Product Research

ThinkUp!™ SCIENCE

Supporting documentation for the development of

TEKS Mastery Series Flip Chart for Science

TEKS Mastery Series Flip Chart for Science

While the federal law Every Student Succeeds Act (ESSA) continues to hold states accountable for academic success, it empowers each state to develop its own accountability plan with continuous improvement as the central focus. To fully prepare students in Texas for success in college, in the workplace, and life in the 21stcentury, rigorous academic standards were developed. These standards place a focus on improving student achievement and go beyond fundamental knowledge and skills. The Texas Essential Knowledge and Skills (TEKS) promote increased accountability in education. Educators may examine the Standards for Mathematics to improve the *what* and *how* of instruction. While these standards identify what students are to know and be able to do, the how decision remains with individual districts, schools, and teachers. Schools in Texas must align standards, instruction, and assessments with 21st century skills. Furthermore, students must learn how to apply these skills in the context of the real world. Research indicates that students understand and retain more when learning is relevant, engaging, and meaningful to students' lives. Instruction that focuses on the TEKS demonstrates rigor and relevance in today's classrooms.

The TEKS Mastery Series Flip Charts™ were developed specifically around the Streamlined Science Texas Essential Knowledge and Skills for Texas (TEA, 2017). The flip charts serve as resources to support teachers in the implementation of science education. The Science Product Development Team consulted the standards and engaged in collaborative discussions prior to and during the creation of these relevant mathematics tools. These educator tools are resources for 1-6 grades that will help teachers of science acquire a clear understanding of the expectations of the Texas Essential Knowledge and Skills as they design engaging learning activities, vocabulary instruction, assessment opportunities, and interventions in addition to what is provided. These resources will also assist teachers in identifying misconceptions, preconceptions, or misunderstandings in science that could possibly impede the improvement efforts of students or even teachers as they plan appropriate instruction and engage in scientific conversations with students. Prompts to address *The 9 Traits of Critical Thinking™,* ideas for formative assessment, and questioning prompts for designing questions that elicit different types of thinking are offered to enable teachers to choose how to integrate these components into engaging and motivating lessons. The TEKS Mastery Series Flip Charts are created for flexible usage, allowing teachers to determine the standard(s) they wish to address after accessing their district's scope and sequence. These valuable tools guide teachers as they present students with multiple and varied opportunities to think critically, to engage in scientific practices, to analyze and interpret data, and to participate in learning activities.

Students' science achievement, however, is ultimately determined and limited by the opportunities they have had to learn. Students must engage in a variety of opportunities to achieve mastery of the Texas Essential Knowledge and Skills. Only then will they be prepared to have their science content and processes measured by local and state assessments. With the passing of Every Student Succeeds Act (ESSA), this federal law requires that academic assessments for "math and reading or language arts be administered annually in grades 3-8 and at least once in grades 9-12; science tests not less than once during grades 3-5, 6-9, and 10-12" (Mandlawitz, 2016, p.1). The critical issue of accountability will continue with ESSA, with assessments being used to help improve schools and inform instruction. The law allows the state and local levels the opportunity to create systems for accountability, resources, interventions and teacher evaluation systems. The federal requirements of Every Student Succeeds Act mandate that all students participate in the state assessment program. Therefore, the flip charts guide the teacher in planning high-quality science instruction aligned with the standards so timely student information can be readily and continuously gathered in order to maintain accountability for academic achievement standards in science.

Project 2061 (AAAS,1989; 1993), comprised of science, mathematics, and technology experts, played an eminent role in helping this nation reach consensus of what literacy is in science and in determining what students need in order to be successful now and in the future. Two reports surfaced as a result of Project 2061, *Science for All Americans* (AAAS, 1990) and *Benchmarks for Science Literacy* (AAAS, 1993). *Science for All Americans* imparts information on effective learning and teaching. Not only is science literacy defined, but it serves as a reference for teachers who may have deficits and need to acquire knowledge of science, mathematics, and technology. Many implications can be taken from the Project 2061 report *Science for All Americans*. Application of the following statement can strengthen science programs on any campus. "Educators should build on the experiences that students bring to class; help them articulate what conceptions they already have of the natural world; and provide them with real-life, structured experiences where students can rethink or even restructure their conceptions in the face of new evidence and new explanatory ideas."

The report *Benchmarks for Science Literacy* identifies sequences of basic goals that will help students achieve the science literacy goals identified in *Science for All Americans.* More specifically, this report states what students should know and be able to do at the end of grades 2, 5, 8, and 12 in science, mathematics, and technology. Teachers can also use this report to determine what to include in core science curricula, when to teach it, and why. In conclusion, information from these reports will enable teachers in elementary, middle, and high school to advance in science literacy and assist students' progress in the development of science literacy.

Both *Science for All Americans* and *Benchmarks for Science Literacy* have influenced the development of TEKS Mastery Series Flip Charts for Science™. This educator resource places emphasis on developing science literacy with time to observe, explore, test ideas, construct models, think, and ask questions. As a result, exploration, questioning, critical thinking, and scientific reasoning are emphasized in the flip charts rather than placing importance on "the" answers and memorization of general facts.

While experts determine what constitutes science literacy, still others offer recommendations for the types of instructional experiences that help students understand what they are learning. Based on the report from the National Research Council (2007), *Taking Science to School: Learning and Teaching Science in Grades K-8*, a book was authored. This book utilized the research implications as case studies are shared, forming a basis for providing rigorous, engaging tasks in classrooms. In *Ready, Set, Science!,* Michaels, Shouse, and Schweingruber (2007) translated a synthesis of research into teaching and learning experiences relative to students in kindergarten through eighth grades. Four strands of science learning are adapted from this source: Understanding Scientific Explanations, Generating Scientific Evidence, Reflecting on Scientific Knowledge, and Participating Productively in Science. Science practitioners can defer to this source to plan productive discussions, design tasks, manage classrooms, and make learning visible for diverse learners as they stay on course to help students progress in science literacy. The TEKS Mastery Series Flip Charts for Science, TEKS aligned resources, are evidence of how the implications of research can be incorporated into productive learning experiences.

Based on previous findings, the Committee on Conceptual Framework for the New K-12 Science Education Standards (National Research Council, 2012) recognizes the need for a framework that directly identifies a broad set of science expectations for students. This committee notes the need for an organizational framework that spans multiple years of school and results in students developing scientific habits of mind, focusing on depth of issues, and resulting in life-long learners who can face future challenges of society. The document, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas,* defines a structure for the improvement of K-12 science education (NRC, 2012). There are numerous statements that offer guidance for science literacy to science practitioners. One statement is, "The theories, models, instruments, and methods for collecting and displaying data, as well as the norms for building arguments from evidence, are developed collectively in a vast network of scientists working together over an extended period" (NRC, 2012, p. 27). Getting Started, Building Mastery, Extension, Critical Thinking Focus, and Assessment comprise some of the features of the TEKS Mastery Series Flip Charts for Science that complement the direction offered by the committee's statement.

Science opens new avenues for exploration and offers students lifelong enrichment opportunities. Every school is responsible for science education, and for engaging students in science practices that deepen their understanding of the core ideas. Students should be provided opportunities to carry out scientific investigations and to gain knowledge of science practices, concepts, and core ideas. If students are to engage in discussions on science related issues, learn to be critical consumers in their everyday lives, and continue to learn about science throughout their lives, then they need a relevant and well-designed science learning curriculum with appropriate instructional resources.

Student data from the Spring 2016 STAAR® Science Summary Report (TEA, 2016) demonstrate a range of scores for students in grades five and eight. The total fifth grade students tested were 363,919. For the category Matter and Energy, fifth graders answered 70% of items correctly or an average of 5.6 items out of 8; for Force, Motion, and Energy category, fifth graders answered 70% of items correctly or an average of 7.0 items out of 10; for Earth and Space, fifth graders answered 68% of items correctly or an average of 8.1 items out of 12; and for Organisms and Environments, fifth graders answered 71% of items correctly or an average of 9.9 items out of 14. The total eighth grade students tested were 352, 976. For the category Matter and Energy, eighth graders answered 69% of items correctly or an average of 9.6 items out of 14; for Force, Motion, and Energy category, eighth graders answered 63% of items correctly or an average of 7.5 items out of 12; for Earth and Space, eighth graders answered 66% of items correctly or an average of 9.3 items out of 14; and for Organisms and Environments, eighth graders answered 68% of items correctly or an average of 9.6 items out of 14.

Several reasons might account for the lower range results. The following reasons indicate most likely why students answered in the lower range: Dual-coded items per assessment has increased in number and higher levels of thinking for the assessed Scientific Investigations and Reasoning skills have been included in the STAAR assessments. Also, students must understand how hands-on opportunities from the classroom apply to assessment items. As evidenced by these results, there appears to be a need for quality resources that support the implementation of science content, investigation and reasoning skills through hands-on investigations, and shows a strong potential for improving outcomes for students no matter the level of student understanding.

The TEKS Mastery Series Flip Charts provide an essential framework that offers all students exposure to instructional activities for content and process standards that encourage deep thinking, and offer opportunities to make connections to the real world, highlight a variety of levels of questions so that students must think more critically and inferentially about a variety of scientific applications as well as about using context to interpret vocabulary and determine word meaning. Teachers are offered instructional support in the form of formative assessment, intervention, and extending student thinking opportunities through the featured content of the flip charts. Thus, the resource TEKS Mastery Series Flip Charts are designed to offer teachers quality support for increasing student performance and teacher instruction in science.

Student success hinges on teacher practice. One important function of formative assessment is to inform instruction. Rice (2003) states that teacher quality weighs heavily on student achievement. Research shows that the expectations held by teachers have a profound effect and a powerful influence on student learning. Formative assessment will help teachers make more targeted adjustments and increase responsive adjustments and interventions based on student needs. A panel is dedicated to formative assessment in the TEKS Mastery Series Flip Charts. Suggestions are shared to encourage teachers to utilize formative assessment and to offer formative feedback to students. According to (Black et al., 2013) formative assessment contributes to achievement of standards and intervention support. The incorporation of formative assessment is essential because it improves teaching and learning. Several researchers indicate the difference that can be made when formative assessment is embedded into instruction (Darling-Hammond, 2004; Marzano, 2003, 2006; Shepard, 2000; Heritage, 2007).

Vocabulary plays a significant role in comprehension. An extensive review of research indicates effective vocabulary instruction allows for both incidental and planned experiences (National Reading Panel, 2000). The notion that students will learn the necessary vocabulary by chance is merely an assumption. A word that is not part of a student's oral vocabulary causes difficulty in grasping the meaning of what the student is reading. All students need and benefit from direct vocabulary instruction (Gunning, 2003; Vacca et al., 2003). A variety of strategies for acquiring new vocabulary and extending the depth of vocabulary learning should be employed. Encountering the vocabulary frequently to deepen the meaning is a finding upheld by Beck, McKeown and Kucan (2002) and Nagy (2005). The Vocabulary Mastery activities included with each standard develop or reinforce essential vocabulary. A separate panel for glossary support is included in the TEKS Mastery Series Flip Charts so that teachers can guide students to build the academic background knowledge they need to fully understand mathematical content for the grade level specified on the flip chart.

Common errors or misunderstandings that children possess about science can have a serious impact on science achievement. When students have no idea that what they think they know is inaccurate, then they could possibly build on current incorrect understandings and affect their future learning. Students who are unaware of what they don't know can fail to grasp essential scientific concepts (*Fries-Gaither, J. 2008, March).*

It is crucial that teachers be aware of misunderstandings aligned with select science areas. Knowledge of possible perceptions and interpretations could explain how students learn science and how teachers can increase their effectiveness in teaching (Driver et al. 1996). Science teachers should help students make connections between accurate prior knowledge and newly introduced science concepts. The literature indicates that best practices show that meaningful learning only takes place when students are provided opportunities to: actively engage in learning, acknowledge the errors of their own misunderstandings, and explain the newly acquired information conceptually.

The science field has documented misconceptions for a wide array of topics or areas of study. Instructional best practices in science include uncovering misconceptions, probing student ideas to gain understanding, and using this information to inform and plan lessons. Several web sites are available to research misconceptions, including one known as *New York Science Teacher* (2018) and another site attributed Ohio State University that detailed *Common Misconceptions About Plants* (Fries-Gaither, 2009). In the past, science educators such as Keogh and Naylor (1997) declared that classroom climates conducive to inquiry compels teachers to address misconceptions as they form. Page Keely (2018) recommended the use of formative assessment to help teachers uncover possible student misconceptions. Her book *Uncovering Student Ideas in Science* contains numerous formative assessment tools to use to help teachers identify what students are thinking and adjust lessons to meet the learners' needs.

Lucariello and Naff (2018) attest that alternative conceptions (misconceptions) are a normal part of the learning process. Due to all ideas not identifying evidence to support concept development sometimes even teachers, not just students, have misconceptions of the material. Misunderstandings can cause barriers. According to Burgoon, Heddle, and Duran (2010), existing barriers prevent students from learning or grasping a concept or impede the progress of student knowledge. Lucariello and Naff (2018) report that strategies have been discovered that help students overcome misunderstandings and replace them with correct concepts or theories, although it isn't always easy to do. These researchers state that strategies like lectures, labs, reading texts are not always successful at overcoming student misconceptions. Eaton, Anderson, and Smith (1983) further assert that once students learn material incorrectly, it can prove challenging to overcome. They share that some studies have found it difficult to persuade students to discard a long-standing misconception and favor an accurate scientific explanation. Chi (2000) noted that the strategy *self-repair* be used to help students clear up misconceptions. If students participate in a process that requires them to offer their own explanations rather than that of others, then conceptual change is more likely. Asking students to pause, explain, and interpret text aloud while reading content aloud is a factor in preventing misunderstandings or addressing them as they surface before rippling through a course of study. Due to the significant impact misunderstandings can have on student achievement, the Science Product Development decided to address misunderstandings in the TEKS Mastery Series Flip Charts for Science.

Critical thinking skills are essential for students to succeed, not only in their school work but also in their life after graduation. There is a large emphasis on thinking in Mentoring Minds TEKS Mastery Series Flip Charts. For students to meet state content standards, they must be able to critically examine information. After graduation, the ability to think and adapt will stand them in good stead in college and in their careers. Albert Einstein stated that education "is not the learning of the facts, but the training of the mind to think" (as cited in Frank, 1947, p. 185). Similarly, Margaret Mead (n.d.) commented, "Children must be taught *how to think,* not what to think." Educators have an opportunity and a responsibility to equip students with the critical thinking skills that can help them organize their thinking and transfer what they have learned to new situations.

Critical thinking and problem-solving skills are identified as two key areas in preparing students for college and career readiness (MetLife, 2011; Achieve, 2015). Based on an examination of top-performing global educational systems, a key identifier of successful systems is rigor (Ripley, 2013). Schools have been criticized for not adequately preparing students for the level of rigor they will encounter in college (Achieve, 2006). In 2011, only 25% of high school graduates taking the ACT successfully passed all four of the ACT's College Readiness Benchmarks, and 28% of high school students did not pass any of them. ACT predictions have been confirmed: nearly one third of students entering post-secondary education take remedial courses in one or more subjects because they lack the skills to take standard credit-bearing courses (National Center for Education Statistics, 2011). Moreover, research into the success rates of college students and high school seniors has shown that students' level of critical thinking is predictive of their grades or cumulative college grade point average (Facione, 1990a, 1990b; Sternberg, 2008).

In terms of employment, an overwhelming percentage of employers (93%) have indicated that job candidates' capacity to think critically, communicate clearly, and solve complex problems is more important than their college major (Association of American Colleges and Universities, 2013). When asked in 2015 how American public high schools could do a better job of preparing students for the expectations of college and the working world, college instructors and employers emphasized the need for critical thinking and problem-solving skills. This is especially true today, where new knowledge is rapidly accelerating and information is instantly available. Students with critical thinking and problem-solving skills can interpret and evaluate what they read, see, and hear to effectively make the transition to college and career.

Educators, parents, and community members also agree that critical thinking and problem-solving skills are important skills for students. The findings of the Project Tomorrow (2014), a survey of district administrators, teachers, parents, and community members, show critical thinking and problem-solving skills as essential skills needed by students for future success. There is even a connection between critical thinking skills and success in life—

not just in college and the workplace. Research has found that adults who scored higher on critical thinking assessments reported fewer negative life events. Possessing critical thinking skills helped the participants make positive life choices (de Bruin, Parker & Fischoff, 2007). This is echoed by Nisbett (2016), who states, "Schools cannot claim to prepare students for life unless they help students learn to reason effectively and to make choices that will improve their lives and the lives of others" (p. 28).

In short, thinking skills can help equip students with the ability to navigate challenging life circumstances, economic changes, and complex political challenges. There are direct implications for educators in elementary and high schools. As educators design instruction, it is crucial to design curricula and assessment that emphasize authentic real-world problems, inquiry-based learning, and opportunities for students to apply what they know in meaningful ways (Stobaugh, 2013a; 2013b).

Promoting thinking is central to student learning as is noted by the critical thinking that is embedded throughout the TEKS Mastery Series Flip Charts. In education, a shift from a focus on content to an emphasis on thinking skills is apparent. Thinking must be integrated with content to make meaning and deepen learning. Costa and Kallick (2009, p. 5) state that the standards "suggest that successful instruction in skillful thinking should be done *while* teaching subject matter instead of *in addition to* teaching subject matter. Thinking and subject matter content are neither separate from nor in opposition to each other. The implication is that a student cannot demonstrate mastery of any of these required standards without performing one or more important thinking skills." Thus, the TEKS Mastery Series Flip Charts promote deeper learning, encouraging students to share evidence or reasoning for solutions, rather than simply providing facts or a single answer.

Multiple classroom examples and tools exist to support teachers. As educators conceptualize critical thinking, there are a few frameworks that define the various levels of critical thinking. In 1956, Benjamin Bloom in his book *Taxonomy of Educational Objectives* proposed a thinking taxonomy that is still used by teachers as an established hierarchy of critical thinking skills. Recognizing the existence of different levels of thinking behaviors important to learning, Benjamin Bloom and his colleagues developed Bloom's Taxonomy, a common structure for categorizing test questions and designing instruction. The taxonomy is divided into six levels, from basic factual recall, or Knowledge, to the highest order, Evaluation, which assesses value or asks the teacher or learner to make judgments among ideas. This framework was revised and clarified (Anderson et al., 2001). The revised taxonomy changed the names of each level to verbs to show that thinking is active and changed the order of the sixth or highest level of thought, making Evaluate the fifth level and Create the sixth level. The six levels of thinking are known as the Cognitive Domain and a second domain was added, termed the Knowledge Domain. Each flip chart identifies and defines the six levels of thinking and suggests multiple questioning prompts for each of the levels.

Another framework highlighted is Norman Webb's Depth of Knowledge (DOK), which was developed in 1997. Norman Webb's Depth of Knowledge framework (2002) was expanded to the content areas and is used to categorize a task or an assessment item according to the complexity of thinking required of students to successfully engage with and complete the task or item. The four levels of DOK require students to interact with content in different and deeper ways as the cognitive demand progresses with each level: Level 1: Recall and Reproduction; Level 2: Skills and

Concepts; Level 3: Strategic Thinking/Reasoning; Level 4: Extended Thinking. Webb's DOK levels can be applied across all content areas. This useful tool guides teachers to better design instruction and assessment that increases rigor and develops deeper understanding. Unlike RBT, the verb does not categorize the level of thinking; the key factor is the context in which the verb is used and the depth of thinking required. Attention seems to increase so much more than in previous years in the amount of attention given to students' abilities to think critically (Hobgood, Thibault, and Walberg, 2005). Still another framework described is the Cognitive Rigor Matrices (CRMs) devised in 2009 by Karin Hess by combining Revised Bloom's Taxonomy with Webb's DOK. Instructional curricular examples are featured on each matrix. Teachers can use these frameworks to guide instructional planning and assessment to ensure that higher-level thinking is incorporated into everyday learning.

In the 1950s, Bloom found that 95% of the test questions developed to assess student learning only required thinking at the lowest level of learning, recall of information. Similar findings indicated an overemphasis on lower-level questions and activities with little emphasis on the development of students' thinking skills (Risner, Skeel, and Nicholson, 1992). Studies over the last 40 years have confirmed Bloom's Taxonomy of the Cognitive Domain as a framework to establish intellectual and educational outcomes. The conclusions reached by researchers substantiate that students achieve more when they manipulate topics at the higher levels of thinking.

Studies show that the art of asking questions with an emphasis on higher-level thinking can advance student achievement. Marzano, Pickering, and Pollock (2001) reported how teachers can increase their effectiveness in teaching and learning by using research findings on questioning strategies. An important conclusion showed learning to increase in classrooms where teachers asked questions related to essential content rather than questions teachers gleaned would interest students (Alexander, Kulikowich, & Schulze, 1994; Risner, Nicholson, & Webb, 1994). Fillippone (1998) found that teachers ask lower-level questions more times than not.

Evolving teaching standards have embraced a new view of questioning. Danielson's Framework for Teaching (2013), adopted in many states as a basis for their teaching standards, has included an indicator based on effective questioning and discussion techniques. New teaching standards promote more student engagement in the questioning process and call for higher levels of thinking with more open-ended questions allowing multiple correct answers.

Wait-time should be acknowledged before and after asking a question. Usually teachers give less than one second for students to respond to a question and the results are short responses or no response at all. Student-to-student interaction and quality of responses increase when wait-time is addressed noted Fowler (1975). Rowe (1974a;1974b) studied the effect of questions used by teachers on elementary students. Results showed three to five seconds of wait-time led to increases in student responses, student confidence, evidence supporting the response, and student conversation. This finding is consistent at the middle and high school levels when wait-time is allowed after asking a question. A recommendation is to allow five seconds of wait-time. Students must be informed that this time is their think-time and time should also be adjusted to the cognitive level of the questions. Near the back of the TEKS Mastery Series Flip Charts, direction is offered in how to use wait-time and think-time.

Research indicates there are specific behaviors that high-quality thinkers demonstrate. Effective thinkers and high-performing individuals do appear to portray certain characteristics (Goleman, 1995; Perkins, 1991). Costa and Kallick (2008, p.16) report there are certain characteristics that successful individuals "such as lawyers, mechanics, teachers, entrepreneurs, salespeople, physicians, athletes, entertainers, leaders, parents, scientists, artists, and mathematicians" tend to exhibit when faced with solving problems. They define these identifiable characteristics as "habits of mind."

In 2017, a group of educators from Mentoring Minds generated a list of traits they have observed throughout their education careers that were indicative of students who exhibited skillful thinking and deeper levels of thought. Based on their varied backgrounds of teaching and leadership experiences; elementary and secondary levels of curricula expertise; a range of 5-38 years working with children; and 7 months of focused discussions, careful study, and deliberation; these educators collaboratively narrowed their lists to nine behaviors that students exhibited more times than not when thinking critically. Collectively, these nine behaviors were entitled *The 9 Traits of Critical Thinking™*. These nine traits, when explicitly taught, modeled, and practiced, will guide students in becoming more successful when engaging in cognitively demanding tasks and in social interactions at school and in life beyond the classroom. The traits are emphasized in context with the activities that align to each featured standard as well as appear in a separate panel to help teachers integrate them into their content and social interactions with students. The traits help students become increasingly aware of thinking and more alert to strategies that can be utilized in a variety of settings. The intent is for students to practice and skillfully apply each trait, causing their actions to become more productive and automatic when they encounter unknown or challenging situations in the classroom and in the real world. With the resources or support provided, The TEKS Mastery Series Flip Charts empower teachers to establish a thinking climate from which to integrate standards-based science instruction.

Research indicates that thinking skills instruction makes a positive difference in the achievement levels of students. Past studies that reflect achievement over time show that learning gains can be accelerated. In verbal learning, research reports that the depth with which students process information has a definite impact on retention (Craik, 1979; Haller, Child, and Walberg, 1988). These results indicate that the teaching of thinking skills can enhance the academic achievement of participating students (Bass and Perkins, 1984; Freseman, 1990; Matthews, 1989; Nickerson, 1984). In the flip charts, emphasis is placed on an expectation of higher order thinking and learning. This is a significant shift towards what Ritchhart (2015) describes as cultures of thinking. Zohar and Dori (2003) found that when such a shift was placed on thinking and learning that all students, both high achievers and low achievers made considerable progress in higher order thinking when exposed to processes that were designed to nurture higher order thinking skills. It appears that when higher order skills are used in the application of knowledge then diverse students grasp a better understanding of content. Activities within the flip charts are designed to be cognitively challenging. According to Tharp et al., 2000, p. 30), cognitively challenging activities should reflect "productive tension" which means they are neither too easy nor difficult. Producing correct answers is not always the goal of such challenging activities, but rather the goal is to lead students to consider alternatives as they think and problem solve. High expectations for learning are intended to be the result of cognitively challenging activities. Therefore, Mentoring Minds' TEKS Mastery Series Flip Charts provide support in setting higher expectations in teaching critical thinking and meeting the requirements for incorporating research-based strategies and pedagogically sound principles for teaching and learning. A review of literature does suggest that a focus on higher order thinking can yield positive achievement gains.

Based on each state's accountability plans, all states and schools will have challenging, yet well-defined standards of achievement and accountability plans, requiring all students to reach mastery of the standards for each content area. These standards give direction to teachers as they strive to provide high-quality lessons in science. These skillfully designed teaching tools provide quick-and-easy access to State Standards. To help educators prepare students for success, the TEKS Mastery Series Flip Charts for Science are excellent critical thinking resources.

Bibliography for the TEKS Mastery Series Flip Chart for Science

Abdi, S.W. (2005). Correcting student misconceptions. *NSTA WebNews Digest*. National Science Teachers Association. Retrieved from http://www.nsta.org/publications/news/story.aspx?id=51397

Achieve. (2006). Closing the expectations gap 2006: An annual 50-state progress report on the alignment of high school policies with the demands of college and work. Retrieved from www.achieve.org/files/50-state-06-Final.pdf

Achieve (2015). *Rising to the challenge: Views on high school graduates' preparedness for college and careers.* Retrieved from http://www.achieve.org/rising-challenge-survey-2-powerpoint

Alexander, P. A. (2006). *Psychology in learning and instruction*. Upper Saddle River, NJ: Pearson Education, Inc.

Alexander, P., Kulikowich, J., & Schulze, S. (1994). How subject-matter knowledge affects recall and interest. *American Educational Research Journal*, 31(2), 313-337.

American Association for the Advancement of Science (AAAS). (1990). *Science for all Americans.* New York: Oxford University Press. Retrieved from http://www.project2061.org/publications/sfaa/online/sfaatoc.htm

American Association for the Advancement of Science (AAAS). (1993). Benchmarks for science literacy: Project 2061. New York: Oxford University Press. http://www.project2061.org/publications/bsl/online.

Anderson, L., Krathwohl, D., Airasian, P., Crusikshank, K., Mayer, R., Pintrich, P., Raths, J., & Wittrock, M. (2001). *A taxonomy for learning, teaching, and assessing.* New York, NY: Addison Wesley Longman, Inc.

Association of American Colleges and Universities (2013). *It takes more than a major: Employer priorities for college learning and student success.* Washington, DC: Hart Research Associates. https://209.29.151.145/sites/default/files/files/LEAP/2013_EmployerSurvey.pdf

Bass, G., Jr. & Perkins, H. (1984). Teaching critical thinking skills with CAI. *Electronic Learning* 14, 32, 34, 96.

Beck, I., McKeown, M., & Kucan, L. (2002). *Bringing words to life: Robust vocabulary instruction.* New York: Guilford Press.

Black, P., Harrison, C., Lee, C., Marshall, B., & Wiliam, D. (2003, April). *A successful intervention—Why did it work?* Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Bloom, B., Englehart, M., Furst, E., Hill, W., & Krathwohl, D. (1956). *Taxonomy of educational objectives: Handbook I: Cognitive Domain*. New York: McKay.

Burgoon, Jacob N., Heddle, Mandy L., & Duran, Emilio. (2010). Re-Examining the Similarities between Teacher and Student Conceptions about Physical Science. *Journal of Science Teacher Education,* (7), 859-872.

Chi, M. T. H. (2000). Self-explaining: The dual processes of generating inference and repairing mental models. In R. Glaser (Ed.), *Advances in instructional psychology (Vol 5): Educational design and cognitive science* (pp. 161-238). Mahwah, NJ: Erlbaum.

Costa, A. & Kallick, B. (Eds) (2008). *Learning and Leading with Habits of Mind: 16 Essential Characteristics for Success*. Alexandria, VA: ASCD.

Costa, Arthur & Kallick, Bena, Eds. (2009). *Habits of mind across the curriculum: Practical and creative strategies for teachers.* Alexandria, VA: Association for Curriculum and Development.

Craik, F. (1979). Human memory. *Annual Review of Psychology*, 30, 63-102.

Danielson, C. (2013). *The framework for teaching evaluation instrument*. Author.

Darling-Hammond, L. (2004). Standards, accountability and school reform. *The Teachers College Record*, 106(6), 1047–1085.

de Bruin, W. B., Parker, A. M., & Fischhoff, B. (2007). Individual differences in adult decision-making competence. *Journal of Personality and Social Psychology, 92*, 938–956.

Driver, R., Leach, J., Millar, R. & Scott, P. (1996). Young people's images of science. Buckingham UK: Open University Press.

Eaton, J.F., C.W. Anderson, & E.L. Smith. 1983. When students don't know they don't know. *Science and Children* 20 (7): 7–9.

Facione, P. A. (1990a). *Technical report #1: Experimental validity and content validity.* Millbrae: California Academic Press. (ERIC 327 549).

Facione, P. A. (1990b). *Technical report #2: Factors predictive of CT skills*. East Lansing, MI: National Center for Research on Teacher Learning. (ERIC ED 327 550).

Fillippone, M. (1998). *Questioning at the elementary level.* Master's thesis, Kean University. (ERIC Document Reproduction Service No. ED 417 421).

Fowler, T. (1975). *An investigation of the teacher behavior of wait-time during an inquiry science lesson.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, Los Angeles. (ERIC Document Reproduction Service No. ED 108 872).

Frank, P. (1947). *Einstein: His Life and Times*. New York: Alfred A. Knopf.

Freseman, R. (1990). *Improving higher order thinking of middle school geography students by teaching skills directly*. Fort Lauderdale, FL: Nova University.

Fries-Gaither, J. (2008, March). Common Misconceptions About the Polar Regions: Geography and Mapping. Ohio State University. Retrieved from http://beyondpenguins.ehe.osu.edu/issue/a-sense-of-place/common-misconceptions-about-the-polar-regions-geography-and-mapping

Fries-Gaither, J. (2009, March). Common misconceptions about plants. Ohio State University. Retrieved from https://beyondpenguins.ehe.osu.edu/issue/polar-plants/common-misconceptions-about-plants

Gunning,T. (2003). *Creating Literacy Instruction for All Children*, Fourth Edition. Boston, MA: Allyn & Bacon/ Pearson Education.

Haller, E., Child, D., & Walberg, H. (1988). Can comprehension be taught? A quantitative synthesis of metacognitive studies. *Educational Researcher*, 17, 5-8.

Heritage, M. (2007). Formative assessment: What do teachers need to know and do? *Phi Delta Kappan,* 89(2), 140-145.

Hess, K., Carlock, D., Jones, B., & Walkup, J. (2009). What exactly do fewer, clearer, and higher standards" really look like in the classroom? Using cognitive rigor matrix to analyze curriculum, plan lessons, and implement assessments. In Hess' Local Assessment Toolkit: Exploring Cognitive Rigor. Retrieved from http://www.karin-hess.com/#!Fewer-clearer-and-higher-standards/cmbz/91/01F31B21-D92E-4550-AEB6-81AFBE0A20BC

Hobgood, B., Thibault, M., & Walbert, D. (2005). *Kinetic connections: Bloom's taxonomy in action*. University of North Carolina at Chapel Hill: Learn NC.

Keely, P. (2018). *Uncovering student ideas in science*. Arlington, VA: National Science Teachers Association Press (NSTA).

Keogh, B., & S. Naylor. (1997). *Starting points for science*. Cheshire, UK: Millgate House Publishers.

Kilpatrick, J., Swafford, J., & Findell, B. (eds.) (2001). *Adding it up: Helping children learn mathematics*. Washington, DC: National Academy Press.

Lucariello, J. & Naff, D. (2018). How do I get my students over their alternative conceptions (misconceptions) for learning? *American Psychological Association.* Retrieved from http://www.apa.org/education/k12/misconceptions.aspx

Mandlawitz, Esq., M.R. (January, 2016). Every student succeeds act: Summary of key provisions. Retrieved from http://www.casecec.org/legislative/Every%20Student%20Succeeds%20Act_CASE%20(2).pdf

Marzano, R. (2003). *What works in schools: Translating research into action*. Alexandria, VA: ASCD.

Marzano, R. (2006). *Classroom assessment and grading that work*. Alexandria, VA: ASCD.

Marzano, R., Pickering, D., & Pollock, J. (2001). *Classroom instruction that works: Research-based strategies for increasing student achievement.* Alexandria, VA: Association for Supervision and Curriculum Development.

Matthews, D. (1989). The effect of a thinking-skills program on the cognitive abilities of middle school students. *Clearing House*,62, 202-204.

MetLife. (2011). The MetLife survey of the American teacher: Preparing students for college and careers. Retrieved from www.metlife.com/about/corporate-profile/citizenship/metlife-foundation/metlife-survey-of-the-american-teacher.html?WT.mc_id=vu1101.

Michaels, S., Shouse, A.W., & Schweingruber, H. (2007). *Ready, set, science!: Putting research to work in K-8 science classrooms*. Washington, DC: National Academies Press.

Nagy, W. (2005). Why vocabulary instruction needs to be long-term and comprehensive. In E. Hiebert & M.L. Kamil (Eds.), *Teaching and learning vocabulary: Bringing research to practice* (27-44). Mahwah, NJ: Eflbaum.

National Center for Education Statistics (2011). The condition of education 2011. Retrieved from http://nces.ed.gov/pubs2011/2011033_4.pdf.

National Reading Panel (NRP). (2000). *The Report of the National Reading Panel: Teaching Children to Read*. Washington, D.C: National Institute of Child Health and Human Development Clearinghouse.

National Research Council (NRC). (2007). *Taking science to school: Learning and teaching science in grades K-8.* Washington, DC: The National Academies Press.

National Research Council (NRC): Committee on Conceptual Framework for the New K-12 Science Education Standards. (2012). *A Framework for K-12 Science Education: Practices, crosscutting concepts, and core ideas.* Washington, DC: The National Academies Press.

New York Science Teacher. (2018). Science misconceptions. Retrieved from http://newyorkscienceteacher.com/sci/pages/miscon/index.php

Nickerson, R. (1984). *Research on the Training of Higher Cognitive Learning and Thinking Skills*. Final Report # 5560. Cambridge, MA: Bolt, Beranek and Newman, Inc.

Nisbett, R. E. (2016). Tools for smarter thinking. *Educational Leadership, 73*(6), 24-28.

No Child Left Behind. (2001). Washington, D.C.: U.S. Department of Education.

Perkins, D. (1991). What creative thinking is. In A. Costa (Ed.), *Developing minds: A resource book for teaching thinking* (Rev. ed., Vol. 1, pp. 85–88). Alexandria, VA: ASCD.

Phillips, G. (2007). *Chance favors the prepared mind: Mathematics and science indicators for comparing states and nations.* Washington, DC: American Institutes for Research.

Project Tomorrow (2014). The new digital learning playbook: Advancing college and career ready skill development in K-12 schools. Irvine, CA: Project Tomorrow. Retrieved from: http://www.tomorrow.org/speakup/pdfs/SU13Educatorreport_WEB.pdf

RAND Mathematics Study Panel (2003). *Mathematics proficiency for all students: Toward a strategic research and development program in mathematics education*. RAND, Santa Monica, CA.

Rice, J. (2003). Teacher quality: Understanding the effectiveness of teacher attributes. Washington, DC: Economic Policy Institute.

Ripley, A. (2013). *The smartest kids in the world.* New York, NY: Simon & Schuster.

Risner, G., Nicholson, J., & Webb, B. (1994). Levels of comprehension promoted by the Cooperative Integrated Reading and Composition (CIRC) Program. Florence: University of North Alabama. (ERIC Document Reproduction Service No. ED 381 751).

Risner, G., Skeel, D., & Nicholson, J. (1992). A closer look at textbooks: what research says. *Science and Children*, 30, 42-45, 73.

Ritchhart, R. (2015). *Creating cultures of thinking: The 8 forces we must master to truly transform our schools*. San Francisco, CA: Jossey-Bass.

Rowe, M. (1974). Wait-time and rewards as instructional variables, their influence on language, logic, and fate control: part one - wait-time. *Journal of Research in Science Teaching,* 1974, 11, (2), 81-94.

Rowe, M.B. (1974b). Reflections of wait-time: Some methodological questions. *Journal of Research in Science Teaching, 11(3),* 263-279.

Shepard, L. (2000). The role of assessment in a learning culture. *Educational Researcher*, 29(7), 4-14.

Stahl, S. & Fairbanks, M. (1986). The effects of vocabulary instruction: A model-based meta-analysis. *Review of Educational Research*, 56, 72-110.

Sternberg, R. J. (2008). Cognitive psychology (5th ed.). Belmont, CA: Thomson-Wadsworth

Stobaugh, R. (2013a). *Assessing critical thinking in elementary schools: Meeting the Common Core.* Larchmont, NY: Eye on Education.

Stobaugh, R. (2013b). *Assessing critical thinking in middle and high schools: Meeting the Common Core*. Larchmont, NY: Eye on Education.

Texas Education Agency (TEA) Student Assessment Division. (2016). STAAR statewide summary reports 2016-2017. Austin, Texas: Texas Education Agency. Retrieved from https://tea.texas.gov/Student_Testing_and_Accountability/Testing/State_of_Texas_Assessments_of_Academic_Readiness_(STAAR)/STAAR_Statewide_Summary_Reports_2016-2017/

Texas Education Agency (TEA). (2017). Streamlined science Texas essential knowledge and skills. Austin: Texas Education Agency. Retrieved Fall 2017 from https://tea.texas.gov/Academics/Curriculum_Standards/TEKS_Texas_Essential_Knowledge_and_Skills_(TEKS)_Review/Science_TEKS_Streamlining/

Tharp, R. G., Estrada, P., Dalton, S.S. & Yamauchi, L.A. (2000). *Teaching Transformed. Achieving Excellence, Fairness, Inclusion, and Harmony*. Boulder, Colorado: Westview Press, 30-31.

U.S. Department of Education. (1990–2007). National Assessment of Educational Progress. National Center for Educational Statistics. Retrieved September 1, 2007 from http://nces.ed.gov/nationsreportcard/

Vacca, J., Vacca, R., Cove, M., Burkey, L., Lenhart, L., & McKeon, C. (2003). *Reading and Learning to Read*, Fifth Edition. New York, NY: Longman.

Webb, N. (March 28, 2002) "*Depth-of-Knowledge Levels for four content areas*," unpublished paper.

Webb, N. (August 1999). Research Monograph No. 18: "Alignment of science and mathematics standards and assessments in four states." Washington, D.C.: CCSSO. Webb, N. (1997). Research Monograph Number 6: "Criteria for alignment of expectations and assessments on mathematics and science education. Washington, D.C.: CCSSO.

Zohar, A., Degani, A., & Vaaknin, E. (2001). Teachers' beliefs about low achieving students and higher-order thinking. *Teaching and Teachers' Education*, 17, 469-485.