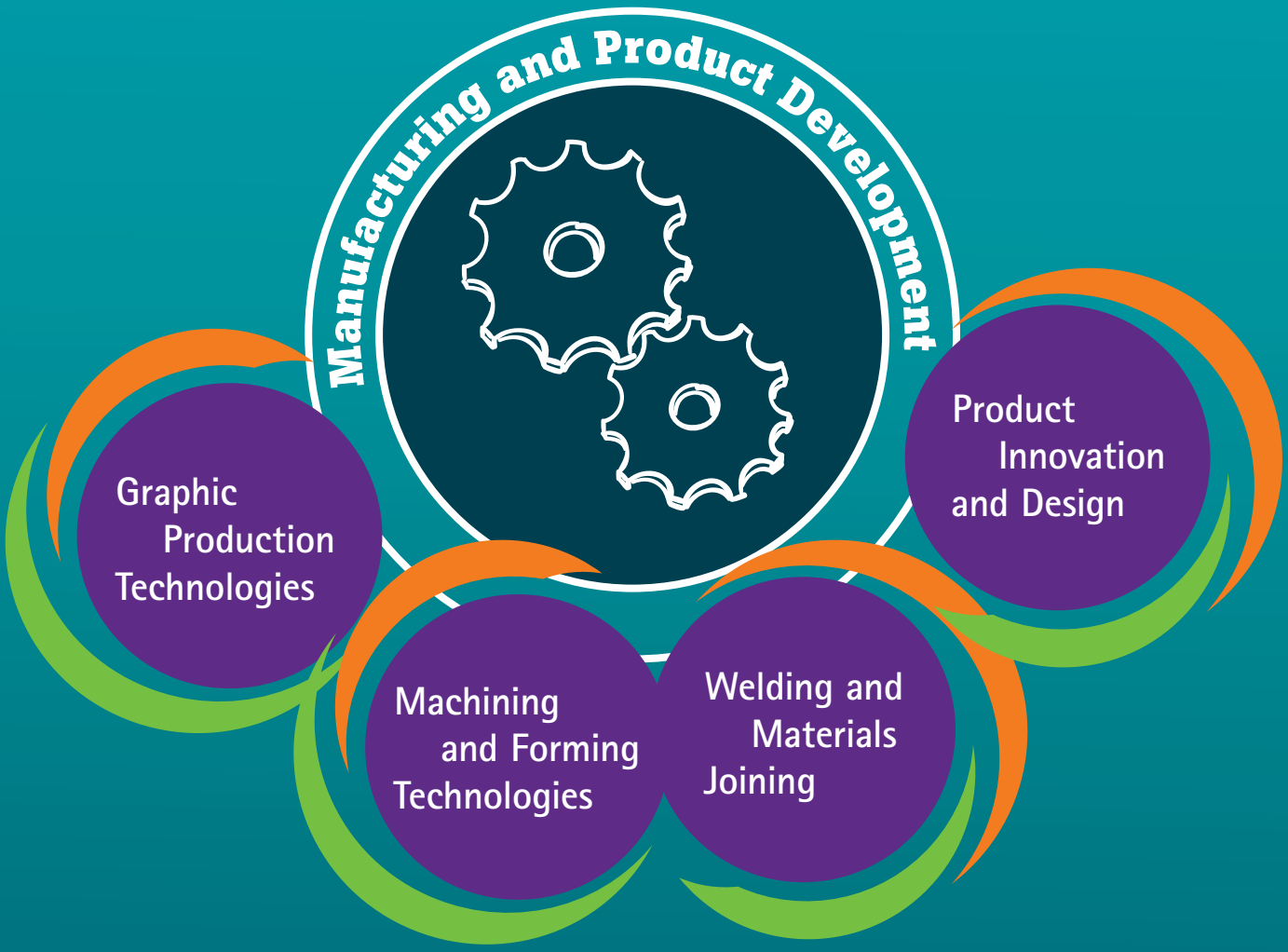
California Career Technical Education Model Curriculum Standards



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Overview

The Career Technical Education (CTE) Model Curriculum Standards publication is organized for use as a complete document or for access to individual industry sectors and pathways. The document includes Standards for Career Ready Practice—which describe the knowledge and skills that students need prior to entering a career technical education program—as part of the career technical education sequence or as integrated elements of other course work in preparation for careers and college.

Each of the 15 industry sector sections includes a description, anchor standards, pathway standards, and an academic alignment matrix. The standards can be adjusted to be part of the curriculum (grades seven through twelve), provided through adult education, or included in community college programs. The document also lists the representatives who participated in each sector's content development and the references that were consulted to revise the CTE standards.

Standards for Career Ready Practice

California's Standards for Career Ready Practice, which follow this overview, are based on the Career Ready Practices of the Common Career Technical Core (CCTC), a state-led initiative sponsored by the National Association of State Directors of Career Technical Education Consortium (NASDCTEc):

> Career Ready Practices describe the career-ready skills that educators should seek to develop in their students. These practices are not exclusive to a Career Pathway, program of study, discipline or level of education. Career Ready Practices should be taught and reinforced in all career exploration and preparation programs with increasingly higher levels of complexity and expectation as a student advances through a program of study. (NASDCTEc 2012, 2)

California's 12 Standards for Career Ready Practice align with the state's CTE anchor standards and reflect the expectations from business and industry, labor and community organizations, and secondary and postsecondary education representatives from 42 participating states.

Anchor Standards

The 11 anchor standards build on the Standards for Career Ready Practice and are common across the 15 industry sectors. Content for these standards was drawn from several documents: "Preparing Students for the 21st Century Economy" (American Association of Colleges for Teacher Education and the Partnership for 21st Century Skills 2010); *How Should Colleges Prepare Students to Succeed in Today's Global Economy?* (Association of American Colleges and Universities and Peter D. Hart Research Associates, Inc. 2006); "Importance of Skills and Knowledge for College and Career Readiness," from *The MetLife Survey of the American Teacher: Preparing Students for College and Careers* (MetLife, Inc. 2011); and *Are They Really Ready to Work? Employers' Perspectives on the Basic Knowledge and Applied Skills of New Entrants to the 21st Century U.S. Workforce* (The Conference Board et al. 2006).

Each anchor standard is followed by performance indicators using action verbs from the Beyond Knowledge Construct, presented in a hierarchical progression of simple tasks to more complex tasks. Performance indicators provide guidance for curriculum design and standards measurement.

The industry-sector anchor standards have been customized with selected additions to better reflect the needs and special conditions of each industry sector.

Anchor Standard 1 (Academics) guides users to sector-specific core academic standards related to each industry sector, which are listed in the alignment matrix at the end of each sector section. Anchor standards 2–10 are deliberately aligned with one of the Common Core English language arts standards, using similar language demonstrating the natural connections between the two subjects. Anchor Standard 11 (Demonstration and Application) highlights classroom, laboratory, and workplace learning specific to the individual sector and pathways.

Pathway Standards

All 15 industry sectors contain multiple pathways. In order to be identified and listed for an industry sector, each pathway had to meet the following criteria:

- unique to an industry sector
- has an occupational focus
- consistent in size and scope
- composed of similar functions
- inclusive of all aspects of the industry
- includes 8–12 pathway-specific standards
- demonstrates sequence potential
- reasonable and appropriate for high school
- leads to high-skill, high-wage, or high-demand jobs
- sustainable and viable over the next 10 years

Academic Alignment Matrix

Each sector includes an academic alignment matrix that displays where a natural, obvious alignment occurs. Compiled by five teams of academic content experts in collaboration with industry-sector consultants, teachers, and other advisers, the alignment was selected if it was determined that the pathway standard would enhance, reinforce, or provide an application for a specific academic subject standard.

The alignment matrices include the subjects of Common Core English language arts and mathematics standards, history/social studies standards, and Next Generation Science Core Ideas. To assist with further review and implementation, each academic alignment is notated with specific pathway standards codes.

Implementation

The Standards for Career Ready Practice can be integrated with a course or incorporated into several courses over multiple school years (grades seven through twelve). The practices are expectations for all students, whether they are enrolled in a CTE program or following a more generalized course sequence. It is expected that all students who exit high school will be proficient in these practices.

The anchor standards are the basis for each of the pathways within each sector. These standards are designed to assist with the development of course curricula and instructional lesson plans; they describe what is to be taught and measured. In most cases, the teacher determines the sequence and strategies to be used to meet the needs of the student population he or she is serving.

The performance indicators that follow each standard offer guidance for both course design and student assessment. They are intended to guide course work as it is developed. The pathways organize the standards with a career focus, but they are not designed to be offered as single courses. Rather, the standards from each pathway are collected and organized into a sequence of learning. To meet local demands of business and industry and particular student populations, standards can be collected from more than one sector to create a course.

Using the academic alignment matrices as a resource, academic and CTE teachers can see where enhancements and support for both sets of standards can be initiated. CTE teachers can quickly identify academic standards that have a substantial relationship to their instruction. Likewise, academic teachers can specify individual academic standards and quickly identify related CTE standards, which will assist them in incorporating application and technology in their curricula and lessons.

The CTE Model Curriculum Standards are intended to serve the entire education community—from middle schools and high schools to postsecondary colleges and career training programs. A major aim of these standards is to prepare students for postsecondary education and training and to help them make a smooth transition into the workforce. In order for both the people and the economy of California to prosper, it is essential for all students to emerge from schools ready to pursue their career and college goals. Equipping all high school students with the knowledge and skills necessary to plan and manage their education and careers throughout their lives will help to guarantee these important outcomes. Strong CTE programs will continue to provide important educational opportunities to assist students as they pursue their dreams and strive for economic prosperity. The CTE Model Curriculum Standards are a resource for educators and the business world for ensuring high-quality CTE learning experiences and improved student outcomes in the twenty-first-century economy.

California Standards for Career Ready Practice

Standards for Career Ready Practice describe the fundamental knowledge and skills that a career-ready student needs in order to prepare for transition to postsecondary education, career training, or the workforce. These standards are not exclusive to a career pathway, a CTE program of study, a particular discipline, or level of education. Standards for Career Ready Practice are taught and reinforced in all career exploration and preparation programs with increasingly higher levels of complexity and expectation as a student advances through a program of study. Standards for Career Ready Practice are a valuable resource to CTE and academic teachers designing curricula and lessons in order to teach and reinforce the career-ready aims of the CTE Model Curriculum Standards and the Common Core State Standards.

1. Apply appropriate technical skills and academic knowledge.

Career-ready individuals readily access and use the knowledge and skills acquired through experience and education. They make connections between abstract concepts with real-world applications and recognize the value of academic preparation for solving problems, communicating with others, calculating measures, and other work-related practices.

2. Communicate clearly, effectively, and with reason.

Career-ready individuals communicate thoughts, ideas, and action plans with clarity, using written, verbal, electronic, and/or visual methods. They are skilled at interacting with others, are active listeners who speak clearly and with purpose, and are comfortable with the terminology common to the workplace environment. Career-ready individuals consider the audience for their communication and prepare accordingly to ensure the desired outcome.

3. Develop an education and career plan aligned with personal goals.

Career-ready individuals take personal ownership of their own educational and career goals and manage their individual plan to attain these goals. They recognize the value of each step in the educational and experiential process and understand that nearly all career paths require ongoing education and experience to adapt to practices, procedures, and expectations of an ever-changing work environment. They seek counselors, mentors, and other experts to assist in the planning and execution of education and career plans.

4. Apply technology to enhance productivity.

Career-ready individuals find and maximize the productive value of existing and new technology to accomplish workplace tasks and solve workplace problems. They are flexible and adaptive in acquiring and using new technology. They understand the inherent risks—personal and organizational—of technology applications, and they take actions to prevent or mitigate these risks.

5. Utilize critical thinking to make sense of problems and persevere in solving them.

Career-ready individuals recognize problems in the workplace, understand the nature of the problems, and devise effective plans to solve the problems. They thoughtfully investigate the root cause of a problem prior to introducing solutions. They carefully consider options to solve the problem and, once agreed upon, follow through to ensure the problem is resolved.

6. Practice personal health and understand financial literacy.

Career-ready individuals understand the relationship between personal health and workplace performance. They contribute to their personal well-being through a healthy diet, regular exercise, and mental health activities. Career-ready individuals also understand that financial literacy leads to a secure future that enables career success.

7. Act as a responsible citizen in the workplace and the community.

Career-ready individuals understand the obligations and responsibilities of being a member of a community and demonstrate this understanding every day through their interactions with others. They are aware of the impacts of their decisions on others and the environment around them and think about the short-term and long-term consequences of their actions. They are reliable and consistent in going beyond minimum expectations and in participating in activities that serve the greater good.

8. Model integrity, ethical leadership, and effective management.

Career-ready individuals consistently act in ways that align with personal and community-held ideals and principles. They employ ethical behaviors and actions that positively influence others. They have a clear understanding of integrity and act on this understanding in every decision. They use a variety of means to positively impact the direction and actions of a team or organization, and they recognize the short-term and long-term effects that management's actions and attitudes can have on productivity, morale, and organizational culture.

9. Work productively in teams while integrating cultural and global competence.

Career-ready individuals positively contribute to every team as both team leaders and team members. They apply an awareness of cultural differences to avoid barriers to productive and positive interaction. They interact effectively and sensitively with all members of the team and find ways to increase the engagement and contribution of other members.

10. Demonstrate creativity and innovation.

Career-ready individuals recommend ideas that solve problems in new and different ways and contribute to the improvement of the organization. They consider unconventional ideas and suggestions by others as solutions to issues, tasks, or problems. They discern which ideas and suggestions may have the greatest value. They seek new methods, practices, and ideas from a variety of sources and apply those ideas to their own workplace practices.

11. Employ valid and reliable research strategies.

Career-ready individuals employ research practices to plan and carry out investigations, create solutions, and keep abreast of the most current findings related to workplace environments and practices. They use a reliable research process to search for new information and confirm the validity of sources when considering the use and adoption of external information or practices.

12. Understand the environmental, social, and economic impacts of decisions.

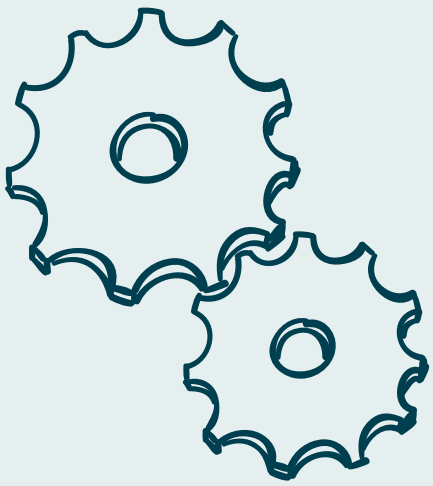
Career-ready individuals understand the interrelated nature of their actions and regularly make decisions that positively impact other people, organizations, the workplace, and the environment. They are aware of and utilize new technologies, understandings, procedures, and materials and adhere to regulations affecting the nature of their work. They are cognizant of impacts on the social condition, environment, workplace, and profitability of the organization.

Note: As stated previously, California's Standards for Career Ready Practice are based on the CCTC Career Ready Practices posted at https://careertech.org/ (accessed June 8, 2016).

Manufacturing and Product Development

Sector Description

The Manufacturing and Product Development sector provides a foundation for secondary students in California in manufacturing processes and systems, including graphic design production, machine tooling and forming, welding and materials joining, and product innovation and design. Students engage in an instructional program that integrates academic and technical preparation and focuses on career awareness, career exploration, and skill preparation in four pathways. The pathways emphasize real-world, occupationally relevant experiences of significant scope and depth in manufacturing. The knowledge and skills are acquired within a sequential, standards-based pathway program that integrates hands-on, project-based, and work-based instruction. Standards in this sector are designed to prepare students for entry to a career, postsecondary education, or advanced technical training.



1.0 Academics

Analyze and apply appropriate academic standards required for successful industry sector pathway completion leading to postsecondary education and employment. Refer to the Manufacturing and Product Development academic alignment matrix for identification of standards.

2.0 Communications

Acquire and accurately use Manufacturing and Product Design sector terminology and protocols at the career and college readiness level for communicating effectively in oral, written, and multimedia formats. (Direct alignment with LS 9-10, 11-12.6)

2.1 Recognize the elements of communication using a sender–receiver model.

2.2 Identify barriers to accurate and appropriate communication.

2.3 Interpret verbal and nonverbal communications and respond appropriately.

2.4 Demonstrate elements of written and electronic communication such as accurate spelling, grammar, and format.

2.5 Communicate information and ideas effectively to multiple audiences using a variety of media and formats.

2.6 Advocate and practice safe, legal, and responsible use of digital media information and communications technologies.

3.0 Career Planning and Management

Integrate multiple sources of career information from diverse formats to make informed career decisions, solve problems, and manage personal career plans. (Direct alignment with SLS 11-12.2)

3.1 Identify personal interests, aptitudes, information, and skills necessary for informed career decision making.

3.2 Evaluate personal character traits such as trust, respect, and responsibility and understand the impact they can have on career success.

3.3 Explore how information and communication technologies are used in career planning and decision making.

3.4 Research the scope of career opportunities available and the requirements for education, training, certification, and licensure.

3.5 Integrate changing employment trends, societal needs, and economic conditions into career planning.

3.6 Recognize the role and function of professional organizations, industry associations, and organized labor in a productive society.

3.7 Recognize the importance of small business in the California and global economies.

3.8 Understand how digital media are used by potential employers and postsecondary agencies to evaluate candidates.

3.9 Develop a career plan that reflects career interests, pathways, and postsecondary options.

4.0 Technology

Use existing and emerging technology, to investigate, research, and produce products and services, including new information, as required in the Manufacturing and Product Design sector workplace environment. (Direct alignment with WS 11-12.6)

4.1 Use electronic reference materials to gather information and produce products and services.

4.2 Employ Web-based communications responsibly and effectively to explore complex systems and issues.

4.3 Use information and communication technologies to synthesize, summarize, compare, and contrast information from multiple sources.

4.4 Discern the quality and value of information collected using digital technologies, and recognize bias and intent of the associated sources.

4.5 Research past, present, and projected technological advances as they impact a particular pathway.

4.6 Assess the value of various information and communication technologies to interact with constituent populations as part of a search of the current literature or in relation to the information task.

5.0 Problem Solving and Critical Thinking

Conduct short, as well as more sustained, research to create alternative solutions to answer a question or solve a problem unique to the Manufacturing and Product Design sector using critical and creative thinking, logical reasoning, analysis, inquiry, and problem-solving techniques. (Direct alignment with WS 11-12.7)

5.1 Identify and ask significant questions that clarify various points of view to solve problems.

5.2 Solve predictable and unpredictable work-related problems using various types of reasoning (inductive, deductive) as appropriate.

5.3 Use systems thinking to analyze how various components interact with each other to produce outcomes in a complex work environment.

5.4 Interpret information and draw conclusions, based on the best analysis, to make informed decisions.

6.0 Health and Safety

Demonstrate health and safety procedures, regulations, and personal health practices and determine the meaning of symbols, key terms, and domain-specific words and phrases as related to the Manufacturing and Product Design sector workplace environment. (Direct alignment with RSTS 9-10, 11-12.4)

6.1 Locate, and adhere to, Material Safety Data Sheet (MSDS) instructions.

6.2 Interpret policies, procedures, and regulations for the workplace environment, including employer and employee responsibilities.

6.3 Use health and safety practices for storing, cleaning, and maintaining tools, equipment, and supplies.

6.4 Set up a work area, or shop, to avoid potential health concerns and safety hazards including but not limited to ergonomics, electrical (shock), wires (tripping), fumes (lung health), noise (hearing loss), fire (burns), and so forth, incorporating ergonomics.

6.5 Practice personal safety when lifting, bending, or moving equipment and supplies.

6.6 Demonstrate how to prevent and respond to work-related accidents or injuries and emergencies.

6.7 Maintain a safe and healthful working environment.

6.8 Be informed of laws/acts pertaining to the Occupational Safety and Health Administration (OSHA).

7.0 Responsibility and Flexibility

Initiate, and participate in, a range of collaborations demonstrating behaviors that reflect personal and professional responsibility, flexibility, and respect in the Manufacturing and Product Design sector workplace environment and community settings. (Direct alignment with SLS 9-10, 11-12.1)

7.1 Recognize how financial management impacts the economy, workforce, and community.

7.2 Explain the importance of accountability and responsibility in fulfilling personal, community, and workplace roles.

7.3 Understand the need to adapt to changing and varied roles and responsibilities.

7.4 Practice time management and efficiency to fulfill responsibilities.

7.5 Apply high-quality techniques to product or presentation design and development.

7.6 Demonstrate knowledge and practice of responsible financial management.

7.7 Demonstrate the qualities and behaviors that constitute a positive and professional work demeanor, including appropriate attire for the profession.

7.8 Explore issues of global significance and document the impact on the Manufacturing and Product Design sector.

8.0 Ethics and Legal Responsibilities

Practice professional, ethical, and legal behavior, responding thoughtfully to diverse perspectives and resolving contradictions when possible, consistent with applicable laws, regulations, and organizational norms. (Direct alignment with SLS 11-12.1d)

8.1 Access, analyze, and implement quality assurance standards of practice.

8.2 Identify local, district, state, and federal regulatory agencies, entities, laws, and regulations related to the Manufacturing and Product Development industry sector.

8.3 Demonstrate ethical and legal practices consistent with Manufacturing and Product Design sector workplace standards.

8.4 Explain the importance of personal integrity, confidentiality, and ethical behavior in the workplace.

8.5 Analyze organizational culture and practices within the workplace environment.

8.6 Adhere to copyright and intellectual property laws and regulations, and use and appropriately cite proprietary information.

8.7 Conform to rules and regulations regarding sharing of confidential information, as determined by Manufacturing and Product Design sector laws and practices.

9.0 Leadership and Teamwork

Work with peers to promote divergent and creative perspectives, effective leadership, group dynamics, team and individual decision making, benefits of workforce diversity, and conflict resolution as practiced in the SkillsUSA career technical student organizations. (Direct alignment with SLS 11-12.1b)

9.1 Define leadership and identify the responsibilities, competencies, and behaviors of successful leaders.

9.2 Identify the characteristics of successful teams, including leadership, cooperation, collaboration, and effective decision-making skills as applied in groups, teams, and career technical student organization activities.

9.3 Understand the characteristics and benefits of teamwork, leadership, and citizenship in the school, community, and workplace setting.

9.4 Explain how professional associations and organizations and associated leadership development and competitive career development activities enhance academic preparation, promote career choices, and contribute to employment opportunities.

9.5 Understand that the modern world is an international community and requires an expanded global view.

9.6 Respect individual and cultural differences and recognize the importance of diversity in the workplace.

9.7 Participate in interactive teamwork to solve real Manufacturing and Product Design sector issues and problems.

10.0 Technical Knowledge and Skills

Apply essential technical knowledge and skills common to all pathways in the Manufacturing and Product Design sector, following procedures when carrying out experiments or performing technical tasks. (Direct alignment with WS 11-12.6)

10.1 Interpret and explain terminology and practices specific to the Manufacturing and Product Design sector.

10.2 Comply with the rules, regulations, and expectations of all aspects of the Manufacturing and Product Design sector.

10.3 Construct projects and products specific to the Manufacturing and Product Design sector requirements and expectations.

10.4 Collaborate with industry experts for specific technical knowledge and skills.

11.0 Demonstration and Application

Demonstrate and apply the knowledge and skills contained in the Manufacturing and Product Design anchor standards, pathway standards, and performance indicators in classroom, laboratory, and workplace settings, and through the SkillsUSA career technical student organizations.

11.1 Utilize work-based/workplace learning experiences to demonstrate and expand upon knowledge and skills gained during classroom instruction and laboratory practices specific to the Manufacturing and Product Design sector program of study.

11.2 Demonstrate proficiency in a career technical pathway that leads to certification, licensure, and/or continued learning at the postsecondary level.

11.3 Demonstrate entrepreneurship skills and knowledge of self-employment options and innovative ventures.

11.4 Employ entrepreneurial practices and behaviors appropriate to Manufacturing and Product Design sector opportunities.

11.5 Create a portfolio, or similar collection of work, that offers evidence through assessment and evaluation of skills and knowledge competency as contained in the anchor standards, pathway standards, and performance indicators.

A. Graphic Production Technologies Pathway

The Graphic Production Technologies pathway provides students with an understanding of printing and manufacturing processes and systems common to careers in the graphic arts and printing technology industries. Representative topics include the principles of design composition, graphic design and layout, typography, image generation and file preparation, photography, digital imaging, prepress preparation, printing and screen printing technologies, binding and finishing processes, multimedia blending, business and entrepreneurship principles, prototype product design, computer-aided design, and computer-aided manufacturing.

Sample occupations associated with this pathway:

- Animator; Computer-Designed Parts
- Commercial Photographer
- Digital/Graphic Artist; CAD/CAM Apprentice
- Printing Press Operator
- Production Assistant

A1.0 Apply the basic graphic design principles to achieve effective visual communication.

- A1.1 Identify the relationships between space, color, image, and content.
- A1.2 Demonstrate the graphic design principles and the utilization of the grid system in applying those principles.
- A1.3 Create a basic layout applying images, text, and typography.
- A1.4 Create and choose font styles.

A2.0 Demonstrate an understanding of the psychology of color and color theory as it relates to visual communication.

- A2.1 Understand the science of color spectrum and other aspects of color as it relates to hue, value, and chroma.
- A2.2 Explain the differences between methods used to describe color, including cyan, magenta, yellow, black (CMYK) and red, green, blue (RGB).
- A2.3 Produce a printed product in monotone and in multicolor.

A3.0 Apply graphic design software and desktop publishing as a means of creating effective communication.

- A3.1 Differentiate between and operate Macintosh (Mac) and personal computer (PC) platforms for development.
- A3.2 Apply desktop publishing and electronic imaging software principles and processes used to prepare graphic design products.
- A3.3 Demonstrate how to produce single and multicolor images and know how to apply them across various types of printed products.

A3.4 Create a visually effective layout that communicates an intention using graphic software that integrates graphics, text, photographic imagery, and color.

A3.5 Produce a printed product that demonstrates the application of graphic design principles and color theory using desktop publishing and electronic imaging software.

A4.0 Demonstrate technical illustration and vector drawing skills.

A4.1 Create technical illustration and vector drawings.

A4.2 Convert and edit formats including encapsulated postscript (eps), drawing (dwg), and portable document file (pdf).

A5.0 Adhere to the prepress process and procedures required to reproduce single-color and multicolor printing.

A5.1 Gain proficiency in applying the principles and processes used to prepare design work for the prepress phase of graphic design.

A5.2 Explain the differences in prepress for different output printing methods.

A5.3 Produce a printed product with the use of desktop publishing and electronic imaging software starting with the prepress phase through to reproduction.

A6.0 Apply the processes and procedures involved in producing image files for the reproduction of single-color and multicolor products.

A6.1 Identify the variables that affect the image transfer process for reproduction.

A6.2 Employ the process for creating image files that are appropriate for graphic design reproduction and specified printing requirements.

A7.0 Develop a proficiency in applying the processes and procedures required for the reproduction of printed products and the image transfer process.

A7.1 Explain how various processes may be used to produce multiple-imaged copies.

A7.2 Identify the variables that affect the image transfer process.

A7.3 Produce a single-color and multicolor quality project applying the procedures and image transfer processes with a minimum of waste.

A8.0 Understand various binding and finishing processes.

A8.1 Identify the variations, characteristics, and functions of binding and finishing operations in the production of printed products.

A8.2 Produce a bound and finished product such as a notepad, brochure, or booklet.

A9.0 Demonstrate an understanding of the screen printing process.

A9.1 Identify the various applications of screen printing and the outcomes it produces.

A9.2 Identify materials and operations used in the screen printing process.

A9.3 Identify the variables that affect the image and results of the screening process.

A9.4 Produce a screen printed product on various substrates using appropriate inks and procedures.

A10.0 Understand the analog and digital photographic applications.

A10.1 Employ various photographic technology, processes, and materials used in graphic design.

A10.2 Identify the visual characteristics and differences between analog and digital outputs.

A10.3 Apply the principles of composition and lighting used in photography.

A10.4 Produce black-and-white and color images under natural and studio lighting conditions in both analog and digital output.

A11.0 Apply various animation and motion graphic software to create dynamic visual communication outcomes.

A11.1 Explore and apply animated effects to the elements of design, which include text, color, and imagery.

A11.2 Produce a visually dynamic communication project that applies animated effects to various elements of the design.

A12.0 Demonstrate a proficiency in digital video production and the postproduction process.

A12.1 Identify the functions involved in the preproduction, production, and postproduction phases of video production.

A12.2 Apply digital video technology processes and procedures used in producing a multimedia project.

A12.3 Produce a digital media project from a storyboard utilizing current production and postproduction technologies.

A13.0 Understand and apply integrated graphic multimedia technologies, combining graphics, photographic imagery, motion graphics and animation, video, and special effects.

A13.1 Apply design strategies in selecting graphic multimedia technologies to produce dynamic effective visual communication.

A13.2 Practice the steps in producing an integrated graphic multimedia project designed to inform, teach, or sell.

A13.3 Produce an integrated graphic multimedia project.

A14.0 Identify the different industries that utilize graphic design and identify other potential business opportunities for graphic design applications.

A14.1 Apply research methodologies and business and entrepreneurial principals to identify potential business opportunities to apply graphic and multimedia design.

B. Machining and Forming Technologies Pathway

The Machine and Forming Technologies pathway provides students with an understanding of manufacturing processes and systems common to careers in machine tool and materials forming industries. Representative topics include trade vocabulary; shop math; basic material identification; proper use of hand and machine tools; reading precision measuring tools within .001" and the interpretation of machined and formed-part prints; the cutting, shaping, fastening, and finishing of machined parts; fixtures: forging, molding (casting), cold forming, and shearing processes.

Sample occupations associated with this pathway:

- CAD/CAM Specialist
- CNC Machinist
- Manufacturing Engineer
- Materials/Supply Management Specialist
- Quality Assurance Technician

B1.0 Validate that a provided part meets specifications from its engineering drawing by comparing specifications (geometric dimensioning and tolerancing) and by demonstrating proper technique using appropriate precision measuring tools.

- B1.1 Identify and describe how the isometric and the orthographic views and the tolerance, scale, and material from an engineering drawing are used with an actual part.
- B1.2 Demonstrate the correct use of precision measuring tools such as vernier and dial calipers, height gages, and micrometers utilizing both English and Metric systems.
- B1.3 Demonstrate the correct use of a gage block (set) to check a part or to calibrate the accuracy of other precision measuring tools.
- B1.4 Explain calibration, tolerancing, and conditions that cause parts to fall out of tolerance.

B2.0 Describe and layout a project according to specifications or engineering drawings. Demonstrate proper technique with layout tools and work-holding devices such as three- and four-jaw chucks, collet chucks, angle plates, sine bars, parallels, and v-blocks to machine a real part.

- B2.1 Describe and then contrast when to use work-holding fixtures, such as v-block, angle plate, toe clamp, vises, chucks, or custom fixtures.
- B2.2 Describe and demonstrate how to indicate a vice on a milling machine to "square up" a block on a mill using a micrometer and a precision square measure to confirm that the block is square.
- B2.3 Use a dividing head or turn table to demonstrate the proper procedure for indexing a part requiring flats, hex, or equally spaced geometry per print specifications.
- B2.4 Use a surface plate, surface gage, height gage, prick and center punches, scriber, layout dye, and other appropriate tools to locate hole centers, radii, and locations matching the specifications provided.

B2.5 Describe and demonstrate the engine lathe by grinding a high speed tool bit focusing on the tool cutting geometry and tip radius, speeds and feeds for the materials being cut and using their tool bit and precision measuring tool, machine a part within specifications.

B3.0 Research and compare the properties of two metals using two different material specifications and a process specification.

B3.1 Classify the difference between ferrous and nonferrous metals and contrast low-, medium-, and high-carbon steels by their common uses in industry.

B3.2 Describe both the alloys from their classification systems utilizing Unified Numbering System (UNS) or American Iron and Steel Institute-Society of Automotive Engineers (AISI-SAE) and explain how characteristics such as the Rockwell Hardness Test affect machining operations.

B3.3 Demonstrate how to calculate, then revise the calculations, for spindle speed and feed rate, for both alloy examples, for either a vertical mill or a lathe.

B4.0 Demonstrate a cutoff saw operation(s) to produce a length of bar stock to specification.

B4.1 Using a length of bar stock and a process specification or drawing, cut a length of bar stock matching the cut list and demonstrate no sharp edges.

B4.2 Cut one steel bar and one aluminum plate determining the correct or optimal blade material (carbon steel, high speed, or bimetal), the proper sawtooth set to use for each, and explain why.

B5.0 Demonstrate bending, shaping, other metal forming, and fabrication techniques, including processes such as basic hand filing, knurling on a lathe, forging metal shapes or objects, green sand casting, sheet metal machines, spot welding equipment or rivets, cold form bending with cold forming machinery or homemade devices, and shapes (tooling) to achieve a specific design specification.

B5.1 Discuss and demonstrate the wide variety of metal cutting hand files: materials, sizes, shapes, cuts, and tooth configurations.

B5.2 Describe and demonstrate the care and use of the common file which can be used to form radii on a variety of commercially available metals or those that have been casted or forged.

B5.3 Describe and demonstrate cold forming (i.e. knurling on a lathe).

B5.4 Describe and demonstrate the safe use of the open forge, anvil, and tooling to custom shape hot metal.

B5.5 Describe and demonstrate the process of making a pattern, mulling and chemistry of the green sand, the use of parting powder, and ramming the casting flasks.

B5.6 Describe and demonstrate the safety procedures of heating and pouring the metal (aluminum, brass, or bronze) from a crucible furnace.

B5.7 Produce a cast part and finish to specifications.

B5.8 Describe and demonstrate the safe use of sheet metal shears, box and pan breaks, bar folders, spot welders, and riveting tools.

B5.9 Complete a layout project using a detailed set of sequential instructions to manufacture the project to plan specifications.

B6.0 Identify and select the right grinding wheel; perform wheel dressing; and grind the provided part/material to the size and surface finish specifications provided.

B6.1 Set up and safely operate pedestal and surface grinders.

B6.2 Recommend a choice of grinding wheels for a variety of conditions determining which ones are serviceable for use and selecting the right size, mounting, and dressing for grinding.

B6.3 Complete a part in semi-finished (oversize) state; square-up and finish the block to the tolerance for size, surface finish, and squareness specified by the plan or drawing.

B7.0 Perform a series of routine boring operations from a set of specifications or a drawing and explain the selection of proper tools (drill, reamer, countersink, spot facer, counter bore, tap, and center drill) for each step of the process.

B7.1 Set up and safely operate a drill press.

B7.2 Square-up and lay out a block according to provided drawing and/or specifications.

B7.3 Drill, tap, or ream holes according to specifications.

B7.4 Research the proper material machinability and tooling recommendations from trade resources such as 'Machinery's Handbook'; choose the correct tool and holder; and calculate the spindle rpm and the feed rate for holes.

B7.5 Perform secondary operations on each hole to specification including: reaming, countersinking, counter boring, tapping, and deburring.

B7.6 Use a pin gage or thread gage to validate each hole or that a tapped thread meets specifications.

B8.0 Describe and demonstrate the machining of an external and internal taper, knurled part, and threaded and bored part on an engine lathe to plan specification or drawing to produce a part and measure each end diameter within tolerance.

B8.1 Demonstrate proper cutting tool selection and speeds for an engine lathe.

B8.2 Set up and safely operate an engine lathe taper attachment or turning center.

B8.3 Produce a shoulder-bushing to the specification of the drawing provided.

B9.0 Produce parts to specification using a boring head or angular cutting with a sine bar, a keyway, and pockets with a typical vertical mill.

B9.1 Set up and safely operate a vertical milling machine.

B9.2 Demonstrate proper cutting tool selection and speeds and demonstrate an efficient setup to minimize work-holding setups.

B9.3 Produce a part with keyway to specification demonstrating proper end mill selection, proper tool-path, and proper speeds.

B9.4 Mill an angular surface on a square block using a vice, sine bar, and gage blocks; measure angle to ensure it meets the specification.

B10.0 Produce parts to specifications or drawings provided on a computer numerical controlled (CNC) mill or lathe. Demonstrate common functions or controls through manual input and through programmed (stored) input. Introduce basic G and M Code Programming focusing on the use of the Cartesian coordinate system and machine axis.

B10.1 Discuss and demonstrate the setup and safe operation of a CNC turning or milling center: the setup of tools in tool holders; referencing the vice or chuck to the machine's control; and referencing the cutting tool to the machine's control.

B10.2 Demonstrate control panel commands to perform basic milling or turning commands for motion of the tool path along the coordinate axis.

B10.3 Convert a provided three-dimensional (3-D) or computer-aided design (CAD) data set to a set of machine instructions (G code) and then run the program producing the part to specifications provided.

B10.4 Demonstrate a tooling change and tool selection to complete a multistep process on a CNC milling or turning center.

B10.5 Produce a part with tight-radius pocket features by demonstrating proper cutting tool selection, proper tool-path, and proper speeds on a CNC milling machine.

B11.0 Understand and defend the purposes and processes of inspection and quality control in machining and forming processes.

B11.1 Identify and explain machining and forming imperfections and their causes.

B11.2 Identify and explain destructive and nondestructive examination practices.

B11.3 Describe the reasons for inspection and quality control in the manufacturing of machined and formed parts.

B11.4 Analyze and identify the steps to check for distortion, misalignment, and poor fit before and after and machining or forming a part.

B11.5 Perform continuous online quality control inspections of machined and formed parts.

B11.6 Evaluate and know how to troubleshoot performance problems of machined and formed parts.

C. Welding and Materials Joining Pathway

The Welding and Materials Joining pathway provides students with an understanding of manufacturing processes and systems common to careers in welding and related industries. The following pathway standards are based on, but not limited to, well established American Welding Society (AWS) EG2.0 Guidelines for the Entry Level Welder. Representative topics include the interpretation and layout of welded and assembled-part prints, cutting, mechanical bonding, joining, cohesive bonding, adhesive bonding, and mechanical fastening.

Sample occupations associated with this pathway:

- Metal Fabricator
- Sales
- Welders, Cutters, and Fitters
- Welding Inspector
- Welding Engineer

C1.0 Interpret and demonstrate the planning and layout operations used in the welding processes.

- C1.1 Use current information technology ideation and design process systems in the manufacturing of welded parts and products.
- C1.2 Interpret scaled welding blueprints; gather design and materials information; perform calculations; and use the detail to plan, lay out, and produce parts or finished products.
- C1.3 Analyze welding symbols on drawings, specifications, and welding procedure specifications.
- C1.4 Critique the design parameters across welding processes to produce a welded part or product.

C2.0 Understand and demonstrate how materials can be processed through the use of welding tools and equipment.

- C2.1 Introduce joint preparation methods and explain how to identify joint specifications.
- C2.2 Use standard and new emerging welding tools and equipment, such as oxygen fuel cutting (OFC), plasma arc cutting (PAC), and carbon arc cutting (CAC) to cut materials for the purpose of completing a finished product that meets the standards of the AWS or a similar industry standard.
- C2.3 Use welding tools and equipment such as oxy fuel welding (OFW), shielded metal arc welding (SMAW), gas metal arc welding (GMAW), flux-cored arc welding (FCAW), gas tungsten arc welding (GTAW), forge, and furnace to combine or join manufactured parts and products resulting in a finished product that meets the standards of the AWS or a similar industry standard.
- C2.4 Compare and contrast the physical qualities of various industrial materials and how these qualities affect the ability of the materials to be processed to produce useful welded parts and products.

C3.0 Differentiate and apply various types of welding assembly processes.

- C3.1 Use welding tools such as OFW, SMAW, GMAW, FCAW, GTAW, forge, and furnace and the equipment and assembly processes appropriate to the design criteria of a specific product to result in a finished part or product that meets the standards of the AWS or similar industry welding standards.
- C3.2 Produce bonded industrial materials by using adhesive such as flow, pressure, and fusion welding.
- C3.3 Compare and contrast existing material bonding methods with future innovative bonding processes.

C4.0 Understand finishing processes and the differences between various types of finishing materials used in the manufacture of welded parts and products.

- C4.1 Employ and explain the steps to be taken, and the choices to be made, in finishing welded materials.
- C4.2 Apply the processes used for finishing welded materials.
- C4.3 Assess how to select an appropriate finishing process to meet the design criteria of a specific welded product.

C5.0 Understand and defend the purposes and processes of inspection and quality control in welding manufacturing processes.

- C5.1 Identify and explain weld imperfections and their causes.
- C5.2 Identify and explain destructive and nondestructive examination practices.
- C5.3 Describe the reasons for inspection and quality control in the manufacturing of welded parts.
- C5.4 Analyze and identify the steps to check for distortion, joint misalignment, and poor fit-up before and after welding.
- C5.5 Perform continuous online quality control inspections of welded parts.
- C5.6 Evaluate and know how to troubleshoot performance problems of welding systems.

C6.0 Explore and understand various welding systems that require standard hand and machine tools.

- C6.1 Select and use appropriate welding tools, equipment, and inspection devices to manufacture parts or products.
- C6.2 Compare and contrast the various welding systems used in conventional manufacturing industries in order to select and use appropriate tools, equipment, and inspection devices.
- C6.3 Research new and emerging welding systems and their effects on the standard hand and machine manufacturing industry.

C7.0 Understand various automated welding systems, welding design for manufacturing, flexible manufacturing systems, and materials resource planning.

- C7.1 Recognize materials and processes in relation to welding systems.
- C7.2 Understand the importance of maintaining documentation for welding systems.
- C7.3 Distinguish between welding processes involved in the following manufacturing systems: "just in time," design for manufacturing, flexible manufacturing systems, and materials resource planning.
- C7.4 Use computers to design and produce welded products, write numerical control programs, and control robots.
- C7.5 Compare and contrast the ways in which emerging welding systems may be integrated into current manufacturing processes.

C8.0 Understand various joining or combining processes, including welding processes used in manufacturing, maintenance, and repair.

- C8.1 Recognize the importance of base metal preparation and joint fit-up and alignment.
- C8.2 Analyze and be able to defend various welding processes used to complete a fabrication, an assembly, or a repair.
- C8.3 Produce a completed fabrication, an assembly, or a repair by using appropriate joining and mechanical fastening techniques and processes.

C9.0 Understand how a manufacturing company is organized and the elements of welding production management.

- C9.1 Know how scheduling, quality control, accident prevention, and inventory control are used efficiently and appropriately in a welding production management system.
- C9.2 Understand that a welding production management system includes planning, engineering, organizing, and controlling resources and manufacturing processes.
- C9.3 Diagram corporate structures that affect welding production.

D. Product Innovation and Design Pathway

The Product Innovation and Design pathway provides students with an understanding of the design and manufacturing technologies common to careers in the fields of product design and manufacturing. Representative topics include the product design and development process, the principles of design, computer-aided design, fabrication and manufacturing processes, sustainability, and the principles of business, entrepreneurship, and global design. Students can also learn computer-aided manufacturing.

Sample occupations associated with this pathway:

- Commercial/Industrial Designer
- CAD Designer
- Model Maker
- Product Developer
- Product Manager

D1.0 Understand the basic product design and development process as it relates to the design of a product, line of products, system design, or services.

- D1.1 Identify the variations in the product design and development process as it relates to the designing of a product, product line, system design, or service.
- D1.2 Apply and identify the various phases of the product design development process to an existing product, product line, system design, or service.

D2.0 Understand and apply research methodologies as a means to identify a need, problem, or opportunity for a new product, product line, system design, or service.

- D2.1 Employ research methodologies, using primary research and electronic reference materials, to gather information relevant to the topic or area of opportunity.
- D2.2 Organize information to identify and define an area of opportunity, need, or problem that can be resolved through design.
- D2.3 Identify potential design areas (e.g., product, product line, system design, or service) that would address the need, problem, or opportunity.
- D2.4 Research and identify the user demographic for the product, product line, system design, or service (local, national, global market).

D3.0 Understand and apply various ideation techniques to develop ideas and concepts.

- D3.1 Apply ideation techniques to explore and produce multiple concepts.
- D3.2 Edit concepts and identify key idea(s) that solve the problem, fulfill a need, or address an opportunity.
- D3.3 Assess the environmental impact of the design solution and other sustainability issues and product life cycle considerations.
- D3.4 Synthesize information and experiment with nontraditional possibilities for innovative design solutions.

D4.0 Apply various two-dimensional (2-D) graphic and/or three-dimensional (3-D) modeling techniques to development concept.

- D4.1 Create a preliminary design of a product concept utilizing drawing, computer software (graphic or CAD), and/or conceptual model fabrication techniques.
- D4.2 Identify materials, mechanisms, technologies, and other requirements (e.g., safety, manufacturing, sustainability) the concept may require.
- D4.3 Analyze and assess the strengths and weaknesses in the design, function, ergonomics, features, and benefits and identify possible resolutions for improvement.

D5.0 Develop the concept into a well-defined product for prototyping.

- D5.1 Produce technical drawings and other specifications required for the prototyping or manufacturing of the product.
- D5.2 Recognize the safety issues related to the reliability, functionality, and use of the product.
- D5.3 Communicate and collaborate with fabricators, manufacturers, engineers, technologists, or other industry experts to review requirements and specifications and to validate the design.

D6.0 Produce a prototype of a product.

- D6.1 Build a looks-like, works-like prototype of the model using the appropriate fabrication, manufacturing, or reproduction techniques or technologies.
- D6.2 Assess the outcome of the prototype product and analyze any issues that need redesigning or refining related to function, construction, or other factors.
- D6.3 Resolve and/or redesign issues with a prototype.

D7.0 Evaluate the prototype to determine if it meets the requirements and objectives.

- D7.1 Create a performance criteria and a quality standard to measure and evaluate a prototype.
- D7.2 Test the functionality and other features of the prototype against the performance criteria and quality standard and evaluate the results.
- D7.3 Identify any redesigning or additional corrections required to improve the overall quality, look, and performance of the prototype model.

D8.0 Understand and apply basic business and entrepreneurial principles and identify potential markets and/or other business opportunities for distribution of the product.

- D8.1 Apply research methodologies to identify potential investors or business opportunities to market the product.
- D8.2 Create a marketing plan for the product that includes target consumer, price, product name, brand, and product positioning in the retail market.

D9.0 Produce a package design concept for a product or line of products.

- D9.1 Understand physical packaging construction and materials used; e. g., chipboard, cardboard, PVC, plastic blisters, etc. as it relates to protecting the product, costs, and logistic requirements.
- D9.2 Understand and apply packaging graphic strategies that effectively communicate and influence the purchasing of the product.
- D9.3 Create a packaging concept utilizing drawing computer software (graphic or CAD).
- D9.4 Produce a physical package with graphics for the product.

D10.0 Produce a presentation of the product, product line, system design, or service.

- D10.1 Create a presentation of the design solution (e.g., product, product line, system design, or service) that effectively communicates its features and benefits.
- D10.2 Integrate into the presentation a marketing plan that may include an advertisement, promotion, and packaging/retail strategy using one or more visual communication tools (e.g., graphics, multimedia).

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MANUFACTURING AND PRODUCT DEVELOPMENT	PATHWAYS			
	A. Graphic Production Technologies	B. Machining and Forming Technologies	C. Welding and Materials Joining	D. Product Innovation and Design
ENGLISH LANGUAGE ARTS				
Language Standards – LS – (Standard Area, Grade Level, Standard #)				
11-12.3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening.	A3.0, A13.0			D8.0, D10.0
Reading Standards for Literature – RSL – (Standard Area, Grade Level, Standard #)				
11-12.4. Determine the meaning of words and phrases as they are used in the text, including figurative and connotative meanings; analyze the impact of specific word choices on meaning and tone, including words with multiple meanings or language that is particularly fresh, engaging, or beautiful.	A2.0, A5.0, A6.0, A8.0, A9.0, A12.0, A13.0, A14.0			
Reading Standards for Informational Text – RSIT – (Standard Area, Grade Level, Standard #)				
11-12.7. Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.	A1.0, A13.0	B2.0	C1.0	D4.0
Reading Standards for Literacy in Science and Technical Subjects – RLST – (Standard Area, Grade Level, Standard #)				
11-12.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.	A3.0		C3.0, C4.0, C5.0	
11-12.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.	A9.0, A10.0, A12.0, A13.0, A14.0	B4.0, B5.0, B6.0, B7.0, B8.0, B9.0, B10.0	C2.0, C3.0, C4.0, C5.0, C6.0, C7.0, C8.0	D2.0, D3.0
11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.	A2.0, A5.0, A6.0, A8.0, A9.0, A12.0, A13.0, A14.0	B10.0	C1.0	D3.0

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Reading Standards for Literacy in Science and Technical Subjects – RLST – (Standard Area, Grade Level, Standard #) *(continued)*				
11-12.6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.	A1.0	B6.0	C1.0	
11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.	A13.0	B2.0	C1.0, C2.0, C3.0, C4.0, C5.0, C6.0, C7.0, C8.0	D4.0
11-12.10. By the end of grade 12, read and comprehend science/technical texts in the grades 11-12 text complexity band independently and proficiently.	A1.0, A2.0, A3.0	B1.0, B2.0, B3.0, B4.0, B5.0, B6.0, B7.0, B8.0, B9.0, B10.0	C1.0, C2.0,C3.0, C4.0, C5.0,C6.0, C7.0, C8.0, C9.0	D1.0, D2.0, D3.0, D4.0, D5.0, D6.0, D7.0, D8.0, D9.0, D10.0
Writing Standards – WS – (Standard Area, Grade Level, Standard #)				
11-12.3 Write narratives to develop real or imaged experiences or events using effective technique, well-chosen details, and well-structured event sequences.	A3.0	B1.0, B2.0		
11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.	A1.0, A2.0, A3.0, A11.0	B3.0		D10.0
11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.	A1.0	B3.0		D7.0, D9.0
11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation including footnotes and endnotes.	A3.0, A13.0	B3.0		D7.0, D9.0
11-12.9. Draw evidence from literary or informational texts to support analysis, reflection, and research.	A1.0, A3.0, A13.0	B3.0	C5.0	D7.0, D9.0

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Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects – WHSST – (Standard Area, Grade Level, Standard #)				
11-12.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.	A1.0, A2.0, A3.0, A11.0			D8.0
11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.	A14.0	B3.0		D7.0
11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.		B3.0		D7.0, D9.0
11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.	B1.0	B3.0	C5.0, C9.0	D7.0, D9.0
MATHEMATICS				
Algebra – A-CED – Creating Equations				
Create equations that describe numbers or relationships				
1. Create equations and inequalities in one variable including ones with absolute value and use them to solve problems in and out of context, including equations arising from linear functions. 1.1 Judge the validity of an argument according to whether the properties of real numbers, exponents, and logarithms have been applied correctly at each step. (CA Standard Algebra II - 11.2)			C1.0	D4.0
2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.	A1.0	B5.0		D4.0, D5.0, D9.0
3. Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.				D2.0, D3.0
4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R.		B3.0, B7.0		

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Algebra – A-REI – Reasoning with Equations and Inequalities				
Understand solving equations as a process of reasoning and explain the reasoning				
1. Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.			C3.0, C4.0, C5.0	D2.0, D9.0
2. Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise.				D9.0
Solve systems of equations				
6. Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.		B10.0		
9. (+) Find the inverse of a matrix if it exists and use it to solve systems of linear equations (using technology for matrices of dimension 3 x 3 or greater).		B10.0		
Functions – F-IF – Interpreting Functions				
Understand the concept of a function and use function notation				
1. Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If *f* is a function and *x* is an element of its domain, then *f(x)* denotes the output of *f* corresponding to the input *x*. The graph of f is the graph of the equation *y = f(x)*.			C3.0, C4.0, C5.0	D2.0, D9.0
2. Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.				D9.0
Interpret functions that arise in applications in terms of the context				
4. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.		B3.0		D4.0, D5.0, D7.0, D9.0

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Functions – F-LE – Linear, Quadratic, and Exponential Models				
1. Distinguish between situations that can be modeled with linear functions and with exponential functions. a. Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals. b. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another. c. Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another.	A1.0, A2.0			
Geometry – G-C – Circles				
2. Identify and describe relationships among inscribed angles, radii, and chords. Include the relationship between central, inscribed, and circumscribed angles; inscribed angles on a diameter are right angles; the radius of a circle is perpendicular to the tangent where the radius intersects the circle.		B9.0	C1.0	
Geometry – G-CO – Congruence				
Experiment with transformations in the plane				
1. Know precise definitions of angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line, distance along a line, and distance around a circular arc.		B1.0, B2.0, B5.0	C1.0	
2. Represent transformations in the plane using, e.g., transparencies and geometry software; describe transformations as functions that take paints in the plane as inputs and give other points as outputs. Compare transformations that preserve distance and angle to those that do not (e.g., translation versus horizontal stretch).		B2.0, B5.0	C1.0	
5. Given a geometric figure and a rotation, reflection, or translation, draw the transformed figure using, e.g., graph paper, tracing paper, or geometry software. Specify a sequence of transformations that will carry a given figure onto another.		B1.0, B5.0	C1.0	
Make geometric constructions				
12. Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.		B2.0, B5.0	C1.0	D6.0

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Geometry – G-GMD – Geometric Measurement and Dimensions				
Visualize relationships between two-dimensional and three-dimensional objects				
5. Determine how changes in dimensions affect the perimeter, area, and volume of common geometric figures and solids.			C1.0	D6.0
Number and Quantity – N-Q – Quantities				
Reason quantitatively and use units to solve problems				
1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.		B10.0	C1.0	
2. Define appropriate quantities for the purpose of descriptive modeling.		B1.0	C8.0	D4.0, D5.0
3. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.		B1.0		D4.0, D5.0
Statistics and Probability – S-IC – Making Inferences and Justifying Conclusions				
Understand and evaluate random processes underlying statistical experiments				
1. Understand statistics as a process for making inferences about population parameters based on a random sample from that population.	A6.0, A7.0			D1.0
2. Decide if a specified model is consistent with results from a given data-generating process, e.g., using simulation. For example, a model says a spinning coin falls heads up with probability 0.5. Would a result of 5 tails in a row cause you to question the model?				D1.0, D7.0
Make inferences and justify conclusions from sample surveys, experiments, and observational studies				
3. Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.	A6.0, A7.0		C4.0	
5. Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant.	A7.0			
6. Evaluate reports based on data.		B7.0	C6.0	D2.0

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Statistics and Probability – S-ID – Interpreting Categorical and Quantitative Data				
Summarize, represent, and interpret data on a single count or measurement variable				
1. Represent data with plots on the real number line (dot plots, histograms, and box plots).	A9.0	B7.0	C1.0	D2.0
Summarize, represent, and interpret data on two categorical and quantitative variables				
5. Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.	A2.0		C9.0	D7.0
Calculus – C				
4.0 Students demonstrate an understanding of the formal definition of the derivative of a function at a point and the notion of differentiability: 4.1 Students demonstrate an understanding of the derivative of a function as the slope of the tangent line to the graph of the function. 4.2 Students demonstrate an understanding of the interpretation of the derivative as an instantaneous rate of change. Students can use derivatives to solve a variety of problems from physics, chemistry, economics, and so forth that involve the rate of change of a function. 4.3 Students understand the relation between differentiability and continuity. 4.4 Students derive derivative formulas and use them to find the derivatives of algebraic, trigonometric, inverse trigonometric, exponential, and logarithmic functions.			C7.0	
14.0 Students apply the definition of the integral to model problems in physics, economics, and so forth, obtaining results in terms of integrals.		B6.0, B10.0		
15.0 Students demonstrate knowledge and proof of the fundamental theorem of calculus and use it to interpret integrals as anti-derivatives.		B6.0, B10.0		
16.0 Students use definite integrals in problems involving area, velocity, acceleration, volume of a solid, area of a surface of revolution, length of a curve, and work.		B6.0, B10.0		
17.0 Students compute, by hand, the integrals of a wide variety of functions by using techniques of integration, such as substitution, integration by parts, and trigonometric substitution. They can also combine these techniques when appropriate.		B6.0, B10.0		

Academic Alignment Matrix

MANUFACTURING AND PRODUCT DEVELOPMENT	PATHWAYS			
	A. Graphic Production Technologies	B. Machining and Forming Technologies	C. Welding and Materials Joining	D. Product Innovation and Design
Calculus – C *(continued)*				
18.0 Students know the definitions and properties of inverse trigonometric functions and the expression of these functions as indefinite integrals.		B10.0		
19.0 Students compute, by hand, the integrals of rational functions by combining the techniques in standard 17.0 with the algebraic techniques of partial fractions and completing the square.		B10.0		
20.0 Students compute the integrals of trigonometric functions by using the techniques noted above.		B10.0		
SCIENCE				
Scientific and Engineering Practices – SEP				
1. Asking questions (for science) and defining problems (for engineering)	A1.0, A2.0, A7.0	B1.0, B3.0	C1.0, C6.0	D2.0, D3.0
2. Developing and using models	A2.0	B1.0, B3.0	C1.0	D4.0
3. Planning and carrying out investigations	A6.0, A7.0		C2.0, C3.0	D2.0, D7.0
4. Analyzing and interpreting data		B1.0, B3.0, B10.0	C1.0	D2.0, D4.0, D7.0
5. Using mathematics and computational thinking		B1.0, B2.0, B4.0, B5.0, B6.0, B7.0, B9.0, B10.0	C7.0	D4.0
6. Constructing explanations (for science) and designing solutions (for engineering)	A2.0, A5.0, A6.0, A7.0	B1.0, B2.0, B5.0	C1.0, C4.0	D5.0, D10.0
7. Engaging in argument from evidence	A3.0		C1.0, C6.0, C7.0	D2.0, D3.0, D10.0
8. Obtaining, evaluating, and communicating information	A1.0, A2.0, A3.0, A12.0, A13.0	B1.0	C1.0, C4.0, C5.0, C7.0, C9.0	D1.0, D2.0, D5.0, D8.0, D10.0
Crosscutting Concept – CC				
1. Patterns	A1.0, A8.0, A9.0, A11.0	B1.0, B5.0, B8.0, B9.0, B10.0	C.10, C2.0, C3.0, C4.0, C5.0, C6.0, C7.0, C9.0	D1.0, D2.0, D3.0, D4.0, D10.0
2. Cause and effect: Mechanism and explanation	A2.0, A3.0, A11.0		C2.0, C3.0, C4.0	D7.0

Academic Alignment Matrix

MANUFACTURING AND PRODUCT DEVELOPMENT	PATHWAYS			
	A. Graphic Production Technologies	B. Machining and Forming Technologies	C. Welding and Materials Joining	D. Product Innovation and Design
Crosscutting Concept – CC *(continued)*				
3. Scale, proportion, and quantity	A1.0, A4.0, A11.0	B1.0, B10.0	C1.0, C9.0	D4.0
4. Systems and system models	A2.0			D1.0, D2.0
5. Energy and matter: Flows, cycles, and conservation			C2.0, C3.0	
6. Structure and function		B1.0, B3.0	C5.0	D4.0
7. Stability and change		B1.0, B3.0	C5.0	D4.0
Physical Sciences – PS				
PS1: Matter and Its Interactions				
PS1.A: Structure and Properties of Matter		B3.0	C2.0, C3.0	
PS1.B: Chemical Reactions			C2.0, C3.0	
PS3: Energy				
PS3.B: Conservation of Energy and Energy Transfer			C2.0, C3.0	
PS3.D: Energy in Chemical Processes and Everyday Life				D2.0, D3.0
Earth and Space Sciences – ESS				
ESS3: Earth and Human Activity ESS3.A: Natural Resources ESS3.B: Natural Hazards ESS3.C: Human Impacts on Earth Systems ESS3.D: Global Climate Change	A1.0			
Engineering, Technology, and the Applications of Science – ETS				
ETS1: Engineering Design ETS1.A: Defining and Delimiting an Engineering Problem ETS1.B: Developing Possible Solutions ETS1.C: Optimizing the Design Solution	A1.0, A9.0, A11.0	A1.0, B5.0, B8.0, B9.0, B10.0	C1.0, C2.0, C.3.0, C4.0, C5.0, C6.0, C7.0	D1.0 D2.0, D3.0, D4.0, D10.0

Academic Alignment Matrix

MANUFACTURING AND PRODUCT DEVELOPMENT	PATHWAYS			
	A. Graphic Production Technologies	B. Machining and Forming Technologies	C. Welding and Materials Joining	D. Product Innovation and Design
Engineering, Technology, and the Applications of Science – ETS *(continued)*				
ETS2: Links Among Engineering, Technology, Science, and Society ETS2.A: Interdependence of Science, Engineering, and Technology ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World	A1.0, A8.0, A9.0, A11.0	A1.0, B5.0, B8.0, B9.0, B10.0	C1.0, C2.0, C.3.0, C4.0, C5.0, C6.0, C7.0	D1.0 D2.0, D3.0, D4.0, D10.0
HISTORY/SOCIAL SCIENCE				
Principles of American Democracy and Economics – AD				
12.8 Students evaluate and take and defend positions on the influence of the media on American political life.	A1.0			
Principles of Economics – PE				
12.2 Students analyze the elements of America's market economy in a global setting.	A14.0			D5.0, D6.0, D7.0, D8.0
12.4 Students analyze the elements of the U.S. labor market in a global setting.				D5.0, D6.0, D7.0, D8.0
U.S. History and Geography – US				
11.2 Students analyze the relationship among the rise of industrialization, large-scale rural-to-urban migration, and massive immigration from Southern and Eastern Europe.				D1.0, D2.0
11.5 Students analyze the major political, social, economic, technological, and cultural developments of the 1920s.				D5.0, D6.0, D7.0
11.6 Students analyze the different explanations for the Great Depression and how the New Deal fundamentally changed the role of the federal government.				D5.0, D6.0, D7.0
11.7 Students analyze America's participation in World War II.				D5.0, D6.0, D7.0
World History, Culture, and Geography – WH				
10.3 Students analyze the effects of the Industrial Revolution in England, France, Germany, Japan, and the United States.				D1.0, D2.0
10.11 Students analyze the integration of countries into the world economy and the information, technological, and communications revolutions (e.g., television, satellites, computers).	A1.0	B10.0	C6.0, C7.0	D4.0

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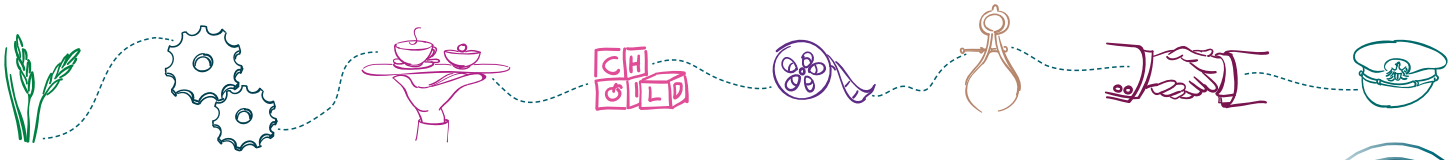

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References

ACT. 2010. *A First Look at the Common Core and College and Career Readiness.* http://www.act.org/research/policymakers/pdf/FirstLook.pdf (accessed December 4, 2012).

American Association of Colleges for Teacher Education (AACTE) and the Partnership for 21st Century Skills. 2010. "Preparing Students for the 21st Century Economy." http://www.edsynergy.org/wp-content/uploads/2011/07/PREPARING-STUDENTS-FOR-THE-21ST-CENTURY-ECONOMY-3.doc (accessed December 4, 2012).

Anderson, Lorin W., David R. Krathwohl, Peter W. Airasian, Kathleen A. Cruikshank, Richard E. Mayer, Paul R. Pintrich, James Rahts, and Merlin C. Wittrock. 2001. *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives.* New York: Pearson.

Association of American Colleges and Universities. 2007. *College Learning for the New Global Century.* http://www.aacu.org/advocacy/leap/documents/GlobalCentury_final.pdf (accessed December 4, 2012).

Association of American Colleges and Universities and Peter D. Hart Research Associates, Inc. 2006. *How Should Colleges Prepare Students to Succeed in Today's Global Economy?* http://www.aacu.org/leap/documents/Re8097abcombined.pdf (accessed December 4, 2012).

California Department of Education. 2006. *California Career Technical Education Model Curriculum Standards, Grades Seven Through Twelve.* http://www.cde.ca.gov/ci/ct/sf/documents/ctestandards.pdf (accessed December 4, 2012).

———. 2007. *Career Technical Education Framework for California Public Schools, Grades Seven Through Twelve.* http://www.cde.ca.gov/ci/ct/sf/documents/cteframework.pdf (accessed December 4, 2012).

California Employment Development Department. 2010. *California's Green Economy: Summary of Survey Results.* http://www.labormarketinfo.edd.ca.gov/contentpub/GreenDigest/CA-Green-Economy-SummarySurveyResults.pdf (accessed December 4, 2012).

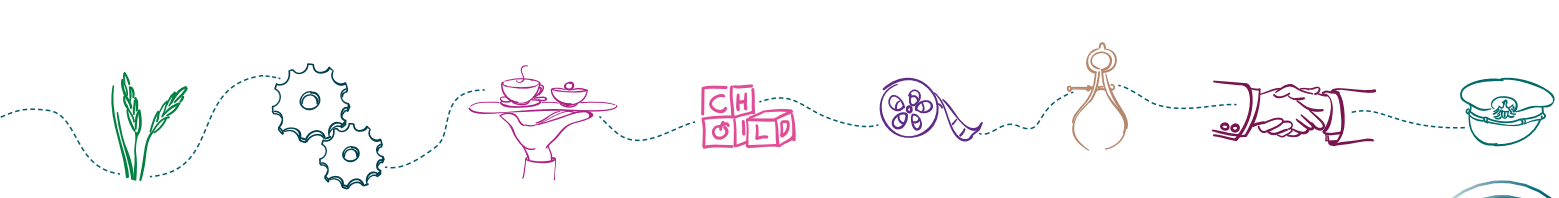
Children Now. 2010. *California Report Card 2011–12: Setting the Agenda for Children.* ~~http://www.childrennow.org/uploads/documents/reportcard_2011.pdf~~ [Link no longer valid] (accessed December 4, 2012).

The Conference Board, Partnership for 21st Century Skills, Corporate Voices for Working Families, and the Society for Human Resource Management. 2006. *Are They Really Ready to Work? Employers' Perspectives on the Basic Knowledge and Applied Skills of New Entrants to the 21st Century U.S. Workforce.* http://www.shrm.org/research/surveyfindings/documents/are they really ready to work survey report.pdf (accessed December 4, 2012).

Conley, David T. 2010. *College and Career Ready: Helping All Students Succeed Beyond High School.* San Francisco: Jossey-Bass.

Conley, David T., Kathryn V. Drummond, Alicia de Gonzalez, Jennifer Rooseboom, and Odile Stout. 2011. *Reaching the Goal: The Applicability and Importance of the Common Core State Standards to College and Career Readiness.* Eugene, OR: Educational Policy Improvement Center. http://www.epiconline.org/publications/documents/ReachingtheGoal-FullReport.pdf (accessed December 4, 2012).

Darling-Hammond, Linda, Ruth Chung Wei, Alethea Andree, Nikole Richardson, and Stelios Orphanos. 2009. *Professional Learning in the Learning Profession: A Status Report on Teacher Development in the United States and Abroad.* Palo Alto, CA: National Staff Development Council and the School Redesign Network at Stanford University. http://learningforward.org/docs/pdf/nsdcstudy2009.pdf (accessed December 4, 2012).



Institute of Education Sciences, National Center for Education Statistics. 2012. *The Condition of Education*. http://nces.ed.gov/programs/coe/ (accessed December 4, 2012).

International Center for Leadership in Education. 2012. "Rigor/Relevance Framework." Rexford, NY. ~~http://www.leadered.com/rrr.html~~ [Link no longer valid] (accessed December 4, 2012).

Intersegmental Committee of the Academic Senates (ICAS) of the California Community Colleges. 2002. *Academic Literacy: A Statement of Competencies Expected of Students Entering California's Public Colleges and Universities*. http://asccc.org/sites/default/files/AcademicLiteracy.pdf (accessed December 4, 2012).

Kober, Nancy, and Diane Stark Rentner. 2011. *States' Progress and Challenges in Implementing Common Core State Standards*. Washington, DC: Center on Education Policy. http://www.cep-dc.org/displayDocument.cfm?DocumentID=343 (accessed December 4, 2012).

Marzano, Robert J., and John S. Kendall. 2007. *The New Taxonomy of Educational Objectives*. 2nd ed. Thousand Oaks, CA: Corwin Press. ~~http://www.marzanoresearch.com/site/default.aspx~~ [Link no longer valid] (accessed December 4, 2012).

MetLife, Inc. 2011. *The MetLife Survey of the American Teacher: Preparing Students for College and Careers*. https://www.metlife.com/assets/cao/contributions/foundation/american-teacher/MetLife_Teacher_Survey_2010.pdf (accessed December 6, 2012).

National Association of State Directors of Career Technical Education Consortium (NASDCTEc). 2011. "CTE and College and Career Ready Standards: Preparing Students for Further Education and Careers." Silver Spring, MD. http://www.careertech.org/ (accessed December 4, 2012).

———. 2012. "Introduction to the Common Career Technical Core."

National Center for Education Statistics. 2008. *Trends in International Mathematics and Science Study 2007*. http://nces.ed.gov/timss/index.asp (accessed December 4, 2012).

National Governors Association, Council of Chief State School Officers, and Achieve, Inc. 2008. *Benchmarking for Success: Ensuring U.S. Students Receive a World-Class Education*. Washington, DC: National Governors Association. http://www.nga.org/files/live/sites/NGA/files/pdf/0812BENCHMARKING.PDF (accessed December 4, 2012).

Organisation for Economic Co-operation and Development (OECD). 2011. *Strong Performers and Successful Reformers in Education: Lessons from PISA for the United States*. Paris, France. http://www.oecd.org/pisa/46623978.pdf (accessed December 4, 2012).

Owen Wilson, Leslie. 2006. "Dr. Leslie Owen Wilson's Curriculum Pages: Beyond Bloom—A New Version of the Cognitive Taxonomy." Stevens Point, WI: University of Wisconsin–Stevens Point. http://www4.uwsp.edu/education/lwilson/curric/newtaxonomy.htm (accessed December 4, 2012).

Public Broadcasting Service (PBS). 2012. PBS TeacherLine: Professional development for PreK–12 educators. http://www.pbs.org/teacherline (accessed December 4, 2012).

United States Department of Labor, Employment and Training Administration. 2009. "Secretary's Commission on Achieving Necessary Skills." http://wdr.doleta.gov/SCANS/ (accessed December 4, 2012).

WestEd, the California Department of Education, and the California Community Colleges Chancellor's Office. 2008. *2008–2012 California State Plan for Career Technical Education*. http://www.schoolsmovingup.net/cte/downloads/cteplan_122808.pdf (accessed December 5, 2012).