

A Physics Mosaic: **Scientific Skills and Explorations for Students**

One of the skills necessary for a 21st century education is the management and analysis of information in an ever more digital age. High school students (like all of us) are inundated with information from many sources all the time, and informed citizenship increasingly depends on the ability to be a critical consumer of data. Students are not always taught, however, how to make sense of the data that comes into their lives. In the scientific community, experimental data from remote, high quality observational systems are increasingly available in real time. The same networks providing data also allow scientists to use the ubiquity of internet access to enlist citizen scientists to help with research.

Our teaching unit is an attempt to both address these needs and leverage these trends. We worked during the summers 2010 and 2011 as part of the NSF-funded Research Experience for Teachers (RET) program at MIT Haystack Observatory. Our unit uses accessible, real-time science data to teach high school physics students about the nature and process of scientific research, with the goal of teaching our students how to be informed citizens, regardless of their eventual vocation. By teaching students how science is done, they learn skills that will serve them well whether they continue their studies of science or not. The opportunity to do research on the atmosphere provides increased engagement in the classroom, and students have an authentic experience of asking and answering scientific questions when the answer cannot simply be Googled.

MOSAIC (Mesospheric Ozone System for Atmospheric Investigations in the Classroom) is a relatively inexpensive tool for measuring mesospheric ozone by taking advantage of the sensitivity of commercially produced satellite TV dishes to the 11.072545 GHz rotational transition of ozone. It was developed by Alan Rogers at Haystack, and came out of his (and other's) work with the Very Small Radio Telescope (VSRT), another system using small satellite dishes. Because the signal from ozone in the lower atmosphere is pressure-broadened, the system is able to isolate the signal from the 1% of Earth's ozone that comes from the mesosphere. This allows the system to make ground-based measurements of mesospheric ozone located 80 km above the surface of Earth. Because mesospheric ozone is an area of science in which not a lot of research has been done, students have the possibility of making real contributions to our understanding through their work.

Our Physics MOSAIC unit includes an introductory unit on measurement, uncertainty, and data analysis, a final project in which students are encouraged to use the MOSAIC web interface to collect their own data and analyze it, and a series of lessons on topics of physics that relate to MOSAIC and which must be understood before taking on a research. Through each of the units, we have tried to develop options to allow the units to be as self-directed as a teacher or student needs. Students learn best when they need to construct their own knowledge through inquiry, and we have tried to provide teachers with the tools to allow students to progress with as much or as little guidance as they need. Units can be taken together, and, like a mosaic, they will come together to

construct a complete curriculum. Alternatively, each lesson or unit can be utilized on its own to help a teacher illustrate a point or provide extra background information for particularly motivated, curious, or struggling students. Some of our activities do not directly relate to MOSAIC, but do relate to our philosophy of encouraging students to access real data and perform their own analyses of what they find.

Too often, physics is seen as an intimidating topic, full of scary equations and really old concepts. While it is true that it is precisely those equations and old concepts that appeal to some of us, all of us can appreciate the appeal of contributing to a changing, dynamic field where our understanding is changing as we collect more data. MOSAIC provides students and teachers with that possibility.

We hope you and your students find these units interesting. Please let us know your thoughts if you use them; we appreciate the feedback.

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