Product Research

ThinkUp!™ MATH

Supporting documentation for the development of
TEKS Mastery Series Flip Chart for Math

i-Ready Learning

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TEKS Mastery Series Flip Chart for Math

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 Mathematics Standards for Texas (TEA, 2012) and serve as resources to support teachers in the implementation of mathematics education. The Mathematics Product Development Team also consulted the most recent Mathematics TEKS Supporting Information Documents in the TEA online resources (TEA, 2017) for the creation of these relevant mathematics' tools. The flip charts are resources for 1-8 grades that will help teachers of mathematics 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 common errors and misconceptions in mathematics that could possibly impede the improvement efforts of students or even teachers as they plan appropriate instruction and engage in mathematical 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 determine how they choose to integrate these components into their 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.

Students' mathematical achievement, however, is ultimately determined and limited by the opportunities they have had to learn. "All students must learn to think mathematically, and they must think mathematically to learn" (Kilpatrick, Swafford, and Findell, 2001, p.16). The RAND Mathematics Study Panel (2003) also emphasized the importance of mathematics. Furthermore, the panel declared that it is essential that students develop math proficiency. With the passing of the 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..." (Mandlawitz, 2016, p.1). As mentioned earlier, 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 the Every Student Succeeds Act mandate that all students participate in the state assessment program.

The United States Department of Education (2004) shared that "the recent National Assessment of Educational Progress (NAEP, the Nation's Report Card) showed that 27% of eighth-graders could not correctly shade 1/3 of a rectangle and 45% could not solve a word problem that required dividing fractions." Philips (2007) offered statistics that indicated adults have difficulties with everyday applications of mathematics in the real world. Other research indicates that students and adults experience problems in foundational mathematical skills (Hecht, Bagi, & Torgeson, 2007). The Third International Mathematics and Science Study (TIMSS) released data that indicate that students in the United States experience deficits in science and mathematics education as compared to 41 other countries. Fourth graders from the U.S. achieved the top ranking in science and the middle ranking in mathematics. However, eighth graders from the United States performed just above the median in science and below the median in mathematics. This trend does not bode favorably for the United States. Based on these findings, the evidence clearly shows mathematics literacy is a serious problem in the United States. Therefore, it is understandable why the National Mathematics Advisory Council (NMAC) expresses concern for mathematics education in the United States. While some data indicate progress, there continues to be a need for the United States to focus on improvement in mathematics education.

Thus, the resource TEKS Mastery Series Flip Charts are designed to offer teachers quality resources for increasing student performance and teacher instruction in mathematics.

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. 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).

The intent of all mathematics instruction is providing effective, high-quality mathematics instruction at all times. However, educators do recognize that students make mistakes in mathematics based on common misunderstandings. As students make sense of content, these mistakes may result for several reasons, including the pace of work, lack of attention, gap in knowledge, or confusion.

Researchers report that some mistakes could be predicted prior to lesson delivery and tackled at the lesson planning stage to prevent or address possible misconceptions. For this to happen, Steven Leinwand (2010) states that effective teachers have always understood "that one of their critical roles is to anticipate these misconceptions in their lesson planning and to have at their disposal an array of strategies to address common misunderstandings" (Bamberger et al., 2010, p. v). Steven Leinwand is a Principal Research Analyst at the American Institutes for Research in Washington, D.C., an avid supporter of mathematics initiatives, an author, a former mathematics supervisor in the Connecticut Department of Education, and a past president of National Council Supervisors of Mathematics (NCSM).

Ryan & Williams (2000) carried out extensive research into the strategies behind common misconceptions in mathematics. Previously, other researchers also studied misconceptions and how imperative it is that teachers have knowledge of those related to the topic addressed (Owens 1993, Carroll et al., 1997; Kamii, 2006; Ryan et al., 2007). Teachers need a great deal of support in deciding how best to present the concept to students, requiring considerable pedagogical knowledge as well as content based. Earlier, Thompson (1984) suggested that teachers' beliefs about mathematics and the practices they use in mathematics instruction are influenced by personal experiences with mathematics and the way they learned. Studies conducted by Tirosh (2000) confirmed these findings. It was also discovered that teachers experienced difficulties in the same areas as students. To maintain a focus on learning, it seems imperative that teachers anticipate the misconceptions that could occur in the lesson. Exposure to misconceptions if they occurred and the use of questions (e.g., Why? How? What would happen if…?) help teachers probe student understanding of the concept.

In the book Math Misconceptions: From Misunderstanding to Deep Understanding (Bamberger, Oberdorf, and Schultz-Ferrell, 2010), the premise is teachers can prevent or minimize many common misconceptions. Furthermore, teachers can prevent or correct misunderstandings if instruction is designed that consistently probes students' understandings and provides opportunities for students to show and explain their reasoning. These mathematics' educators presented vignettes with practical instructional strategies and activities that avoid as well as address misconceptions. It appears that scaffolding student learning is a valuable technique, yet to do this, teachers need accurate information about the concept attainment level of students to promote deeper comprehension of the concept. Embedding informal observations and formative assessment into daily instruction is a must.

Due to research and literature written about misconceptions in mathematics, the Mathematics Product Development Team concluded that teachers should have knowledge of what the misconception might be, why these errors may have occurred, or and how to approach the difficulties for learning to continue. Findings revealed formative assessment techniques were essential in day-to-day instruction to reveal student thinking, yet it would be helpful if practical ideas to address the particular learning needs were identified. Thus, in the TEKS Mastery Series Flip Charts, a component was included to lend support to teachers during the lesson.

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 at each grade level 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.

Critical thinking skills are essential for students to succeed, not only in their school work but also in their life after graduation. 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. 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. The back of the TEKS Mastery Series Flip Charts offers direction 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.

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 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 strive to provide high-quality lessons in mathematics. The TEKS Mastery Series Flip Charts ensure that each teacher who uses this resource has a set of academic standards as required for one through sixth grade levels in Mathematics. These skillfully designed teaching tools provide quick-and-easy access to State Standards. The TEKS Mastery Series Flip Charts for Mathematics are excellent critical thinking resources to help educators prepare students for success.

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