USING SCIENCE TECHBOOK TO SUPPORT GREAT MIDDLE SCHOOL STEM EDUCATION

The key to great STEM education is a product that supports a transdisciplinary approach.

Middle school students today live in a world of constant stimulation. Whether it's Xbox, social media, or television, students have continuous access to highly enticing visual information, entertainment, and connectivity. As middle school leaders, our task is to implement a STEM (science, technology, engineering, and mathematics) education program that will capture the imagination of today's students. How do we engage students amid all the diversions? The era of the teacher as "the sage on the stage" is over. Students thrive on problem-based, interactive, authentic learning. As leaders, we all want a product that is standards-based, flexible, and easy-to-use. We want classrooms to be engaging, interactive, and as compelling as all of the competing stimuli.

The key to great STEM education is a product that supports a transdisciplinary approach. In transdisciplinary instruction, learners are active participants who use problem-solving processes and the powerful critical thinking and exploration practices commonly used in effective STEM classrooms to:

- Ask deep, real-world questions.
- Collaborate with their peers.
- Arrive at meaningful conclusions.

Students also explore and think about the careers of individuals who study similar problems and questions on a daily basis as well as construct their own context from the world around them.

Great STEM education is built around eight essential elements as identified in the University of Chicago STEM School Study (S3)[1] Outlier, the research and evaluation arm of the Center for Elementary Mathematics and Science Education at the University of Chicago, has a grant from the National Science Foundation to study 20 inclusive STEM high schools in seven states (California, New York, Ohio, Texas, Washington, Tennessee, and North Carolina). The purpose of the study is to comprehensively describe the

[1] LaForce, M., Noble, E., King, H., Holt, S., & Century, J. (2014). The 8 elements of inclusive STEM high schools. Chicago, IL: Outlier Research & Evaluation, CEMSE | The University of Chicago. Retrieved April 5, 2016, from http://outlier.uchicago.edu/s3/

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characteristics of models for inclusive STEM high schools. The study also seeks to examine the relationship between model components and a range of student outcomes. Initial S3 research lists eight essential elements of a STEM school. Although the research was compiled by studying high schools, the essential elements make sense for schools at all levels.

The eight elements identified in the study are:

- Problem-Based Learning
- Rigorous Learning
- School Community and Belonging
- Career, Technology, and Life Skills
- Personalization of Learning
- Connection to the Broader and External Community
- Staff Foundations
- Essential Factors

The first six of these elements are identified as core elements, and the remaining two are supporting and contributing elements.

Discovery Education has products and services that support all eight essential elements across all grade bands, kindergarten to high school. Let's look specifically at how **Science Techbook** supports four of the core elements for middle school learners: problem-based learning; rigorous learning; career, technology, and life skills; and personalization of learning.

1. Problem-Based Learning

Middle school students using Science Techbook are active learners in the classroom. They act as scientists and engineers to construct solutions and investigate problems. They collect and analyze data, develop scientific explanations for phenomena, identify problems, conduct research, build and test prototypes, and determine the best solution to an engineering need. Throughout this process, they use appropriate technology and apply mathematics to real-world situations.

Each concept within **Science Techbook** contains a model lesson for teachers and a progression of learning experiences for students. The resources within **Science Techbook** give middle school students multiple opportunities to investigate problems and explore real-world phenomena. Additionally, the model lesson provides supports for the middle school teacher around how to structure the learning to reflect student-driven, problem-based learning. Model lessons were developed to align with the standards in the Next Generation Science Standards (NGSS)[2] and use the well-researched 5E instructional model[3].

The Elaborate with STEM component of each concept includes a section entitled "STEM Project Starters." Within this tab, students and teachers have between two and four choices of short- and long-term projects that expect students to apply their content knowledge using the practices of scientists and engineers. STEM Project Starters identify questions and problems that may be of interest to students and give them ideas for how to begin their investigations. For example, the middle school life science unit Environmental Problems and Solutions includes five concepts featuring 14 project choices.

Examples include:

> **Project: Technology and Endangered Species** *Students are asked to do research to find out how scientists are using technology to save an endangered species.*
>
> **Project: Something Fishy** *Students are asked to analyze data on the population of the North Atlantic swordfish and to relate their analysis to the concept of sustainable fishing practices.*

[2] The Next Generation Science Standards. (n.d.). Retrieved May 11, 2016, from http://www.nextgenscience.org/sites/ngss/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf

[3] Bybee, R., Taylor, J., Gardner, A., Van Scotter, P., Powell, J., Westbrook, A., & Landes, N. (2006, June 12). The BSCS 5E instructional model: Origins and effectiveness. Retrieved November 9, 2015, from http://bscs.org/sites/default/files/_media/about/downloads/BSCS_5E_Full_Report.pdf

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Teachers can use the STEM Project Starter that best matches the interests or needs of students or can allow individual students to choose which project they will investigate. The project topics are designed in a way that helps students relate unit concepts to life outside of the classroom. STEM Project Starters require middle school students to use skills from other disciplines, such as technology, engineering and/or mathematics, to investigate the problem. Students also develop the inquiry and research skills they will need to explore personal or professional problems later in life.

Middle school students and teachers using **Science Techbook** are members of the Discovery Education Network. They receive advance notice of virtual field trips and opportunities to communicate live with scientists, mathematicians, engineers, and other STEM professionals. They also have access to a treasure trove of archived footage of these professionals solving real-world problems. Middle school students can design community gardens, plan for the relocation of an endangered animal, explore a modern automotive manufacturing plant, or get a behind-the-scenes look at the animators, producers, engineers, and designers who create games such as Madden NFL. Students routinely have opportunities to see how STEM disciplines are integrated and applied in the real world. From these experiences, students gain understanding of the problems STEM professionals design solutions for each and every day.

2. Rigorous Learning

The courses in **Science Techbook** were designed from the ground up to address the rigorous requirements of three-dimensional learning as outlined in the NGSS. Each model lesson includes a standards overview that identifies the performance expectations from the NGSS and identifies the disciplinary core idea(s), crosscutting concept(s), and science and engineering practice(s) woven together in the lesson.

In the middle school concept Transportation Systems, the model lesson includes multiple learning sessions. Within these sessions, students engage the science and engineering practices through several hands-on activities and are expected to make crosscutting concept connections as they collect evidence from a variety of online digital resources to deepen their understanding of the disciplinary core ideas.

To support teacher planning, the sessions in the model lesson include a summary statement entitled "Three-Dimensional Learning in Focus" to explain how the lesson authors envision students using the practices and concepts to deepen understanding of the disciplinary core ideas.

Throughout the experiences, middle school students are taught to construct explanations around the following lesson questions:

- Why do people need transportation?
- How do different forms of transportation meet people's transportation needs?
- What factors influence a community's choice of a transportation system?
- What forces affect the motion of transportation vehicles?
- What engineering design processes are necessary to solve a particular transportation problem?

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A scientific explanation is a tool that is introduced in the primary grades and is used consistently in **Science Techbook** lessons. The tool was developed using a framework for constructing scientific explanations proposed by McNeill and Krajcik.[4] Students are taught that a scientific explanation includes three parts:

- A claim that answers the question being studied.
- Evidence to support the claim.
- Scientific reasoning that explains how the evidence supports the claim.

Writing scientific explanations also addresses the Common Core ELA writing standard that requires students to use evidence and reasons to support claims. By providing middle school students with support and repeated practice in developing scientific explanations, **Science Techbook** strengthens students' ability to participate productively in scientific practices and discourse. Students also deepen their understanding of the science concepts they are learning and develop logical reasoning skills that are beneficial across the curriculum and useful in everyday life.

3. Career, Technology, and Life Skills

As middle school leaders we know the importance of preparing students with the skills they will need to succeed in an interconnected, global society. **Science Techbook** places an emphasis on developing the four Cs: critical thinking, communication, collaboration, and creativity. As students experience three-dimensional learning experiences, they are expected to demonstrate all of these skills at the appropriate grade level. **Science Techbook** *intentionally* includes strategies and activities that develop creativity and innovation.

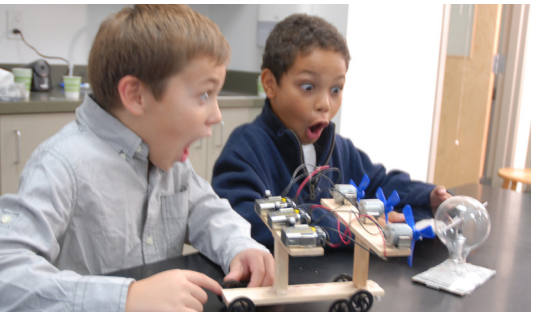
For example, middle school physical science students look at a number of substances and are asked to describe the substances they are studying in as many ways as possible. One possibility shared with students is creating shape poems to describe each substance. As they describe the physical and chemical properties of the substances they are studying, students are encouraged to use models, diagrams, graphs, and oral presentations to share their descriptions with classmates and the teacher. Students are encouraged to use the Board Builder that is within Techbook or to attach audio or video files that include their descriptions.

An additional approach to developing creativity with Discovery Education materials is asking students to take objects apart and investigate how they work. Students are then challenged to find creative ways to improve the object. For example, in one reverse engineering project, students analyze the structure and function of a variety of assistive devices (walker, neck brace, wheelchair, crutch), identify the problem each was designed to solve, infer the constraints involved in its design, and then brainstorm improvements to the design and function of the assistive device.

By interacting with **Science Techbook**, middle school students are building their skills in manipulating, extracting, and creating information using technology. These skills are essential in all career fields. Through their own experiences, students learn how technology is used to improve and expand scientific knowledge and extend human capabilities to solve problems.

Another strength of **Science Techbook** and the associated resources from Discovery Education is the wide array of STEM careers it presents to students. Every lesson includes a component entitled "STEM in Action." This component presents information on a career related to the concept of the lesson. It may include core interactive text, one or more videos, activities, and/or ideas for learning more about similar careers in the local area. **Science Techbook** presents careers such as zookeeper, astronaut, naturalist, meteorologist, environmental engineer, robotic engineer, forensic scientist, physicist, chemical engineer, roller coaster designer, simulation engineer, coastal

[4] McNeill, K., & Krajcik, J. (2012). *Supporting grade 5-8 students in constructing explanations in science: The claim, evidence, and reasoning framework for talk and writing.* Boston: Pearson.



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engineer, geneticist, technical writer, sound engineer, chemist, and statistician. Students learn about careers at NASA, careers in agricultural engineering, opportunities in veterinary medicine, and a host of other STEM fields. The professionals come from a wide variety of backgrounds and in some of the interviews they describe the path they took to their current careers. Some knew what they wanted to do from the time they were in elementary school, and others figured it out much later in life. The information helps middle school students understand that there are many pathways to interesting careers in the STEM fields.

4. Personalization of Learning

When learning is personalized, instruction shifts from the traditional educational model of a teacher-led classroom to a model that is student centered and teacher facilitated. Students have some choice as to the specific assignments they complete, and they often have choice as to the specific pathway they follow in completing assignments within a unit of study. **Science Techbook** is a perfect tool to support personalized learning. Teachers and students have access to a wealth of relevant resources such as readings, investigations, videos, and STEM Project Starters. These can all be individually assigned to students. All resources can be student facing, giving students the power to determine the order in which they complete assigned tasks and the types of resources they access. Alternatively, the teacher can require that certain tasks be completed in a specified order.

Additionally, students can personalize the look of their homepage and access a Resource Center, games, and blogs as well as their assignments. Students can tell at a glance when assignments are due and can view their scores on completed assignments. **Science Techbook** allows middle school students to take greater responsibility for directing their own learning and gives middle school students and teachers the tools they need to succeed in a personalized learning environment.

Conclusion

Implementing a great middle school STEM education program is an enormous challenge. Attracting middle school students' attention, developing their problem- solving skills, and preparing them for challenging 21st-century careers is important work. Our world is becoming increasingly complex. All students, whether or not they go on to pursue STEM careers, need a solid STEM education. **Science Techbook** is a 21st-century instructional resource designed to help middle schools succeed with the challenge of engaging, inspiring, and empowering all students.

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