Product Research & Documentation

total motivation™ science
for the Next Generation

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Mentoring Minds®
Critical Thinking for Life!™

Education is about the creation of a universally literate nation. Literacy includes reading, mathematics, technology, and science. Developing science literacy is imperative for students to address personal decisions and those in the 21st century. Schools must carefully seek resources to support meaningful instruction in science education to help students become careful consumers of scientific and technological information in their everyday lives, achieve mastery of grade-specific standards, and develop college and career readiness. The development of the NGSS appears to be an important force for improvement in science education, teacher development, and assessments.

The rationale behind the development of Total Motivation™ Science for the Next Generation is to provide a supplemental support to teachers as they plan high-quality science learning opportunities and successfully implement science learning experiences based on the NGSS. These experiences provide students with opportunities to learn and apply three-dimensional learning: Science and Engineering Practices (SEPs), Crosscutting Concepts (CCCs), and Disciplinary Core Ideas (DCIs) as defined by the NGSS. Transference of standards into modules of instruction that align with the standards is essential. Total Motivation Science for the Next Generation addresses the need for a resource that translates the NGSS standards into classroom instruction and assessment activities that complement a school's science curriculum.

According to the National Research Council (NRC, 2012), the NGSS are founded on *A Framework for K-12 Science Education,* both of which are designed to improve science education. The *Framework* is grounded in the most current research on science and science learning and identified the science all K–12 students should know. The National Research Council (NRC), the National Science Teachers Association, the American Association for the Advancement of Science, and Achieve worked together to develop the NGSS. This collaborative development process with states and other stakeholders in science, science education, higher education, and industry was managed by Achieve (2013). The NGSS were a set of high quality, college- and career-ready K–12 standards which were presented and ready for state adoption in April 2013 (NGSS Lead States, 2013).

Pratt (2013b) recommended that the NGSS integrate and build the standards around three dimensions: Scientific and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas. As stated previously, scientists, engineers, science teachers, general educators, and science educators formed a team for the purpose of defining essential and fundamental knowledge and abilities that represented science and engineering. The result was "a conceptual framework of knowledge and skills that learners need to continue their study of science and meet their obligations as citizens" (Bybee, 2013, p. 163). An intention of the NGSS was to improve states' standards, which simply means to produce higher levels of achievement for all learners. There were 26 lead states directly involved throughout the process, and two public reviews were also provided. This transparent process led to draft revisions, and later to the standards themselves. According to Bybee, there appeared to be overwhelming support for the NGSS from science teacher organizations, state leaders, and several individuals in businesses and industry, even though one reviewer's critique indicated otherwise.

Most science teachers already incorporate content and scientific practices throughout all of their lessons. In regards to three-dimensional learning specified in the NGSS, the challenge for teachers is to incorporate as many Scientific and Engineering Practices, Crosscutting Concepts, and

Disciplinary Core Ideas into cohesive lessons throughout the school year. Total Motivation Science for the Next Generation integrates multiple Scientific and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts within each module and bundles Performance Expectations to ensure three-dimensional learning experiences occur throughout the school year.

With the release of the NGSS and recent emphasis on college and career readiness, public awareness for STEM has grown. The acronym STEM stands for science, technology, engineering, and mathematics. Bybee (2013a) identified STEM-related goals and made connections between these goals and the NGSS. School curricula and classroom practices must focus on these in order to reach the reach the vision that represents both STEM and the NGSS. As new dimensions for science education are showcased, multiple opportunities demonstrated by STEM become evident. For students to explore deeper learning, educators must understand how technology can support teaching and learning by making complex concepts more approachable, emphasize Crosscutting Concepts and ideas, and engage students in the practices of science and engineering,

Total Motivation Science for the Next Generation allows students to experience the innovative science classroom from the lens of both the NGSS and STEM, meet the expected rigor, and align with these philosophies. STEM is an educational philosophy in which K-12 students become prepared for college courses in the fields of science, technology, engineering, and mathematics. Not only do students receive subject-specific content in science, technology, engineering, and mathematics, but STEM also promotes and improves critical thinking, collaboration, and reasoning skills.

STEM programs exhibit specific practices, including those that Integrate ELA/Literacy strategies to support Science and Engineering Practices, support inquiry-based instruction, encourage students to collaborate, develop the engineering design process, permit multiple correct answers, and accept failure as an important part of learning. The science resource from Mentoring Minds complements the philosophy of STEM in multiple ways. Several connections to STEM are identified in the following paragraphs.

Total Motivation Science for the Next Generation integrates ELA/Literacy strategies to support Science and Engineering Practices by having students routinely research using appropriate and reliable Internet and library sources, utilize research information to ask testable questions, conduct short research projects, summarize learning from a list of student-determined sources, reflect on learning and/or experiences, communicate information, formulate arguments based on evidence from both research and investigations, and strengthen viewpoints by using supporting evidence and discussion points taken from multiple sources.

The capacity for students to participate in hands-on experiences is built through Total Motivation Science for the Next Generation. Teachers present modules using varied inquiry-based instruction techniques: structured inquiry, guided inquiry, and open inquiry. To scaffold learning during investigations, the level of teacher support varies between and throughout modules. Support can be adjusted on any investigation to best meet student needs. Students can ask testable questions, conduct shortened research projects, summarize learning from student-determined sources, create multimedia presentations or displays, and reflect on learning and experiences.

The STEM practice of collaboration is embedded throughout Total Motivation Science for the Next Generation. Student collaboration is promoted through group investigations, discussions, arguments accompanied by supporting or refuting evidence, and evaluations of peer explanations and products. Another STEM practice evidenced in this science resource is the opportunity for students to demonstrate an understanding of how to utilize the steps in the engineering design process. Multiple experiences engage students in defining and delimiting engineering problems, developing possible solutions, and optimizing the design solution.

While STEM promotes multiple answers, so does Total Motivation Science for the Next Generation. Students gain insight into how some questions or problems can lead to more than one correct answer or solution. Open inquiry invites students to ask their own questions or to define their own problems, then plan an investigation, or find a solution, and collect data. With this resource, students share their application of learning through experiences, interests, or hobbies as they respond to open-ended questions and participate in reflection opportunities, journaling, projects, and much more.

STEM recognizes that taking risks and experiencing failure are a natural part of learning experiences for students. Total Motivation Science for the Next Generation encourages learning, revision, and improvement based on the failure of design solution. Engineering design requires students to design initial solutions to solve a problem, refine the initial design solution, test the design solution, then revise the solution to best solve the design problem by determining failure points or issues. Engineering failure produces improved design solutions, which is considered a typical step in the engineering design process.

The aforementioned connections describe how Total Motivation Science for the Next Generation integrates STEM practices. As observed through the experiences, STEM requires careful integration of science, technology, engineering, and mathematics, not teaching these subjects in isolation. STEM prepares students to apply these subjects in everyday life as critical thinkers who are prepared to be successful in college and/or careers.

Taking Science to School (Duschl et al., 2007) and *Ready, Set, Science!* (Michaels, et al., 2008) are two sources that the Science Product Development Team considered as the Total Motivation Science for the Next Generation was developed. The team recognized the significance of four proficiencies that connect content to science practices. As Duschl et al. (2007) pointed out, "Students who are proficient in science know, use, and interpret scientific explanations of the natural world; generate and evaluate scientific evidence and explanations; understand the nature and development of scientific knowledge; and participate productively in scientific practices and discourse" (p. 2). The idea of learning progressions influenced the development of *A Framework for K-12 Science Education* (NRC, 2012) and the NGSS (Achieve, 2013). A deeper understanding was gained about the implications of learning progressions on core ideas and practices. The Science Team collaborated to determine what precisely was meant by practices and other ideas gleaned from the literature. This reflection led to the acquisition of a working knowledge of how the teaching and learning of science can be enhanced prior to writing a science resource that brought the NGSS to life in the classroom.

As a result of a Biological Sciences Curriculum Study (BSCS, 1987) led by Rodger Bybee, the 5E Instructional Model was developed by a curriculum group while on a retreat in Colorado. The task of the group of science educators was to develop an instructional model to teach inquiry science with as many or as few phases as needed, provided they all began with the same letter. Another requirement to the instructional mode was that it should be based on the literature and research about best practices for teaching and learning. Thus, the 5E Model was developed.

In any development process, every BSCS program is field-tested nationwide to ensure that the activities work well in the classroom and improve students' understanding of the concepts (Bybee et al., 2006) The results of the field tests inform a careful revision of the program or approach before it is published. The use and refinement of the BSCS 5E Model continued over time, showing the 5Es to be relevant to curriculum today and to contribute to scientific literacy (Bybee, 2013). As research continued by BSCS to verify that the 5E Model is important in classrooms today, one such study was conducted in order to increase teachers' pedagogical knowledge. The study revealed that significant increases in content knowledge of teachers and in teacher practices and strategies aligned with research. Findings revealed that teachers' implementation of high-quality instruction increased as a result of employing the 5Es to structure units or modules and developing an understanding of how each phase of the model was aligned to research. In conclusion, it appears that when teachers teach as research tells us we should teach because it is based on how we learn, then a difference in student performance can occur. This conclusion shows that changing the quality of teaching and learning can produce a favorable impact (BSCS, 2014).

Research reports (Bransford, Brown & Cocking, 2000; Donovan & Bransford, 2005) have confirmed that an instructional model is effective when it is supported by relevant research, revealing consistent implementation while yielding the desired effect on teaching and learning. For a model to support students in their learning, the instructional model must have sustained usage and reflect a research base. The NGSS and the NRC *Framework* do not assert that there is only one instructional approach for engaging students in the practices. There are actually multiple instructional models that can be productively used to implement the learning goals of the NGSS. In order to meet the requirements of the science standards, a model should be used in order to bring structure to the lessons or units of study and engage students in practices.

Bybee (2013) attested to the 5E Model as an appropriate instructional model for the NGSS framework in order to guide lessons and make the teaching and learning more explicit. The 5E Instructional Model is a foundation for classroom instruction based on performance expectations. The content that students learn, as well as the context in which students learn the content, is addressed. At every phase this model, which offers an integrated instruction sequence, incorporates best practices with how students learn. The five phases are *engage, explore, explain, elaborate/extend,* and *evaluate*. Students and teachers assume roles within each of the phases. Total Motivation Science for the Next Generation reminds teachers of the 5E Model as every science module encapsulates each phase. In the Teacher's Edition, the teacher is guided through the five phases, delineating the implementation expectations of the teacher and students during each phase.

In creating modules or units of instruction that build on the *NGSS*, the Science Product Development Team began the development process from the end and worked backward, as advised by the NGSS developers. This process is called 'backward design'. First, a set of performance expectations (PE) were selected from the standards. Then the team applied the 5E Instructional Model and designed an evaluate activity. Next, the Science team designed a series of activities that connected the expectations with the knowledge and skills students will have in place at the beginning of instruction, based on the engage, explore, explain, and elaborate experiences. Wiggins and McTighe (2005) endorsed this process by saying that it guides teachers to reach higher levels of student learning. Furthermore, these researchers described the process that the Science Team followed in Total Motivation Science for the Next Generation. First, the learning outcomes (performance expectations from the NGSS) were identified. Then, the team determined the evidence of learning that students must demonstrate to indicate mastery of the competencies contained in the expectation(s). Afterwards, the team then moved forward in the process and designed activities for students to demonstrate learned concepts and practices that appear in the three dimensions. The performance expectations also serve as a guide to lead educators to think in depth about the achievement of the scientific literacy goal. Constantly, teachers must return to the PEs during lessons in order to determine the evidence that demonstrates that the lesson connects to performance expectations.

With the passing of the 2015 Every Student Succeeds Act (ESSA), academic assessments are required by federal law to be administered annually for "science tests not less than once during grades 3–5, 6–9, and 10–12" (Mandlawitz, 2016, p. 1). The critical issue of accountability has been around for years and continues with ESSA, with assessments being used to help improve schools and inform instruction, and not only as a measure of accountability. The continued emphasis on assessments may be a way for science to receive more attention in schools and to consider the resources that will be needed to implement quality science programs, with attention being placed on improving teaching practices and assessments in science. Bybee (2013b) indicated that research on how students learn and the new standards may bring challenges, but the inclusion of science and engineering practices (learning outcomes and instructional strategies) may have a great impact on student learning and also result in the teacher being more efficient. The ESSA allows state and local levels the opportunity to create systems for accountability, resources, and evidence-based interventions.

The federal requirements of ESSA mandate that all students participate in the state assessment program. Therefore, assessment-focused activities are interwoven into each module of Total Motivation Science for the Next Generation from whence the teacher as well as the student can gather timely student information. Data results can lead educators to readily and continuously measure and maintain accountability, improve instructional practices, and plan appropriate interventions and instruction for academic achievement of standards. Thus, this science resource is an instructional and assessment resource that can support both teachers and students.

In a report published by a committee representing the National Research Council (Pellegrino et al., 2014), there was much discussion on how the NGSS should be assessed. This document was studied by the Mentoring Minds Science Product Development Team. A focus was placed on the different types of questions suggested for three-dimensional learning assessment. Appropriate assessment choices for Total Motivation Science for the Next Generation included open-ended response, multiple-choice, multi-set, and hands-on performance tasks.

Molly Ewing (2015) assisted in the coordination of the development of a rubric for reviewing and evaluating the quality of lessons or units for science education as they align with the NGSS. The Educators Evaluating the Quality of Instructional Products (EQuIP) Rubric for science classroom resources contains rigorous criteria developed by Achieve and NSTA in 2014 and revised in 2016. The rubric criteria are divided into three categories: NGSS 3D Design, NGSS Instructional Supports, and Monitoring NGSS Student Progress. To fully meet the criteria, the resources must be three-dimensional in nature, have coherence across lessons and units, feature numerous instructional supports, and provide methods to monitor student progress.

Monitoring student progress is essential for evaluating the achievement of standards, identifying where misconceptions might arise, determining the next steps in learning, and adjusting instruction. The EQuIP Rubric 3.0 (NSTA, 2016) was used to critique Total Motivation Science for the Next Generation in many assessment areas, and this resource was found to meet the vision of EQuIP and to comply with the rubric's descriptors. In relation to the three dimensions, this science resource provides teachers and students with visible learning evidence that demonstrates the understanding and proficiency of students in relation to science and engineering practices, disciplinary core ideas, and crosscutting concepts.

In meeting a specific criterion on the rubric, Total Motivation Science for the Next Generation provides varied opportunities for formative assessment throughout each module. When assessment for learning is the priority, then students' learning is promoted (Black & Harrison, 2004). Formative assessment techniques inform teaching by allowing the teacher to continuously gather information on students' thinking and learning. From this, data-informed decisions can be linked to planning for or adjusting instructional science activities, monitoring instruction, and perhaps identifying misconceptions that prevent accurate learning among students. Teachers can assess student understanding frequently, with immediate changes made to address diversity among student needs. The next steps for instruction are supported as strong evidence-based interventions are offered for students struggling with content, while students who need additional challenges can engage in activities titled Extended Thinking and Cross-Curricular Connection. Achievement is measured in this science supplemental tool through the provision of aligned scoring rubrics and integrated answer keys for every activity in each module. These tools provide teachers with the information required for planning lessons and providing timely and relevant feedback to students. If information from the assessment is used as feedback by the teacher to adjust teaching and learning activities and by students in assessing themselves or their peers, then it is used to promote learning (Black et al., 2003). The assessment information helps students become more metacognitive about their own thinking when students actively seek the feedback from peers to enable them to self-assess their thinking. This science resource provides many opportunities where students can engage in assessment.

Seeking to provide unbiased tasks and items as required in the EQuIP Rubric, Total Motivation Science for the Next Generation provides a wide range of methods to assess student learning, including investigations, research, discussions, journaling, organizers, vocabulary activities, and hands-on performance tasks. According to the Partnership for 21st Century Skills (Fadel, Honey, & Pasnik, 2007, p. 34), the workplace will require "new ways to get work done, solve problems, or create new knowledge"—the assessment of students will need to be largely performance-based so that students can show how well they are able to apply content knowledge to critical thinking, problem solving, and analytical tasks throughout their education. Hess (2016) advocated that students must be able think deeply—process information analytically, independently draw inferences and reach conclusions, and solve problems. When classrooms focus on assessment where students are presented with opportunities to examine, revise, and improve their own thinking, then the classroom reflects assessment that supports learning (Donovan & Bransford, 2005). Metacognitive strategies are enhanced, including when students can actually monitor their own learning by predicting outcomes, explaining ideas to themselves, and recognizing areas where difficulties arise that hinder their learning (Bransford et al., 2000). Total Motivation Science for the Next Generation supports assessment-centered learning and metacognitive thinking strategies.

A variety in types of assessments ensures that teachers solicit knowledge from students by using the aforementioned range of methods so as to not exclude a student's preferred response. A coherent assessment system is indicative of this science resource. Numerous assessment opportunities (pre-assessment, formative assessment, summative assessment, and self-assessment) are featured throughout each module to determine the level of student understanding of three-dimensional learning, which informs instructional changes to meet the needs of all students. To further meet the indicators on the rubric, Total Motivation Science for the Next Generation utilizes multiple opportunities throughout each module for students to demonstrate their understanding of Disciplinary Core Ideas and Crosscutting Concepts. This hands-on approach ensures that students engage in experiences with which to recall and retrieve three-dimensional learning.

With the diversity that exists in today's classrooms, all students including English language learners, struggling students, and high-achieving students need support to enable them to succeed. Many schools are turning to differentiated instruction as a means to address the numerous learning needs. Due to limited research on differentiation, experts and practitioners (Allan & Tomlinson, 2000; Anderson, 2007; Hall et al., 2003) have reported that there are practices which are part of the foundation of differentiation that have been found to produce favorable results. Several differentiation practices occur when Total Motivation Science for the Next Generation is implemented with fidelity. These practices include using effective classroom management procedures; promoting student engagement and motivation; assessing student readiness; responding to learning styles; grouping students for instruction; and addressing zones of proximal development (Allan & Tomlinson, 2000; Ellis & Worthington, 1994; Vygotsky, 1978). Each module is built around the 5E Instructional Model with each of the five phases bringing structure to the lesson. Materials management is also noted in the procedures, containing information helpful for managing activities. The practice of promoting student engagement and motivation is addressed by each module beginning with an Engage activity in the 5E Instructional module. The Engage/Introduction activity captures student interest through experiences that focus on engaging phenomena. The activities are designed to motivate students and help them focus on the questions or problems to be explored in the module. The practice of assessing student readiness is also featured in each module. A Pre-Assessment is included to determine what students remember from prior learning in grades K-4 as related to the module content. In regards to the practice of responding to learning styles, activities are varied to appeal to auditory, visual, and kinesthetic learners. Another practice, grouping students for instruction, is recommended for each activity. Additionally, the Accommodations section in the Teacher Edition provides some ideas for partnering students. Suggestions are given for English language learners, hearing impaired, visually impaired, and below-level readers. The practice of teaching to the student's zone of proximal development is also embedded in this science resource. To scaffold learning, the level of teacher support during the Explore/Inquiry investigations varies by module and includes structured inquiry (teacher provides the question or problem, materials, and procedures), guided inquiry (teacher provides the question or problem and materials; students plan investigation and data collection), and open inquiry (students ask questions or define problems, plan the investigation, and plan collection). Some modules include an additional instructional activity called Building Background to help activate prior learning. Total Motivation Science for the Next Generation provides several Intervention activities per module which utilize different representations, models, investigations, discussions, etc. to support struggling students to meet proficiency for the Performance Expectations. Total Motivation Science for the Next Generation suggests several activities to extend learning for students with high interest for the topic or who have already met proficiency for the Performance Expectations. These activities include content at higher levels of Bloom's Taxonomy according to the Performance Expectation, application of content to different subject areas (Math, ELA, Physical Education, Visual Arts, Social Studies, etc.), and children's literature that extends the content being studied.

Total Motivation Science for the Next Generation provides many opportunities for teachers to differentiate instruction, which denotes several ways this resource aligns with the EQuIP Rubric (NSTA, 2016). Intervention activities offer support and provide different approaches from other module activities for struggling students as they gain proficiency of Performance Expectations. One idea represented in the EQuIP Rubric is that instructional materials should build toward a bundle of performance expectations, which this resource does. There are instructional options that address students' unique needs and preferred learning styles, with differentiation being delivered in small groups or with targeted instruction. During instructional activities, multiple alternatives to read, write, listen, and speak help those students who read below grade level, have special needs, or need additional support demonstrating their understanding and what they have learned. Examples and models are used to demonstrate the expectations required of students. Optional Vocabulary Activity is a section in the resource that provides support by offering focused practice with terms that students could potentially struggle with.

To develop a deeper understanding of the three dimensions, Total Motivation Science for the Next Generation provides opportunities to make real-world connections that help students view their learning as meaningful and relevant. Students are also provided with practice to achieve mastery of concepts in the modules at a higher, yet deeper, level of understanding as determined by Bloom (Anderson et al., 2001; Bloom et al., 1956) and by Hess' Science Cognitive Rigor Matrix (Hess, 2013) to align with the level required by the Performance Expectation. Science concepts in Total Motivation are related to other subject areas (career and technical education, English Language Arts, forensic science, geography, history, mathematics, performing arts, physical education, social science, and visual arts).

Professional development for teachers is a critical factor on the impact of the NGSS. Developing a balance between understanding the NGSS and the three dimensions while also supporting teachers and administrators with tools and processes to enable them to engage in discussions about curricular issues is essential (Brunsell, Kneser, & Niemi, 2014). Changes in teachers' knowledge, skills, and engagement with student learning and achievement are necessary for successful implementation of the NGSS. To achieve higher levels of student learning, teachers must learn how to facilitate learning rather than merely conveying the content. Learning to integrate the three dimensions into curriculum, instruction, and assessments will take intentional effort and support (Bybee, 2013b). Thus, the conceptual shifts required by the NGSS and the new generation of state science standards involves significant training and time for teachers to successfully implement. Because every teacher, school, and district may possibly be at different places in their preparedness and will face different challenges during the implementation process, Total Motivation Science for the Next Generation provides full support for the inexperienced educator and presents a wide variety of evidence-based techniques to enrich a veteran teacher's skillset.

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 achieve mastery of standards, engage in discussions on science related issues, learn to be critical consumers of scientific and technological related to their everyday lives, continue to learn about science outside of school, and have the skills to enter certain careers, a relevant and well-designed science learning curriculum with appropriate instructional resources is required. Total Motivation Science for the Next Generation is a resource designed to support current instruction in science education.

During the development process for Total Motivation Science for the Next Generation of Science Standards, the Mentoring Minds Science Product Development Team gathered feedback and support from science teachers, science educators and leaders, analysis of research practices and documents, and conversations with practitioners. Resources that helped the team define the standards (NGSS Lead States, 2013b; Pratt, 2013b) as well as interpret the *Framework* (Pratt, 2012; 2013a) were consulted as needed. The NGSS Appendices (NGSS Lead States, 2013a) were also instrumental during the development and editing phases of Total Motivation Science for the Next Generation. Through careful study of the *Framework* (Pratt, 2013a), the NGSS, the EQuIP rubric, and other literature resources, the science team created a practitioner's science resource that equips teachers with a tool that helps them navigate through the NGSS and cultivate a science classroom that inspires students. The vision of the science team was to provide teachers with developmentally appropriate learning experiences and outcomes that are achievable regardless of the diversity in abilities of students. While standards cannot dictate the lessons or strategies, there is a need for a resource that can transfer standards into classroom activities and practices and that is accompanied by professional development support. More specifically, a need exists for a product that can make implementation of the NGSS a reality. Total Motivation Science for the Next Generation of Science Standards fulfills this need.

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One International Place, Suite 1400, Boston, MA 02110
800.585.5258 • mentoringminds.com