.62	2.75	0.75
KCS11	1.84	0.83	69%	2.67	0.97	3.42	0.51
KCS12	1.74	0.69	65%	3.82	0.39	3.45	0.52
KCS13	1.68	0.57	63%	3.48	0.68	3.33	0.89
KCS14	1.96	0.88	70%	3.45	0.67	3.33	0.49
KCS15	1.71	0.64	61%	2.90	0.72	2.92	1.00
KCS16	1.69	0.70	85%	2.80	0.77	2.67	0.78
KCS17	1.53	0.52	36%	2.71	0.83	2.58	0.79
KCS18	1.55	0.82	40%	3.10	0.74	2.83	0.72
KCS19	1.73	0.63	63%	3.05	0.74	3.08	0.90
KCS20	1.68	0.78	74%	2.62	0.92	2.92	0.90
KCS21	1.73	0.90	56%	2.30	0.95	2.50	1.09
KCS22	1.68	0.67	69%	3.06	0.64	3.08	0.90
KCS23	1.72	0.57	63%	2.94	0.75	3.25	0.75
KCS24	1.71	0.77	62%	2.73	0.70	2.91	0.94
KCS25	1.80	0.77	69%	3.00	0.78	3.17	0.72
KCS26	1.89	0.94	75%	2.83	0.79	3.17	0.72
KCS27	1.33	0.50	29%	2.63	1.06	2.55	1.21
KCS28	1.60	1.07	25%	3.22	0.97	2.45	0.93
KCS29	2.36	1.29	67%	2.70	0.82	2.92	0.90
KCS30	1.56	0.62	50%	2.65	1.06	3.08	0.90
KCS31	1.79	0.70	54%	2.71	0.91	2.92	0.90
Total	**1.81**	**0.79**		**2.89**	**0.85**	**2.95**	**0.88**

Teaching Practices

	Question 1		Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% with Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
TP001				3.52	0.59	3.00	1.11
TP002				3.42	0.78	3.38	0.77
TP003				3.33	1.01	3.38	0.87
TP004				3.58	0.65	3.77	0.44
TP005				3.63	0.49	3.62	0.51
TP006				3.36	0.79	3.42	0.67
TP007	**N/A**			3.22	0.90	3.38	0.87
TP008				3.71	0.46	3.46	0.52
TP009				2.64	0.95	3.23	0.60
TP010				3.08	0.88	3.38	0.65
TP011				3.42	0.72	3.46	0.78
TP012				3.08	0.72	3.33	0.65
Total				**3.34**	**0.80**	**3.40**	**0.73**

Appendix E: Ratings Results – Mathematics Courses

These questions use the same ratings scales as presented in Appendix B.

Mathematics Outcomes

	Question 1		Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
MA001	1.88	0.74	58%	2.46	0.72	2.75	0.74
MA002	2.08	1.08	50%	2.50	1.00	2.43	0.99
MA003	1.33	0.65	36%	3.17	1.03	2.36	0.95
MA004	1.86	1.03	69%	2.93	1.00	2.35	0.88
MA005	1.71	0.96	55%	3.24	0.83	2.65	0.93
MA006	1.50	0.94	62%	3.50	0.65	2.39	0.99
MA007	1.75	0.86	40%	2.60	0.74	2.24	0.77
MA008	2.61	1.20	79%	3.03	0.89	2.85	0.92
MA009	2.53	1.08	61%	2.81	0.81	2.77	0.91
MA010	1.95	0.92	50%	2.58	0.72	2.52	0.82
MA011	2.09	1.03	60%	2.88	0.83	2.52	0.96
MA012	1.65	0.83	61%	3.00	0.87	2.40	0.96
MA013	1.63	0.81	50%	3.13	0.72	2.50	1.02
MA014	1.88	0.95	65%	3.00	0.78	2.48	0.87
MA015	2.18	1.06	61%	2.71	0.74	2.44	0.80
MA016	2.07	1.04	50%	2.38	0.71	2.38	0.85
MA017	1.95	1.00	50%	2.80	0.89	2.29	0.91
MA018	1.94	0.93	56%	3.19	0.83	2.63	0.92
MA019	1.86	0.89	54%	2.75	0.89	2.20	0.96
Total	**2.00**	**1.01**		**2.85**	**0.85**	**2.48**	**0.91**

Key Cognitive Strategies

	Question 1		Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% with Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
KCS01	2.10	0.94	52%	2.90	0.70	3.17	0.78
KCS02	2.26	0.81	41%	2.72	0.67	2.96	0.64
KCS03	2.03	0.89	58%	3.03	0.80	3.27	0.60
KCS04	1.91	0.83	55%	2.91	0.70	3.14	0.89
KCS05	2.25	1.16	50%	2.88	0.64	2.86	1.08
KCS06	1.89	1.05	44%	2.67	0.50	2.59	0.73
KCS07	1.64	0.74	57%	2.50	0.85	2.61	0.78
KCS08	2.41	1.28	35%	2.59	0.80	2.73	0.94
KCS09	2.22	1.17	59%	2.45	0.60	2.91	0.67
KCS10	2.00	0.91	59%	2.56	0.66	2.96	0.73
KCS11	2.24	1.02	43%	3.08	0.80	3.32	0.69
KCS12	2.50	0.90	65%	3.36	0.58	3.48	0.71
KCS13	2.20	0.93	60%	3.45	0.63	3.62	0.64
KCS14	2.59	1.09	56%	3.23	0.72	3.48	0.65
KCS15	2.25	1.28	57%	2.71	0.95	3.09	0.75
KCS16	2.55	0.99	57%	2.57	0.69	2.91	1.00
KCS17	2.19	0.93	35%	2.81	0.70	3.17	0.82
KCS18	2.61	0.95	60%	3.10	0.72	2.88	0.85
KCS19	2.29	1.05	65%	2.75	0.86	3.13	0.81
KCS20	2.39	1.24	76%	2.59	0.62	3.04	0.82
KCS21	1.88	0.99	88%	2.88	1.13	2.62	0.92
KCS22	2.82	0.94	68%	3.34	0.58	3.56	0.51
KCS23	2.49	0.85	44%	2.94	0.74	3.04	0.77
KCS24	2.14	0.83	50%	2.95	0.67	2.83	0.78
KCS25	2.41	1.05	56%	2.94	0.75	3.36	0.64
KCS26	2.61	0.99	61%	3.04	0.81	3.21	0.88
KCS27	2.20	1.03	80%	3.60	0.70	3.14	0.99
KCS28	1.92	0.86	46%	3.08	0.76	3.14	0.89
KCS29	2.36	1.03	50%	3.09	0.59	3.08	0.95
KCS30	2.22	0.67	33%	2.44	0.53	2.95	0.65
KCS31	3.05	1.08	67%	3.06	0.73	2.91	0.79
Total	**2.34**	**1.00**		**2.97**	**0.75**	**3.08**	**0.82**

Teaching Practices

	Question 1		Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% with Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
TP001				3.49	0.51	3.52	0.79
TP002				3.43	0.62	3.35	0.78
TP003				3.59	0.54	3.48	0.59
TP004				3.72	0.46	3.48	0.60
TP005				3.17	0.80	3.29	0.85
TP006				3.21	0.74	3.37	0.60
TP007		**N/A**		3.34	0.57	3.50	0.61
TP008				3.39	0.58	3.38	0.50
TP009				2.77	0.77	2.90	0.79
TP010				3.18	0.75	3.38	0.74
TP011				3.48	0.62	3.29	0.85
TP012				2.91	0.89	3.10	0.70
Total				**3.31**	**0.71**	**3.34**	**0.71**

Appendix F: Ratings Results – Computer Science Courses

These questions use the same ratings scales as presented in Appendix B.

Computer Science Outcomes

	Question 1		Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
CS001	2.22	1.24	86%	3.54	0.72	3.44	0.62
CS002	1.95	1.19	72%	3.30	0.73	3.11	0.96
CS003	2.00	1.33	76%	3.00	0.82	3.00	0.97
CS004	1.73	0.98	90%	3.30	0.82	3.47	0.61
CS005	1.57	0.85	50%	2.93	0.70	2.76	1.03
CS006	1.67	0.90	71%	2.63	0.72	3.06	0.93
CS007	1.71	0.92	82%	3.11	0.81	3.06	0.83
CS008	1.73	0.98	77%	3.17	0.87	3.11	0.74
CS009	1.42	0.69	56%	2.89	0.74	2.81	0.66
CS010	1.29	0.47	71%	2.63	0.81	2.94	0.77
CS011	1.42	0.51	75%	2.71	0.91	2.82	0.81
CS012	1.59	1.00	69%	2.67	0.91	2.83	0.92
CS013	1.92	1.02	86%	3.21	0.66	3.17	0.71
CS014	1.56	0.78	76%	3.39	0.61	3.29	0.59
CS015	1.91	1.06	81%	3.52	0.59	3.39	0.78
CS016	1.55	0.89	84%	3.48	0.60	3.18	0.64
CS017	1.79	1.02	68%	3.46	0.58	3.37	0.68
CS018	1.47	0.84	78%	3.45	0.60	3.17	0.71
CS019	1.56	0.53	71%	3.20	0.79	3.06	0.83
CS020	1.33	0.49	75%	3.29	0.73	3.12	0.78
Total	**1.70**	**0.96**		**3.19**	**0.78**	**3.11**	**0.79**

Key Cognitive Strategies

	Question 1		Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% with Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
KCS01	2.11	0.96	60%	2.76	0.66	3.20	0.77
KCS02	2.06	0.68	60%	2.88	0.62	3.13	0.64
KCS03	2.07	0.70	64%	2.93	0.70	3.20	0.68
KCS04	1.57	0.51	77%	2.64	0.63	2.87	1.06
KCS05	1.63	0.62	64%	2.80	0.77	2.88	0.96
KCS06	1.63	0.52	57%	2.14	0.69	2.36	0.93
KCS07	1.82	0.87	56%	2.60	0.70	2.80	1.15
KCS08	1.86	0.66	67%	2.77	0.73	3.27	0.70
KCS09	1.60	0.51	62%	2.64	1.01	3.13	0.74
KCS10	1.73	0.59	54%	2.83	0.58	3.31	0.63
KCS11	1.89	0.81	67%	3.11	0.66	3.57	0.51
KCS12	1.90	0.91	68%	3.11	0.81	3.40	0.63
KCS13	2.00	0.82	57%	3.41	0.59	3.63	0.50
KCS14	1.76	0.75	69%	3.18	0.53	3.54	0.52
KCS15	1.89	0.78	86%	3.00	0.53	3.14	0.86
KCS16	1.72	0.75	69%	2.88	0.72	3.13	0.74
KCS17	1.71	0.69	69%	3.29	0.77	3.36	0.74
KCS18	2.04	1.02	77%	3.48	0.68	3.28	0.75
KCS19	1.80	0.63	67%	2.78	0.67	2.93	0.83
KCS20	1.91	0.70	40%	2.80	0.92	2.93	1.00
KCS21	2.00	0.63	50%	2.60	1.14	2.57	0.94
KCS22	1.62	0.65	64%	2.77	0.83	2.93	1.07
KCS23	2.08	0.90	82%	3.27	0.65	2.80	1.01
KCS24	2.00	0.82	73%	3.13	0.64	3.36	0.74
KCS25	1.67	0.50	75%	2.78	0.83	2.93	0.92
KCS26	2.17	0.75	60%	3.00	0.89	2.71	0.91
KCS27	1.88	0.99	57%	2.86	0.69	2.86	0.86
KCS28	2.00	0.53	57%	3.00	0.00	2.93	1.00
KCS29	1.94	0.97	73%	3.25	0.93	3.31	0.79
KCS30	2.00	0.58	67%	2.83	0.75	2.86	0.95
KCS31	1.94	1.00	82%	3.44	0.62	3.25	0.68
Total	**1.87**	**0.77**		**2.98**	**0.75**	**3.09**	**0.85**

Teaching Practices

	Question 1		Question 2	Question 3		Question 4	
	Mean Score	St. Dev	% with Adequate Knowledge	Mean Score	St. Dev	Mean Score	St. Dev
TP001				3.59	0.50	3.50	0.71
TP002				3.38	0.73	3.12	0.99
TP003				3.34	0.61	3.38	0.62
TP004				3.66	0.48	3.69	0.48
TP005				3.55	0.51	3.56	0.51
TP006				3.48	0.63	3.56	0.63
TP007		**N/A**		3.45	0.69	3.50	0.73
TP008				3.48	0.58	3.44	0.63
TP009				3.21	0.94	3.38	0.62
TP010				3.29	0.81	3.38	0.62
TP011				3.38	0.78	3.33	0.82
TP012				3.24	0.83	3.13	0.74
Total				**3.40**	**0.70**	**3.41**	**0.69**

Appendix G: Sources

Educational Organizations

Computer Science Teachers Association
Engineering Education Service Center
Malheur ESD
Mathematics, Engineering Science Achievement
Northwest Regional Educational Laboratory
Northwest Regional ESD
OCEPT
Oregon Council of Computer Chairs
Oregon Council of Teachers of Mathematics
Oregon Mathematics Education Council
Oregon Robotics Tournament and Outreach Program
Oregon Science Education Council
OSU Extension 4-H BIT
Saturday Academy
Saturday Academy OSU
The SMILE Program
TWIST

Policy Groups and Strategies, Oregon

AEED (Academic Excellence and Economic Development Working Group), OUS
AAWG (Access and Affordability Working Group)
EDP (Excellence in Delivery and Productivity Working Group)
ETIC (Oregon Engineering and Technical Industry Council)
OMEC (Oregon Mathematics Education Council)
ODE (Oregon Department of Education)
OSBE (Oregon State Board of Education)
OSBHE (Oregon State Board of Higher Education)

Programs, Initiatives & Classroom Curricula, Oregon

Canby High School
College Now/ Tech Prep at Central Oregon Community College
CWW (Compressed Work Week) at PSU
Facts about TechPrep in Oregon
High School - Community College Transitions in Oregon
Hillsboro High School
Capital Center High School Technology Institute
STARS (Students Taking Authentic Routes to Success College and Career Exploration Program, David Douglas High School

The Center for Advanced Learning
North Salem High School
Oregon Small Schools Initiative
Roseburg High School
Sherwood High School
SuperQuest - SAOF (Software Association of Oregon Foundation)
OSU College of Science Outreach & Education Programs
TeachEngineering

Programs, Initiatives & Classroom Curricula, Other

AP (Advanced Placement Programs)
Amatrol: integrated technical learning systems
Autodesk Design Academy
CEEO (Center for Engineering Educational Outreach), Tufts University
Infinity Project
Intel Innovation in Education
IB (International Baccalaureate)
JASON Foundation for Education
PLTW (Project Lead the Way)
SEEK-16 (Strategies for Engineering Education K-16 Summit)
MESA (Mathematics, Engineering, Science Achievement), Washington

Programs & Initiatives, Co-Curricular, Oregon

ACCESS (Alternative Career Choices for Equitable Student Success), Lane CC
CASE (Creating Avenues, Support and Equity for Women and Minorities in Advanced Technologies), PCC
Design and Discovery
EXITE (EXploring Interests in Technology and Engineering, IBM)
GATEway to Engineering, SWE Columbia River Chapter
Intel NWSE (Northwest Science Expo) / ISEF (International Science and Engineering Fair)
MESA (Mathematics, Engineering, Science Achievement), PSU, Oregon
Oregon Building Congress Mathematics and Science Workshops
ORTOP (Oregon Robotics Tournament Outreach Program), OUS
Saturday Academy - PSU / OHSU
SMILE (Science and Mathematics Investigative Learning Experiences), OSU
STARBASE (Science and Technology Academies Reinforcing Basic Aviation and Space Exploration), Portland and Klamath Falls
UO (University of Oregon) Youth Enrichment and TAG Programs
Willamette-SAOF High School Programming Contest
Youth Exploring Science - YES

Appendix H: Final Budget

Budget Category	Quarter 1 (Apr – Jun 06)	Quarter 2 (Jul – Sept 06)	Quarter 3 (Oct – Dec 06)	Quarter 4 (Jan – Mar 07)	Quarter 5 (Apr – Jun 07)	Quarter 6 (Jul – Aug 07)	Total
Personnel Expenses							
Compensation	2,907	17,971	8,218	10,356	14,077	4,000	57,529
Employee benefits	1,192	7,368	3,369	1,788	3,322	1,800	18,839
Document raters	0	170	0	0	4,224	0	4,394
Subtotal	***4,099***	***25,509***	***11,587***	12,144	21,623	5,800	80,762
Operating Expenses							
Travel	126	0	0			0	126
Materials, supplies	424	450	450	450	20	500	2,294
Telecom	165	165	165	165	0	0	660
Subtotal	***715***	***615***	***615***	615	20	500	3,080
Other Expenses							
Indirect costs	770	4,180	1,952	2,041	3,463	0	12,406
Rent/facilities	900	900	900	900	0	0	3,600
Total	***$6,484***	***$31,204***	***$15,055***	***$15,700***	***$25,106***	***$6,300***	***$99,849***