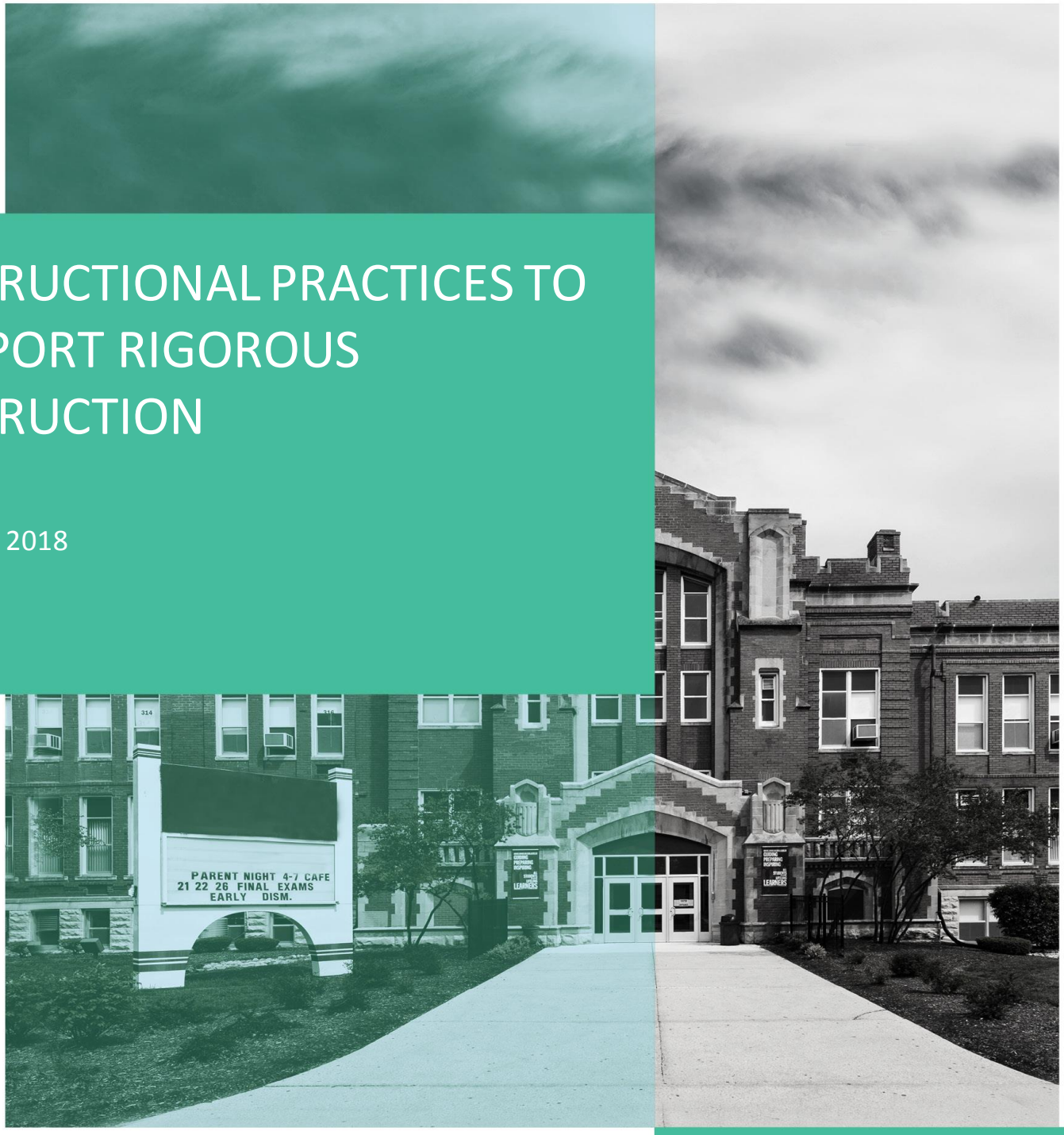
INSTRUCTIONAL PRACTICES TO SUPPORT RIGOROUS INSTRUCTION

January 2018



In the following report, Hanover Research (Hanover) explores best practices in core instruction to promote rigorous instruction. Specifically, Hanover reviews teacher clarity, vocabulary development, meta-cognition, problem-based learning, and student goal setting and reflection. Hanover also discusses the types of professional development districts can provide to support teachers in implementing these instructional practices.

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SECTION III: META-COGNITION

In this section, Hanover discusses how teachers can promote meta-cognitive skills and the impacts of this instructional practice on students.

INSTRUCTIONAL PRACTICES

Higher order thinking (HOT) refers to a collection of related skills and abilities that go beyond rote memorization and recall of facts, which is sometimes referred to as "lower order thinking." Lower order thinking is characterized by its simplicity, transparency, and certainty.[39] However, while lower order thinking suffices for solving problems that people have already encountered, HOT skills become necessary when tackling unfamiliar challenges and dilemmas. By building upon prior content knowledge and experiences, people rely on HOT skills to develop non-obvious solutions to complex problems.[40]

At the middle school level, a focus on HOT is particularly important. The fast pace of adolescent brain development means that students are rapidly developing the skills associated with abstract thinking, complex problem solving, and long-term planning. In particular, maturation of the prefrontal cortex indicates that adolescents are well equipped to exercise the decision-making areas of their brain.[41] Middle school students often demonstrate a "heightened interest in causes and justice," which educators can leverage to help students apply, analyze, and evaluate core content knowledge in ways that they find new and engaging.[42]

Meta-cognition is one type of HOT skill. John Hattie's meta-analysis of factors that influence student learning[43] found that meta-cognitive strategies had a 0.69 effect size,[44] which means that students show more than one year of growth over one school year when teachers incorporate meta-cognitive strategies. Broadly defined, meta-cognition refers to how students understand their own processes for thinking about and interpreting new concepts or information.[45] Thus, meta-cognition is a type of "higher-order thinking which involves active control over the cognitive process engaged in learning"[46] and is recognized as an important skill for postsecondary readiness.[47] Students with strong skills in meta-cognition

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[39] "Teaching Higher-Order Thinking." Teaching as Leadership. p. 54. http://teachingasleadership.org/sites/default/files/Related-Readings/LT_Ch5_2011.pdf

[40] King, F.G., L. Goodson, and F. Rohani. "Higher Order Thinking Skills." Center for Advancement of Learning and Assessment. p. 1. http://www.cala.fsu.edu/files/higher_order_thinking_skills.pdf

[41] Wilson, L.M. and H.W. Horch. "Implications of Brain Research for Teaching Young Adolescents." *Middle School Journal*, 34:1, 2002. pp. 57–61. Retrieved from EBSCOhost.

[42] "Ask Ms. DeBose About Teaching the Middle Grades." U.S. Department of Education Official Blog, March 23, 2012. https://blog.ed.gov/2012/03/ask-ms-debose-about-teaching-the-middle-grades/

[43] "About This Website," Op. cit.

[44] Hattie, J. *Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement*. Routledge, 2008. p. 188.

[45] Hattie, *Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement*, Op. cit., p. 188.

[46] Ibid.

[47] Soland, J., L.S. Hamilton, and B.M. Stecher. "Measuring 21st Century Competencies: Guidance for Educators." Asia Society and RAND Corporation, November 2013. pp. 3–8. http://asiasociety.org/files/gcen-measuring21cskills.pdf

can recognize how to approach a given task and monitor their progress towards task completion, remaining self-reflective throughout the process and receptive to feedback.[48] In total, there are three types of meta-cognitive knowledge:[49]

- **Strategic Knowledge**: Strategic Knowledge is knowledge of general strategies for learning, thinking, and problem solving. These strategies are applicable across all or most academic disciplines.
- **Knowledge About Cognitive Tasks**: Knowledge of tasks includes knowledge that different tasks can be more or less difficult and may require different cognitive strategies.
- **Self-Knowledge**: Self-Knowledge includes knowledge of one's own strengths and weaknesses. For example, a student who knows that he or she generally does better on multiple-choice tests than on essay tests has some metacognitive self-knowledge about his or her test-taking ability.

The remainder of this subsection reviews strategies teachers can use to promote meta-cognitive skills in their students. This review is not exhaustive; however, the strategies included represent some of the major practices researchers and practitioners recommend for effective instruction.

STRATEGY INSTRUCTION

Strategy instruction focuses on practices for accomplishing a task. In a review of research, researchers describe three "levels" of strategy instruction.[50] ***Cognitive strategies*** are those learners use to comprehend or complete academic or social tasks, such as underlining text or questioning, for example. These strategies are what enable learning to occur. ***Problem-solving strategies*** center on techniques that may be used to overcome challenges to learning, such as the use of the predict–observe–explain technique to increase comprehension. Problem-solving strategies are more advanced than cognitive strategies and are implemented to increase understanding. Finally, ***critical thinking strategies*** "involve gathering, analyzing, evaluating, and integrating information for the purpose of drawing a conclusion."[51] In his meta-analysis, Hattie discusses the importance of study skills for meta-cognitive learning, many of which overlap with strategies for increasing understanding and achievement.[52] While there are many different instructional techniques to help students organize, manage,

[48] Ibid.

[49] Bullet points were taken verbatim from Pintrich, P.R. "The Role of Metacognitive Knowledge in Learning, Teaching, and Assessing." *Theory into Practice*, 41:4, 2002. pp. 220–221. http://cmapspublic2.ihmc.us/rid=1JTPTQ9XB-1142BSK-17N3/A01-004.pdf

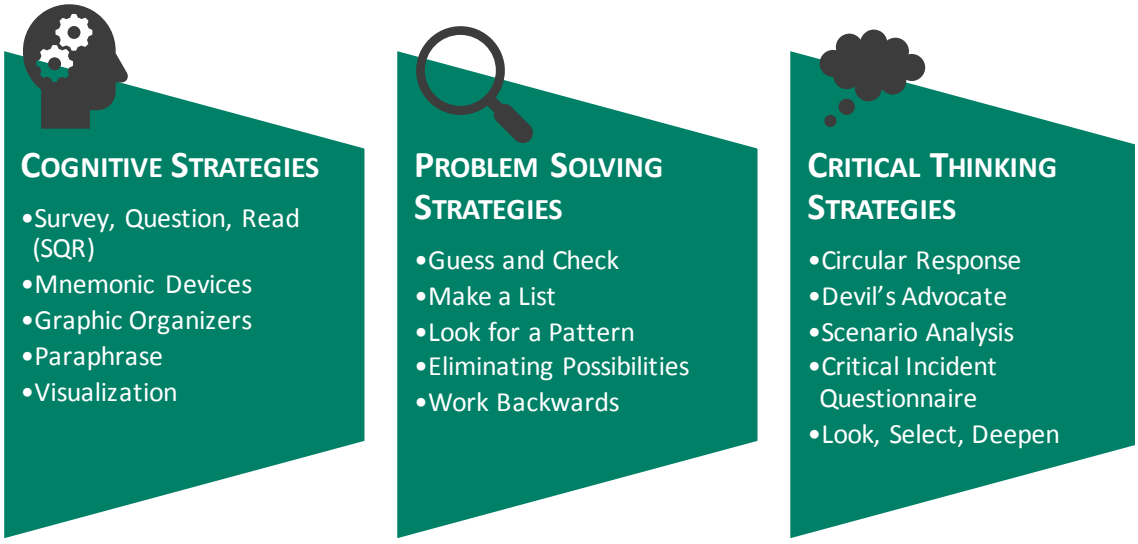
[50] Schraw, G., K. Crippen, and K. Hartley. "Promoting Self-Regulation in Science Education: Metacognition as Part of a Broader Perspective on Learning." *Research in Science Education*, 36, 2006. pp. 121–122. https://www.researchgate.net/profile/Kent_Crippen/publication/225234905_Promoting_Self-Regulation_in_Science_Education_Metacognition_as_Part_of_a_Broader_Perspective_on_Learning/links/0c960535004739c6ce000000.pdf

[51] Ibid.

[52] Italicized text embedded in Hattie, *Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement*, Op. cit., p. 191.

monitor, and evaluate their learning, Figure 3.1 provides several key examples in the areas of cognitive, problem solving, and critical thinking instruction.

Figure 3.1: Examples of Strategy Instruction



Source: Florida Department of Education and Academic Exchange Quarterly[53]

INQUIRY-BASED LEARNING AND SELF-QUESTIONING

Inquiry-based learning instructional strategies are those that prompt students to pose questions to themselves about what they have yet to learn or expect to learn.[54] "Inquiry learning is the process of students being engaged in learning in which they pose questions and construct solutions; that is, they construct conceptual understanding as the goal of the learning experience."[55] By asking students to develop questions prior to and as they learn course material, students have the opportunity to become more engaged in the learning process. This practice also encourages students to be self-reflective as they monitor the extent to which their questions are addressed.[56] Rather than providing students with direct instructions, students are asked to create their own content-focused questions, which are then used to guide their understanding.[57]

Figure 3.2 on the following page is reproduced in part from an article focused on science teaching, in which inquiry-based learning is considered critical, and displays a sample of the types of questions that a teacher may use to encourage student questioning. These questions

[53] [1] Cognitive and problem solving strategies were adapted from "Classroom Cognitive and Meta-Cognitive Strategies for Teachers." Florida Department of Education, 2009. http://floridarti.usf.edu/resources/topic/academic_support/kops/class_strategies.pdf
[2] Critical thinking strategies were adapted from Sereni-Massinger, C. and N. Wood. "Teaching Strategies for Critical Thinking Skills." *Academic Exchange Quarterly*, 19:3, 2016. http://rapidintellect.com/AEQweb/5637z5.pdf

[54] Schraw, Crippen, and Hartley, Op. cit., p. 117.

[55] Ibid., pp. 117–118.

[56] Ibid., p. 118.

[57] "Inquiry-Based Teaching." Center for Inspired Teaching, Issue Brief, 2008. http://inspiredteaching.org/wp-content/uploads/impact-research-briefs-inquiry-based-teaching.pdf

are sorted into three categories: those centered on planning, monitoring, and evaluating. See **Appendix A** for the complete table.

Figure 3.2: Sample Self-Questions to Promote Meta-Cognition During a Class Session

STAGE	QUESTIONS
Planning	▪ What are the goals of the class session going to be? ▪ What do I already know about this topic? ▪ How could I best prepare for the class session? ▪ Where should I sit and what should I be doing (or not doing) to best support my learning during class? ▪ What questions do I already have about this topic that I want to find out more about?
Monitoring	▪ What insights am I having as I experience this class session? What confusions? ▪ What questions are arising for me during the class session? Am I writing them down somewhere? ▪ Do I find this interesting? How could I make this material personally relevant? ▪ Can I distinguish important information from details? If not, how will I figure this out?
Evaluating	▪ What was today's class session about? ▪ What did I hear today that is in conflict with my prior understanding? ▪ How did the ideas of today's class session relate to previous class sessions? ▪ What do I need to actively go and do now to get my questions answered and my confusions clarified? ▪ What did I find most interesting about class today?

Source: CBE—Life Sciences Education[58]

COLLABORATION AND THINK ALOUD

Although collaboration "of all forms is increasingly seen as an essential and important part of education," collaboration among students is critical for advancing students' skills in meta-cognition.[59] Teachers may use collaborative practice to encourage inquiry-based learning, the sharing of ideas and thoughts among multiple students and a teacher, and making explicit personal beliefs or perspectives.[60] In fact, cooperative learning groups and think aloud instruction are some of the most common forms of collaborative support for meta-cognition.[61] Indeed, research links these instructional approaches with greater meta-cognition, especially when students form questions together and are provided with more in-depth instruction for how to work in these small group settings.[62]

[58] Figure reproduced in part from Tanner, K.D. "Promoting Student Metacognition." *CBE - Life Sciences Education*, 11:2, June 4, 2012. p. 115. http://www.lifescied.org/content/11/2/113.full.pdf+html
[59] Schraw, Crippen, and Hartley, Op. cit., p. 120.
[60] Ibid.
[61] Ibid.
[62] Ibid., pp. 120–121.

Think aloud instruction—like modeling—requires teachers to demonstrate their thinking by articulating their thoughts about a given topic, question, or problem.[63] This instructional strategy is particularly appropriate for middle and high school students.[64] As discussed by the Centre for Innovation and Excellence in Learning (CIEL), "[a]nytime you can talk out loud ('think aloud') about how you view a document or a picture or think about a book, or share your thinking processes with students[,] you are helping them become more metacognitive in their own approaches to the subject."[65] As teachers think aloud, they should aim to demonstrate: ***1)*** how they begin to approach a question or problem, ***2)*** how they decide what steps to take next to solve the challenge, ***3)*** how they check their work, and ***4)*** how they know when they have reached understanding.[66] Using resources provided by CIEL, Figure 3.3 demonstrates this approach.

Figure 3.3: Example of Think Aloud and Collaborative Instruction

Once you have modeled for them how you would solve a problem or interpret a piece of writing, have students work in pairs to talk out loud as to how they are thinking about an assignment piece of homework or an assignment.

1) One student talks out loud while the partner records what they are saying (the strategy going to be used to complete the homework or do the assignment). The partner also guides them to think through all the steps.

2) Students switch roles and do the same for each other.

3) Now students have thought out the process for completing the assignment or homework, received some feedback from their partner and possibly have a plan written down as to how they are going to undertake the task. Debrief briefly with class as to lessons learned.

Source: Centre for Innovation and Excellence in Learning[67]

[63] "Ten Metacognitive Teaching Strategies." Centre for Innovation and Excellence in Learning. https://ciel.viu.ca/teaching-learning-pedagogy/designing-your-course/how-learning-works/ten-metacognitive-teaching-strategies

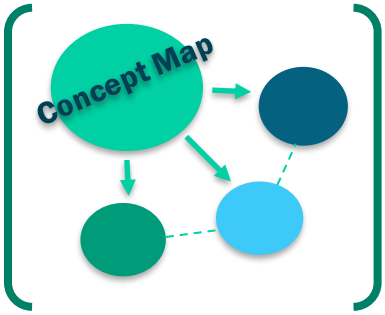
[64] Armstrong, T. "6 Metacognitive Strategies for Middle and High School Classrooms." American Institute for Learning and Human Development, February 7, 2017. http://www.institute4learning.com/2017/02/07/6-metacognitive-strategies-for-middle-and-high-school-classrooms/

[65] "Ten Metacognitive Teaching Strategies," Op. cit.

[66] Chick, N. "Metacognition." Vanderbilt University Center for Teaching. https://wp0.vanderbilt.edu/cft/guides-sub-pages/metacognition/

[67] Figure contents were taken verbatim from "Ten Metacognitive Teaching Strategies," Op. cit.

CONCEPT MAPPING



Having students develop concept maps is another effective instructional practice that helps students synthesize information and define relationships between concepts, enabling them to reflect on their learning as they piece together information. This instructional approach is effective for promoting meta-cognitive skills in middle and high school students.[68] Concept maps are made up of an arrangement of concepts presented in illustrations where lines symbolize relationships between concepts or other phenomena.[69] Thus, concept maps act as tools that organize and represent knowledge through the ordering of relationships. Often, they are hierarchical, in which overarching concepts are included at the top of the map. More specific concepts are then drawn below.[70] Students may use a focus question to begin constructing their hierarchical concept map and conceptual subcomponents. Cross-links, or relationships between different segments of concepts, enable students to see "how ideas in different domains are related."[71]

Overall, concept maps can be altered, expanded, and referred to throughout the duration of a class or topical area.[72] Students can also work alone or in groups to continually share and expand on their concept maps. CIEL recommends taking the three-step approach presented in Figure 3.4 when instructing students to create concept maps.

Figure 3.4: Developing Concept Maps

Source: Centre for Innovation and Excellence in Learning[73]

IMPACT ON STUDENTS

Hattie estimated meta-cognitive instruction to have a 0.69 effect size on students' academic achievement. In total, Hattie reviewed two meta-analyses with an explicit focus on meta-cognitive strategies, both of which, however, were published prior to the start of the 21st century. Hattie also assessed 14 additional meta-analyses on study skills and another three that examined the effects of self-verbalization and self-questioning, many of which include more recent dates of publication. With a broad range of analytic strategies spanning these

[68] Armstrong, Op. cit.
[69] "Using Concept Maps." Carnegie Mellon University Eberly Center for Teaching, Excellence, and Educational Innovation. https://www.cmu.edu/teaching/assessment/assesslearning/conceptmaps.html
[70] Ibid.
[71] Ibid.
[72] "Ten Metacognitive Teaching Strategies," Op. cit.
[73] Figure contents were taken verbatim from Ibid.

meta-analyses, the evidence overwhelmingly points towards the benefit of instruction in meta-cognition and self-regulation for learning.

With a broad range of analytic strategies spanning these meta-analyses, the evidence overwhelmingly points towards the benefit of instruction in meta-cognition and self-regulation for learning.

Research on meta-cognitive strategies has flourished in recent years. In 2004, researchers Veenman, Wilhelm, and Beishuizen applied a developmental perspective to meta-cognition, exploring its relationship with intelligence, metacognitive skillfulness, and learning performance among students in Grades 4, 6, and 8 as well as those enrolled in college. The authors found that metacognitive skillfulness applies to students across these grade levels rather than in domain-specific content areas[74] and that it plays a definitive role in predicting learning performance as measured by student responses to standardized questions.[75] In fact, meta-cognitive skillfulness accounted for 14 percent of the variance in learning performance separate from that of intelligence. Though, intelligence did mediate the development of meta-cognitive skills.[76] Regardless, Veenman, Wilhelm, and Beishuizen concluded that metacognitive skill development plays an important role as students learn and intellectually develop over time.[77] Indeed, in a more recent literature review on meta-cognitive skills, author Pintrich writes that "[m]eta-cognitive knowledge can play an important role in student learning and, by implication, in the ways students are taught and assessed in the classroom."[78]

More specific to meta-cognitive teaching strategies for student learning, Ellis, Bond, and Denton wrote a literature review in 2012 on the effects of these strategies for primary and secondary students. The central aim of this literature was to identify the instructional approaches that best enhance meta-cognitive skill development among students across grade levels. In total, the authors explored 13 studies on K-12 student populations that evaluated the impact of meta-cognitive strategies in classroom settings using an experimental or quasi-experimental design.[79] After analyzing these studies, Ellis, Bond, and Denton first recognized five key features of the learning environment for building stronger meta-cognitive skills: engaging curriculum, assessment integration, consistent practice, explicit strategy instruction, and verbalizing.[80]

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[74] Veenman, M.V.J., P. Wilhelm, and J.J. Beishuizen. "The Relation between Intellectual and Metacognitive Skills from a Developmental Perspective." *Learning & Instruction*, 14:1, February 2004. p. 103. http://www4.ncsu.edu/~jlnietfe/Metacog_Artides_files/Veenman,%20Wilhelm,%20%26%20Beishuizen%20%282004%29.pdf

[75] Ibid., p. 104.

[76] Ibid.

[77] Ibid., pp. 103–106.

[78] Pintrich, Op. cit., p. 222.

[79] Ellis, A.K., J.B. Bond, and D.W. Denton. "An Analytical Literature Review of the Effects of Metacognitive Teaching Strategies in Primary and Secondary Student Populations." *Asia Pacific Journal of Educational Development*, 1:1, 2012. p. 11. https://www.naer.edu.tw/ezfiles/0/1000/img/72/42-An_Analytical_Literature_Review_of_the_Effects_of_Metacognitive_Teaching_Strategies.pdf

[80] Ibid., pp. 12–13.

Given these general practices for creating classroom environments conducive to meta-cognitive skill development, Ellis, Bond, and Denton then identified more explicit instructional methods that supporting meta-cognitive learning in the form of planning, monitoring, and evaluating. The authors discovered that modeling was the most common practice for enhancing meta-cognition, followed by diagramming and practice. Mnemonics, answer checking, checklist, and goal attainment were less frequently used. [81] A follow-up study by the same authors published in 2014 confirmed these findings and the effectiveness of these strategies for student learning.[82]

[81] Ibid., p. 17.
[82] Ellis, A.K., D.W. Denton, and J.B. Bond. "An Analysis of Research on Metacognitive Teaching Strategies." *Procedia - Social and Behavioral Sciences*, 116, February 2014. https://core.ac.uk/download/pdf/82653329.pdf

APPENDIX A: PROMOTING META-COGNITIVE SKILLS IN STUDENTS

This Appendix presents prompts and questions that teachers can use to promote meta-cognitive skills in their students.

Figure A.1: Sample Prompts for Integrating Meta-Cognition into Course Activities

PAIR DISCUSSION AFTER A CLICKER QUESTION	ACTIVE-LEARNING TASKS AND/OR HOMEWORK ASSIGNMENTS (E.G., CASE STUDIES, CONCEPT MAPS, PROBLEM SETS)	PREPARATION FOR QUIZZES OR EXAMS
▪ Share how you thought about what the question was asking. ▪ Share the process you used to arrive at an answer you wanted to choose. ▪ What was your main reason for choosing your answer, and what were the main reasons you did not choose each of the other answers? ▪ How did your ideas compare with your neighbor's ideas? ▪ What was most confusing to you about this question? ▪ How confident are you in your answer? Why? What else would you need to know to increase your confidence?	▪ Pose three questions that you had about the concepts you explored in your assignment that you still cannot answer. ▪ Describe at least two ideas related to this assignment that you found confusing. ▪ "I learned a lot in doing this assignment." To what extent do you agree? disagree? ▪ How was the way you approached completing this assignment different compared with the last time we had an assignment like this? ▪ What advice would you give yourself based on what you know now if you were starting this assignment all over again?	▪ How do you plan on preparing for the upcoming exam? Why? ▪ What resources are available to support you? How will you make sure to use these? How does your strategy for exam preparation compare with at least three colleagues in your lab section? (Go ask them!) ▪ What concepts have you found most confusing so far? What concepts have been most clear? Given that, how should you spend your study time in preparing for the exam? ▪ Based on your performance on the first exam, write a letter to yourself with advice about preparing for the next exam.

Source: CBE—Life Science Education[165]

[165] Figure contents were taken verbatim from Tanner, Op. cit., p. 117.

Figure A.2: Sample Self-Questions to Promote Student Meta-Cognition About Learning

ACTIVITY	PLANNING	MONITORING	EVALUATING
Class session	▪ What are the goals of the class session going to be? ▪ What do I already know about this topic? ▪ How could I best prepare for the class session? ▪ Where should I sit and what should I be doing (or not doing) to best support my learning during class? ▪ What questions do I already have about this topic that I want to find out more about?	▪ What insights am I having as I experience this class session? What confusions? ▪ What questions are arising for me during the class session? Am I writing them down somewhere? ▪ Do I find this interesting? Why or why not? How could I make this material personally relevant? ▪ Can I distinguish important information from details? If not, how will I figure this out?	▪ What was today's class session about? ▪ What did I hear today that is in conflict with my prior understanding? ▪ How did the ideas of today's class session relate to previous class sessions? ▪ What do I need to actively go and do now to get my questions answered and my confusions clarified? ▪ What did I find most interesting about class today?
Active-learning task and/or homework assignment	▪ What is the instructor's goal in having me do this task? ▪ What are all the things I need to do to successfully accomplish this task? ▪ What resources do I need to complete the task? How will I make sure I have them? ▪ How much time do I need to complete the task? ▪ If I have done something like this before, how could I do a better job this time?	▪ What strategies am I using that are working well or not working well to help me learn? ▪ What other resources could I be using to complete this task? What action should I take to get these? ▪ What is most challenging for me about this task? Most confusing? ▪ What could I do differently mid-assignment to address these challenges and confusions?	▪ To what extent did I successfully accomplish the goals of the task? ▪ To what extent did I use resources available to me? ▪ If I were the instructor, what would I identify as strengths of my work and flaws in my work? ▪ When I do an assignment or task like this again, what do I want to remember to do differently? What worked well for me that I should use next time?

ACTIVITY	PLANNING	MONITORING	EVALUATING
Quiz or exam	▪ What strategies will I use to study (e.g., study groups, problem sets, evaluating text figures, challenging myself with practice quizzes, and/or going to office hours and review sessions)? ▪ How much time do I plan on studying? Over what period of time and for how long each time I sit down do I need to study? ▪ Which aspects of the course material should I spend more or less time on, based on my current understanding?	▪ To what extent am I being systematic in my studying of all the material for the exam? ▪ To what extent am I taking advantage of all the learning supports available to me? ▪ Am I struggling with my motivation to study? If so, do I remember why I am taking this course? ▪ Which of my confusions have I clarified? How was I able to get them clarified? ▪ Which confusions remain and how am I going to get them clarified?	▪ What about my exam preparation worked well that I should remember to do next time? ▪ What did not work so well that I should not do next time or that I should change? ▪ What questions did I not answer correctly? Why? How did my answer compare with the suggested correct answer? ▪ What questions did I not answer correctly? Why? What confusions do I have that I still need to clarify?
Overall course	▪ Why is it important to learn the material in this course? ▪ How does success in this course relate to my career goals? ▪ How am I going to actively monitor my learning in this course? ▪ What do I most want to learn in this course? ▪ What do I want to be able to do by the end of this course?	▪ In what ways is the teaching in this course supportive of my learning? How could I maximize this? ▪ In what ways is the teaching in this course not supportive of my learning? How could I compensate for or change this? ▪ How interested am I in this course? How confident am I in my learning? What could I do to increase my interest and confidence?	▪ What will I still remember 5 yrs from now that I learned in this course? ▪ What advice would I give a friend about how to learn the most in this course? ▪ If I were to teach this course, how would I change it? ▪ What have I learned about how I learn in this course that I could use in my future biology/science courses? In my career?

Source: CBE—Life Science Education[166]

[166] Figure contents were taken verbatim from Ibid., p. 115.

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