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Bird song, sound waves, and urban ecology: Issues of authentic science, assessment and scalability in curriculum design

Over the past two years, in collaboration with the Urban Ecology Institute and science educators in the School of Education, I have been developing a bioacoustics curriculum for 9th grade physics students in Boston Public Schools. Our goal was to create a locally-relevant, engaging, hands-on curriculum where students learn about sound waves, urban ecology and the process of doing science. Students explore the challenges of bird communication in the urban environment through posing questions, and collecting and analyzing data to address these questions. In the process students learn about and apply their conceptual knowledge of the physics of sound waves. The bioacoustics curriculum engages students with multiple technologies which also aid in the authenticity of the project. Students record and analyze bird songs in or adjacent to their schoolyard using the same equipment used by university researchers. Recordings are analyzed in Raven, a bioacoustics analysis software package developed at Cornell, which allows students the opportunity to visualize and quantify what they hear. Furthermore, students use Excel, PowerPoint and the Internet to prepare their final presentations. Pre and post-assessments examine conceptual understanding of topics related to sound waves and urban ecology, as well as their interest and engagement in science. Interviews and observations of a smaller subset of students will also be conducted this fall to further probe students' conceptual understanding.

Success

Over the past two years, the bioacoustics curriculum has been piloted at a medium-sized urban high school with some success. In our first year, some related activities as well as the functionality of the equipment in the classroom were tested and students seemed to be highly engaged. In our second year, we challenged our 9th grade students, having already completed the Active Physics unit on sound (and light) waves, with the task of designing a research question, collecting and analyzing their data, and presenting it in a mini-conference format to their peers and local scientists. While the developing of questions and preparation of presentations required some scaffolding, students were generally engaged during both the field recordings and the analysis of songs (all during the month of June). The majority of the students were able to learn Raven, the spectrogram analysis program, within 2 class periods and were excited to have the opportunity to work on laptops. Over the 3 week period, students previously struggling with use of physics terminology, such as frequency, improved their usage in describing their data.

Teachers also reported that they enjoyed participating in the pilot and were impressed with students' level of interest and engagement, perhaps resulting from it being both technology-rich and locally-relevant. Connections to the district mandated curriculum (e.g., Active Physics) and the City and State standards were also noted as positives.

Vexations

I have two vexations related to the design and assessment of curriculum. The first is in assessing student learning, particularly as it relates to conceptual understanding of sound waves. While we have noticed students improve upon their use of terminology, they still struggle with it even when they seem to understand conceptually. This makes it difficult when assessing students in multiple choice or open response assessments. This is compounded in an urban school where a significant portion of the students come from non-English speaking households. Assessment of understanding is further complicated by the level of complexity of the models used to express sound waves. Students struggle with the jump from understanding sound waves as vibrating particles to visualizing sound waves in a sinusoidal figure (as often seen on standardized tests). This past year, I gave students a multiple choice content assessment, however little change was seen. This was likely the case because it used items similar to those seen on standardized tests, such as measuring wavelength in sinusoidal waves, while the pilot focused primarily on students recording and analyzing songs using spectrograms. For this year, I am intending to still use this assessment as a distal assessment, but also develop an assessment which more directly relates to the curriculum taught. Furthermore, I am intending to conduct student interviews and potentially examine student conversations and written work. Are there additional techniques in which I might assess student growth and understanding in ways which more fully capture their conceptual understanding rather than simply their mastery of vocabulary? Are there assessment methods which I might use, particularly with ELL students, which might allow students to adequately demonstrate conceptual knowledge without being confused or frustrated by difficulties in mastery of the vocabulary?

My second vexation relates to scalability. While one of the strengths of the curriculum is that it exposes students to a variety of technologies, it is also creates a significant challenge. While cheaper recording decks might be available, the need for cheaper solutions is balanced against the clarity of recordings the decks provide and the authenticity the "real" decks lend to the project from the students' view. Access to computers is also a continuing challenge. Many of these schools have a single computer lab, which is often difficult to gain access to and even more difficult to install the software on. There is a great strength in sharing data across schools, but the logistics of sharing the limited sets of recording equipment, and even computers has proven challenging. Furthermore, funding for large scale equipment purchases in these urban schools is rarely available. It is also possible to provide the students with access to the appropriate bird songs for their area via the web and have them download the files and manipulate them using the software. Though this would be a necessary step for those schools without access to recording equipment, it may (and I suspect) diminish the value of the experience and students may find it more of a "school" task than a "scientific" one. The question that I would like to explore that is most relevant to this issue is what is lost in the scientific process from the student perspective if the students are given data rather than collecting the data themselves. A corollary question is what constitutes authentic science for urban students? The project is based upon a recent scientific study which found that small songbirds (*Parus* major) breeding within the Dutch city of Lieden sing at a higher pitch than those in quieter rural locations (Slabbekoorn & Peet 2003). The study was elegant, simple and ripe for repeatability by students and by conducting similar studies in their own schoolyard or local park they will be collecting data that will contribute to the scientific enterprise at both the local and national level. However, the issue remains will such a study prove to be interesting and engaging to urban students across the city?

Another issue related to scaling my work is that the materials are connected to a national curriculum and will serve as an enhancement (and perhaps an improvement) to the Active Physics materials. As such, the issue is how to include appropriate training for teachers so they will be able to undertake the program themselves. Related to this issue is how to design the student and teacher materials that will facilitate both the student and teacher learning the necessary background content to successfully complete the project. One strategy could be to design the materials based upon the emerging "educative materials" framework or is there another curriculum design framework that would be better suited this work? Lastly, in order to determine the final success of the project I will need to determine what constitutes instructional fidelity of the curriculum. That is, how can I evaluate student learning as the project is taken to scale when teachers will adapt the materials in ways that they feel are best for their students? That is, if no two implementations of the curriculum are the same then how will I be able to make claims and comparisons about student learning outcomes?

Slabbekoorn, H. & Peet M., 2003. Birds sing at a higher pitch in urban noise. *Nature* 424: 267.