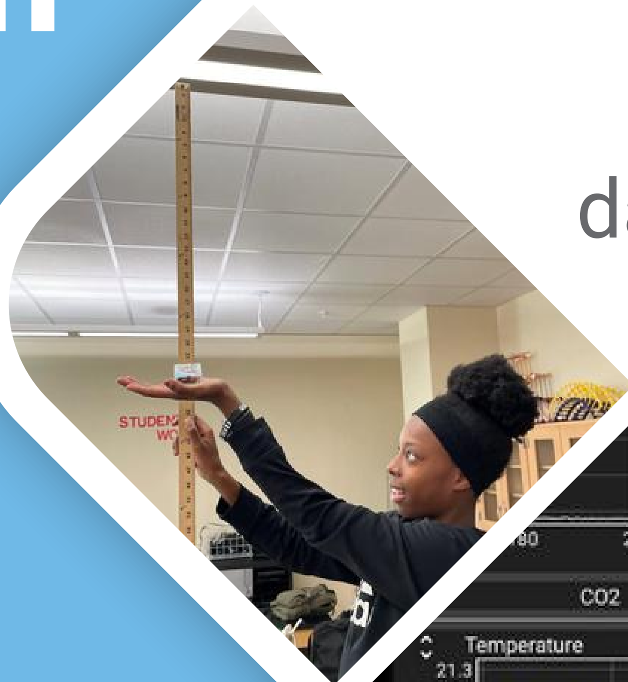
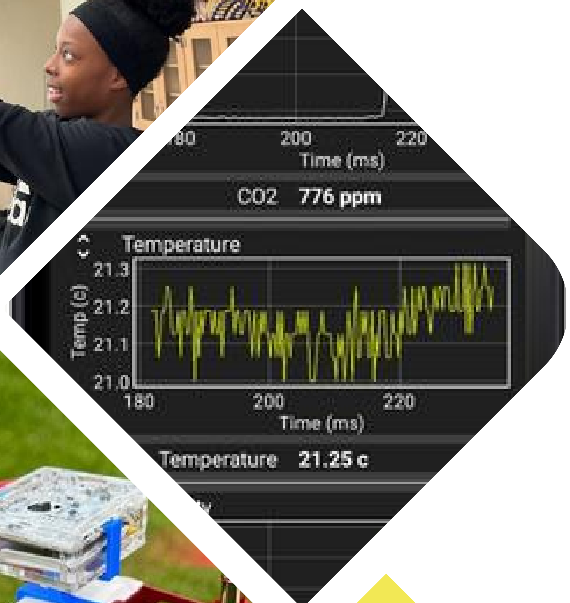
RESEARCH

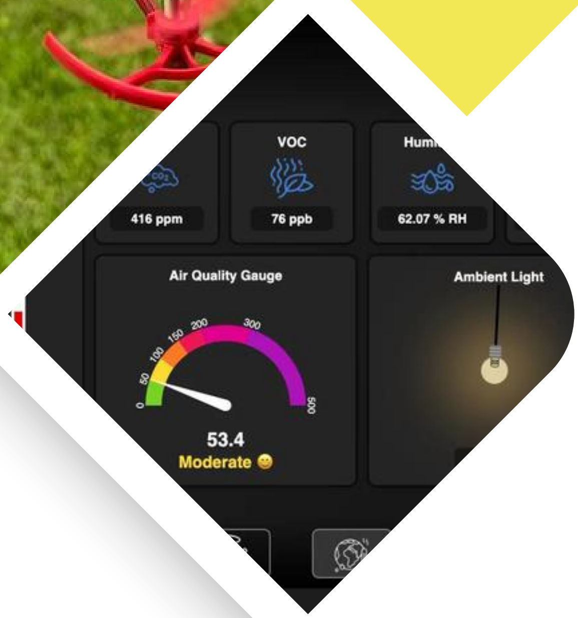
databot.

WHY SENSORS

Transforming STEAM Education Worldwide







Mission

The world is driven by data and we are driven to teach future generations how to use it for good. We create data powered technology and brilliant activities that empower students everywhere to think deeply, explore with passion, and solve our planetary scale challenges.

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Introduction

databot™ packs 16 sensors into a low-cost, tiny 1.67" footprint and offers a simple, elegant solution for STEAM programs. For science, one touch simplicity enables educators and students to gather data from one or multiple sensors simultaneously and the variety of sensors available can be used to explore topics across physics, chemistry, life science, earth science, and the environment. The included sensors are:

- Accelerometer
- Air Pressure
- Altimeter
- Ambient Light
- CO2
- Color
- Gesture
- Gyroscope
- Humidity
- Magnetometer
- Proximity (Time of Flight
- Proximity (close range)
- Sound
- Temperature Probe (2x supported)
- UV Index
- Volatile Organic Compounds

1.67" x 1.67"

In addition, the databot open hardware design enables the addition of other sensors using I2C and connecting to other devices and systems using WiFi, Bluetooth, and UART. These capabilities enable work beyond science affording rich opportunities for computer science, physical computing and technology.

The Importance of Sensors for Exploring Science

Using sensors for learning provides important benefits for students including meeting a variety of educational standards required in math, science, technology, engineering, and computer science standards frameworks. Sensors provide a powerful tool for students to engage in hands-on learning, collect and analyze data, explore real-world applications, enhance motivation, foster collaboration, and strengthen STEM education. By incorporating sensors into the learning process, students can develop critical skills and a deeper appreciation for the subjects they are studying.

Hands-on and Experiential Learning
Sensors allow students to engage in hands-on learning experiences, enabling them to interact directly with the physical world. This experiential learning approach helps students develop a deeper understanding of scientific concepts and principles by observing real-time data and making connections between theory and practice.

Data Collection and Analysis
Sensors facilitate the collection of accurate and precise data in various fields such as physics, biology, chemistry, and environmental science. Students can use these data sets to analyze patterns, identify trends, and draw conclusions. This process encourages critical thinking, problem-solving, and the development of analytical skills.

Real-World Applications

By utilizing sensors, students can explore real-world applications of scientific concepts. For example, they can measure environmental factors like temperature, humidity, and air quality to understand how they impact ecosystems or human health. This practical approach helps students appreciate the relevance of their learning and fosters a stronger connection between classroom knowledge and the world around them.

Engagement and Motivation

Incorporating sensors into the learning process can increase student engagement and motivation. Sensors provide immediate feedback and visual representations of data, making learning more interactive and enjoyable. Students are more likely to be actively involved in their studies when they can see tangible results and have a sense of ownership over their learning process.

Collaboration and Teamwork

Sensor-based learning often encourages collaborative work among students. They can design experiments together, collect data as a team, and analyze the results collectively. This collaborative approach fosters communication, cooperation, and teamwork skills, which are essential in many aspects of life beyond the classroom.

STEAM Education Enhancement

Sensors play a vital role in enhancing STEAM (Science, Technology, Engineering, and Mathematics) education. They enable students to explore scientific phenomena, conduct experiments, and engage in engineering design challenges. By using sensors, students can gain practical skills and a deeper understanding of STEAM subjects, preparing them for future careers in these fields.

Equity of Access

Sensor technology has never been more accessible or affordable due to a proliferation of physical computing, DIY electronics, and K12 robotics programs. databot makes this technology accessible and easy-to-use for educators and students out-of-the-box, no assembly, soldering, or coding necessary. Students in early elementary as well as high school now have equity of access to this technology.

A mobile STEM outreach program operated by Agastya International Foundation in India reaches students throughout India, even in remote rural areas. databot's tiny footprint & versatility makes it ideal for mobile STEM solutions.

The use of sensors in your classroom explorations, regardless of the age of your students, accomplishes significant educational objectives including the application of important science and engineering practices, improving test scores, improving teaching practices, and deepening student's understanding of important science concepts.

A History of Probeware

Decades of research now exists supporting the use of sensors in well-designed inquiry and problem-based science curricula. The "History of Probeware," Robert Tinker (Concord Consortium), June 2000, offers a comprehensive overview of the development and impact of probeware technology in education. Tinker's narrative captures the transformative potential of integrating sensors and data-logging technologies into the science classroom. From the early explorations in the 1980s to the widespread adoption in schools worldwide by 2000, this history illustrates the evolving role of probeware in enhancing student engagement, understanding, and achievement in science education. Tinker's account underscores the synergy between technological innovation and pedagogical strategies, highlighting the significance of hands-on, inquiry-based learning experiences in cultivating scientific literacy and critical thinking skills among students.

A DC Public Schools middle school student explores light intensity.

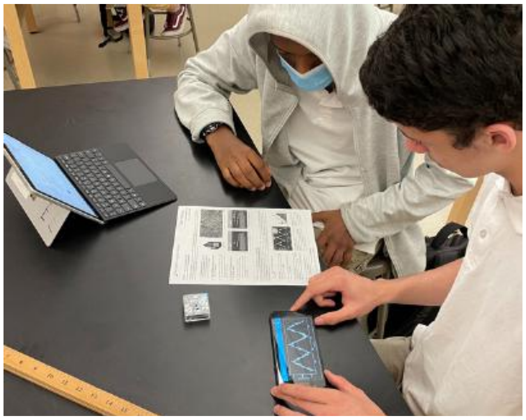
St. Mary's County Middle School math student gathering accelerometer data from catapult launches.

"John was a national leader in physics education who advocated project-based learning and the importance of a set of sensors that could be used with an oscilloscope. His dream was a shoebox of sensors that students could use to measure almost everything (King, 1962)."

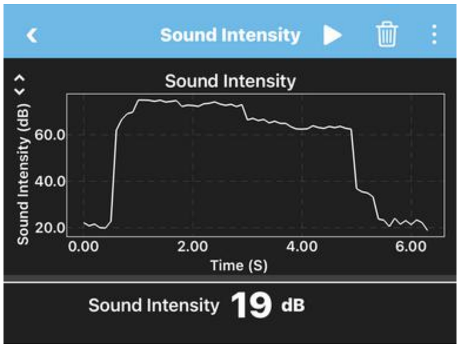
Robert Tinker on John King
"A History of Probeware"

...the next generation of learners will have access to instrumentation that was only recently confined to advanced science researchers. With these tools, tomorrow's students will be able to learn through guided exploration at a level of detail and sophistication that will greatly increase their interest, experiences, and retention.

Robert Tinker, c. 2000
"A History of Probeware"



The Research

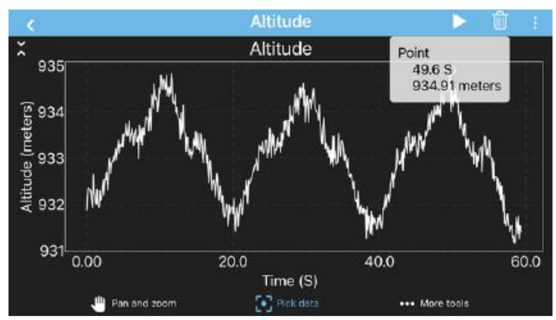


Building on the foundational insights provided by "A History of Probeware" 20 years ago, the body of research supporting probeware in science education is extensive and diverse. Studies such as those conducted by S. A. Scheckelhoff, T. T. Lye & M. W. J. Kee, R. Yerrick, C. S. C. Ng & M. J. W. Lee, A. A. Zucker et al., V. Prain & B. Waldrip, S. J. Metcalf & R. F. Tinker, R. M. Schneider et al., R. T. Lazarowitz & J. S. Huppert, R. K. Thornton & D. R. Sokoloff, and H. Brassell have collectively demonstrated the positive effects of probeware on student learning across various aspects of science education. These studies reveal how probeware facilitates deeper engagement with scientific concepts, enables real-time data analysis, and supports the development of critical scientific process skills. As we transition from the historical context to examining these specific research findings, it becomes evident that probeware is not just a tool for teaching science but a catalyst for reimagining how science is taught and learned in the digital age.

S. A. Scheckelhoff (2013).
"The Impact of Handheld Probeware on High School Student Achievement in One-Year Chemistry Courses."
This dissertation explored how the use of handheld probeware affects student achievement in high school chemistry. The study found that students who used probeware showed significantly higher achievement on assessments of chemistry knowledge compared to students who did not use the technology.

T. T. Lye & M. W. J. Kee (2012).
"Effect of a mobile learning application on students' improvements in learning." Journal of Educational Technology & Society, 15(4), 205–215.
This study focused on the use of mobile learning applications, including those integrating sensors for science education, and found positive effects on students' learning outcomes. The interactive and engaging nature of the technology was credited for the improvements observed.

Yerrick, R. (2010).
"How Notebook Computers, Digital Media, and Probeware Can Transform Science Learning in the Classroom."
This white paper explores the transformative impact of integrating MacBook computers, iLife software, and probeware into middle school science classrooms. Conducted in a suburban New York middle school during the 2007–2008 academic year, the study reveals significant enhancements in student engagement, understanding of science concepts, and performance on standardized tests. "Students involved in this project reported a greater engagement with the scientific process, an improved ability to communicate scientific knowledge, and an increased confidence in using technology for science learning," according to Yerrick. The research underscores the effectiveness of technology-enriched instructional strategies in not only elevating students' scientific literacy but also fostering an enthusiasm for science that extends beyond traditional classroom settings. The study highlights a crucial shift towards incorporating technology in education to meet diverse learning needs and prepare students for future challenges.



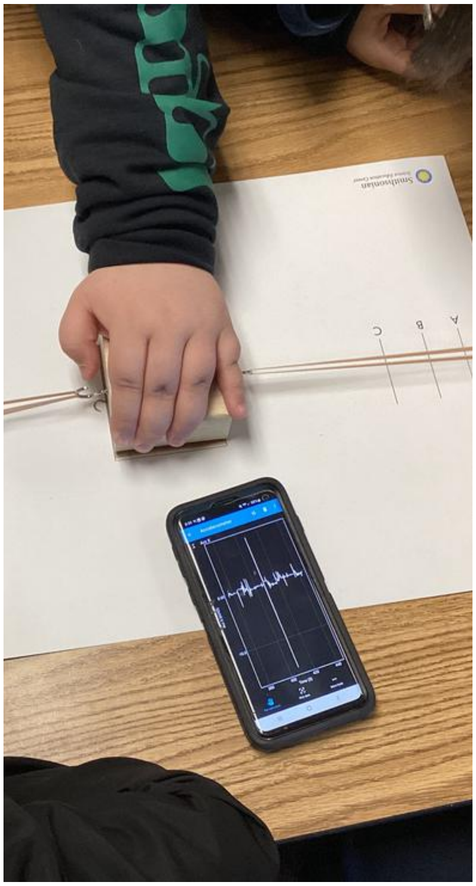
MS math student in San Diego Unified schools captures altitude data changes for a linear regression.

C. S. C. Ng & M. J. W. Lee (2009).
"Integrating data logging in primary science classrooms: Its impact on students' cognitive and affective responses." Computers & Education, 52(3), 616-628.
This study examined the integration of data logging technology in primary science classrooms and its impact on students' cognitive and affective responses. The results indicated that the use of data logging technology enhanced students' understanding of scientific concepts and positively affected their attitudes towards science.

MS students in Charlotte-Mecklenberg schools compare real data to Newton's Law of Cooling.

Zucker, A. A., Tinker, R. F., Staudt, C., Mansfield, A., & Metcalf, S. (2008). "The impact of probeware and data-logging technology in science classes."
Data from the TEEMSS project demonstrate that using computers and probes in elementary and middle school classrooms can result in substantial learning gains. For certain curriculum units, use of computers and probes results in larger learning gains than instruction on the same topics without computers and probes.

Van den Berg, E., Schweickert, F., & Van den Berg, R. (2007). "Science Sensors and Graphs in Primary Schools."
Within the European POLLEN project, this study developed and tested sensor-based science activities for Dutch primary school students aged 10 to 12 in the inner city of Amsterdam. Using simplified probeware, the study facilitated hands-on learning experiences in measuring and graphing temperature, light, and sound, focusing on minimal text and exploration-driven learning. Conducted with 282 children across four schools, the research underscored the potential of ICT-enriched activities to significantly enhance primary science education. Findings highlighted the efficacy of using sensors and graphs to support students' understanding of scientific concepts and the practical application of technology in classroom settings. This study contributes valuable insights into the integration of technology in primary education, advocating for a balanced approach that marries technical tool use with foundational scientific inquiry and problem-solving skills.



3rd Grade Students in Garden City, KS, study balanced and unbalanced forces using accelerometer data.

Prain, V., & Waldrip, B. (2006).
"Investigating the use of multi-modal representations in middle school science classes."
This research explored the impact of using multi-modal representations, including data-logging technologies, on middle school students' science learning. The study revealed that "students who used these technologies demonstrated improved understanding of scientific concepts and performed better on assessments." This finding highlights the importance of incorporating various forms of technology in education to enhance students' comprehension and academic performance in science.

HS students at Archbishop Carroll High School in Washington, D.C. gather rocket launch acceleration and altitude data.

Metcalf, S. J., & Tinker, R. F. (2004).
"The impact of probeware on middle school student learning in physical science classrooms."
This study examined the effectiveness of using probeware in middle school science education. The researchers found that "students who used probeware scored significantly higher on standardized tests in physical science compared to students in traditional lab settings." This evidence suggests that integrating technology like probeware into science education can substantially improve students' understanding and performance in physical science.

Schneider, R. M., Krajcik, J., Marx, R. W., & Soloway, E. (2002).
"Performance of students in project-based science classrooms on a national measure of science achievement." Journal of Research in Science Teaching, 39(5), 410–422.
This research highlights the effectiveness of a project-based science (PBS) curriculum enriched with probeware in elevating students' science achievement. Specifically, "the use of a PBS curriculum incorporating probeware resulted in improved test scores on a publicly released version of the NAEP Science Test," with a notable increase in students' conceptual understanding. The study further notes that "the longer the response required by the question, the better the PBS students did in comparison to the national sample," particularly in extended open-response items that demanded deep conceptual understanding, where PBS students significantly outperformed their peers in the national sample. This underscores the value of integrating technology like probeware in educational settings to foster a deeper understanding of science concepts among students.

R. T. Lazarowitz & J. S. Huppert (1993).
"Science process skills of 10th-grade biology students in a computer-assisted learning setting." Journal of Research on Computing in Education, 25(4), 366-382.
This research investigated the effect of computer-assisted learning, including the use of sensors and probeware, on the development of science process skills among 10th-grade biology students. The findings suggested that the technology-enhanced learning environment contributed to significant gains in students' process skills critical for scientific inquiry.

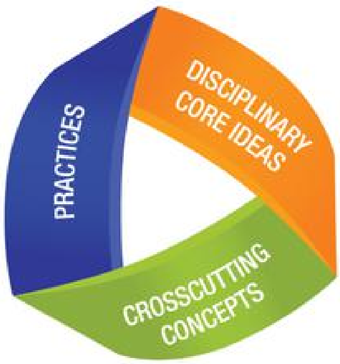
Thornton, R. K., & Sokoloff, D. R. (1990).
"Learning motion concepts using real-time microcomputer-based laboratory tools." American Journal of Physics, 58(9), 858-867.
This study focuses on the application of motion detectors and probeware in teaching kinematics concepts to students. The authors demonstrated that "real-time interactive experiments with probeware significantly enhance students' understanding of motion and dynamics, making abstract concepts more accessible and engaging." The research highlighted the effectiveness of integrating technology into the physics curriculum, showcasing how probeware can transform the learning experience by providing immediate visual feedback and hands-on involvement, thereby deepening students' conceptual grasp of physics principles.

DC Public Schools MS students conduct experiments in acceleration.

Brassell, H. (1987).
"The effect of real-time laboratory graphing on learning graphic representations of distance and velocity." Journal of Research in Science Teaching, 24(4), 385-395.
This study explored the impact of wait time during experiments using probeware, specifically investigating the hypothesis that a delay in displaying graphs derived from experimental data might enhance student learning. Contrary to expectations, the findings revealed that "only the simultaneous display of real-time data resulted in significant learning," thereby emphasizing the importance of immediate feedback through real-time data display for the effective comprehension of graphically represented scientific concepts. This research underscores the value of integrating real-time probeware technologies in science education to facilitate a deeper understanding of abstract concepts through immediate visualization and interaction with experimental data.

Science and Engineering Practices

In addition to mastering and increasing a depth of understanding for scientific concepts, activities with databot also develop and reinforce important science and engineering practices. The Next Generation Science Standards (NGSS) frame a transformative approach to education, emphasizing the integration of Science and Engineering Practices (SEPs) into teaching and learning. These practices encourage students to engage in scientific inquiry and the engineering design process, mirroring the work of professionals in these fields. databot, a versatile sensor device, serves as an exemplary tool for bringing the eight SEPs to life within classroom settings. Through hands-on experiments, students can actively participate in asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, and more.



Science and Engineering Practices are the important skills stuents master when learning science. They are what students "do" when conducting investigations.

databot facilitates a deep engagement with these practices by enabling students to collect and analyze real-world data, fostering a direct connection between theoretical concepts and tangible outcomes. This experiential learning approach not only enhances students' understanding of scientific and engineering processes but also cultivates critical thinking, problem-solving skills, and a curiosity-driven exploration of the world around them.

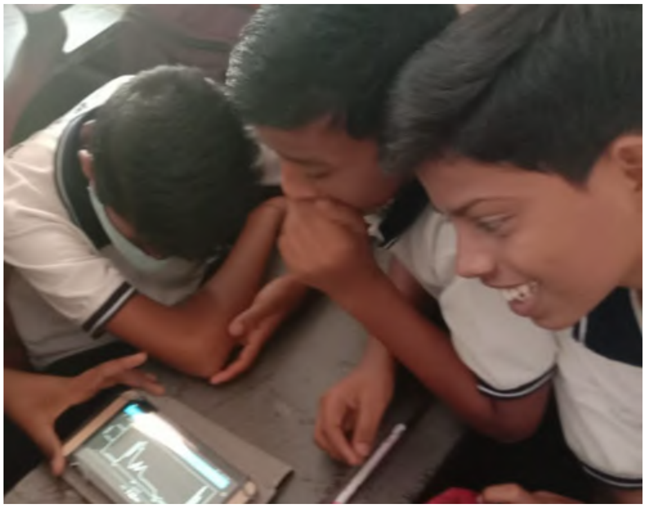
The Science and Engineering Practices

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

Conducting databot activities applies and reinforces these practices through hands-on experiments, challenges, and discussion preparing students to not just memorize science concepts, but to master the practices associated with learning and doing science.

Conclusion

The incorporation of databot into educational curricula from kindergarten through high school offers a compelling strategy to foster a deep, practical understanding of science and engineering principles among students. Research underscores the significance of engaging students in hands-on, inquiry-based learning experiences from an early age, promoting critical thinking, problem-solving skills, and a passion for discovery. Studies such as those highlighted by Scheckelhoff (2013) and Zucker et al. (2008) demonstrate that the use of probeware and sensor technology in science education significantly enhances students' understanding of scientific concepts and improves their performance on standardized tests. By integrating databot, a versatile multi-sensor device, into science and engineering education, educators can provide students with tangible, real-world applications of abstract concepts, thus making science both accessible and engaging.



Starting as early as kindergarten, the use of databot aligns perfectly with the Next Generation Science Standards' emphasis on Science and Engineering Practices (SEPs). Through interactive experiments that utilize databot for data collection and analysis, students can actively participate in the practices of asking questions, developing and using models, planning and carrying out investigations, and more. This hands-on experience with databot not only supports the development of essential scientific inquiry and engineering design skills but also enables students to see themselves as scientists and engineers from a young age. As students progress through their education, the complexity of the investigations can increase, catering to their growing analytical capabilities and understanding of scientific concepts. Implementing databot consistently from kindergarten through high school ensures a cohesive, experiential learning journey that prepares students for future challenges, fostering a generation of innovative thinkers and problem solvers equipped to contribute meaningfully to society and the scientific community.