Standard III
Element D

Level 4 and Level 5 Practices

The result of successful implementation of the professional practices referenced in Element D will be students who use questioning strategies to develop and test ideas and use evidence to justify conclusions and synthesize knowledge. Students who apply critical thinking skills and problem-solving skills construct logical arguments and use concepts to solve problems.

Students:

6 ***Use questioning strategies to develop and test innovative ideas.***

"8 Strategies to Help Students Ask Great Questions"
https://www.teachthought.com/critical-thinking/8-strategies-to-help-students-ask-great-questions/

"Generating Effective Questions
Four ways to come up with questions that guide students to engage deeply with class content. Plus: a pop for you."
https://www.edutopia.org/blog/new-classroom-questioning-techniques-todd-finley

7 ***Use evidence to justify conclusions and synthesize knowledge.***

"Second grade teacher Apryl Whitman began teaching her students to synthesize their thinking in fiction by reading fables with them. Fables are a useful genre for introducing synthesizing because of their short structure and straightforward messages. Ms. Whitman chose a pyramid-shaped graphic organizer with three parts to illustrate how our thinking grows from the smaller top of the chart to the larger base. She used Debbie Miller's approach of modeling how her thinking changed from one part of the story to the next **See Introduction to Summarizing and Synthesizing and Suggested Readings.**"
https://readingrecovery.clemson.edu/summarize-and-synthesize/

"Highlights

- Science is combined with other rationales to support stances on complex dilemmas.
- Students use scientific knowledge for advocating freedom of personal choice.
- Students appear to assume a mutual understanding of scientific knowledge.
- Students' rationale including scientific knowledge reflects uncritical trust in experts."

https://www.sciencedirect.com/science/article/pii/S0742051X16301822

8 ***Construct logical arguments.***

"Think of a student sitting in a mathematics exam and making a crucial mistake in a proof. Then the student's answer is invalid and therefore, bad. Of course, a professor might have reasons to think that the student's answer still deserves marks (maybe even full marks) even though the student's answer is bad – in our understanding of 'bad'."
HTTPS://WWW.FUTURELEARN.COM/COURSES/LOGICAL-AND-CRITICAL-THINKING/0/STEPS/9153

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"TAKING THE LESSON FURTHER: CRAFTING A LOGICAL ARGUMENT"
https://www.lead2feed.org/2014/03/06/taking-lesson-crafting-logical-argument/

9 ***Use concepts to solve problems.***

"'How students can apply their learning to solve real-world problems'"
https://www.tes.com/us/news/breaking-views/how-students-can-apply-their-learning-solve-real-world-problems

"Chemical educators have often assumed that success in solving mathematical problems should indicate mastery of a chemical concept. To this end, we have developed algorithms. However, Nurrenbern and Pickering (7) and Pickering (2) found little connection between solving an algorithmically-based problem and understanding the chemical concept behind that problem. Sawrey (3) further supported Nurrenbern and Pickering's findings."
https://pubs.acs.org/doi/pdf/10.1021/ed070p190

Classroom Examples

Early childhood: Preschool students are working on the Colorado Academic Standard 2: Geography, Grade Level Expectation 1--Develop spatial understanding, perspectives, and connections to the world.

At the beginning of a unit on transportation, the teacher introduces materials that students can use to build an airport, a train station, and/or highways. ***(Plans lessons that incorporate critical-thinking and problem-solving skills.)*** The teacher also introduces ways students can make a plan for what they will build. She models how she made a plan to build an airport that included pictures of different size blocks and toy airplanes. ***(Models critical-thinking and problem-solving skills.)*** During center time, the teacher uses questioning to ask students about their plans:

- "Tell about your plan."
- "What are you building?"
- "Why did you use these blocks?"
- "Why are you building the airport tower so high?"

The teacher then asks the students to compare their plans to the structure that was built to see if they are missing anything. If they added something to the structure, they can add it to their drawing. ***(Uses questioning strategies to develop students' critical-thinking and problem-solving skills.)***

Elementary reading, writing, and communicating: Students are working on the Colorado Academic Standard 2: Reading for All Purposes, Grade Level Expectation 1—Strategies are needed to make meaning of various types of literary genres.

The teacher is reading aloud a novel to her 3rd-grade students in order to increase reading and vocabulary comprehension. In one passage, the author writes that a wealthy woman "pulled in her skirts" when a poor orphan boy passed her. For students to understand the meaning of this statement, they must make an inference about the author's intent. ***(Establishes expectations at a level that challenges students.)*** The teacher asks her students, "How do you think this woman felt about the orphan?" She provides time for students to process their response, and asks them to write it in their reading journals. ***(Uses wait time to encourage student responses.)*** As students write, she circulates to check their thinking. When she sees students using evidence from different places in the text along with the passage she already has pointed out, and combining it with what they know from their own

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experiences, she stops and acknowledges their work. Then, she pauses before taking a response from a boy in her class who says, "She didn't like the little boy." The teacher decides to probe a little further, and asks him why he thinks that. ***(Uses questioning strategies to develop students' critical-thinking and problem-solving skills.)*** The student replies, "I could tell she didn't like the little boy because she pulled her skirt away when he walked by. That's because she didn't want to get dirty from his dirty clothes." The teacher nods and intentionally waits another few seconds to let this thought permeate the classroom, ***(Uses wait time to encourage student responses)*** and, to her surprise, the student continues without prompting, "I don't think she was very nice. It's not a very nice way to think because we are all equal." (Walsh & Sattes, 2005, p. 81)

Middle school mathematics: Students are working on Colorado Academic Standard 4: Shape, Dimension, and Geometric Relationships, Grade Level Expectation 1: Modeling geometric figures and relationships leads to informal spatial reasoning and proof.

During a unit on geometry, the 7th-grade teacher invites architects and construction engineers to visit the classroom and explain how geometric shapes are used in the design and construction of buildings. Students will complete a project in which they apply their knowledge of shapes to various types of architecture and draw conclusions as to why the architect selected the geometric shapes utilized. They then will design a building or bridge using geometric shapes and explain their design in writing, based on their knowledge of geometry. ***(Establishes expectations at a level that challenges students.)*** Prior to students beginning the project, the teacher provides an exemplar of a project she completed. She shares her thinking that led to her conclusions and building design. As she does this, she connects to what she knows about geometry and information obtained from the guest speakers. ***(Models critical-thinking and problem-solving skills.)***

Middle school science: Students are working on Colorado Academic Standard 2: Life Science, Grade Level Expectation 1. All living things are made up of cells, which is the smallest unit that can be said to be alive.

During a study of photosynthesis and respiration in plants, a science teacher asks questions that are scaffolded across various levels of Bloom's Taxonomy. The questions begin with basic recall of terms related to the parts of plants and their location and function. The questions progress to a higher level of the taxonomy where students compare and contrast the two processes and evaluate symbols that represent the processes. ***(Establishes expectations at a level that challenges students. Uses questioning strategies to develop students' critical-thinking and problem-solving skills.)*** As questions become more challenging, the teacher requires students to write their responses prior to sharing them with a partner. As students write, wait time is provided for each student to process the question and develop a response. ***(Uses wait time to encourage student responses.)*** The lesson concludes with students creating their own symbols or illustrations for how photosynthesis and respiration in plants are connected. As students share their models with one another, their peers create questions to ask why they created the specific model and how it relates to the two processes. ***(Models critical-thinking and problem-solving skills.)***

High school mathematics: Students are working on Colorado Academic Standard 4: Shape, Dimension, and Geometric Relationships, Grade Level Expectation 1—Objects in the plane can be transformed, and those transformations can be described and analyzed mathematically.

Students are developing their verbal and written communication skills in order to compose proofs for geometric theorems. Students took a pre-assessment, and the teacher reviewed the results to provide questions that will help them refine their solutions throughout their upcoming lessons. Today's lesson requires students to engage in deep mathematical thinking by strategizing and collaborating with their peers. ***(Plans lessons that incorporate critical-thinking and problem-solving skills.)***
The teacher presents the learning targets: (1) understand the concept of length and area, and (2) construct examples and counterexamples to help justify or refute conjectures. She also refers to the Mathematical Practices

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highlighted in the day's lesson: MP2: Reason abstractly and quantitatively, and MP3: Construct viable arguments and critique the reasoning of others.

The teacher then poses a conjecture about whether equal areas are formed by the diagonals of a quadrilateral. Students develop their thoughts on whether the statement is always, sometimes, or never true. ***(Uses questioning strategies to develop students' critical-thinking and problem-solving skills. Uses wait time to encourage student responses.)*** Once students have had time to develop and share their thoughts with a partner, the teacher brings the class together to discuss which quadrilaterals the students have worked with, their results, and their chosen methods for proving the conjecture. The students explain their ideas to each other using prompts, such as, "Josh thinks this statement is sometimes true. Susan why do you think John thinks this?" ***(Establishes expectations at a level that challenges students.)***

Note: This lesson and others are available on the Mathematics Assessment Project Website at http://map.mathshell.org/materials/lessons.php?taskid=212&subpage=concept. Where indicated throughout the site, materials are free to use and have been released under the Creative Commons Attribution.

Planning/Coaching Questions

- How do you establish expectations at a level that challenges all students?
- How do you model critical-thinking and problem-solving skills to students?
- How do you provide opportunities for students to apply critical-thinking and problem-solving skills?
- How do you ensure the questions I ask are challenging for all students?
- How do you plan for the scaffolding of questions?
- How do you ensure all students are provided appropriate wait time?

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