I. Curriculum

The purpose of this document is to provide an overview or guide focused on supporting teachers like you in implementation of real-world, authentic science learning in their classrooms.

Far be it from us to tell you how to teach. Rather we hope to provide you information on the ways in which 4K Microscopy can be employed in teaching to many state standards in the science disciplines. Some samples of lesson plans with Tennessee-specific standards and learning objectives are also provided.

POSSIBILITIES

The sky's the limit; many of the standard scientific practices taught in our schools can be approached using this model.

1. **What kind of data can be gathered?** By video recording the data stream from the remote microscope, students can gather data to allow them to analyze many quantitative and qualitative metrics in service of any given learning objective. In the *qualitative* realm, students can focus on the frequency of a particular event; the relative sizes of particular specimens in a given sample; in the *quantitative* realm students can count the number of species present in a sample; measure the relative sizes of specimens in a sample; and quantify many other metrics.
2. **How do I meet state learning standards using telemicroscopy?**
Teaching content and skills through telemicroscopy engages students in science on an advanced level. Due to the versatility of applications, many State Performance Indicators (SPIs), including content, embedded inquiry, embedded engineering and embedded math standards can be covered in one unit. When approaching learning through an inquiry, PBL framework, the focus shifts from learning a bunch of disconnected facts to students working together to make meaningful, in-depth connections about science, skills, and the real world. If a students can operate on this level of critical thinking, with guidance from their teacher, meaningful content mastery will take place.
3. **What scientific practices does this enable me to teach?** Virtually all Habits of Practice can be explored using this model of Project Based Learning. See Table 1 below. For a thorough overview of the possible connections between TN Standards and classroom telemicroscopy, see the appendix (item i: Standard Connections & Assessments).

Table 1: TN Biology Content Standard Connections to Telemicroscopy Applications (adapted from NSF Grant written by Keri Randolph)

Biology State Performance Indices	Associate structural, functional, and behavioral adaptations with the ability of organisms to survive under various environmental conditions. (5.1, 5.2: Form Fits Function) "I can recognize how form fits function in living things through adaptations and environmental factors."
Selected TN Biology I Course Level Expectations:	(Associate structural, functional, and behavioral adaptations with the ability of organisms to survive under various environmental conditions.
Telemicroscopy Applications for Project-Based Learning:	Create a video using footage from the Digital Cinema Microscope of both freshwater and marine ecosystems to demonstrate adaptations of microbes which make them well-suited to their native environment.
Student Response/Project:	Students design and conduct an experiment that answers that following question: How does salinity of water affect the population growth of brine shrimp? Students learn what data to collect, and learn how to collect it, collaborate, write up procedures, write formal lab reports, use and refine science processing skills, etc. Brine shrimp, salt and Petri dishes are inexpensive resources and little lab equipment is necessary. Possible Deliverable: poster (see sample Student Posters in appendix)
Relevant Habits of Practice:	-Asking questions (for science) and defining problems (for engineering); -Planning and carrying out investigations; -Analyzing and interpreting data;

	-Constructing explanations (for science) and designing solutions (for engineering); -Engaging in argument from evidence: -Obtaining, evaluating, and communicating information.

IMPLEMENTATION

1. **How do I create and assess projects around this model?**
    a. Project Based Learning as a style of instruction has begun to gain momentum. Though there is a learning curve to moving away from traditional instruction, the value in doing so is clear, and the support for doing so is robust. The opportunity provided by TelemeterED presents a springboard for you to delve into the transformation of your teaching and the student experience.
    b. A chief task in this transformation is in relinquishing control; instead of delivering information to your students wholesale, PBL instruction is characterized by supporting your students as they pursue answers to their investigations. These investigative inquiries come from the students' endeavors to link the learning targets to their daily observations. In brainstorming possibilities for your students' investigations, consider the learning targets in the sample Biology I syllabus provided in the appendix (item ii: Sample Biology I Syllabus) and spend a few moments generating possible inquiries of your own.
    c. A common challenge in this approach to teaching and learning is the adjustment to different pacing of lessons and units. Given the strict academic schedule we are bound to, this seems nearly impossible; however, anecdotal evidence supports that this non-traditional approach proves to be more efficient, effective and enjoyable.

"

    d. In the transition from lecture-based to project-based learning (PBL), there are abundant resources available to you. Possibly the most valuable experience you could have to support your work in PBL is the professional development available through DevX. Additionally we hope that you will find useful the Sample PBL Unit, the Sample PBL Unit

Template, the Sample PBL Lesson Plan and the Sample PBL Lesson Plan Template provided by Shannon Seigle (see items iii, iv, v and vi respectively).

e. **Other resources**: to see examples of student work see appendix item vii, to see examples of the rubrics used in assessing these projects see item viii and to see examples of templates used during the project see item ix. For editable versions of these templates and rubrics, please visit TelemeterED.com

2. **How can I supplement the necessary hardware with the resources available to me?**
    a. Outside of the remote microscope-4K monitor connectivity there are ample opportunities to extend the telemicroscopy student-experience and to tailor it to your talents, your needs, and your resources. In addition to incorporating telemicroscopy into multiple units of your syllabus, you can plug in a variety of other technologies in order to individualize the student experience and allow for creativity and investigation.
    b. Scaling with available resources: **What can I do if...**
        i. *...my classroom has no microscopes or devices for students*?
            1. Students can still obtain practical experience by preparing slides for their experiments in the classroom, and then sending them via the courier system to the microscope hub to be viewed at a later day.
            2. Students can also manipulate the video they take from their samples using our web portal on any internet connected device, so computer labs, library resources, and other available computers will be helpful to them in this endeavor.
        ii. *...my classroom has no microscopes but my students all have a personal device?*
            1. Students will be able to use their personal devices to view and edit their videos, and will prepare slides for use with the 4K hub microscope ahead of time.
        iii. *...my classroom has a few microscopes that can be shared by an entire class?*

1. If your classroom has microscopes of their own, they can supplement the experience with the 4K video with experience using microscopes in the classroom. This can be to help students become proficient in using the microscopes and to help them identify things they will be looking for when the 4K scope is used.
2. Additionally, Moticams can be purchased, and attached to the microscopes in the classroom. These cameras project their own wi-fi network, which allows the students to capture and share their results amongst themselves, and to obtain data on their own, in addition to the 4K scopes.

EXTENSION

3. **How and my students stay engaged outside of my classroom and in the community?**
    a. Encouraging students with FabLab access to push their projects further
        i. Chattanooga Public Library FabLab: The "4th floor" is a public laboratory and educational facility with a focus on information, design, technology, and the applied arts. The more than 12,000 sq foot space hosts equipment, expertise, programs, events, and meetings that work within this scope. The 4th floor is unique because it supports the production, connection, and sharing of knowledge by offering access to tools and instruction. Students exposed to the 4K experience can continue to nurse their interest in technology, science and creative applications by availing themselves of this amazing, free, public resource.
4. **How do I educate my students about STEM careers?**

    a. Science careers: through the telemicroscopy experience and PBL students are learning to think, not to take tests. In an era in which creative, critical thinkers are critical in our communities, it is imperative that as we prepare our future workforce we emphasize those skills. Using an inquiry-based approach to science, students learn to think creatively, to unbridle their curiosity and to love science. They also interact with science in a realistic way that shows them what kinds of careers they can pursue. However, simply because you're employing this teaching approach in your science classroom, you're not only preparing your students for science careers.
    b. Technology careers: as students experience a more engaging, more empowering approach to learning, they're able to leverage their skills and interest in technology. The software and hardware and user interfaces involved in running the telemicroscopy project introduces them to complex engineering and programming and allows for opportunities to learn what happens behind the scene in order to make telemicroscopy possible.
    c. Community Partners and Extensions for learning and for work experience:
        i. Interdisciplinary possibilities: building on the Teacher Development Group's "Habits of Practice" there are ample opportunities to plan for cross-disciplinary projects.

ii. Step up Chattanooga: STEP-UP Chattanooga helps bridge the gap between our talented young people and the needs of our region's workforce. STEP-UP Chattanooga provides young people with internships at local companies, nonprofits and public agencies, providing critical work-readiness training, on-the-job experience, professional connections and ongoing support for career and college success.

"I would encourage and invite educators and stakeholders to help me shift the paradigm of what science should look like in classrooms. With gigabit connectivity, and students hunger to participate in their own learning, we can affect more students across the country and help more students really love science. "

--Shannon Seigle