Chief Reader Report on Student Responses:

2019 AP® Computer Science Principles Performance Tasks

- Number of Students Scored: 96,105
- Number of Readers: 555
- Score Distribution

Exam Score	N	%At
5	13,219	13.8
4	20,205	21.0
3	35,635	37.1
2	18,066	18.8
1	8,980	9.3

- Global Mean: 3.11

The following comments on the 2019 free-response questions for AP® Computer Science Principles were written by the Chief Reader, Paul Tymann, Rochester Institute of Technology. They give an overview of each performance task and of how students performed on the task, including typical student errors. General comments regarding the skills and content that students frequently have the most problems with are included. Some suggestions for improving student preparation in these areas are also provided. Teachers are encouraged to attend a College Board workshop to learn strategies for improving student performance in specific areas.

Task: Create Performance Task | **Topic:** Application from Ideas

	Max. Points:	Mean Score:
Row 1	1	0.96
Row 2	1	0.40
Row 3	1	0.59
Row 4	1	0.95
Row 5	1	0.71
Row 6	1	0.41
Row 7	1	0.76
Row 8	1	0.58

What were the responses to this question expected to demonstrate?

Programming is a collaborative and creative process that brings ideas to life through the development of software. Programs can help solve problems, enable innovations, or express personal interests. In this performance task, students developed a program of their choice. The students' development process includes iteratively designing, implementing, and testing their program. Students were strongly encouraged to work with another student in their class.

How well did the responses address the course content related to this question? How well did the responses integrate the skills required on this question?

Developing a program with a purpose

- Students were asked to develop a working program and use a video to demonstrate the running of at least one feature of their program. In general, students were able to write a working program and create a video that clearly and accurately illustrated the purpose of the program.
- Students were asked to describe the incremental and iterative development process they used to develop their program, focusing on two distinct points in the process. While most students were able to identify two distinct points in the process as difficulties or opportunities, many did not describe an incremental and iterative development process used when writing their entire program.
- Student projects based on curriculum provider activities with trivial modifications resulted in a low score. Depending on the scope of the modifications, these programs may be flagged as a security violation.

Applying Algorithms

- Students were asked to incorporate complex algorithms into their program that integrated mathematical and/or logical concepts and that integrated two or more algorithms, to accurately identify the purpose of the algorithm, and to describe how at least one of the two integrated algorithms works independently. While students were able to identify an algorithm in their program that used mathematics and/or logic, a significant number of students chose algorithms that were trivial. Many students would describe how the algorithm functioned as opposed to the role of the algorithm in the overall program. Few responses explicitly identified the two integrated algorithms. Students who did identify the integrated algorithms, often failed to explain how one of them functioned independently.

Applying Abstraction

- Students were asked to incorporate abstraction into their program and explain how the abstraction served to manage complexity of the program. While many students were able to accurately select an abstraction used in their programs, some students selected predefined abstractions (e.g. event handlers, for loops) rather than student developed abstractions. Additionally, some students struggled to explain clearly why the abstraction they chose manages complexity within the context of their program.

Common Misconceptions/Knowledge Gaps	*Responses that Demonstrate Understanding*
Responses 1 and 2a: *Developing a Program with a Purpose* Row 1 • Short videos that do not demonstrate that a working program has been created. • Poor sound quality videos with significant background noise made voice narrations indiscernible.	Row 1 • High scoring submissions include a full length video (approximately one minute) that clearly illustrates the program running. • High scoring responses clearly described the purpose of the program. For example, *"to help users memorize terms and their definitions more effectively."*
Response 2b: *Developing a Program with a Purpose* Row 2 • Writing exclusively about time spent brainstorming ideas prior to beginning the design and implementation of the program. • A significant number of responses did not address the development process (coding) of the entire program. • Confusing "iterative development" with iteration. Students would conflate "iterative development" with keeping track of the "number of lives" in a game. Row 3 • Describing difficulties in determining what type of program to create is not part of the design and implementation of the program.. • Identifying difficulties or opportunities but not describing specifically how they were resolved or incorporated. • Describing knowledge gaps in terms of programming skills as difficulties and identified learning the skills as their resolution process.	Row 2 • High scoring submissions describe the overall development of the program, which can include the design of the user interface, the algorithmic components needed for the program, and the debugging and testing process as the program is developed. For example, *"setting up the background and arranging the cards before developing the Card class ... determined the coordinates ... tested the program multiple times ... confirm the accuracy of the program by running it to check if it worked ... getting them [cards] to flip."* Row 3 • High scoring submissions include details about portions of program code that were not functioning properly. The descriptions included how errors were identified and how these difficulties were resolved. • High scoring submissions clearly described how the difficulty was resolved or how the opportunity was incorporated. For example, *"I used a debugger to determine that my loop count was off by one. I corrected the corresponding code and the program worked as expected,"* as opposed to *"I fixed a problem in my program."*

Response 2c: *Applying Algorithms* Row 4 • Writing a program that consists only of a few buttons and switches screens when a button is clicked. These responses leave little or no evidence of algorithms. Row 5 • Identifying an algorithm with mathematics or logic, but not explicitly describing what the algorithm does in relation to the overall purpose of the program. • Describing what an algorithm does in relationship to the overall program or explaining how an algorithm functions, but not both. Row 6 • Identifying the selected algorithm without clearly identifying either one of the two integrated algorithms. • Identifying more program code than described in the written response. • Selecting and describing two non-integrated algorithms • Selecting algorithms that contain only one line of code (i.e., one computation). • Confusing the independent creation of algorithms with how algorithms function independently.	Row 4 • High scoring submissions clearly identified a non-trivial algorithm with sequence, iteration, and/or selection. Row 5 • High scoring submissions explicitly describe what the algorithm does in relation to the overall program. For example, *"[b]oth algorithms are essential because in unison they allow the program to work, as without the first algorithm the code would not work as nothing would be displayed nor nothing would be subtracted so the function would eventually reach zero. While without the second algorithm result would always be one less than the value set for countdown and there be no command telling it to repeat the process in algorithm number one."* Row 6 • High scoring submissions include a non-trivial algorithm, clearly identifying two non-trivial integrated algorithms, and explaining how at least one of the integrated algorithms would function on its own.
Response 2d: *Applying Abstraction* Rows 7 and 8 • Identifying an abstraction that is not student-defined (e.g. an event handler or a for loop). • Describing how the abstraction functions as an alogirthm, as opposed to how the abstraction manages complexity in the program.	Rows 7 and 8 • High scoring submissions include student-defined abstractions like a procedure or a data list. These submissions clearly explain how the abstraction manages complexity through code reuse, improved readability, encapsulation, reduction in code due to data abstractions like a list (e.g. a list allows use of a loop to examine all elements), and/or improved debugging. • High scoring submissions include the abstraction along with the code that uses the abstraction to illustrate clearly how it manages complexity.

Based on your experience at the AP® Reading with student responses, what advice would you offer to teachers to help them improve the student performance on the exam?

Developing a Program with a Purpose—Submission Requirement 1 and 2a:

- Give students several opportunities to complete a practice Create performance task of shorter duration to gain a better understanding of the learning objectives and skills required for the program. Completing these would also give students multiple experiences using an iterative and incremental development processes in action so they are comfortable using and describing them in their submissions.
- Have students view high-quality examples of the Create performance task to become familiar with the task requirements.
- Ensure that students have access and opportunity to practice using computational video tools to capture their program features.
- Students need additional practice making sure that any text in the video is clearly visible and readable for scoring. If using a voice over narration, encourage recording using a loud, clear voice in a noise-free environment.
- Make it clear to students that while it is okay to base their programs on one used in class, they must make significant changes to it by adding additional functionality. For example, changing a one player game to be a two player game. However, changing the background, or sprites used in a program is not a significant change.

Developing a Program with a Purpose - Submission Requirement 2b:

- While students may work collaboratively on their projects, they may not be get help from others outside of the class, including but not limited to family members. Students cannot get help from their teacher(s).
- Students need more experience creating programs using an incremental and iterative development process. Encourage students to keep a log of the work they do on their projects. Reviewing the log when the project is complete will help them to describe the development process that was used.

Applying Algorithms and Abstractions - Submission Requirements 2c and 2d:

- Students need explicit instruction and experience taking screen captures of code segments and incorporating them into their written responses. Additionally, they need instruction on how to add ovals and/or rectangles to their program code.
- Students can and should include multiple program code segments to demonstrate the full utility of their algorithm and abstraction, such as procedures along with the call to the procedure. These program code segments may come from more than one area of the program code.
- Teachers can review high-quality examples with students to help them understand the computational principles of algorithms and abstraction more clearly. For algorithms, show how each algorithm is independent; show how this is easier to explain when the integrated (additional) algorithms have separate functionality. For abstraction, show students how the program becomes more complex to manage when the abstraction is removed
- Teachers need to avoid providing students with task templates that provide fill-in-the-blank spaces for task requirements. These are a violation of the performance task guidelines and can result in student submissions being flagged for plagiarism.

What resources would you recommend to teachers to better prepare their students for the content and skill(s) required on this question?

- Teachers should provide students with the Assessment Overview and Performance Task Directions for Students. This document provides clear guidelines for completing the performance tasks, include, and what students may and may not do during the administration.
- The assessment section of the Course and Exam Description provides teachers with similar guidelines for what they may and may not do to assist their students during the administration of the performance task.
- Teachers should review both sets of guidelines with students to help them understand why teachers cannot offer assistance during the administration of the task.
- Additional student samples are added to the exam page each year after the AP Reading. Teachers should spend time reviewing these samples, along with the Scoring Guidelines and Notes and Commentary, to help students understand how their work will be evaluated.

- The AP with WE Service Computer Science A Healthcare and Education modules can be modified to use with AP Computer Science Principles. Suggested AP CSP adaptations will be provided for the three programming activities within these modules. The third adaptation will provide a scaffolded experience for students to focus on abstraction and prepare for the Create Performance Task. The AP with WE Service modules and AP CSP adaptations can be found here this fall.

Task: Explore Performance Task		**Topic:** Impact of Computing Innovations
	Max. Points:	**Mean Score:**
Row 1	1	0.95
Row 2	1	0.93
Row 3	1	0.89
Row 4	1	0.64
Row 5	1	0.64
Row 6	1	0.65
Row 7	1	0.71
Row 8	1	0.63

What were the responses to this question expected to demonstrate?

Computing innovations impact our lives in ways that require considerable study and reflection for us to fully understand them. In this performance task, students explored a computing innovation of their choice. The close examination of this computing innovation deepens the students' understanding of computer science principles.

How well did the responses address the course content related to this question? How well did the responses integrate the skills required on this question?

Using Development Processes and Tools

- Students were able to create computational artifacts that conveyed a computing innovation's purpose, function, or effect.

Analyzing Impact of Computing

- Students had a difficult time understanding the difference between the "function," "purpose," "feature," and "effect" of an innovation. A function of a mobile phone, for example, is to make phone calls or to receive text messages. An effect is a result of the intended use of the innovation. A driver can use a mobile phone to call for help if the car breaks down. This allows the driver to remain safe inside the car rather than walking along a highway or soliciting help from strangers.
- While most students were able to identify beneficial effects of a computing innovation, many struggled to fully describe the effect and provide specific evidence tying it to society, economy, or culture. Additionally, many students did not include a harmful effect of a computing innovation.

Analyzing Data and Information

- Students had a difficult time separating the data from the sensors, or type of information the innovation uses. For example, "Snapchat uses data from the phone camera to transform each picture into a snap." A phone is capable of generating many different types of data. Many students were no able to explicitly identify the data in their responses. Students who were able to identify the data being used were sometimes unable to clearly explain how the innovation consumes, produces, or transforms data.
- Students were able to identify a data concern, but many did not connect this concern to a computing innovation.

Finding and Evaluating Information

- Most students included at least three references in response 2D, but often did not include in-text citations of these references throughout their responses.

Common Misconceptions/Knowledge Gaps	*Responses that Demonstrate Understanding*
Responses 1 and 2a: Using Development Processes and Tools Rows 1 and 2 • Investigating an innovation that is not a computing innovation. A computing innovation is one that includes a computer or program code as an integral part of its function. According to this definition, a self-driving car would be a computing innovation, whereas a fiber optic cable would not be. Responses must clearly identify and describe the computer or program code that is part of the innovation. • Confusing technological innovations, such as a car, with computing innovations, such as the computers and sensors used in a self-driving car.	Rows 1 and 2 • High scoring submissions included descriptions of physical computing innovations such as virtual reality, augmented reality, Snapchat, Skype Translator, personal assistants (i.e., Alexa, Siri, Google Home, etc.), and facial recognition software. • All submissions must include acknowledgement of sources or authors of any and all information or evidence taken from the work of someone else. Acknowledgements can be done by adding a citation to the computational artifact itself, by adding a credits page to a video, or by including these with the references included in submission requirement 2e.

Response 2c: *Analyzing Impact of Computing*
 	
Row 3
• Confusing an "effect" with a purpose, function, or feature. An effect is something that happens as a result of the intended use of the innovation. For example: "[o]ne beneficial effect of Snapchat is that it allows for people to communicate in an easy and entertaining way" This is the purpose of Snapchat, not an effect of Snapchat.
 	
Row 4
• Identifying two effects without clearly indicating whether the effects are harmful, or beneficial: "Augmented reality has significant potential to change the way we interact in the future, by providing us with beneficial information such as time, messages, directions, and other relevant or timely information with ease."
	Row 3
	• High scoring submissions clearly identify a result (effect) of the intended use of the innovation. For example, "Google Glass will allow people, regardless of their physical restrictions, to access electronic devices free-handed. This effect is beneficial to the society of people with disabilities"
	
	Row 4
	• High scoring submissions clearly identify both a harmful and beneficial effect of the innovation. For example:
	  ○ a beneficial effect: *"The need to learn a new language for the sake of communication is dwindling, changing society for the better as it lowers the cost of school…"*
	  ○ A harmful effect: "*Skype translator and other translators may cause the necessity for foreign languages to plummet as well as the demand for human translators … causing an economic change for the …*

	worse as the number of unemployed translators increases dramatically."
Row 5 • Connecting at least one of the identified effects to society, economy or culture.	Row 5 • High scoring responses clearly tied an effect of the innovation to society, economy, or culture: *"A beneficial effect is facial recognition allows for greater security for wanted people. This security, due to more cameras and social media, allows law enforcement officials to trackdown wanted suspects as well as identifying known suspects."*

Response 2d: *Analyzing Data and Information* Row 6 • Not clearly identiying the data used by the innovation: *"Virtual reality uses the data from your phone to create the image, eye tracking data, and motion tracking data so that you are immersed in the virtual world."* • Neglecting to demonstrate an understanding of how a computing innovation uses and transforms data. For example, a submission might identify that a computing innovation stores video, but neglects to explain how this video is being used. Row 7 • Stating a data storage, privacy, or security concern without stating how the concern is connected to the computing innovation: *"The way Skype filters it through a third party, (although it is a bot), causes worry over the security of the conversations."*	Row 6 • High scoring responses clearly identify the data used by the innovation: *"Big token uses the user information which is their name, age, location, connercting to social mediam other items you like from stores, and many different types of questions"* Row 7 • High scoring responses clearly identified the concern, and described how the concern was tied to the innovation: *"All of Alexa's interactions are recorded and conversations the user has with Alexa are not kept completely private. They are stored and linked to the users amazon account. They're stored and linked to the users amazon account. Amazon uses the data in subsidiary marketing and advertising companies to provide targeted advertisements."*
Response 2e: *Finding and Evaluating Information* Row 8 • Neglecting to provide in-text citations.	

Based on your experience at the AP® Reading with student responses, what advice would you offer to teachers to help them improve the student performance on the exam?

Using Development Processes and Tools

- Give students several opportunities to complete a practice Explore Performance task to gain a better understanding of the learning objectives and skills required to answer the prompts.
- Have students view high-quality examples of the Explore Performance Task to become familiar with the performance task requirements.
- Ensure that students have access and opportunity to practice using the tools to be used to create computational artifacts.
- Most students listed features of the computing innovation instead of illustrating the innovation's intended purpose or function. Helping students to understand the difference between the features of an innovation and the purpose of the innovation would result in higher scores.
- Remind students that the computational artifact must be student-developed. Submitting an artifact that was simply copied from the internet is not allowed. It is permissible to make use of artifacts found on the internet, but their use must be cited.

Analyzing Impact of Computing

- Explain to students the importance of selecting a computing innovation that has easily identifiable effects, data, and data storage/privacy/security concerns.
- Class exercises that give students multiple opportunities to identify the function and effects of several computing innovations will help students to internalize the difference.
- Provide students with multiple opportunities to identify beneficial or harmful effects of computing innovations.

Analyzing Data and Information

- Provide students with examples of computing innovations that make use of data that is easy to identify and that have clear data privacy/security/storage concerns. Have students identify the specific data that is used. For example, a self-driving car has a sensor that collects location data.
- Give students multiple opportunities to identify data storage, data privacy, and data security concerns of computing innovations.

Finding and Evaluating Information

- Students should be reminded that when working on the performance task, they should not be getting any help from others outside of the class, including but not limited to teachers and family members. Interviewing individuals outside of class for background information is allowed, however. If information from these interviews is included in the response, it must be cited.
- Provide clear instruction and practice constructing proper citations and references. This could be done by providing students with several articles during the course that include citations and references. A specific style of citation (e.g. MLA) is not required in a response, but the response must provide and cite at least three references to receive a high score.

What resources would you recommend to teachers to better prepare their students for the content and skill(s) required on this question?

- Teachers should provide students with the Assessment Overview and Performance Task Directions for Students. This document provides clear guidelines for completing the performance tasks and it includes what students may and may not do during the administration.
- The assessment section of the Course and Exam Description provides teachers with similar guidelines for what they may and may not do to assist their students during the administration of the performance task.
- Teachers should review both sets of guidelines with students to help them understand why teachers cannot offer assistance during the administration of the task.

- Additional student samples are added to the exam page each year after the AP Reading. Teachers should spend time reviewing these samples, along with the Scoring Guidelines and Notes and Commentary, to help students understand how their work will be evaluated.
- The Explore Curricular Requirements teacher resource will be released this fall. Teachers may use this to prepare their students for the Explore Performance Task.
- Use this Kahoot quiz to reinforce the difference between an effect of a computing innovation and the computing innovation's purpose or function.