

How to Use the **5E Instructional Model** with Next Generation Science Standards



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**This eBook is an updated version of “Aligned” vs. Designed: Using a 5E Instructional Model with Next Generation Science Standards.*

Introduction

The widely established 5E teaching sequence – which includes the progressive stages **Engage, Explore, Explain, Elaborate, and Evaluate** – is helpful for informing the design of science programs, units, and lessons.

However, it's important to pose the question: Does their current incarnation actually work to support the Next Generation Science Standards and deepen STEM (science, technology, engineering and math) learning in our students, or *does it require adaptation to best serve NGSS?*

In this eBook, we'll look at using a 5E instructional model with the Next Generation Science Standards. The main question we will seek to answer is: How can we make more effective use of the 5Es under NGSS?

We will start with an examination of what the 5Es are and what they represent, with an eye toward how these may be used and modified to help students take on the roles of scientists and engineers each time they step into the science classroom.

We will then explore how the 5Es are transitioning from their current widespread application as a linear application that takes a regimented phased approach toward a system that's much more nonlinear and comparable to science and engineering in the real world.

We believe that by combining and employing different aspects of the 5Es *simultaneously* as part of an instructional environment, you can significantly increase learning outcomes in your classroom or district.

In this eBook, we will ask several questions, including:

- Do the 5Es represent constructivist learning?
- Should we reconsider the KWL chart's appropriateness in NGSS?
- How can we make more effective use of the 5Es under NGSS?
- How can we create a 5E model that is both non-linear and iterative?

So without further ado, let's jump in by exploring the 5Es in their current iteration and then considering whether or not the 5Es actually represent constructivist learning.

SECTION 1:

Understanding the 5E Model

1 Chapter 1: What Are the 5Es?

The 5Es are an instructional model encompassing the phases Engage, Explore, Explain, Elaborate, and Evaluate, steps which educators have traditionally taught students to move through in phases.

First, instructors open a lesson with an activity or question meant to **engage** students, snag their interest, and offer the opportunity for them to share what they already know on the subject. This phase might include helping them make connections between their preexisting knowledge base and the new ideas that will come down the pipeline in the lesson or unit. Many educators use traditional KWL charts, in which students list what they already know and what they want to learn during this step. At the end of the lesson, students go back to this chart to list what they learned.

The standard KWL chart is often used during the “engage” part of a lesson. It asks students to list out what they already know, what they want to learn in the lesson, and what they learned at the end.

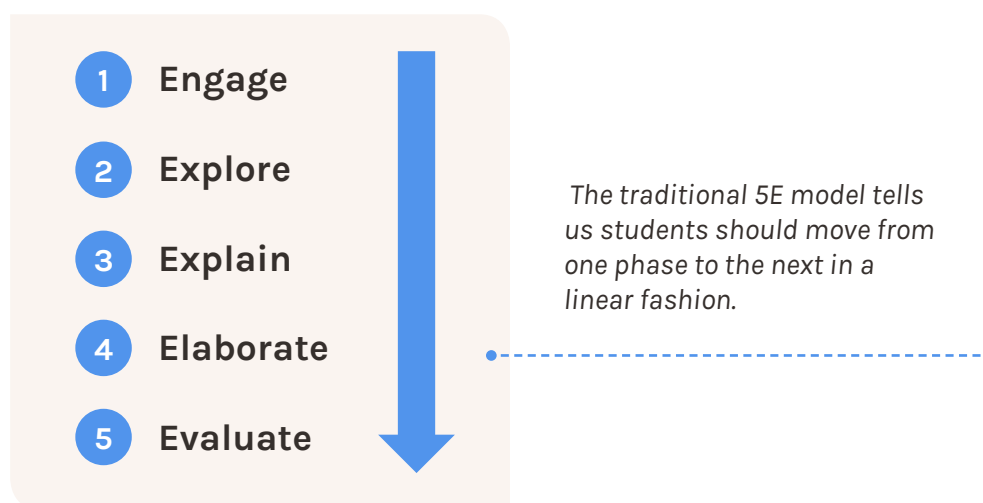
K	W	L
What I Know	What I Want to Learn	What I Have Learned

After engage comes **explore**, in which students carry out hands-on activities. Through their experiments or other interactions with the material, they deepen their understanding of the content.

Once they've explored, students attempt to **explain** what they have learned and experienced with help from the teacher – who only then explains concepts or terms encountered during exploration.

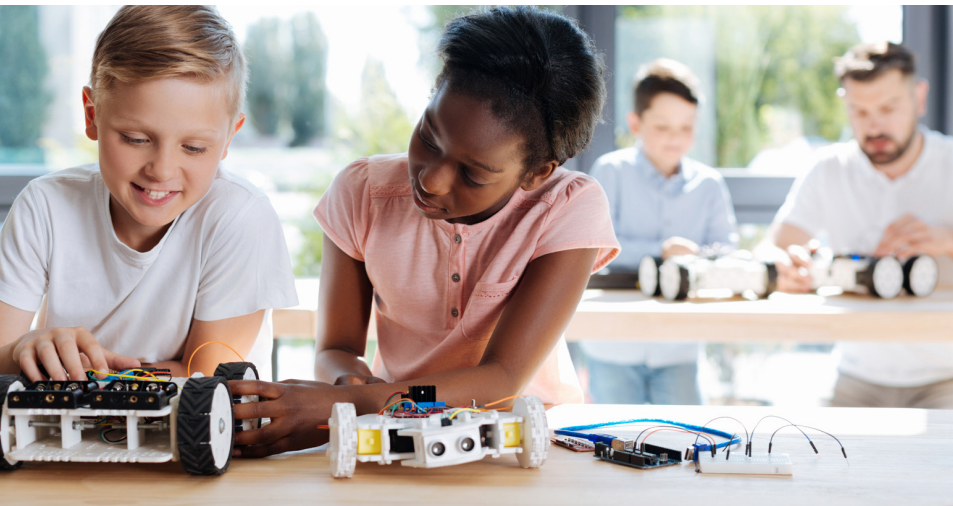
From there, students **elaborate** on their understanding, applying what they've learned to new situations to deepen their skills. In the final phase, students **evaluate**, reflecting on and providing evidence of their new understanding of the material.

At first glance, this seems like a good model for hands-on, student-centered instructional learning. However, this model misfires in one critical sense: it is used as a linear progression. Engagement comes first, exploring, explaining, and elaborating follow, and then evaluating wraps up the process.



The issue with this approach is that the 5Es are not actually a linear progression. Engaging is not separate from exploring. Exploring is not necessarily separate from explaining. Part of exploring requires elaborating. All of these elements require evaluating. Each step informs the others, even when they are more than once removed. To think of these phases in a linear sense, or to structure a lesson plan in this way, does not set students up to become scientists and engineers in the way required by the Next Generation Science Standards.

That doesn't mean we should throw the baby out with the bathwater. The 5Es are still an incredibly useful tool in teaching and learning. To see how they might be used better, however, we must take a moment to understand the history of the 5E model to see what they are really meant to represent: constructivist learning.



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Chapter 2: The 5Es and Constructivist Learning



Jean Piaget

The 5Es go all the way back to Jean Piaget, a Swiss psychologist in the early 20th century. Piaget came up with the idea of constructivism, a learning model that posits that human knowledge comes from experience and reflection, which then informs an individual's understanding and perception of the world.

The basic concept behind constructivism is *internalizing knowledge through our experiences*.

The assumptions behind the constructivist theory hold that humans are curious, and that we use patterns of knowledge to remember and respond to information. There are two mechanisms for this.

1. The first is that when we (particularly children) learn something new, we match it to our framework of understanding and then assimilate it. If what we experience already matches what we know, it fits in our framework easily.
2. The second mechanism kicks in if our experience doesn't match our framework of understanding. When this happens, we have to change our framework in some way. If we encounter something that doesn't match our experiences, then we are forced to accept that our understanding was false, accommodate that new information, and revise our framework of understanding.

Imagine you're having coffee with your principal or with your peers. You know the coffee is hot because you've been told it. However, you can also experience it yourself, such as when you burn your tongue.



We know that coffee is typically served hot and that a steaming cup can burn our tongue if we aren't careful. But do we understand this basic beverage tenet because we have been told that coffee is hot, or because we have experienced coffee's ability to burn at least once in our lifetime? How does our understanding of the idea "hot coffee" change when we go from hearing about it to encountering it ourselves? According to constructivism, it changes significantly.

In other words, you have two ways of acquiring this information: hearing it or experiencing it. If you've just heard that coffee is hot but you've never experienced it for yourself, you may understand conceptually that it is hot, but you might not internalize what exactly that means.

If you've experienced hot coffee, such as by scalding your tongue when drinking it or spilling it on your hand, you have a new understanding of what is meant by the term "hot coffee."

This concept is important because only when we understand the basic mechanisms of human learning—the idea that humans must experience something themselves to either match it to their framework or modify their understanding—can we really understand what it means to educate students in next generation learning environments.



Constructivism in a Science Classroom

In most traditional classrooms, educators want students to understand what they're experiencing so they tell them all about it. Of course, in a classroom, we remove that basic element of fear. (There should be no burned tongues!)

To extend the coffee metaphor, when an adult tells a child, “Hey! Hot coffee can burn your tongue!”, the adult is trying to do is prepare the child by telling them about those experiences.

This approach can help to keep children safe and is important in some contexts. However, in a classroom environment where the goal is lasting learning, the problem is that *telling* students something does not inform their understanding of their world in the same way that allowing them to experience it does.

Despite all of the focus on hands-on learning and inquiry that has gone mainstream over the last few decades, there's still a strong emphasis on listening in the classroom. This isn't to say that

listening is necessarily a bad thing; it just means that our focus needs to move away from creating good listeners toward helping students understand the actual learning process.

Part of Piaget's idea of constructivism is that students have an understanding of their learning process. Essentially, we as educators need to help students develop the tools to build their own knowledge. We need to set them up to be able to answer questions and to solve problems hands-on.

In today's science classrooms, students need to experience what it is to be scientists and engineers if they are to successfully use the practices and critical thinking skills in later life. Any application of the 5Es and attendant materials and teaching models must therefore underpin this goal.

An Everyday Example

Let's consider a visual representation through another common everyday experience: a car that breaks down.

If a car breaks down on the side of the road, someone who has learned about car mechanics by listening to someone else tell them facts will draw on their memory, perhaps thinking something along the lines of: "Has anyone told me about this before? What can I take from what I've been told and use that exactly to solve this problem?"

Unfortunately, if they haven't been told the specific answer to this specific problem, then they don't know how to approach finding an answer themselves. They won't be able to fix the car themselves.



If a car breaks down, a student who has been taught through listening will reach for the specific information they have on the subject of car breakdowns. Lacking real-world experience, students operate with an ungrounded framework of understanding that is theoretical, which makes it more difficult to generalize and apply their knowledge to any problem, especially one that is unfamiliar.

In the same way that you can't tell someone every variable that may cause their car to break down or the various ways to fix it, you cannot tell students every variable that they will encounter on a standardized test.

Instead, we need to think about developing students' skills, creating an environment where students can encounter problems and build a framework out of those experiences that helps them internalize their knowledge. In this way, students gain a classroom experience that prepares them for that later challenge, even though we can't ever predict exactly what that challenge may be.

Students taught this way have a tool set and relevant experiences to assist them in solving problems and answering questions on their own.

Again, Piaget’s idea of how students internalize knowledge or experiences is underpinned by this idea that students have an understanding of their own learning process. This is where *metacognition*, or thinking about thinking, comes in. This is the student’s personal reflection on their own experiences in life and their understanding of the world to date. When they have an experience, it leads to a deeper understanding of what they know or believe.

This is where a nonlinear, iterative 5E model comes in. We’ll explore how the 5E model can be modified so that it can better serve the learning goals of the Next Generation Science Standards.



SECTION 2:

Making More Effective Use of 5Es Under NGSS

The 5Es are still a valid instructional model for STEM education, but in order to ensure they can help prepare students to master the Next Generation Science Standards, we need to better understand how each phase should be used.

1 Chapter 1: What Each “E” Now Stands for in Practice

If it is to be of use with the Next Generation Science Standards, the 5E instructional model must move from a traditional model of instruction to a next generation model of instruction. Specifically, here is how it looks for each of the Es:

- **“Engage”** transitions from “I tell them or show them” to helping students reflect on what they already know and ask questions about what they don’t yet understand, which propels them toward an initial feeling of dissatisfaction.
- **“Explore”** moves away from thoughts such as “I give them,” “I demonstrate,” or “They look at a model” and toward students themselves unpacking the problem, developing a model, and gathering data.
- **“Explain”** no longer means turning and talking, having a carousel discussion, or asking questions like “What did” and “What was.” Now, it means digging deeply into where

the question has been answered or the problem solved, and using evidence to support claims.

- **“Elaborate”** is less about reading, watching or introducing new ideas, and more about forging the incredibly valuable concept-to-self, concept-to-concept and concept-to-world connections that help tie anchor and investigative phenomena together.
- **“Evaluate”** cannot simply mean vocabulary assessments or graded journals anymore; now it means reflecting critically on the investigative process, the hypothesis, and the anchor phenomena.

	Traditional (I do)	Now with NGSS (You do)
Engage	I tell them... I show them...	Student reflects Student questions
Explore	I give them... I demonstrate... They look at a model...	Student unpacks problem Student develops model Student gathers data
Explain	Turn & Talk Carousel “Discussion” What did... What was...	How have you answered the question? How have you solved the problem? How does evidence support this claim?
Elaborate	Read about Watch Introduce new idea	Concept-self connections Concept-concept connections Concept-world connections Anchor → Investigative Phenomena
Evaluate	Give vocab. assessment Keep journals to grade	Reflect on investigative process Reflection hypothesis New reflection on anchor phenomena



The 5E Model with NGSS

With NGSS, engagement begins with anchor phenomena, which are complex, real-world situations. They can be investigated in the classroom through an investigation that students or student teams have planned, and are a way of encountering just a thread of often much more complex ideas.

Part of the challenge here is to engage students in a complex real-world situation that causes them to be dissatisfied in some way, either with what they know or can explain, or with the fact that this phenomenon even exists. That causes them to engage in an investigation that not only stems from inner motivation but that also adds meaningfully to their experience of the world. This is where the investigative process goes back to Piaget's research and to constructivism.

Let's go back to the traditional KWL chart and ask how phenomena-led teaching and learning fit in. Here at KnowAtom, we argue that the KWL chart isn't that useful, and should instead be replaced by a WWH model—Why, What, and How.

Instead of trying to start the student experience with what they know, start with *why*. In the case of KnowAtom, we use nonfiction text, visuals, and sometimes even videos as the beginnings of anchor phenomena. The purpose of that is to establish a *reason to care*.

Next is *what*. What are the elements in that anchor phenomena that we could explore? What are the problems or questions that we see with this? This is where we get students really dissatisfied, where they examine a belief to find out what's really behind it. What evidence do we have for believing it?

Now, we're going to ask *how*. How we will explore one of these problems or one of these questions? After all, that anchor phenomenon has many variables. As scientists or engineers, we can't explore every variable at once. We have to narrow it down to one aspect. So how can we gather evidence to try and solve our dissatisfaction with what we know?

This is where students come up with the problem or question that will be the primary focus of the investigation. This is where they gather data or evidence to really dig in and see what's going on, and so it leads to the exploration phase of the 5E model.

Student exploration is a critical time for students to begin developing the eight science and engineering practices of NGSS.

The practices of science and engineering are very specific, involving eight steps that work together to give students the ability to engage successfully with phenomena and situations that they have not encountered before.

- 1 **Asking** questions (for science) and **defining problems** (for engineering)
- 2 **Developing** and using models
- 3 **Planning** and carrying out investigations
- 4 **Analyzing** and interpreting data
- 5 Using mathematics and computational **thinking**
- 6 **Constructing** explanations (for science) and **designing** solutions (for engineering)
- 7 Engaging in **argument from evidence**
- 8 **Obtaining, evaluating** and **communicating** information

(NRC Framework 2012)

It's important that teachers support their students in productive struggle through that planning process so that they actually internalize the skills and develop them as a habit when they encounter something that requires investigation or when they encounter something that does not meet their framework of understanding.

Evaluating is really about evaluating from a higher order thinking standpoint. It's about reflecting on the investigative process that students or teams used, and asking "How did that process impact our results?" How can students reflect back on our hypothesis, and reflect back on the larger anchor phenomena through the investigative phenomena they experienced?

That's what Piaget was talking about: When we don't have enough knowledge to accommodate an idea, we're forced to investigate until we can gather enough information to revise our thinking. This is a basic human tendency that can be encouraged in the classroom to create students proficient in STEM fields and prepared to take on the roles of question-answerers and problem-solvers in later life, even outside of the fields of science and engineering.

The realignment of each E helps science classrooms cleave much more closely to the intentions of the Next Generation Science Standards and, indeed, to the natures of science and engineering themselves.

At the same time, it's important to remember that these five phases do not exist in isolation. You don't stop exploring when you're elaborating or explaining. Exploring is actually a *method* of explaining. You need to be engaged throughout all of these reflectively and critically.

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Chapter 2: How We Use the 5Es in an Iterative Spiral



This is how KnowAtom has re-imagined the 5Es as an iterative spiral, dispensing with the linear “beginning” and “end” of the process and instead forming a loop in which debriefing after a lesson or unit sets students up to explore the next, using each of the Es multiple times along the way.



In order to properly prepare students for mastery and meeting the NGSS performance expectations, we must change our perception of the 5Es from a linear process to an iterative spiral. As you can see in the image above, with KnowAtom's approach each phase now includes multiple Es, linking together one to the next. When you reach the 5th stage, the cycle is not "complete," but ready rather to inform a new iteration. Our breakdown goes like this:

In nonfiction reading, students **engage** with complex real-world anchor phenomena as well as **explain** different connections within the phenomena to demonstrate their conceptual understanding.

When we move to Socratic dialogue, students **engage** in critical and reflective group dialogue by making concept-concept, concept-self, and concept-world connections. They then **explain** how elements of anchor phenomena may be explored and perhaps explained scientifically. Teachers coach students to **elaborate** on their ideas to make additional connections, while students **evaluate** their ideas and the ideas of others with factual evidence as they move toward deeper understanding in the dialogue. Students then prepare to **explore** ideas that they identify as weak or lacking evidence.

Next it's time for planning and carrying out investigations. In this phase, students **engage** with investigative phenomena that provide real-world contexts for what they will investigate,

presenting a question to answer or problem to solve. They also **explore** the investigative phenomena, working independently or in teams, and **explain** how they will investigate the phenomena and the kinds of data they will collect.

Afterwards, students have an opportunity to share their conclusions – the results from their investigation, experiment, or engineering lab – to **explain** the investigative phenomena scientifically by forming a conclusion, complete with a claim reasoned with evidence gathered during their investigation (both in writing and verbally).

Lastly, debriefing and transition are opportunities for students to **elaborate** on their conclusion, making connections back to the anchor phenomena and the big-picture questions the investigation addressed. Teachers **evaluate** student understanding, assessing for misconceptions before moving onto the next lesson.

As you can see, this is a much more dynamic process both in terms of how the 5Es get delivered as well as in how they interact with the curriculum and the learning environment.



Role of the Teacher

Throughout the year, the teacher's role changes. At the beginning of the year, students have a significantly less well-developed skill set in relation to higher order questioning and Socratic dialogue, so teachers play the role of coach much more, asking more questions and encouraging discussion. As students learn the skills to argue scientifically and ask the questions themselves, however, the teacher can step back. The students have built a habit of elaborating that they can employ on their own.

Sharing conclusions is an opportunity for students to explain their reasoning and learn scientific argumentation, and it is a critical skill. The same goes for making connections back to original hypotheses and evaluating one another's work – having scientific discourse, in other words.

The ability to move from one concept to the next iteratively, using the 5Es along the way, is an incredibly valuable skill. These are, in fact, habits of mind.

3 Chapter 3: Habits of Mind and the Classroom Experience

“Habits of mind” is a buzzword these days, but we shouldn't dismiss it because of that. By way of quick background, the habits of mind are a set of 16 life skills related to problem-solving, relationship building, creativity, and so forth. Without going into all of them, the habits of mind include abilities such as persisting, managing impulsivity, thinking flexibility, thinking about thinking (metacognition), striving for accuracy, gathering data with all senses, taking responsible risks, and so on.



While each of these constitutes a useful skill in the classroom, we should not get stuck on the traditional 16 habits. Rather, “Habits of Mind” as a whole means patterns of thinking that students can fall back on in unfamiliar and initially inexplicable situations, such as when a car breaks down on the side of the road. Habits include the 5Es and the science and engineering practice skills.

Habits of mind can significantly improve the classroom experience when taught correctly. Where the science and engineering practices intersect with content, and as students develop their critical thinking skills, they’re actually using those habits of mind to develop and use that context to answer questions and solve problems as scientist and engineers. These habits are a powerful mechanism of learning, and it all starts with getting students dissatisfied. We’re putting them in a situation where they take their idea and they test it.

Then, as a result of what they encounter, they either assimilate or they revise their framework of understanding. They are either able to take what they encounter and say “Yes, that is confirmed” or “No, my understanding must be false or incomplete. What I have just encountered now augments my understanding and changes it. I’ve revised it and so now my framework changes.”

This is admittedly a complex idea, that simple modes of thinking could influence so greatly how successfully students are at understanding science and engineering concepts and developing skills. While revising the mental framework is the natural human response to new information, thinking critically and using the habits of mind are not always intuitive skills. In fact, they usually aren’t, which is why it’s so important to ensure good curriculum in our classrooms.

The reason KnowAtom believes it’s important to understand constructivism to understand the 5E model, and it’s important to relate these both to the Next Generation Science Standards, is

because we believe that when students are challenged to be scientists and engineers, they are actually developing the creative, evaluative, and analytical thinking skills that are useful for any college or career choice.

That's key. That's what opens a world of opportunity to any student. That's why we really see these Next Generation Science Standards as going beyond linear, two-dimensional models. This approach is not enough anymore; it is the formation of skills, and the ability to develop and use content, that is so vital to the classroom experience today.

If you would like more information, please reach out and we would be happy to have a conversation with you about how we might help to meet the needs of your students, your classroom or your district.



KnowAtom

KnowAtom believes a quality science, technology, engineering and math education is essential to turning students into critical thinkers with the problem-solving skills to change the world. We give schools everything they need to teach STEM and partner with teachers so that they have more time to engage with students and collaborate with peers. This gives students the ability to be scientists and engineers in the classroom.

KnowAtom's approach teaches students to analyze and evaluate, question and create. These skills aren't just useful in a science classroom. They're applicable to art, ELA, math, and social studies, as well as to college and career. Here, STEM is a way of thinking. Teaching is a way of transforming lives. And good resources are the tools that help everyone focus on what matters in the classroom.

Want to see how your current curriculum measures up?

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