# CAE-II- Unit 4B-Draw-Design-Assemblies- Reverse Engineering

Content Area: **CTE**
Course(s): **Computer Aided Engineering**
Time Period: **September**
Length: **1**
Status: **Published**

## Unit Overview:

Engineers use a process called reverse engineering to understand how something functions and to determine ways it can be improved. By carefully discovering how something was made and how it works, engineers can make suggestions for areas of improvement of the product. Reverse engineering, however, is not simply taking something apart. This process requires careful observation, disassembly, documentation, analysis and reporting. Many times, the reverse engineering process is non-destructive. This means that the object or component can be reassembled and still function just as it did before you took it apart.

Students will practice reverse engineering using different objects or toys. Before we take them apart, students will test the toys and record our predictions of how they work. They will each draw what we think is inside the toys making them work. It is perfectly acceptable to be unsure of a toy's internal "parts. When everyone is done with their first drawing, they will carefully disassemble the toys and make notes about the process so we can reassemble them. Throughout the reverse engineering project, we will think of ways these objects could be improved.

## Enduring Understandings:

The following synthesizes the important ideas and core processes that are central to the CAD discipline and will have lasting value beyond the classroom:

1. Engineering is an applied science to define human problems and design solutions to those problems.
2. Professional engineers in all areas use the engineering design process to solve problems.
3. Everyday people can engage in engineering practices to design their own solutions to meet their needs.
4. The engineering design process is an iterative cycle that involves three main components.
5. Designing problem solutions.
6. Optimizing the design of solutions.

- Improve upon previous designs
- Observation, disassembly, documentation, analysis and reporting
- Analyzing the structure and function of a device or component
- How the objects are designed and how they work
- Suggestions for improvement, such as cost effectiveness, improved functionality, ecological friendliness and any additional functionality they determine is an improvement.
- Technologies, objects and systems through reverse engineering and the engineering design process

## Essential Questions:

- As engineers, how do we figure out how something works?
- Can you redesign this device to make it function differently? How would you do this?
- Describe how the device was disassembled.
- Describe the key components and how they function.
- How could the device be more cost effective to produce?
- How could you change this device to make it more cost effective to produce?
- How would you improve the way this device is made?
- Other than learning about how an object functions, what is another goal of reverse engineering? Example?
- Other than learning about how an object functions, what is another goal of reverse engineering? Example?
- Suggest changes that would improve the device's function
- What did you learn about the device's design and function?
- What do you think reverse engineering means?
- What does this device do? What parts make it work this way?

## Standards/Indicators/Student Learning Objectives (SLOs):

| | |
|---|---|
| ARCH.9-12.9.4.12.B.(1).2 | Employ appropriate representational media to communicate concepts and design. |
| ARCH.9-12.9.4.12.B.(1).9 | Develop technical drawings drafted by hand and computer-generated plans to design structures. |
| ARCH.9-12.9.4.12.B.(1).11 | Apply basic organizational, spatial, structural, and constructional principles to the design of interior and exterior space so that design plans are effective. |
| ARCH.9-12.9.4.12.B.1 | Demonstrate language arts knowledge and skills required to pursue the full range of postsecondary education and career opportunities. |
| ARCH.9-12.9.4.12.B.2 | Demonstrate mathematics knowledge and skills required to pursue the full range of postsecondary education and career opportunities. |
| ARCH.9-12.9.4.12.B.3 | Demonstrate science knowledge and skills required to pursue the full range of postsecondary education and career opportunities. |
| ARCH.9-12.9.4.12.B.7 | Demonstrate use of the concepts, strategies, and systems for obtaining and conveying ideas and information to enhance communication. |
| ARCH.9-12.9.4.12.B.14 | Develop and interpret tables, charts, and figures to support written and oral communications. |
| ARCH.9-12.9.4.12.B.18 | Employ critical thinking skills (e.g., analyze, synthesize, and evaluate) independently and in teams to solve problems and make decisions. |
| ARCH.9-12.9.4.12.B.19 | Employ critical thinking and interpersonal skills to resolve conflicts. |
| ARCH.9-12.9.4.12.B.21 | Conduct technical research to gather information necessary for decision-making. |
| ARCH.9-12.9.4.12.B.22 | Create and implement project plans to accomplish realistic planning in design and construction situations, considering available resources and requirements of a project/problem. |
| ARCH.9-12.9.4.12.B.23 | Describe how design and construction project plans and schedules respond to unexpected |

| | |
|---|---|
| | events and conditions. |
| ARCH.9-12.9.4.12.B.31 | Employ collaborative/groupware applications to facilitate group work. |
| ARCH.9-12.9.4.12.B.33 | Use computer-based equipment (containing embedded computers or processors) to control devices. |
| ARCH.9-12.9.4.12.B.37 | Examine how roles and responsibilities among trades/professions work in concert to complete a project/job. |
| ARCH.9-12.9.4.12.B.38 | Examine all factors affecting the project planning process. |
| ARCH.9-12.9.4.12.B.47 | Employ leadership skills to accomplish goals and objectives. |
| ARCH.9-12.9.4.12.B.52 | Employ mentoring skills to assist others. |
| ARCH.9-12.9.4.12.B.59 | Identify and demonstrate positive work behaviors and personal qualities needed to succeed in the classroom and/or to be employable. |
| ARCH.9-12.9.4.12.B.61 | Demonstrate skills related to seeking and applying for employment in a desired job. |
| ARCH.9-12.9.4.12.B.62 | Maintain a career portfolio to document knowledge, skills, and experience in a career field. |
| ARCH.9-12.9.4.12.B.68 | Examine licensing, certification, and credentialing requirements at the national, state, and local levels to maintain compliance with industry requirements. |
| ARCH.9-12.9.4.12.B.69 | Examine employment opportunities in entrepreneurship as an option for career planning. |
| ARCH.9-12.9.4.12.B.74 | Read, interpret, and use technical drawings, documents, and specifications to plan a project. |
| ARCH.9-12.9.4.12.B.75 | Use and maintain appropriate tools, machinery, equipment, and resources to accomplish project goals. |

## Lesson Titles:

- Capture Data
- Diagram of Unit (inside) Section
- Diagram of Unit (outside) Section
- How Does The Unit Work? (As a system) Section
- How would a Change in the Structure Affect the Function? Section
- Manufacturing
- Refine the Model
- Sub-Assembly Parts - Disassembled to show Individual Parts

## Career Readiness, Life Literacies, & Key Skills

| | |
|---|---|
| TECH.9.4.12.CI.1 | Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a). |
| TECH.9.4.12.CI.2 | Identify career pathways that highlight personal talents, skills, and abilities (e.g., 1.4.12prof.CR2b, 2.2.12.LF.8). |
| TECH.9.4.12.CI.3 | Investigate new challenges and opportunities for personal growth, advancement, and transition (e.g., 2.1.12.PGD.1). |
| TECH.9.4.12.CT.1 | Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3). |

## Inter-Disciplinary Connections:

| | |
|---|---|
| LA.RST.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. |
| LA.RST.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. |
| LA.RST.11-12.9 | Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. |
| LA.RST.11-12.10 | By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently. |
| LA.WHST.11-12.4 | Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. |
| SCI.HS-ETS1-4 | Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. |
| SCI.HS-ETS1-3 | Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. |
| SOC.9-12.1.4.2 | Demonstrate effective presentation skills by presenting information in a clear, concise, and well-organized manner taking into consider appropriate use of language for task and audience. |
| TECH.8.1.12.B | Creativity and Innovation: Students demonstrate creative thinking, construct knowledge and develop innovative products and process using technology. |
| TECH.8.1.12.B.CS1 | Apply existing knowledge to generate new ideas, products, or processes. |
| | Although there are many types of geometry, school mathematics is devoted primarily to plane Euclidean geometry, studied both synthetically (without coordinates) and analytically (with coordinates). Euclidean geometry is characterized most importantly by the Parallel Postulate, that through a point not on a given line there is exactly one parallel line. (Spherical geometry, in contrast, has no parallel lines.) |
| | An understanding of the attributes and relationships of geometric objects can be applied in diverse contexts—interpreting a schematic drawing, estimating the amount of wood needed to frame a sloping roof, rendering computer graphics, or designing a sewing pattern for the most efficient use of material. |
| | Connections to Equations. |
| | In the approach taken here, two geometric figures are defined to be congruent if there is a sequence of rigid motions that carries one onto the other. This is the principle of superposition. For triangles, congruence means the equality of all corresponding pairs of sides and all corresponding pairs of angles. During the middle grades, through experiences drawing triangles from given conditions, students notice ways to specify enough measures in a triangle to ensure that all triangles drawn with those measures are congruent. Once these triangle congruence criteria (ASA, SAS, and SSS) are established using rigid motions, they can be used to prove theorems about triangles, quadrilaterals, and other geometric figures. |
| | Analytic geometry connects algebra and geometry, resulting in powerful methods of analysis and problem solving. Just as the number line associates numbers with locations in one dimension, a pair of perpendicular axes associates pairs of numbers with locations in |

two dimensions. This correspondence between numerical coordinates and geometric points allows methods from algebra to be applied to geometry and vice versa. The solution set of an equation becomes a geometric curve, making visualization a tool for doing and understanding algebra. Geometric shapes can be described by equations, making algebraic manipulation into a tool for geometric understanding, modeling, and proof. Geometric transformations of the graphs of equations correspond to algebraic changes in their equations.

## Instructional Strategies, Learning Activities, and Levels of Blooms/DOK:

- Direct Instruction: Compare & Contrast- Possibilities Include: Explain Multiview Drawings vs. Orthographic drawings
- Direct Instruction: Demonstrations- Possibilities Include: Model for other students Orthographic projection problems on the board.
- Direct Instruction: Lecture- Possibilities Include: Take notes on information given.
- Experiential Learning: Field Trips- Possibilities Include: Attend college visits to explore majors related to architecture and engineering
- Experiential Learning: Focused Imaging- Possibilities Include: Visualizing and executing orthographic projection sketches
- Experiential Learning: Games- Possibilities Include: Use Socrative, a cloud-based student response system (games and quizzes)
- Experiential Learning: Model Building- Possibilities Include: Create computer based drawings on the white board
- Experiential Learning: Simulations- Possibilities Include: Use Autodesk software to model orthographic drawings
- Experiential Learning: Surveys- Possibilities Include: Use Calipers and Micrometers to measure objects
- Independent Study: Assigned Questions- Possibilities Include: Create Multiview Sketching assignments
- Independent Study: Homework- Possibilities Include: Sketch multiview drawings on grid paper
- Independent Study: Research Projects- Possibilities Include: Reverse Engineering
- Indirect Instruction: Problem Solving- Possibilities Include: Create Multiview drawings- Top, Front, Side and Sections
- Instructional Skills: Explaining- Possibilities Include: Industry Standard Concepts
- Interactive Instruction: Brainstorming- Possibilities Include: Working Drawings
- Interactive Instruction: Peer Partner Learning- Possibilities Include: Exploring and sketching the missing orthographic views
- Interactive Instruction: Problem Solving- Possibilities Include: Working Drawings in 2D and 3D Modeling
- Interactive Instruction: Think, Pair, Share- Possibilities Include: Working together to solve a problem

## Modifications

- Classroom: Clarify that student understands directions
- Classroom: Cuing student to refocus (verbal/nonverbal)
- Classroom: Praise for positive behaviors.

- Classroom: Seat student near instruction, avoid distracting stimuli
- Classroom: Study guides provided, when available. Prior knowledge to upcoming quizzes/tests.
- Implements the following teaching strategies with students who need special accommodations. Instructor also implements specific requirements from the students' individual reports.
- Testing: Delsea One – Students benefit from increased opportunities for enrichment and tutoring during Delsea One Tutoring.
- Testing: Extra Time
- Testing: Repeating, clarifying, or rewording directions.

## ELL Modifications:

- Choice of test format (multiple-choice, essay, true-false)
- Continue practicing vocabulary
- Provide study guides prior to tests
- Read directions to the student
- Read test passages aloud (for comprehension assessment)
- Vary test formats
- Repeat, reword, clarify
- Sheltered English Instruction

## IEP & 504 Modifications:

- Allow for redos/retakes
- Assign fewer problems at one time (e.g., assign only odds or evens)
- Differentiated center-based small group instruction
- Extra time on assessments
- Highlight key directions
- If a manipulative is used during instruction, allow its use on a test
- Opportunities for cooperative partner work
- Provide reteach pages if necessary
- Provide several ways to solve a problem if possible
- Provide visual aids and anchor charts
- Test in alternative site
- Tiered lessons and assignments
- Use of a graphic organizer
- Use of concrete materials and objects (manipulatives)
- Use of word processor
- Testing modifications: Students could use calculator and/or other math tools.

## G&T Modifications:

- Alternate assignments/enrichment assignments

- Enrichment projects
- Extension activities
- Higher-level cooperative learning activities
- Pairing direct instruction with coaching to promote self-directed learning
- Provide higher-order questioning and discussion opportunities
- Provide texts at a higher reading level
- Tiered assignments
- Tiered centers

## At Risk Modifications

- Additional time for assignments
- Adjusted assignment timelines
- Agenda book and checklists
- Answers to be dictated
- Assistance in maintaining uncluttered space
- Books on tape
- Concrete examples
- Extra visual and verbal cues and prompts
- Follow a routine/schedule
- Graphic organizers
- Have students restate information
- No penalty for spelling errors or sloppy handwriting
- Peer or scribe note-taking
- Personalized examples
- Preferential seating
- Provision of notes or outlines
- Reduction of distractions
- Review of directions
- Review sessions
- Space for movement or breaks
- Support auditory presentations with visuals
- Teach time management skills
- Use of a study carrel
- Use of mnemonics
- Varied reinforcement procedures
- Work in progress check

## Formative Assessment:

- Anticipatory Set
- Closure
- Conferences between the instructor and student at various points in the semester.
- Graded homework assignments
- Homework exercises as review for exams and class discussions.
- In-class activities where students informally present their results.
- Independent worksheets
- Observations during in-class activities; of students' non-verbal feedback during lecture.
- Portfolios reviewed periodically during the semester.
- Question and answer sessions, formal—planned and informal—spontaneous.
- Student feedback collected by periodically answering specific question about the instruction and their self-evaluation of performance and progress.
- Warm-Up

## Alternative Assessments

Performance tasks

Project-based assignments

Problem-based assignments

Presentations

Reflective pieces

Concept maps

Case-based scenarios

Portfolios

## Benchmark Assessment

Skills-based assessment

Reading response

Writing prompt

Lab practical

## Summative Assessment:

**By Rubric shown below.**

**Evaluation Rubric**

| Category | 1 Does Not Meet Expectations (0-25% of points) | 2 Attempted to Meet Expectations (25-50% of points) | 3 Meets Expectations (50-75% of points) | 4 Surpasses Expectations (75-100% of points) | # of Pts. |
|---|---|---|---|---|---|
| **Defining the Problem** | Offers an unclear statement of the problem. There is no support, documentation, or need for development. Little or no work is evident. | A short description and explanation is offered to the problem without any support and specifications for development pursuits. | A good statement and support/documentation is given to suggest the need to develop the product. Design specifications and constraints are also noted. | A lengthy clear description where design specifications and constraints are offered. Research and supporting documentation shows an overwhelming need that the problem should be pursued by development. | |
| **Research, Brainstorming, and Developing Ideas** | Little research and brainstorming accomplished. Ideas generated are not original. | Research is evident as an outcome of brainstorming. Ideas generated are a result of the brainstorming process and not original. | Ideas generated are new and original as an outcome of brainstorming and research. Little suggestions are offered for the rest of the design process if any. | Many new ideas are generated as an outcome of brainstorming and research. Suggestions and details are given for design constraints of the product and for manufacturing. | |
| **Conceptual Design and Sketching** | Only one sketch is offered for a design review. | At least two sketches are offered for a review. The sketches offer no design specifications or annotation. | More than two sketches are offered for a review. The sketches include design specifications and annotation for developing the design. | Multiple thumbnail drawings are offered (minimum of 5). Additionally, accurate orthographic and isometric views are drawn to proportion for communicating the design for a review. Design specifications and | |

| | | | | | |
|---|---|---|---|---|---|
| | | | | annotations are clearly noted on the sketches. Constraints are also considered and noted. | |

| Category | 1 **Does Not Meet Expectations** (0-25% of points) | 2 **Attempted to Meet Expectations** (25-50% of points) | 3 **Meets Expectations** (50-75% of points) | 4 **Surpasses Expectations** (75-100% of points) | # of Pts. |
|---|---|---|---|---|---|
| **Developing the Design** | A set of sketched working drawings without an assembly drawing. 3D representations of each part of the assembly on the working drawings are missing. Annotations, dimensioning and blocks are not accurate. | A set of production drawings with an assembly and working drawings. Each orthographic drawing includes a 3D representation. Annotations, notations, blocks, and dimensioning are inaccurate. | A set of production drawings with an assembly and working drawings. Mulitview drawings are added additional to orthographic drawings. A 3D representation is included on all multiview drawings. Annotations, notations, blocks, and dimensioning are slightly inaccurate. | Presents a set of production drawings with an assembly and working drawings. Each multiview drawing (including orthographic) includes a 3D representation with accurate annotations, notations, blocks, dimensioning, and tolerancing. | |
| **Making a Model or Prototype** | Model is missing or does not look like concept sketches. | Model is proportional to sketches, inaccurate in scale, and dimensioning does not follow industry standards. | Model is accurate in proportion and dimensioning according to concept sketches and industry standards. | Accurate and proportionally modeled according to design specifications, industry standards, constraints, dimensions, and sketches. | |
| **Engineering Testing and Evaluating the Design** | Testing and evaluating designs/model are missing or not checked/approved. | Testing and verification attempted by checks and approvals without results. | Testing and verification are complete with checks/approvals and detailed results are not following industry standards. | Design and model accurately represent each other following industry standards. Testing or evaluation of designs/models indicate revisions if necessary through checks and approvals. | |

| Category | 1 **Did Not Meet Expectations** (0-25% of points) | 2 **Attempted to Meet Expectations** (25-50% of points) | 3 **Meets Expectations** (50-75% of points) | 4 **Surpasses Expectations** (75-100% of points) | # of Pts. |
|---|---|---|---|---|---|
| **Revising the Design** | No attempt made to revise the design. Revision blocks not completed. | Designs revised without revision blocks completed. | Designs revised according to change requests and revision blocks filled out appropriately, but no approval or checking sought after the first revision. | Production drawings are changed according to testing and check results if needed. Revision blocks are noted and approval/checking/testing continues until plans have final approval. | |
| **Creating a Final Model, Prototype, or Mockup** | Missing prototype model or mockup. | Mockup or prototype model is not accurate according to production drawings | Prototype model or mockup is accurate according to production drawing and created out of materials not specified. | An accurate example of a manufactured model or mockup of the model is created according to final approved production drawings. Accurate design specifications, materials, and constraints are followed and implemented in developing the example. | |
| **Presentation** | A presentation given without preparation and an outline. | A presentation given without a professional presence, good public speaking and a well thought out organized outline. | An organized outlined presentation with a professional presence, a written proposal, good public speaking and visual aids. | An oral professional proposal given, including:<br>1. Written proposal with support documentation.<br>2. Conceptual designs.<br>3. Production drawings.<br>4. Prototype or mockup.<br>5. Testing and evaluation results.<br>6. Outline or slides of presentation given.<br>7. Good public speaking.<br>8. Professional presence. | |

- Alternate Assessment
- Benchmark
- Final examination (a truly summative assessment) about the specified lesson.
- Instructor self-evaluation about the current lesson
- Marking Period Assessment
- Portfolio that include all class assignments.
- Projects (project phases submitted at various completion points could be formatively assessed) about the specified lesson.
- Quiz, Test, MP Assessments about the specified lesson
- Student evaluation of the lesson (teaching effectiveness)

## Resources & Materials:

- Chromebooks
- Desktop Computers
- Large format Printer (plotter)
- Power Point Presentations
- Smart Board Activities
- Textbook- Exploring Drafting, Instructor's Manual Instructor's Manual, 10th Edition by John R. Walker (Author), Bernard D. Mathis
- Textbook- Glencoe Mechanical Drawing: Board and CAD Techniques, Student Edition: 1st (First) Edition by Glencoe McGraw-Hil
- Textbook-Basic Technical Drawing by Spencer, Dygon, Novak Glencoe McGraw-Hill

## Technology:

- Internet Sources
- Software- Auto-CAD from Auto Desk
- Youtube Videos

| | |
|---|---|
| TECH.8.1.12.A | Technology Operations and Concepts: Students demonstrate a sound understanding of technology concepts, systems and operations. |
| TECH.8.1.12.A.1 | Create a personal digital portfolio which reflects personal and academic interests, achievements, and career aspirations by using a variety of digital tools and resources. |
| TECH.8.1.12.A.CS1 | Understand and use technology systems. |
| TECH.8.1.12.A.CS2 | Select and use applications effectively and productively. |
| TECH.8.1.12.B | Creativity and Innovation: Students demonstrate creative thinking, construct knowledge and develop innovative products and process using technology. |
| TECH.8.1.12.B.CS1 | Apply existing knowledge to generate new ideas, products, or processes. |
| TECH.8.1.12.B.CS2 | Create original works as a means of personal or group expression. |
| TECH.8.1.12.C | Communication and Collaboration: Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others. |

| | |
|---|---|
| TECH.8.1.12.C.1 | Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community. |
| TECH.8.1.12.C.CS1 | Interact, collaborate, and publish with peers, experts, or others by employing a variety of digital environments and media. |
| TECH.8.1.12.C.CS2 | Communicate information and ideas to multiple audiences using a variety of media and formats. |
| TECH.8.1.12.C.CS3 | Develop cultural understanding and global awareness by engaging with learners of other cultures. |
| TECH.8.1.12.C.CS4 | Contribute to project teams to produce original works or solve problems. |
| TECH.8.1.12.D | Digital Citizenship: Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. |
| TECH.8.1.12.D.CS3 | Exhibit leadership for digital citizenship. |
| TECH.8.1.12.E | Research and Information Fluency: Students apply digital tools to gather, evaluate, and use information. |
| TECH.8.1.12.E.CS2 | Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media. |
| TECH.8.1.12.E.CS4 | Process data and report results. |
| TECH.8.2.12 | Technology Education, Engineering, Design, and Computational Thinking - Programming: All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment. |
| TECH.8.2.12.A | The Nature of Technology: Creativity and Innovation: Technology systems impact every aspect of the world in which we live. |
| TECH.8.2.12.A.CS3 | The relationships among technologies and the connections between technology and other fields of study. |
| TECH.8.2.12.B.CS2 | The effects of technology on the environment. |
| TECH.8.2.12.C | Design: The design process is a systematic approach to solving problems. |
| TECH.8.2.12.C.2 | Analyze a product and how it has changed or might change over time to meet human needs and wants. |
| TECH.8.2.12.C.4 | Explain and identify interdependent systems and their functions. |
| TECH.8.2.12.C.5 | Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled. |
| TECH.8.2.12.C.6 | Research an existing product, reverse engineer and redesign it to improve form and function. |
| TECH.8.2.12.C.CS1 | The attributes of design. |
| TECH.8.2.12.C.CS2 | The application of engineering design. |
| TECH.8.2.12.C.CS3 | The role of troubleshooting, research and development, invention and innovation and experimentation in problem solving. |