HIGHER EDUCATION COORDINATING BOARD

SCIENCE COLLEGE READINESS DEFINITIONS

PRELIMINARY

JANUARY 2007

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INTRODUCTION

Washington State's 2004 Master Plan for Higher Education calls for defining college readiness in mathematics, science, English, world languages, social studies and the arts. In 2005, the State Legislature provided funding for the Higher Education Coordinating Board to define college readiness in English and science.

The Need

Even though the majority of Washington's students enroll in a 2- or 4-year state college within a year of graduation, a significant number of students do not score high enough on college placement tests to take credit-bearing coursework without first taking remedial coursework in English and/or mathematics.

A recent analysis of Washington's 2004 high school graduating class by the Social and Economic Sciences Research Center, Washington State University (Puget Sound Division), revealed the following:

- Among the 2004 public high school graduates attending Washington's state universities, community and technical colleges in their first year after graduation, 42 percent enrolled in at least one remedial course (English or math, or both).
- About twice as many recent graduates enroll in remedial math than in remedial English.
- Remedial enrollment is much higher among students at the open-enrollment community and technical colleges (55 percent), compared to the competitive admission universities (13 percent).

Since specific placement tests do not exist for the sciences, college remediation rates are neither known nor reported. In addition, the state has developed Grade Level Expectations (GLEs) through the 11-12th grades in mathematics, but English and science GLEs do not exist beyond the 10th grade. The math GLEs contain thoughtfully constructed learning goals that provide useful guidance for both teachers and learners through the 12th grade. The college readiness attributes and definitions included in this document were constructed by teams of educators in Washington State with that same intent—to provide an essential educational framework so that students will be better prepared for the rigors of college-level learning in the sciences and English (reading, writing, and communications).

The Process of Phase I

In January 2006, Phase I of the English and science college readiness project began by engaging content development teams composed of secondary teachers and college faculty whose charge was to define the skills and knowledge that students need to be prepared for entry-level general education college

coursework. Both teams provided a wide range of experience and expertise in various science and English disciplines (see attached list of team members).

To begin their work, the teams examined a summary of college readiness criteria that have been developed by other states and national organizations. The teams also reviewed state K-10 learning goals, such as those contained in Washington's Essential Academic Learning Requirements (EALRs) and Grade Level Expectations (GLEs). Because GLEs do not exist in English or science beyond tenth grade, the teams set out to develop college readiness documents that would bridge the gap between established secondary learning goals and the competencies students need to be prepared for the rigors of college-level courses.

For the past 11 months, the content teams have been engaged in extensive development, writing, reviewing, and editing of draft documents. Their collective efforts have produced the preliminary college readiness attributes and definitions contained in this document. *Preliminary* is stressed because it is anticipated that these attributes and definitions may be modified after they are piloted in classrooms across the state in a planned Phase II of the project.

The English and science college readiness documents are similar in format to the mathematics standards document that was published in 2006 through the efforts of the Transition Mathematics Project, led by the State Board for Community and Technical Colleges. The adoption of similar formats was to facilitate eventual implementation of college readiness strategies across subject areas after field testing and adequate professional development has taken place.

Like the math project, the English and science college readiness attributes and definitions are intended to articulate the relationship between Washington's K-10 learning standards and the knowledge and skills students need to develop throughout high school, particularly during the last two years of high school.

Finally, in proposing English and science college readiness, the development teams emphasized that the intent is not to add another assessment layer or requirement to the K-12 system. While development of measures to determine whether individual students are "college ready" is viewed as valuable for both teacher and learner, additional statewide testing is considered unnecessary and, perhaps, counterproductive at this time.

PROLOGUE

The science college readiness attributes and definitions outlined in this document are a framework for preparing high school students for entry-level, general education coursework in two- and four-year colleges and universities. In addition to outlining definitions which include science content and foundational knowledge upon which to gauge college readiness, this document also identifies several overarching personal attributes that set the tone for successful college-level learning.

The college readiness attributes proposed in this document reflect *how to learn*, while the college readiness definitions reflect *what to learn*. Although the attributes and definitions are necessarily presented as separate and distinct areas, they are clearly interconnected, interdependent and necessary for success in college science courses.

College Readiness Attributes

In general education college science classes, students come from many different backgrounds and follow many different academic paths. A "college ready" student will search for the relevance of academic materials, take responsibility for his/her learning, and actively seek assistance from available resources (instructors, teaching assistants, tutoring centers, etc.) when needed. This intellectual engagement is often daunting, but by acquiring and practicing these essential attributes, students will have a greater set of tools for successful learning.

A student who possesses essential attributes necessary for college success will:

- demonstrate intellectual engagement,
- take responsibility for his or her own learning,
- persevere through the learning process,
- pay attention to detail,
- demonstrate ethical behavior,
- communicate effectively across a variety of audiences and purposes,
- effectively read and organize information presented in questions/problems in order to formulate solutions, and,
- build creative solutions to intellectual and practical real-world problems.

The acquisition and practice of these attributes are fundamental to successful learning in any college-level class as the learning process becomes more demanding, is more complex, and requires more student engagement. Also, the pace of college coursework is more rapid and the transition from small, secondary

classrooms to large, lecture-oriented college classes may work well for some students, but not all. The sheer size of some college-level classes requires students to be almost completely responsible for their own learning, which represents a distinct departure from high school. In small seminar-style classes, students should be prepared to be deeply engaged, active contributors, and to be ready for the intellectual give and take that is expected in college-level learning.

To underscore the value of the essential student attributes noted above, science, mathematics and English college readiness development teams in Washington State, have independently identified and included attributes as essential to college success.

College Readiness Definitions

In the collegiate culture, "knowledge for knowledge sake," is highly valued, if not essential. Faculty often engage in research that may change an established body of knowledge and this manifests itself at the college level in the notion that a body of knowledge is dynamic. Therefore, students should expect that what they have already learned or believe may be challenged. Conversely, students should expect to use their learning to challenge, in a civil fashion, the "accepted wisdom" or assumptions of others from previous eras. This requires a student who wants to learn much more than "what will be on a test." Students with such limited learning goals will find it very difficult to succeed in college-level science.

The college readiness definitions are intended to bridge the gap between K-10 learning goals and the knowledge and skills students need to be prepared for entry-level general education college science. Included below are the content areas and the foundational skills that, together, represent college readiness definitions for science.

<u>Definition A</u>: Science Content ("Big Ideas")

The field of science is so broad that it does not allow for an exhaustive list of all that can or should be covered or considered important in the various science disciplines. Thus, Definition A emphasizes a student's proficiency with core science concepts—"big ideas" in science—at cognitive levels beyond those described in Washington State's grade 10 science EALR 1. Emphasis on learning moves from primarily knowing and understanding towards synthesizing and evaluating big ideas into a coherent and useful picture of the natural world, including physical, life and earth/space sciences.

Definition B: Science Foundational Skills

Students develop scientific thinking through engagement with challenging content. This is how they seek and frame questions, form hypotheses, and consider what science does or does not know. Equally important is the ability to interpret and communicate observations and results, and ultimately to appreciate the importance of science to society. Thus, Definition B covers these science foundational skills.

- Scientific Inquiry and the Nature of Science
- Science and Society
- Quantitative Analysis
- Technology
- Communication

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STUDENT ATTRIBUTES

The student attributes common to English, Science and Math college readiness are in black type; the attributes applicable only to science college readiness are in *blue italic* type.

The personal attributes described below are essential for success in entry level college courses.

COMPONENT	EVIDENCE of LEARNING
Demonstrate intellectual engagement.	• Perceive that every discipline is a way of understanding and not just a sequence or compilation of discrete information. • Develop intellectual curiosity: actively explore new ideas, posing questions about meaning, significance, and implications *by designing and conducting scientific investigations and engaging in scientific inquiry.* • Demonstrate curiosity, honesty, cooperation and skepticism in scientific investigations. • Recognize one's own assumptions, take risks and be challenged as part of the learning process. • Recognize and interpret patterns – as well as variation from previously learned or observed patterns – in data, diagrams, symbols, and words. • Question, integrate, synthesize and connect new ideas to previously learned concepts. • Actively seek to use the resources, tools, *technologies* and strategies necessary for effective learning.
Take responsibility for own learning.	• Engage in self reflection and self evaluation (i.e. examine and learn from errors, seek help when needed and understand that failure is part of the learning process). • Proactively seek input and feedback on ideas and work. • Seek help addressing issues outside the classroom that may interfere with the learning process. • Participate in class sessions and when absent, seek ways to learn the material covered in class. • Devote the time necessary to be successful and plan ahead to meet deadlines. • Conscientiously prepare work assigned for class (for example on time, neatly presented, and taken seriously). • Use effective strategies to learn independently. • Take advantage of available resources - class time, notes, textbook, assignments, tutoring services, supplemental materials, instructor, peers, equipment and electronic resources. • Participate effectively in groups to discuss or complete an assignment. • Contribute to and benefit from group problem-solving activities.

STUDENT ATTRIBUTES

The student attributes common to English, Science and Math college readiness are in black type; the attributes applicable only to science college readiness are in *blue italic* type.

The personal attributes described below are essential for success in entry level college courses.

COMPONENT	EVIDENCE of LEARNING
Persevere through the learning process.	• Demonstrate sustained effort as an important component of successful learning. • Successfully complete tasks that require organizing and applying multiple steps, concepts or techniques, and which may be time-consuming. • *Persist in working on problems that require time and thought and demonstrate original critical thinking.* • Recognize when an approach is unproductive and make logical modifications and/or switch to another approach. • Accept ambiguity as part of the learning process.
Pay attention to detail.	• Correctly and independently follow oral and written directions. • Work toward precision in the use of discipline-specific language and conventions. • Review or edit work prior to submission.
Demonstrate ethical behavior.	• Treat others with respect. • *Demonstrate respect for different cultural perspectives.* • *Recognize that plagiarism is dishonest and unethical.* • *Respect the intellectual and creative work of others by refraining from academically dishonest behaviors, such as copying another's assignment, copying and pasting from the internet, or using sources without attribution.* • *Evaluate the intended and unintended consequences of one's actions on people, society and the environment prior to making decisions.*
Communicate effectively across a variety of audiences and purposes.	• Choose language appropriate to the academic, social and cultural conventions of the particular audience. • Contribute relevant ideas, clear illustrations and clarifying examples. • Express disagreement in ways that permit continued dialogue.
Effectively read, parse, and organize information presented in questions/problems in order to formulate solutions.	• *Employ reading strategies appropriate to scientific literature.* • *Identify the key components of a question to determine what is being asked.* • *Recognize that similar problems may be presented differently and that different problems may, at first, appear similar.* • *Apply discipline-specific knowledge in new situations or contexts* • *Generate possible approaches to unfamiliar problems.* • *Develop a solution to a complex problem that combines multiple concepts.*

DEFINITION A BIG IDEAS IN SCIENCE

NOTE: This definition assumes the student is already proficient with the concepts and procedures described in the Washington State Grade Level Expectations for Science through Grades 9/10*.

Students will demonstrate facility with the core science concepts at cognitive demand levels beyond those described in Washington State Science EALR 1. The emphasis will move from primarily knowing and understanding towards synthesizing, evaluating and transferring knowledge and skills across disciplines to solve problems and generate explanations.

[This is necessary for success in courses that are part of the general education requirements in science in Washington State colleges and universities. Students intending to prepare for majors in science and technical fields should pursue high school courses that target more advanced topics and skills.]

A.1 Physical Science, Life Science, Earth/Space Science	Synthesize knowledge of: • properties of matter, forces, motion, and energy; • living things, ecosystems, human biology, molecular heredity, and evolution and natural selection; • Earth materials and systems, the solar system, stars, galaxies, the universe, and the evolution of the Earth and the universe; • big ideas into a coherent and useful picture of the natural world; and, • real world phenomena and approach the solution of unique problems. Evaluate experimental or observational evidence based on knowledge of: • properties of matter, forces, motion, and energy; • living things, ecosystems, human biology, molecular heredity, and evolution and natural selection; and • Earth materials and systems, the solar system, stars, galaxies, the universe, and the evolution of the Earth and the universe

DEFINITION B SCIENTIFIC INQUIRY AND THE NATURE OF SCIENCE

NOTE: This definition assumes the student is already proficient with the concepts and procedures described in the Washington State Grade Level Expectations for Science through Grades 9/10.

The student understands scientific inquiry and the nature of science.

COMPONENT	EVIDENCE of LEARNING
B.1 Demonstrate understanding of the differences between observation, hypothesis, theory and law.	• Make an hypothesis (or multiple hypotheses) based on an observation that includes a prediction with a cause-effect reason. • Demonstrate creativity and critical thinking to formulate and evaluate hypotheses. • Distinguish between testable and non-testable questions. • Understand the scientific definition of hypothesis, theory, and law. • Understand that a theory does not turn into a law.
B.2 Understand how to plan and conduct scientific investigations using proper data collection and observation methods. [See GLE 2.1.2]	• Use approximation when appropriate; recognize when accuracy and precision are important. • Accurately and thoroughly make and record observations. • Distinguish between inference and observation and understand their roles in scientific investigation. • Understand that predictions are inferential.
B.3 Synthesize a scientific explanation using evidence and data and defend it with logic, and if necessary revise the explanation to account for new evidence. [See GLE 2.1.3]	• Suggest alternative explanations for data and conclusions, and propose alternative hypotheses. • Accept that unexpected or ambiguous results are often part of the experimentation process.
B.4 Use physical, conceptual and mathematical models to represent and investigate objects, events, systems and processes. [See GLE 2.1.4]	• Create physical, conceptual, and/or mathematical models to represent and/or investigate objects, events, systems, and processes. • Evaluate how well a model describes or predicts the behavior of an object, event, system or process.
B.5 Using both oral and written skills, present and produce reports on scientific investigations, explanations of objects, events, systems, and processes. [See GLE 2.1.5]	• Summarize an investigation and discuss how the conclusions support or refute accepted scientific theories and laws. • Effectively communicate investigative results and conclusions.

DEFINITION B SCIENTIFIC INQUIRY AND THE NATURE OF SCIENCE

NOTE: This definition assumes the student is already proficient with the concepts and procedures described in the Washington State Grade Level Expectations for Science through Grades 9/10.

The student understands scientific inquiry and the nature of science.

COMPONENT	EVIDENCE of LEARNING
B.6 Analyze scientific theories, methods and conclusions for validity and reliability. [See GLEs 2.2.1, 2.2.2 and 2.2.4]	• Recognize the importance of performing multiple trials to obtain reliable results. • Understand the limitations of an experimental design and its impact on the validity of conclusions. • Suggest additional experiments that could be performed to explain experimental data or conclusions. • Understand that constructive criticism about scientific investigations is useful and necessary. • Recognize science and pseudoscience and explain why a given concept is or is not scientific.
B.7 Understand how scientific knowledge is dynamic [See GLE 2.2.5]	• Know that science often involves the testing, evaluation and modification of theories based on the application of scientific methods. • Understand that the goal of scientific inquiry and investigation is to lead to a better understanding of the natural world.

DEFINITION C SCIENCE AND SOCIETY

NOTE: This definition assumes the student is already proficient with the concepts and procedures described in the Washington State Grade Level Expectations for Science through Grades 9/10.

The student applies scientific knowledge and solutions to other disciplines and real life situations.

COMPONENT	EVIDENCE of LEARNING
C.1 Analyze local, regional, national, and global problems or challenges in which scientific designs can be or have been used to develop a solution. [see GLE 3.1.1]	• Critically analyze scientific information in current events to make personal choices, or to inform public-policy decisions. • Recognize when more information is needed and demonstrate the skills to acquire such information.
C.2 Recognize that scientific knowledge and technological advances are discovered and developed by individuals and communities in all cultures of the world. [see GLE 3.2.1]	• Describe how our modern way of life has been impacted by scientific knowledge and technological advances from a variety of peoples. • Analyze how scientific knowledge and technological advances contribute to changes in societies.
C.3 Analyze how the scientific enterprise and technological advances have had both positive and negative impacts on society and Earth. [see GLE 3.2.2]	• Investigate and describe specific examples of the unintended consequences of scientific enterprises on the natural world and society.
C.4 Analyze the effects human activities have on Earth's capacity to sustain biological diversity. [see GLE 3.2.4]	• Explain how human activities affect Earth's capacity to sustain biological diversity (e.g. global warming, introduced species, poaching, pollution, habitat destruction, etc.). • Describe and analyze the global impacts created by the predicted exponential growth of human populations and develop possible solutions. • Explain how the use of renewable and nonrenewable natural resources affects the sustainability of an ecosystem.

DEFINITION D QUANTITATIVE ANALYSIS

NOTE: This definition assumes the student is already proficient with the concepts and procedures described in the Washington State Grade Level Expectations for Science through Grades 9/10.

The student uses appropriate mathematical concepts and procedures in scientific investigations.

COMPONENT	EVIDENCE of LEARNING
D.1 Apply concepts and procedures from algebra to analyze data. [see TMP Standard 7]	• Know when it is possible to simplify, solve, substitute in or evaluate equations and expressions and when it is not. For example, expand the expression (x-1) (x +4); substitute a = 2, b = 4 into the formula $a^2 + b^2 = c^2$; solve the equation 0 = (x +3) (x+1); and evaluate the function f(x) =(x+1) (x+4) at x = -1. • Know ways that variables can be represented in mathematical functions (e.g., as a placeholder for an unknown, such as x + 2 = 9, or to represent a range of values, such as -3m - 8). • Understand polynomial, logarithmic, exponential and trigonometric functions.
D.2 Apply concepts and procedures from analytic geometry to analyze data.	• Understand vectors and how they can be used to represent force, velocity, and other physical measurements. • Use vector analysis, vector addition and scalar multiplication to solve problems. • Understand that a curve drawn in a certain location is fully equivalent to a set of algebraic equations.
D.3 Use mathematical knowledge and logical reasoning to define and solve problems. [See TMP, Standard 1].	• Create a variety of models to represent functions, patterns and mathematical relationships (e.g., statements, formulas, and graphs). • Use various strategies to approach problem-solving situations and to revise solution processes.
D.4 Use symbols, diagrams and graphs to clearly communicate mathematical ideas, reasoning and their implications. (see TMP 2.2)	• Use appropriate/applicable method to represent data (e.g. charts, tables, plots and graphs). • Interpolate or extrapolate data points on a graph.
D.5 Accurately apply concepts and procedures from measuring, estimating, probability and statistics to analyze data. [see TMP, Standard 6]	• Select and use appropriate units to express measurements. • Understand the differences between the metric and the traditional U.S. measurement system and be able to convert between the two systems. • Use scientific notation appropriately. • Understand and be able to use descriptive statistics (e.g., mean, median, mode and standard deviation). • Know the difference between accuracy and precision, as well as how to use significant digits appropriately. • Know how to estimate and when to use estimation to solve problems. • Consider the possible sources of measurement errors and their effects on calculations. • Check to be sure that quantities are reasonable and plausible.
D.6 Accurately apply concepts and procedures from proportional reasoning to analyze data.	• Use proportional reasoning to solve problems (e.g., equivalent fractions, equal ratios, constant rate of change, proportions and percents). • Understand ratios, proportions and percents and how each is related to the other. • Determine how changing the value of one variable affects the value of a second variable in an equation (direct or inverse proportionality).

DEFINITION E TECHNOLOGY

NOTE: This definition assumes the student is already proficient with the concepts and procedures described in the Washington State Grade Level Expectations for Science through Grades 9/10.

The student uses appropriate technologies in conducting scientific investigations.

COMPONENT	EVIDENCE of LEARNING
E.1 Use technology in scientific literature research (information literacy).	• Locate varied and reputable sources of information, using available library, electronic, and human resources. • Use resources such as databases and tools such as search engines to access information relevant to a topic. • Critically evaluate information from electronic and other sources.
E.2 Use technology to conduct scientific investigations, and analyze and present scientific data.	• Correctly and safely use available equipment to conduct a scientific investigation. • Use technology and software to accurately collect, analyze and display data. [see OR PASS Standards]

DEFINITION F COMMUNICATION

NOTE: This definition assumes the student is already proficient with the concepts and procedures described in the Washington State Grade Level Expectations for Science through Grades 9/10.

The student effectively communicates scientific knowledge.

COMPONENT	EVIDENCE of LEARNING
E.1 Use appropriate terminology and technology to communicate scientific knowledge.	• Communicate results using pictures, tables, charts, diagrams, graphic displays and text that are clear, neat, accurate, and informative. [PASS & Benchmarks for Scientific Literacy] • Accurately use terminology, symbols, notations, and formulas to report results, identify patterns in data, and propose explanations. [PASS]
E.2 Communicate scientific information and defend scientific arguments both orally and in writing. [National Science Education Standards]	• Translate knowledge of scientific writings and terminology into everyday language. [KSUS] • Clearly explain scientific claims or arguments presented. [PASS]. • Clearly communicate questions, hypotheses, methods, results, and conclusions. • Use scientific evidence, as opposed to anecdote or personal opinion, to support scientific arguments. • Seek and readily accept constructive comments.

The Higher Education Coordinating Board and the College Readiness Content Development Teams wish to express their appreciation to the Office of Superintendent of Public Instruction for its work with the EALRs (Essential Academic Learning Requirements) and the associated GLEs (Grade Level Expectations), and for granting permission for the college readiness definitions to use language directly from the GLEs when appropriate.

Attachment 1

CONCLUDING REMARKS FROM SCIENCE CONTENT TEAM

A major objective of college readiness is to encourage a more cohesive approach to the processes of science education. The science college readiness attributes and definitions should, therefore, be viewed as a framework to better prepare students for entry-level general education science classes. Students planning to major in science, math, or engineering will find additional science and math classes in their junior and senior years of high school to be essential.

One of the strengths of this document is that it builds on the existing framework of standards and assessments used in Washington's secondary education system. It is important to recognize that high school curricula and teaching practices in Washington State already incorporate some of what is included in this college readiness document.

Also, it is both fair and important to state that the causes of student failure or success at the college level can be as varied as the quality of instruction and resources available in K-12 and postsecondary education institutions in our state. Therefore, it is imperative to acknowledge that a student's preparation and likelihood for success in college might be diminished by factors ranging from a lack of trained science educators in elementary grades, to college related factors such as lecture-style teaching to hundreds of students, which we know does not work well for all students.

Perhaps Phase II of this project could identify factors that lead to both success and failure of students during their college years so that needed adjustments can be made at all levels. Significantly more students in our state could meet science college readiness expectations provided our system is adequately equipped to offer a quality, coordinated learning program. Defining science college readiness is considered vital to the goal of a quality coordinated program.

To this end, the capacity of school districts and colleges to offer improved science education also deserves careful consideration and thorough analysis. Some of the most compelling capacity issues include class size, professional development (K-20), equipment and facilities, additional demands placed on teachers without sufficient resources, and teacher compensation and retention.

Another significant challenge is providing resources that address economic disparities and home, community and cultural differences that affect learning. School institutions often are ill equipped to meet the complex needs of our state's diverse and needy student populations.

Attachment 2

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