Bull, G. (2025). Editorial: Developing and using scientific instrumentation in the classroom: Considering Bob Tinker's legacy. *Contemporary Issues in Technology and Teacher Education 25*(4), 781-785.

Editorial: Developing and Using Scientific Instrumentation in the Classroom: Considering Bob Tinker's Legacy

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Scientists routinely use instrumentation connected to computers to monitor and control experiments. Bob Tinker extended this idea to education. The term microcomputer-based laboratories (MBLs) was adopted to describe educational use of scientific probes and instruments connected to computers in schools. (Tinker, 1984; Tinker & Papert, 1989)

Bob Tinker (1941 – 2017) was posthumously recognized with the Educational Leadership Award at the 2025 National Educational Leadership Summit. This award was established to recognize individuals who significantly advanced effective use of technology in teaching and teacher education over the course of their lifetimes.

Bob Tinker (credit: Concord Consortium)

Carolyn Staudt contributed to much of this work at the Concord Consortium (https://concord.org/), the non-profit educational organization that Bob Tinker founded. She accepted the award at NTLS on his behalf and on behalf of the Concord Consortium.

Carolyn Staudt Accepting NTLS Award on Bob Tinker's Behalf (credit: NTLS)

Educational Probeware

The field of educational probeware transformed science education from passive observation to active, real-time data collection and analysis. These innovations made complex scientific phenomena accessible to K-12 students. It established the foundation for modern STEM education technology that continues to impact millions of students worldwide.

The Technology Enhanced Elementary and Middle School Science II project (TEEMSS), funded by the National Science Foundation, produced 15 inquiry-based instructional science units for teaching in grades 3–8. Each unit uses computers and scientific sensors (probeware) to support students' investigations of real-world phenomena using probes (e.g., for temperature or pressure). TEEMSS units were used in more than 100 classrooms by over 60 teachers and thousands of students. A comparison of students using microcomputer-based laboratories found that there were significant differences in science learning favoring the students who used the TEEMSS materials for sound and electricity units in grades 3–4; for a temperature unit in grades 5–6 and a motion unit in grades 7–8. (Zucker et al., 2008).

Many of the challenges that are described in *A History of Probeware* are still relevant today. In that paper, Tinker (2000) expressed a concern about disparities between well-funded school systems and schools with fewer resources:

A teacher attempting to equip a lab with probeware would face a huge cost problem. Commercial probes cost from $30 to $200 and a dozen or more might be needed to support an entire year of science labs or to give students the flexibility to design a wide range of experiments. This means that probes needed by students can be prohibitive. (p. 21)

He suggested a potential solution:

> The solution is to have students build their own. If it were possible to use student-constructed probes, the costs of supporting open-ended projects would be far less and student options would be even greater. Even if each student decided their project needed multiple temperature sensors, there would be no shortage of probes if students could easily make their own. Student probe-making would also save costs and give students valuable experience in design, electronics, and experimentation. (p. 21)

Design and fabrication of scientific tools and instruments is already occurring in university research laboratories. The advent of open-source hardware, or open hardware, made possible by affordable fabrication tools like 3D printers and inexpensive microcontrollers has altered the landscape of scientific research. These capabilities have led to progressively more sophisticated open hardware tools for university research (Baden et al. 2015; Pearce 2014, 2017).

Open-source tools can replace commercial optics equipment worth $15,000 in a university physics classroom with objects printed in-house for $500 using a selection of predesigned components from the open-source optics library (Zhang et al., 2013).

Building on Bob Tinker's Legacy

A current NTLS initiative builds on Bob Tinker's legacy. The goal of this initiative is to enable K-12 engineering students to design and fabricate science instruments for science classes. Engineering students benefit from the opportunity to participate in a project that addresses an authentic school need, which is empowering and motivating. Further, when engineering students observe scientific tools that they have designed being used by science students, it provides an opportunity for direct feedback and iteration leading to enhancement of the tool. (Berry et al., 2024)

The NTLS 3D-printed Microscope was one of the first prototypes of scientific instruments developed through this program. (Watts & Bull, 2025) The International Technology and Engineering Education Association (ITEEA) has been a leader in this initiative. Technology and engineering teachers who are ITEEA members have piloted prototype instruments in their classrooms. (Shapiro et al., 2025)

The NTLS 3D-Printed Microscope

A number of other instruments were identified for possible fabrication by K-12 engineering students at the 2025 National Technology Leadership Summit:

- Visible Light Spectrophotometer or Colorimeter
- Centrifuge
- Temperature and pH Monitoring Station
- Air Quality or CO_2 Monitor
- Magnetic Field Viewer / Magnetic Mapping Device
- Anemometer
- Digital Balance / Scale

Ultimately designs that have been successfully piloted and tested in schools can be made available through publication in the NTLS Educational CAD Model Library. ITEEA also plans to incorporate the process of designing and fabricating scientific instruments into its Engineering by Design curriculum.

The current NTLS work rests on the foundation of Bob Tinker's work and the work of his colleagues at the Concord Consortium and at other institutions. We are pleased to publish the *History of Probeware* as a seminal paper in this issue of the *CITE Journal* to make this prior work available to those contributing to current efforts.

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