Testing and refinement is the deliberate and iterative process of improving a computational artifact. This process includes debugging (identifying and fixing errors) and comparing actual outcomes to intended outcomes. Students also respond to the changing needs and expectations of end users and improve the performance, reliability, usability, and accessibility of artifacts.

**Students should...**

**Systematically test computational artifacts by considering scenarios & using test cases.**

Students should be able to compare results to intended outcomes. Young students should verify whether given criteria and constraints have been met. As students progress, they should test computational artifacts by considering potential errors, such as what will happen if a user enters invalid input.

**Identify and fix errors using a systematic process.**

At any grade level, students should be able to identify and fix errors in programs (debugging) and use strategies to solve problems with computing systems (troubleshooting). Young students could use trial and error to fix simple errors. As students progress, they should become more adept at debugging and logic errors.

**Evaluate and refine a computational artifact to improve performance**

After students have gained experience testing, debugging, and revising, they should begin to evaluate and refine their computational artifacts. As students progress, the process of evaluation and refinement should focus on improving performance and reliability.

**Sample Student Task:**

In this sample task, students will design a simple website and then ask another student to evaluate and refine their website using simple debugging and test-case practices. Students should use a systematic process for identifying errors and deciding on a solution. Students will share their website improvements with the original student designer.

**Resources:**

- NSF "Exploring Computer Science" Lessons
- Introduction to Webpage Design for Students
- K-12 Computational Thinking Practices in Action

Source: K-12 Computer Science Framework