

# Gizmos Support Classroom Scientific Sensemaking

## Executive Summary

*With the wide adoption of new science standards emphasizing scientific sensemaking, engaging and interactive High-Quality Instructional Materials (HQIM) are critical for helping teachers meet modern educational standards, fill gaps in core curriculum, and improve student outcomes in STEM. The current study summarizes responses from nearly 300 teachers on the impact of Gizmos interactive math and science simulations on student engagement and learning in their science classrooms. Teachers reported that Gizmos significantly enhanced student engagement, understanding, and enjoyment in science, outperforming other similar instructional materials. Teachers also noted that Gizmos are a versatile tool supporting online learning, personalized activities, and equitable outcomes for all students.*

## Engaging Minds, Enhancing Knowledge: Insights from Teachers Using Gizmos to Support Scientific Sensemaking

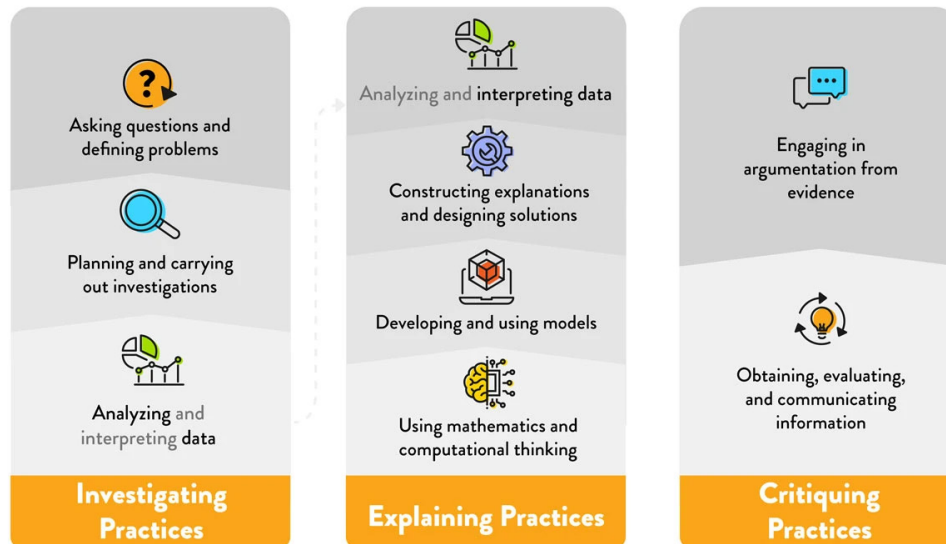
Science classrooms have undergone a major shift in the past ten years. Nearly every U.S. state has adopted new K-12 science standards that emphasize an approach to learning where students actively integrate **the practices of doing science** with the **core ideas of science** in the context of **exploring phenomena** and solving real-world problems. Engagement in the science practices, such as asking questions, developing models, and analyzing data, gives students the opportunity to learn the way scientists do—through active experimentation, exploration, and hands-on inquiry.

*"Science is an essential tool for solving the greatest problems of our time and understanding the world around us."*

*National Academies of Sciences, Engineering, and Medicine, 2021 report*

Inviting students to participate in this kind of “**scientific sensemaking**” has been shown to be the most effective way to deepen students’ understanding, help them build connections across science disciplines, and prepare them to think critically and solve novel problems, a skill set increasingly in demand in today’s workforce. Research with adopters of new K-12 science standards that encourage scientific sensemaking found increased student engagement, deeper student learning, and better outcomes even for low-performing and at-risk students (WestEd, 2020).

## Science and Engineering Sensemaking Practices



High-Quality Instructional Materials (HQIM) are essential for enhancing both instructional effectiveness and efficiency to support teachers in meeting and these challenging new standards and fostering students' sensemaking. HQIM also need to be accessible to all students, including English language learners, students with disabilities, and those from diverse cultural and socioeconomic backgrounds. Lastly, HQIM include assessments that align with the new standards, enabling teachers to track student progress in both knowledge and practices in preparation for state assessments that evaluate the same.

High-Quality Instructional Materials have been increasingly recognized as an important factor in improving educational outcomes. A number of research studies over the last few years have found significant impacts on student learning outcomes as a result of adopting high-quality curriculum materials (see Steiner et al. 2018 for review). These studies suggest that “**switching from a low- to a high-quality [resource] can boost student achievement more than other, more popular interventions** such as expanding preschool programs, decreasing class sizes, or offering merit pay to teachers” (pg. 9), leading to the conclusion that adopting HQIM can be one of the most cost-effective school improvement tools.

### Lack of Truly Aligned Instructional Materials

Although standards-aligned instructional materials are now available for adoption, district leaders indicated that **most materials, if not all, have gaps**. It is unlikely that any instructional materials will be a perfect fit for any district. Even if a district has adopted instructional materials for science, the district should not consider new standards implementation a done deal.

Unfortunately, few K-12 science curricula meet the bar of HQIM and fully address all of the complexities of the new standards. A recent analysis from EdReports highlights the need for more HQIM in K-12 science. While the report found that 96% of science teachers said that materials aligned to their state's science standards are critically important to them, only 37% of those teachers found their current materials to meet the criteria for HQIM.

A further analysis of the materials teachers actually have available to use found that **just 6% of science teachers regularly use HQIM** (EdReports, 2024). Thus, the availability of High-Quality Instructional Materials that teachers are willing to use is a **critical need** for supporting both teachers and their students.

**To meet this need for more HQIM for science instruction**, the **ExploreLearning team designed Gizmos**. The Gizmos resources include both Gizmos simulations, interactive math and science inquiry-based activities for grades 3-12, Gizmos STEM Cases, case studies that put students in the role of STEM professionals tasked with solving real-world problems, along with customizable worksheets to help teachers and students dive even deeper into the problems.

ExploreLearning designed these resources as supplementary HQIM learning materials. Gizmos are intended to integrate with and amp up the focus on science sensemaking of any core curriculum, and be easy to use and implement for both teachers and students. They can also be used for remediation around science sensemaking. The ExploreLearning team was eager to document just how well teachers found Gizmos resources to meet this challenging but important goal.

Researchers conducted the current study to provide a window into teachers' experiences using the Gizmos products and materials to engage their students in inquiry-based learning activities that meet the newest standards and to ascertain what kind of student outcomes are achieved as a result. ExploreLearning designed Gizmos as supplementary HQIM learning materials to integrate with and emphasize the science sensemaking of any core curriculum. Gizmos virtual simulations are easy to use and implement for both teachers and students. Discover how teachers found Gizmos resources to meet challenging but important classroom goals.

The team conducted an online survey of math and science K-12 teachers who used either Gizmos simulations or Gizmos STEM Cases (*referred to collectively here as Gizmos*) during the 2023–2024 school year from three different school districts in the US and Canada. A total of 298 teachers completed the survey, which included both rating scale and open-ended questions. Most teachers used the learning materials frequently, with over half of the teachers (58%) using Gizmos simulations at least once per month, and 31% of Gizmos STEM Case users using them at least once per month. Some of the topics that were addressed in the survey and summarized here are:

- *The ways that Gizmos support the needs of the 21st-century classroom*
- *Using Gizmos to engage students in science sensemaking practices*
- *Positive student outcomes observed from using Gizmos*

## Meeting the Needs of the 21st Century Classroom

Teachers were asked about the ways that Gizmos were particularly impactful in their classrooms. **A number of these comments highlighted the ways that Gizmos serve as a versatile and valuable tool to support the needs of the 21st-century science classroom.** From online learning to supplementing physical labs and ensuring that all students, regardless of their background or learning challenges, have an opportunity to succeed, teachers told us of the many ways that Gizmos uniquely supported their needs.

### 1. Support Online or Blended Learning Strategies

Gizmos were invaluable in a rapid switch to online learning environments, where students needed to engage with science content remotely or asynchronously. Teachers noted how Gizmos allowed them to deliver meaningful, interactive, and engaging lessons in the absence of traditional in-person labs, without sacrificing the “hands-on” aspect of inquiry-based learning.

- *"During the pandemic, students were able to see concepts online that I was not able to demonstrate in person. It made all the difference between theory and practice where students could fully understand the concepts."*
- *"As an online teacher, we don't have a lab in our school, or any science equipment, so having online labs at our disposal is incredibly useful!"*
- *"Gizmos allowed my online science class to practice lab exercises in the most realistic way possible in a virtual class environment."*

### 2. Provide Flexibility in Assigning and Personalizing Activities

Another way that Gizmos simulations meet today’s teaching needs is the flexibility they provide to teachers in terms of assigning activities and adapting them to individual student needs. Teachers appreciated the ability to assign Gizmos as either homework, makeup work, or alternative assignments for students who needed extra time or who were unable to attend class in person. The customizable nature of the activities also made it easy for teachers to align the content with their own teaching objectives or specific student needs, enhancing their teaching strategies. This ability to tailor assignments helped both teachers and students navigate the complexities of different learning paces and circumstances.

- *"The worksheet + teacher answers were so helpful for me to edit for my purpose—having a ready-to-go resource is so helpful."*
- *"Students who do independent credits/credit recovery usually request Gizmo activities as a substitution for other packaged materials"*

Several educators highlighted the convenience of using Gizmos for students who were still learning remotely due to health issues or other circumstances that kept them out of the classroom. For example, one teacher mentioned using Gizmos for a student with severe health concerns, allowing her to achieve course expectations on her own time.

### 3. Complements to Primary or Physical Lab Resources

Most teachers in the survey (89%) reported using Gizmos as a substitute for a laboratory activity. Gizmos were frequently noted as a solution to the challenge of limited physical lab resources. Teachers in schools with restricted budgets or inadequate lab space found that Gizmos provided a meaningful (and cost-effective) way for students to engage in science experiments. This was particularly useful for experiments that required expensive or hard-to-find materials, tools, or lab setups that were not available in the classroom. **The ability to replicate lab experiences with interactive, digital tools allowed students to conduct experiments that might otherwise have been impossible.**

For example, one teacher mentioned that Gizmos were essential in helping students experiment with acids and bases when the school lacked litmus paper and other necessary lab materials. Another teacher emphasized how the **Frog Dissection Gizmo** served as an excellent supplement when behavioral challenges with her students made her nervous about diving right into a physical dissection.

- *"I used the **Melting Points Gizmo** to accompany a lab I did in the classroom. It was great as the Gizmo allowed students to see ionic substances melt, which we could not do in our lab due to limitations."*
- *"This year, I was moved from a science classroom to a cart for a push-in. I went from having a lab classroom to having no space. Gizmos were really helpful this year to explain phenomena."*

#### 4. Ensures Equitable Learning Outcomes for Students

Gizmos were highlighted as an important tool in supporting equitable learning outcomes for diverse student populations, including English Language Learners (ELLs) or Multilingual Learners (MLLs), students with learning disabilities, and students who face behavioral challenges. Teachers noted that the opportunity to work at their own pace with instant feedback helped these students better understand challenging content and build confidence.

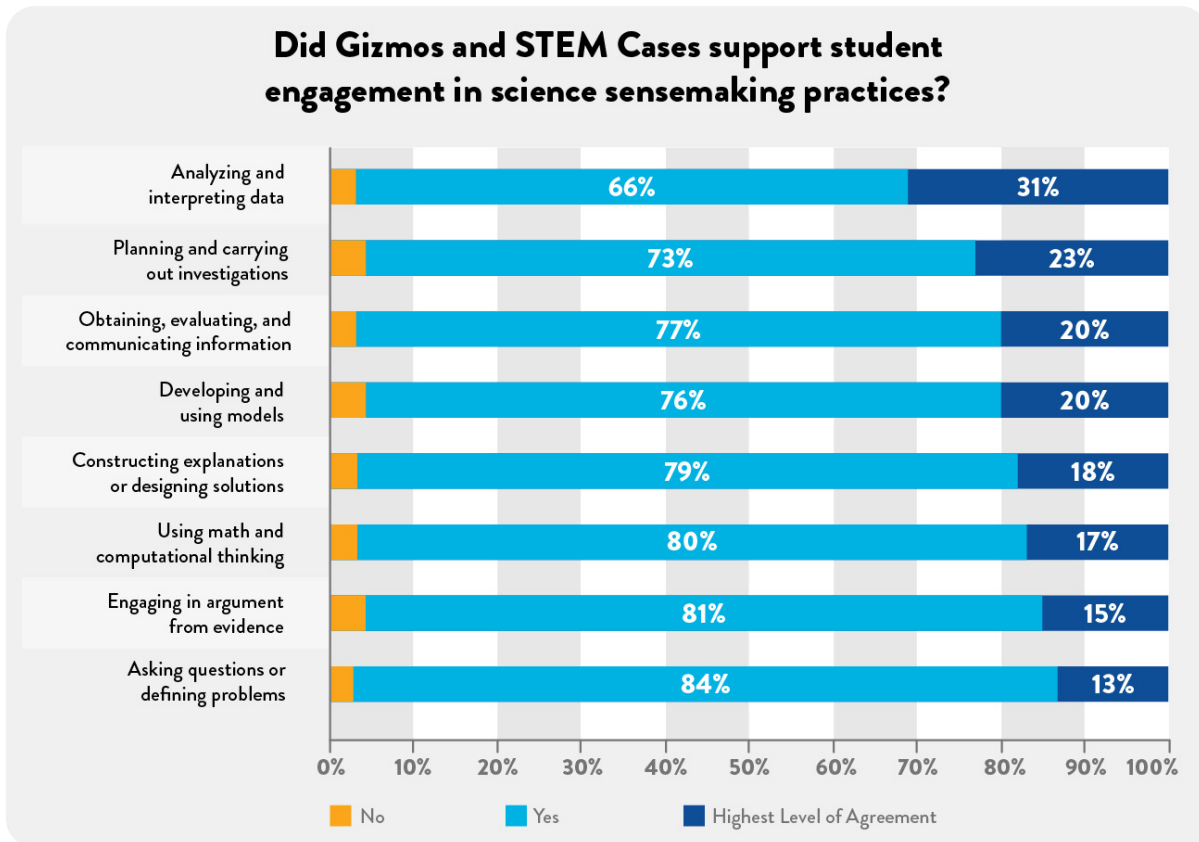
For example, teachers working with MLL students reported that the **visual and interactive elements of Gizmos helped students grasp difficult concepts more effectively, reducing language barriers and enhancing comprehension**. For students with other challenges, Gizmos provided a less intimidating, self-paced way to explore scientific phenomena, which contributed to better engagement and deeper learning.

- *"Gizmos helped my students understand measurement on a deeper level using the modeling tools. This was particularly beneficial for my MLL students."*
- *"A student in my physics class generally had difficulty following concepts during lecture or even while reading the textbook. However, she often would say 'I get it now' after completing Gizmos assignments."*
- *"A student in my class who consistently struggles with maintaining focus told me during the Programmable Rover Gizmo that it was the best day of science they ever had and they loved it. They not only were focused for the entire time but were excited to answer the questions."*

#### Using Gizmos to Engage Students in the Science Sensemaking Practices

To look for evidence that products were delivering on their original value proposition, teachers were asked whether Gizmos supported their students' engagement in each of the eight science and engineering scientific sensemaking practices, and if so, to what extent on a 4-point scale (little - considerable).

**Over 95% of teachers responded that these tools did support student engagement for each of the practices.** Many of these responses indicated that they felt Gizmos and STEM Cases provided "considerable" support for engaging in the practices, particularly the practices of *"Analyzing and Interpreting Data"* and *"Planning and Carrying Out Investigations."*



This can also be highlighted in the many quotes from teachers responding to the question of impactful Gizmos and STEM Cases usage, which cited many of the practices:

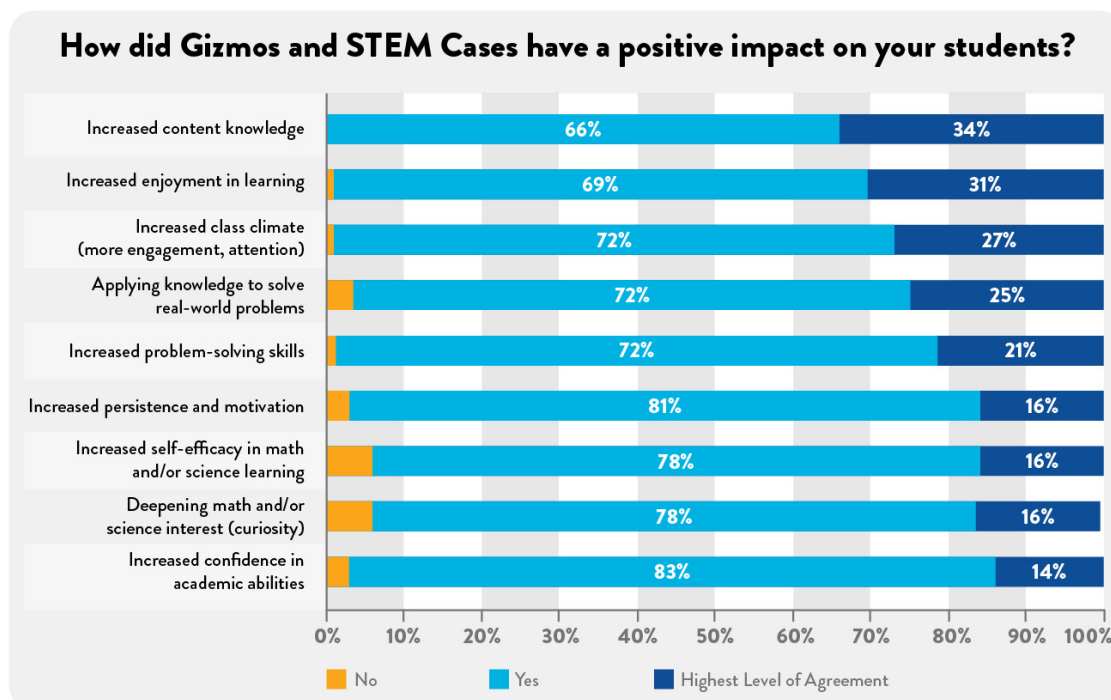
- “Students used the **Heredity and Traits STEM Case**. They were able to see how the behavior of bees resulted from inherited traits and how bees continued to protect the gene pool. Students were able to apply this to human reproduction and heredity and gain a better understanding of the concepts we explored in class. They were able to discuss what they learned and explain traits/heredity using the information from the STEM Case.”
- “I used the **Flood and Storm-Proof Homes Gizmo** during our extreme weather unit...Students saw from a structural engineering point of view why the foundation was so important, and the students were able to see the strength of weather. It was just a very memorable fun lesson and the kids loved playing around with the different building options. We tried to see whose house could withstand the flood for the least amount of money, with the least amount of upgrades, etc. so it turned into so much more than just building a little house in a flood.”
- “This year, my students had difficulty understanding the connection between photosynthesis and cellular respiration. In doing the **Cell Energy Cycle Gizmo** they were able to play with the amount of waste product each cycle produced in order to make a relationship between the two cycles.”

## Student Outcomes from Gizmos and STEM Cases

We were also interested in documenting the student outcomes observed by these teachers after using Gizmos and STEM Cases. For instance, did students improve their content knowledge, problem-solving skills, and application of knowledge to other phenomena? While knowledge is an important outcome, how students feel about learning is also an important outcome that can have a large impact on their future trajectory in STEM courses and STEM careers, but is far less frequently quantified by formal classroom assessments.

Overall, nearly all (93%) of teachers surveyed said that they observed a positive impact of Gizmos on their students, with 42% observing moderate outcomes and 51% observing considerable improvements. This level of learning and engagement observed from Gizmos was an improvement from other HQIM materials they have used to teach similar concepts. **81% of teachers surveyed said that Gizmos were better at improving learning and engagement than any other materials they had used.**

We also asked teachers about the specific outcomes that they observed from student usage of Gizmos, including questions about improved knowledge, improved attitudes toward learning, and problem-solving skills. Over 94% of teachers responded that these materials had a positive impact on students for each one of the outcomes assessed. Many of these responses indicated that they felt Gizmos had “considerable” positive impacts, particularly in the areas of increased content knowledge, application of knowledge to other phenomena, increased class engagement and attention, and increased enjoyment in learning.





These same findings can also be seen in the teacher-provided stories of using Gizmos in ways that resulted in positive impacts on student knowledge and affect:

- *“The **Photosynthesis Lab Gizmo** that uses different colors of light to demonstrate the rate of photosynthesis is always an ‘a-ha’ moment for students. When they get into the Gizmo and start to realize how all the factors that affect photosynthesis work together, it makes the concept really click for the students.”*
- *“[My students] work very well when we work with hands-on concrete examples. Working together through the **Ecosystems STEM Case** we were able to explore how populations grow, shrink, and change. They were able to then take that knowledge and apply it to a novel task where they had to analyze the human population of earth and say how we could change that population to make better use of our resources.”*
- *“My grade 5 students were struggling with understanding decimal numbers and developing negative feelings about the learning. I introduced them to the **Treasure Hunter Gizmo** where they needed to use decimal numbers to find the treasure, and every student was engaged and demonstrating increasing understanding to complete their missions.”*
- *“The **Summer and Winter Gizmo** is a great tool for students to understand why it is colder in the winter and hotter in the summer. It integrates some Optics prelude for the next grade and debunks the myth that the Earth is further from the Sun in the winter!”*
- *“Students enjoy ALL the Gizmos. The students particularly enjoyed the **Frog Dissection Gizmo**. As a teacher it was the next best option to an actual dissection.”*

Feedback from real teachers and classrooms underscores the impact of Gizmos on increasing students’ understanding and overall engagement with science. Gizmos are High-Quality Instructional Materials that enhance and support scientific sensemaking for all students.

## SPOTLIGHT ON CLASSROOM SUCCESS

### We asked teachers to share notable success stories they observed this year.

*“I had a student who was struggling to motivate himself to learn about ecology. However, he did like to fish. I assigned him the Pond Ecosystem Gizmo and our ensuing discussions allowed him to pass the unit.”*

*“Gizmos transformed my 9th-grade biology class, making complex concepts accessible and engaging. Traditionally, students struggled with the intricacies of [cellular respiration], finding it abstract and confusing. Gizmos provided a game-changer. Students could better visualize the stages of cellular respiration in real time. They manipulated variables, observed outcomes, and engaged in trial-and-error learning, which deepened their understanding far beyond textbook explanations.”*

*“One student, who had consistently struggled with science, had an ‘Aha!’ moment. She exclaimed, ‘I finally get it!’ Her newfound confidence spread throughout the class, fostering a collaborative environment where students eagerly discussed their discoveries and hypotheses.”*

*“I teach ‘Interactions in Ecosystems’ and it can be very difficult for some students to create a visual story in their mind about how one species can impact another. Since it is very difficult to create this situation in reality, having the simulations run through Gizmos is a lifesaver. Students can alter the populations and add other factors and see what happens over the simulation.”*

*“My students absolutely loved solving the Cell Respiration STEM Case of the CIA agent being poisoned and they had to figure out which toxin caused it. They used their knowledge of cellular respiration to solve the problem. They felt important and they were doing ‘real’ science work solving the case.”*

*“One of my students struggled with math and found it unengaging. Initially skeptical, she tried a Gizmo on quadratic equations. Manipulating variables and seeing immediate graph changes helped her understand the concept better than traditional methods. She continued using Gizmos throughout the semester. While some topics remained challenging, the visual and exploratory approach made them more approachable. Her participation noticeably increased with Gizmos compared to traditional methods. By the end of the semester, she felt more comfortable with math.”*

*“Recently a student who is reluctant to do a lot of work was able to demonstrate his incredible understanding of how the Fast Plants®- Growth and Genetics Gizmo enabled him to manipulate the outcome of the plants grown. He was then able to be the expert for one of his peers, improving his self-confidence.”*

*“The STEM Cases are amazing. The design exposes students to actual problems and the scientific processes used to solve them. They connect well to the topics being studied. The Cases generate discussion among the students. They also expose students to ways in which the material they are studying is applicable in the real world and how this knowledge can be used in science careers.”*

*“I used the Density Gizmo with students as an inquiry activity which was followed by a hands-on lab to determine the identity of a metal density. Students had a better understanding of what to do as they were able to use what they learned in the simulations.”*

## CITATIONS

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