The College Board

Computer Science: Principles

Big Ideas and Key Concepts

Learning Objectives and Evidence Statements

Computer Science Principles
Learning Objectives and Evidence Statements

Learning Objectives pair course content (Key and Supporting Concepts) with the following Computational Thinking Practices:

P1. Connecting computing
P2. Developing computational artifacts
P3. Abstracting
P4. Analyzing problems and artifacts
P5. Communicating

Big Idea I. **Creativity**: Computing is a creative activity.

Key Concept A. Computing fosters the creation of artifacts.

Learning Objective 1: The student can use computing tools and techniques to create artifacts. [P2]

Evidence for Learning Objective 1: Student work is characterized by:
1a. Creation of a digital artifact with a practical, personal, or societal intent.
1b. Selection of appropriate techniques to develop digital artifacts.
1c. Use of appropriate algorithmic and information-management principles in translating one's intention into a digital artifact.

Learning Objective 2: The student can analyze computational artifacts. [P4]

Evidence for Learning Objective 2: Student work is characterized by:
2a. Explanation of the suitability of a digital artifact as a solution to a problem.
2b. Location of weaknesses and errors in a digital artifact.
2c. Explanation of how a digital artifact functions.
2d. Justification of the appropriateness of a digital artifact.

Key Concept B. Computing fosters creative expression.

Learning Objective 3: The student can use computing tools and techniques for creative expression. [P2]

Evidence for Learning Objective 3: Student work is characterized by:
3a. Use of appropriate computing tools and techniques for creative expression.
3b. Use of new forms of expression enabled by computing.
3c. Selection of appropriate computing techniques for creative exploration.

Key Concept C.   Programming is a creative process.

Learning Objective 4: The student can use programming as a creative tool. [P2]

Evidence for Learning Objective 4: Student work is characterized by:
4a. Creation of a program with a practical, personal, or societal intent.
4b. Creation of a program that satisfies personal curiosity or expresses creativity.
4c. Creation of a program that solves a problem, creates new knowledge, or helps people, organizations, or society.

Big Idea II. **Abstraction**: Abstraction reduces information and detail to facilitate focus on relevant concepts.

Key Concept A. A combination of abstractions built upon binary sequences can be used to represent all digital data.

Learning Objective 5: The student can describe the combination of abstractions used to represent data. [P3]

Evidence for Learning Objective 5: Student work is characterized by:
5a. Explanation of how data is represented for computational use.
5b. Explanation of how number bases, including binary and decimal, are used for reasoning about digital data.
5c. Identification of the abstractions used in reasoning about digital data.

Learning Objective 6: The student can explain how binary sequences are used to represent digital data. [P5]

Evidence for Learning Objective 6: Student work is characterized by:
6a. Explanation of how a finite representation is used to model the infinite mathematical concept of a number.
6b. Explanation of how the interpretation of a binary sequence depends on how it is used (e.g., instruction, number, text, sound, or image).

Key Concept B. Multiple levels of abstraction are used in computation.

Learning Objective 7: The student can develop an abstraction. [P2]

Evidence for Learning Objective 7: Student work is characterized by:
7a. Creation of an abstraction for a hardware, software, or conceptual purpose.
7b. Use of appropriate abstractions in the creation of an artifact.
7c. Selection of appropriate algorithmic and information-management abstractions.

Learning Objective 8: The student can use multiple levels of abstraction in computation. [P3]

Evidence for Learning Objective 8: Student work is characterized by:
8a. Explanation of how binary data is processed by physical layers of computing hardware, including gates, chips, and components.
8b. Explanation of how different levels of programming languages are used in developing software.
8c. Identification of hardware, software, and conceptual abstractions in the design, development, and analysis of applications and systems.

Key Concept C.   Models and simulations use abstraction to raise and answer questions.

Learning Objective 9: The student can use models and simulations to raise and answer questions. [P3]

Evidence for Learning Objective 9: Student work is characterized by:
9a. Use of models and simulations to generate new understanding and knowledge.
9b. Use of different levels of abstraction to represent phenomena.
9c. Use of models and simulations to formulate, refine, and test hypotheses.
9d. Use of simulations to facilitate testing of models.

Big Idea III.   **Data**: Data and information facilitate the creation of knowledge.

Key Concept A.   People use computer programs to process information to gain insight and knowledge.

Learning Objective 10: The student can use computers to process information to gain insight and knowledge. [P1]

Evidence for Learning Objective 10: Student work is characterized by:
10a. Use of computers to find patterns in, and test hypotheses about, digitally represented information.
10b. Drawing of insight and knowledge from translating and transforming digitally represented information.
10c. Explanation of connections between information and knowledge.

Learning Objective 11: The student can communicate how computer programs are used to process information to gain insight and knowledge. [P5]

Evidence for Learning Objective 11: Student work is characterized by:
11a. Explanation of how computer programs are used to process information to gain insight and knowledge.
11b. Use of accurate and precise language, notation, or visualization to describe patterns or hypotheses arising from digitally represented information.
11c. Summary of insight and knowledge resulting from translating and transforming digitally represented information.

Key Concept B.   Computing facilitates exploration and the discovery of connections in information.

Learning Objective 12: The student can use computing to facilitate exploration and the discovery of connections in information. [P1]

Evidence for Learning Objective 12: Student work is characterized by:
12a. Identification of scalability considerations when using datasets.
12b. Explanation of connections between data and metadata.
12c. Use of computing tools to discover connections in information.
12d. Use of computing tools to extract information and knowledge.

Learning Objective 13: The student can use large datasets to explore and discover information and knowledge. [P3]

Evidence for Learning Objective 13: Student work is characterized by:
13a. Use of large datasets to extract information and knowledge.
13b. Explanation of how large datasets can facilitate exploration and discovery.

Key Concept C. Computational manipulation of information requires consideration of representation, storage, security, and transmission.

Learning Objective 14: The student can analyze the considerations involved in the computational manipulation of information. [P4]

Evidence for Learning Objective 14: Student work is characterized by:
14a. Evaluation of trade-offs involved in the many possible ways to represent digital and non-digital information as digital data.
14b. Explanation of how data is stored in many formats depending on its characteristics—such as size and intended use—so that it can be manipulated computationally.

Big Idea IV. **Algorithms**: Algorithms are used to develop and express solutions to computational problems.

Key Concept A. An algorithm is a precise sequence of instructions for a process that can be executed by a computer.

Learning Objective 15: The student can develop an algorithm. [P2]

Evidence for Learning Objective 15: Student work is characterized by:
15a. Selection of appropriate techniques—such as sequencing, selection, iteration, and recursion—to develop an algorithm.
15b. Selection of appropriate combinations of algorithms to make new algorithms.
15c. Creation of an algorithm to solve a problem.
15d. Creation of an algorithm with a practical, personal, or societal intent.

Key Concept B. Algorithms are expressed using languages.

Learning Objective 16: The student can express an algorithm in a language. [P5]

Evidence for Learning Objective 16: Student work is characterized by:
16a. Use of natural language, pseudo-code, or a visual or textual programming language to express an algorithm.
16b. Explanation of how an algorithm is represented in natural language, pseudo-code, or a visual or textual programming language.
16c. Explanation of how the language used to express an algorithm can affect characteristics such as clarity or readability.
16d. Summary of the purpose of an algorithm.

Key Concept C. Algorithms can solve many, but not all problems.

Learning Objective 17: The student can appropriately connect problems and potential algorithmic solutions. [P1]

Evidence for Learning Objective 17: Student work is characterized by:
17a. Identification of problems that can be solved in a reasonable time.
17b. Explanation of why heuristic approaches are necessary to solve some problems in a reasonable time.
17c. Explanation of how some problems cannot be solved using any algorithm.

Key Concept D. Algorithms are evaluated analytically and empirically.

Learning Objective 18: The student can evaluate algorithms analytically and empirically. [P4]

Evidence for Learning Objective 18: Student work is characterized by:

18a. Evaluation of an algorithm's efficiency, correctness, or clarity.

18b. Location and correction of errors in an algorithm.

18c. Explanation of how an algorithm functions.

18d. Explanation of how different correct algorithms for the same problem can have different efficiencies.

Big Idea V. **Programming**: Programming enables problem solving, human expression, and creation of knowledge.

Key Concept A.   Programs are written to execute algorithms.

Learning Objective 19: The student can explain how programs implement algorithms. [P3]

Evidence for Learning Objective 19: Student work is characterized by:
19a. Description of how instructions are processed.
19b. Explanation of how program execution automates processes.
19c. Explanation of how a single program can be run multiple times and on many machines.
19d. Explanation of how executable programs increase the scale of problems that can be addressed.

Key Concept B.   Programming is facilitated by appropriate abstractions.

Learning Objective 20: The student can use abstraction to manage complexity in programs. [P3]

Evidence for Learning Objective 20: Student work is characterized by:
20a. Use of functions as re-usable programming abstractions.
20b. Explanation of how parameterization can be used to generalize a specific solution.
20c. Use of data abstraction as a means of separating behavior from implementation.
20d. Use of Application Program Interfaces (APIs) and libraries to simplify complex programming tasks.

Key Concept C.   Programs are developed and used by people.

Learning Objective 21: The student can evaluate a program for correctness. [P4]

Evidence for Learning Objective 21: Student work is characterized by:
21a. Evaluation of program style.
21b. Location and correction of errors in a program.
21c. Justification of program correctness.
21d. Explanation of how a program functions.

Learning Objective 22: The student can develop a correct program. [P2]

Evidence for Learning Objective 22: Student work is characterized by:
22a. Use of an iterative process to develop a correct program.

22b. Development of program documentation.
22c. Location and elimination of errors in a program written by the student.
22d. Identification of programmer and user concerns in program development.

Key Concept D.   Programming uses mathematical and logical concepts.

Learning Objective 23: The student can employ appropriate mathematical and logical concepts in programming. [P1]

Evidence for Learning Objective 23: Student work is characterized by:
23a. Use of appropriate mathematical and logical concepts in programming.
23b. Explanation of connections between programs and underlying mathematical and logical concepts.

Big Idea VI. **Internet**: The Internet pervades modern computing.

Key Concept A.   The Internet is a network of autonomous systems.

Learning Objective 24: The student can explain the abstractions in the Internet and how the Internet functions. [P3]

Evidence for Learning Objective 24: Student work is characterized by:
24a. Explanation of how the Internet connects devices and networks all over the world.
24b. Explanation of how the Internet and the systems built on it facilitate collaboration.
24c. Description of evolving standards that the Internet is built on, including those for addresses and names.
24d. Identification of abstractions in the Internet and how the Internet functions.

Key Concept B.   Characteristics of the Internet and the systems built on it influence their use.

Learning Objective 25: The student can explain characteristics of the Internet and the systems built on it. [P5]

Evidence for Learning Objective 25: Student work is characterized by:
25a. Identification of the use of hierarchy and redundancy in the Internet.
25b. Description of interfaces and protocols that enable widespread use of the Internet and systems built on it.
25c. Summary of characteristics of the Internet and the systems built on it.

Learning Objective 26: The student can analyze how characteristics of the Internet and systems built on it influence their use. [P4]

Evidence for Learning Objective 26: Student work is characterized by:
26a. Explanation of how hierarchy and redundancy help systems scale.
26b. Explanation of how interfaces and protocols enable widespread use.
26c. Explanation of how size and speed of systems affect their use.

Key Concept C.   Cybersecurity is an important concern for the Internet and systems built on it.

Learning Objective 27: The student can connect the concern of cybersecurity with the Internet and systems built on it. [P1]

Evidence for Learning Objective 27: Student work is characterized by:
27a. Identification of tradeoffs associated with the trust model of the Internet.

27b. Description of software, hardware, and human components involved in implementing cybersecurity.

27c. Explanation of how cryptography is essential to many models of cybersecurity.

Big Idea VII.   **Impact**: Computing has global impacts.

Key Concept A.   Computing affects communication, interaction, and cognition.

Learning Objective 28: The student can analyze how computing affects communication, interaction, and cognition. [P4]

Evidence for Learning Objective 28: Student work is characterized by:
28a. Explanation of how computing enhances communication, fostering new ways to communicate and collaborate.
28b. Explanation of how widespread access to information facilitates identification of problems, development of solutions, and dissemination of results.
28c. Evaluation of how computing enhances human capabilities (e.g., through the use of cyber-physical systems and assistive technologies).
28d. Evaluation of impacts that the Internet and the web have had on society.

Key Concept B.   Computing enables innovation in nearly every field.

Learning Objective 29: The student can connect computing with innovations in other fields. [P1]

Evidence for Learning Objective 29: Student work is characterized by:
29a. Identification of the impacts of computing on innovation in other fields.
29b. Description of how computational approaches and data analysis enable innovation.
29c. Explanation of how computing enables innovation by providing access to and sharing of information.

Key Concept C.   Computing has both beneficial and harmful effects.

Learning Objective 30: The student can analyze the beneficial and harmful effects of computing. [P4]

Evidence for Learning Objective 30: Student work is characterized by:
30a. Evaluation of legal and ethical concerns raised by computing-enabled innovations.
30b. Evaluation of privacy and security concerns that arise in the development and use of computational systems and artifacts.
30c. Evaluation of how technology enables collection, use, and exploitation of information about, by, and for individuals, groups, and institutions.
30d. Evaluation of questions about intellectual property raised by widespread access to digitized information.

Key Concept D.   Computing is situated within economic, social, and cultural contexts.

Learning Objective 31: The student can connect computing within economic, social, and cultural contexts. [P1]

Evidence for Learning Objective 31: Student work is characterized by:
31a. Identification of how computing innovations both influence and are influenced by the economic, social, and cultural contexts in which they are designed and used.
31b. Explanation of connections between the global distribution of computing resources and issues of equity, access, and power.