The College Board

AP Computer Science: Principles

Claims and Evidence Statements

AP Computer Science: Principles is a pilot course under development. It is not an official Advanced Placement course currently being offered by the College Board.

This document is based upon work supported by the National Science Foundation, grant CNS-0938336. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Big Idea I. Computing is a creative human activity that engenders innovation and promotes exploration.

Key Concept I.A. Innovations enabled by computing significantly affect communication, cognition, and human interaction.

Claim 1: The student can analyze how computing affects communication, cognition, and human interaction.

Evidence for Claim 1: Student work is characterized by:
1a. Identification of computing-enabled innovations that facilitate communication, collaboration, and human interaction.
1b. Identification of impacts on society (positive and negative) of the Internet and the web.
1c. Analysis of implications of design decisions on communication, cognition, and human interaction.
1d. Characterization of connections between human needs and functionality of computing-enabled innovations.

Key Concept I.B. Innovations enabled by computing lead to the creation of new artifacts that affect humanity in diverse ways.

Claim 2: The student can work effectively in teams to create a new computational artifact.

Evidence for Claim 2: Student work is characterized by:
2a. Application of effective teamwork practices in employing media for creative expression.
2b. Collaboration of participants in creating new computational artifacts.
2c. Creation of new computational artifacts that depend on active contribution from multiple participants.
2d. Documentation describing the potential beneficial and harmful effects of a computational innovation.

Key Concept I.C. Innovations enabled by computing raise legal and ethical concerns.

Claim 3: The student can communicate the legal and ethical concerns raised by a computational innovation.

Evidence for Claim 3: Student work is characterized by:
3a. Explanation of how technology enables small- and large-scale collection, use, and exploitation of information about, by, and for individuals, groups, and institutions.

3b. Summarization of the privacy and security concerns that arise in the development and use of computational systems and artifacts.
3c. Description of the intellectual property issues that arise due to widespread access to digitized information.
3d. Justification of appropriateness of legal and ethical concerns raised by computing-enabled innovations.

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

Claim 4: The student can analyze the effects of computing within economic, social, and cultural contexts.

Evidence for Claim 4: Student work is characterized by:
4a. Identification of existing and potential innovations enabled by computation and the effects on the economic, social, and cultural contexts in which these innovations are designed and used.
4b. Identification of the implications for equity, access, and power of the distribution of computing resources in a global economy.
4c. Analysis of how computing innovations both influence and are influenced by the cultures in which they are designed and the cultures in which they are used.
4d. Characterization of connections between social and economic values and the design and development of computing innovations.

Big Idea II. Abstraction reduces information and detail to focus on concepts relevant to understanding and solving problems.

Key Concept II.A. Computational systems and problems are developed, analyzed, and solved using multiple levels of abstraction.

Claim 5: The student can use abstractions and models to solve computational problems and analyze systems.

Evidence for Claim 5: Student work is characterized by:
5a. Explanation of how data, information or knowledge are represented at different levels of abstraction.
5b. Use of simulation and randomness to analyze and solve problems.
5c. Explanation of how abstractions are used in software systems at many levels, ranging from programming languages to operating systems to the Internet.
5d. Explanation of the abstractions comprising the physical layers of computing hardware, including gates, chips, and components.

Key Concept II.B. Models and simulations use abstraction to raise and answer questions about real or imagined worlds.

Claim 6: The student can use models and simulations to raise and answer questions about real or imagined worlds.

Evidence for Claim 6: Student work is characterized by:
6a. Explanation of how different levels of abstraction, including data, information or knowledge are used in computational models.
6b. Use of models and simulation to formulate, refine, and test scientific hypotheses.
6c. Use of simulation and randomness to facilitate extensive and rapid testing of models in order to investigate modeled phenomena.
6d. Explanation of how abstractions (facilitated by scientific, mathematical and computational techniques) are used in modeling and simulation.
6e. Collection or generation of data appropriate to a phenomenon being modeled (e.g., random data; conditioned data) to generate new understanding and knowledge.

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

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

Claim 7: The student can use models and programs to process information and gain insight and knowledge.

Evidence for Claim 7: Student work is characterized by:
7a. Explanation of how to translate and transform digital information from one form to another.
7b. Use of simulation and randomness to find patterns in and test hypotheses about digital information.
7c. Explanation of how computer programs can be used to process information that leads to insight and knowledge.

Key Concept III.B. All digital data is represented using a combination of abstractions built upon finite binary sequences.

Claim 8: The student can use a combination of abstractions of finite binary sequences to represent digital data.

Evidence for Claim 8: Student work is characterized by:
8a. Explanation of how the interpretation of a binary sequence depends on how it is used, e.g., an instruction, a number, text, a sound, or an image.
8b. Explanation of how the infinite mathematical concept of a number is modeled with a finite representation.
8c. Explanation of how the abstraction of number bases, including binary and decimal, are used for reasoning about digital data.

Key Concept III.C. Information must be translated into a digital format to be manipulated computationally.

Claim 9: The student can use abstractions and models that translate information into digital representations so that it can be manipulated computationally.

Evidence for Claim 9: Student work is characterized by:
9a. Explanation of how information must be stored so that it can be manipulated computationally.
9b. Use of simulation and randomness in processing noisy information.
9c. Explanation of how abstractions are used to translate information into digital representations so that it can be manipulated

computationally.
9d. Collection of appropriate data from sources such as sensors, databases, or human polls.

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

Claim 10: The student can analyze the implications of the representation, storage, security, and transmission of information.

Evidence for Claim 10: Student work is characterized by:
10a. Identification of potential security issues relating to the representation, storage, and transmission of information.
10b. Identification of ethical implications and positive and negative impacts of the storage and transmission of information.
10c. Characterization of how data is stored in many formats depending on its characteristics (such as size and intended use).
10d. Analysis of the implications, e.g., for accuracy, speed, and ease of manipulation, of how information is represented as digital data.
10e. Characterization of how access to information may be limited due to concerns such as privacy, safety, or for economic reasons.

Big Idea IV. Algorithms are tools for developing and expressing solutions to computational problems.

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

Claim 11: The student can create appropriate algorithms to address specified objectives.

Evidence for Claim 11: Student work is characterized by:
11a. Creation of an algorithm with a practical, personal, or societal intent.
11b. Selection of appropriate techniques---such as sequencing, selection, iteration, and recursion---to develop an algorithm.
11c. Use of appropriate algorithms and data structures to solve a problem.
11d. Location and correction of errors in an algorithm.

Key Concept IV.B. Algorithms are expressed using languages.

Claim 12: The student can develop algorithms using appropriate abstractions and constructs.

Evidence for Claim 12: Student work is characterized by:
12a. Explanation of how an algorithm is represented in a natural language, visual language, or textual programming language.
12b. Use of simulation or randomness in an algorithm.
12c. Explanation of how abstractions are used in expressing an algorithm.
12d. Explanation of how the language used to express an algorithm can affect characteristics such as clarity or readability, but not whether an algorithmic solution exists.

Claim 13: The student can express an algorithm using computer and non-computer languages.

Evidence for Claim 13: Student work is characterized by:
13a. Explanation of how an algorithm scales.
13b. Summarization of the behavior of an algorithm for specified data sets.
13c. Description of an algorithm using appropriate words and visualizations.
13d. Justification of the appropriateness and correctness of a proposed algorithm.

Key Concept IV.C. Computational problems can be categorized by their complexity.

Claim 14: The student can analyze computational problems to categorize them by their complexity.

Evidence for Claim 14: Student work is characterized by:
14a. Evaluation of a tractable problem (problems that have efficient computational solutions that run in reasonable time, e.g., a time polynomial in the size of the problem).
14b. Evaluation of an intractable problem (problems that cannot be solved computationally for small sized instances in a reasonable time, e.g., the solution is exponential in the size of the input).
14c. Evaluation of a problem that has no known efficient solution, and solving one such problem would effectively solve all of them, e.g., finding the longest path in a graph.
14d. Evaluation of a problem that can be solved heuristically, but not optimally in a reasonable time, e.g., packing items to minimize the number of boxes used.
14e. Evaluation of a problem that cannot be solved using a computer, e.g., the Halting problem.

Key Concept IV.D. Algorithms are evaluated analytically and empirically.

Claim 15: The student can evaluate algorithms analytically and empirically.

Evidence for Claim 15: Student work is characterized by:
15a. Evaluation of an algorithm using multiple criteria, e.g., efficiency, correctness, and clarity.
15b. Analysis of tradeoffs (e.g., efficiency) of multiple correct algorithms designed to solve a particular problem.
15c. Analysis of the results produced by an algorithm for particular data sets.
15d. Comparison of empirical running times of different algorithms that have the same analytical efficiency.

Big Idea V. Programming is a creative process that produces computational artifacts.

Key Concept V.A. Translating human intention into a computational artifact is part of programming.

Claim 16: The student can create a computational artifact through programming.

Evidence for Claim 16: Student work is characterized by:
16a. Creation of a computational artifact with a practical, personal, or societal intent.
16b. Selection of appropriate programming language or environment to develop a computational artifact.
16c. Use of appropriate algorithms, instructions, and data structures in the iterative development of a program.
16d. Location and correction of errors in a program.

Key Concept V.B. Programs are developed and used by people.

Claim 17: The student can create programs to be used by people.

Evidence for Claim 17: Student work is characterized by:
17a. Creation of a program chosen by the student as relevant and interesting.
17b. Selection of appropriate techniques in developing a program that is readable and usable.
17c. Use of appropriate algorithms and data structures in a program developed in consultation with users.
17d. Location and correction of errors in a program created by the student individually or on a team.

Claim 18: The student can work effectively in teams when developing programs.

Evidence for Claim 18: Student work is characterized by:
18a. Application of effective teamwork practices when developing programs.
18b. Collaboration of participants, including developers and users, when developing programs.
18c. Production of programs that depend on active contribution from multiple participants working on a team.
18d. Documentation describing the use, functionality, and implementation of a program.

Key Concept V.C. Programming uses mathematical and logical concepts.

Claim 19: The student can use appropriate mathematical and logical concepts when developing programs.

Evidence for Claim 19: Student work is characterized by:
19a. Creation of an program using appropriate mathematical and logical concepts.
19b. Selection of appropriate mathematical and logical concepts to develop a program, e.g., use of numbers, sets, and Boolean algebra.
19c. Use of appropriate mathematical and statistical functions in the development of a program.
19d. Location and correction of errors through the application of logical concepts.

Key Concept V.D. Modularity and parameterization are techniques for writing programs.

Claim 20: The student can appropriately use modularity and parameterization to create computational artifacts.

Evidence for Claim 20: Student work is characterized by:
20a. Creation of an computational artifact using APIs and libraries.
20b. Selection of an appropriate approach to develop a program using data and function encapsulation.
20c. Appropriate use of subprograms and data structures in developing a program.
20d. Appropriate use of parameterization to generalize a specific programming solution.

Big Idea VI. Digital devices, systems, and the networks that interconnect them enable and foster computational approaches to solving problems.

Key Concept VI.A. Networks connect computers, sub-networks, and other networks.

Claim 21: The student can create a solution to a computational problem using networked devices.

Evidence for Claim 21: Student work is characterized by:
21a. Creation of a computational artifact using networked devices.
21b. Selection of appropriate forms of network-based collaboration in the development of a computational artifact.
21c. Use of appropriate network-based communication tools in the development of a computational artifact.
21d. Location and correction of errors in a system of networked devices.

Key Concept VI.B. System development requires the application of appropriate design principles.

Claim 22: The student can analyze system design based on appropriate design principles.

Evidence for Claim 22: Student work is characterized by:
22a. Evaluation of systems and networks in terms of design principles that make them easier to scale.
22b. Analysis of tradeoffs in a system or network including efficiency and security.
22c. Analysis of the modularization of a system.
22d. Evaluation of abstractions and interfaces used in a system or network design.

Claim 23: The student can work effectively in teams to develop systems using appropriate design principles.

Evidence for Claim 23: Student work is characterized by:
23a. Application of effective teamwork practices in developing a modular system.
23b. Collaboration of participants in developing a scalable system using good design principles.
23c. Production of a system design involving multiple participants that considers tradeoffs such as efficiency and security.
23d. Documentation describing the abstractions and interfaces used in a system design.

Key Concept VI.C. Computer systems are composed of input, output, storage, and processing, their relations and interactions.

Claim 24: The student can use appropriate abstractions and models to describe a computer system and the relations among its inputs, outputs, storage, and processing.

Evidence for Claim 24: Student work is characterized by:
24a. Explanation of how data, information, and knowledge are represented in different computer systems and input and output devices.
24b. Use of simulation to investigate computer systems including their inputs, outputs, storage, and processing.
24c. Explanation of how computers and systems compute with different kinds of processors.
24d. Explanation of how abstractions are used in describing different input and output devices that are part of computer systems.

Key Concept VI.D. Characteristics of a system affect the applications for which it can be used.

Claim 25: The student can analyze the characteristics of a system to determine the applications for which it can be used.

Evidence for Claim 25: Student work is characterized by:
25a. Evaluation of the characteristics of a system or network (e.g., size and speed, latency and bandwidth) in term of its suitability for a given application.
25b. Analysis of how changes in the characteristics of a system can require changes to associated algorithms and programs.
25c. Evaluation of the size and speed of a computer component and its suitability for a given application.
25d. Evaluation of the latency and bandwidth of a network and its suitability for a given application.

Big Idea VII. Computing enables innovation in other fields including mathematics, science, social science, humanities, arts, medicine, engineering, and business.

Key Concept VII.A. Computing enables innovation by automating processes.

Claim 26: The student can analyze the effects of innovations enabled by automating processes.

Evidence for Claim 26: Student work is characterized by:
26a. Identification of existing and potential innovations enabled by automating processes, e.g., in financial markets, for tracking and processing goods, and in the delivery of digital information.
26b. Identification of ethical implications and positive and negative impacts of automating processes.
26c. Characterization of how financial markets, transactions, and predictions have been transformed by automation.
26d. Characterization of how the automation of processes for tracking and processing goods has enabled innovation from both business and consumer standpoints.
26e. Characterization of how the automation of processes for delivery of digital information has transformed markets for news, music, movies, literature and other cultural phenomena.

Key Concept VII.B. Computational modeling fosters innovation and knowledge.

Claim 27: The student can use computational modeling to make predictions and gain insight.

Evidence for Claim 27: Student work is characterized by:
27a. Explanation of how data, information or knowledge are represented for computational modeling.
27b. Use of simulation and randomness in making predictions about dynamic systems.
27c. Explanation of how abstractions are used to model and build real and virtual organizations and infrastructures.
27d. Collection or generation of data appropriate to modeling a complex natural or human system.

Key Concept VII.C. Computational approaches and data analysis enable innovation.

Claim 28: The student can analyze data to gain insight.

Evidence for Claim 28: Student work is characterized by:

28a. Analysis of data using appropriate algorithms.
28b. Analysis of data to reveal patterns.
28c. Evaluation of information and data using visualizations.

Claim 29: The student can communicate results of data analysis.

Evidence for Claim 29: Student work is characterized by:
29a. Explanation of how a data analysis can reveal patterns that further knowledge and discovery.
29b. Summarization of discoveries resulting from the analysis of large amounts of data using appropriate algorithms.
29c. Description of information and data using appropriate words and visualizations.
29d. Justification of appropriateness and correctness of data analysis.

Key Concept VII.D. Computing enables innovation by providing access to and sharing of information.

Claim 30: The student can communicate results of information discovery.

Evidence for Claim 30: Student work is characterized by:
30a. Description using appropriate words and visualizations of how online sharing of information enables discovery and new forms of collaboration.
30b. Description using appropriate words and visualizations of how online search of information enables new discoveries and understanding.