Book Review

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Solar Science: Exploring Sunspots, Seasons, Eclipses, and More

Dennis Schatz and Andrew Fraknoi, 2016, 353 pages, ISBN: 978-1-941316-07-8. Price $39.95 US, softcover. Published by National Science Teachers Association Press.

Just in time for the "All-American" eclipse of the sun on August 21, 2017, we have an excellent new textbook about our "daytime star." The sun is especially useful for teaching, because it's conveniently available during school hours, whereas "the stars come out at night, the students don't." The sun is also central to the physical, biological, environmental, and Earth sciences, and has deep connections to history and culture.

Schools are potentially the most efficient and effective channel for mass astronomy education and outreach, since they reach almost everyone, not just those with a prior interest in astronomy (mostly greying white males like me). Unfortunately, most teachers have little or no background in astronomy, or astronomy teaching, so high-quality textbooks, teacher resources, and teacher workshops are essential.

Authors Schatz and Fraknoi have been leaders in astronomy education almost since their graduate school days at UC Berkeley—Dennis through the Pacific Science Center, and Andy through the Astronomical Society of the Pacific, and Foothill College in California. Between them, they have enough awards to paper a wall. In this book, they have drawn on their long experience and expertise to produce a book which is timely, relevant, attractive (full-color), understandable, and pedagogically strong. It's based on the 5 E model: engage, explore, explain, elaborate, and evaluate. The effective use of these and other "best practices" is one reason why I recommend this book so highly.

Evaluation is a topic which is often left to the end of a formal education project such as a textbook. One of the *first* questions that we should ask is: what do I want my students to know, and be able to do? In this book, evaluation is not by the usual memorization and regurgitation of number facts, but by providing engaging activities and projects which develop students' research and communication skills. Both the "elaborate" and "evaluate" sections have ideas which are suitable for these. For me, they were another great strength of the book. The book is recommended (by the publisher) for grades 5 to 8 but, as mentioned below, it is useful for other levels as well. There are ideas which would even be useful at the college "Astro 101" level. The information, activities, and projects are also useful for informal education—science clubs and fairs, youth groups, (daytime) star parties, etc.

The book is divided into four chapters, with a total of 45 classroom-tested, hands-on, inquiry-based activities. Each chapter begins with recommended teaching times for each activity, links to the national Next Generation Science Standards and the Common Core State Standards, and strategies for applying the 5 E model to that chapter.

Chapter 1 is on understanding and tracking the *daily* motion of the sun. In my province of Ontario, Canada, the grade 1 science curriculum requires students to observe and record daily and seasonal changes in their environment. This encourages them to develop skills of observation, and of recording in various formats. In this and the other chapters, there is a strong emphasis on observation, record-keeping, modeling, and visualizing in three dimensions. Safety considerations, of course, are emphasized throughout.

Chapter 2 deals with understanding and tracking the *annual* motion of the sun, and the seasons. This is a minefield! Research shows that, if students are taught about seasons using traditional methods in elementary and secondary school and in college, they will still believe that seasonal changes in temperature are caused by Earth's changing distance from the sun! This misconception is mentioned by the authors, but I would have recommended even more and stronger advice on how to confront this and other deeply-rooted misconceptions, and how to "teach around" these.

Chapter 3 is about solar activity and space weather, including different kinds of electromagnetic radiation from the sun. In my province, this is in the grade 9 science curriculum. This material would also be useful in other science courses, such as physics. The increasing societal implications of this material (to climate change, and space activity, for instance) make this chapter very broadly relevant and interesting.

Chapter 4 is about sun-moon-Earth relations, including phases, eclipses, and more. These topics are also rife with misconceptions, so inquiry-based, hands-on, 3D activities are essential. It's almost impossible to teach these topics with 2D diagrams, which are not to scale, and which go back and forth randomly between an observer-centered frame of reference, and an external one.

Each chapter also includes video connections, math connections, literacy connections, cross-curricular connections, and resources for teachers. Math connections are important, because one of the recommmended remedies for the current "crisis" in students' math achievement is to teach math across the curriculum. The cross-curricular connections are equally important, both because of the sun's broad relevance to science and technology, and also because of its deep links to geography, history, and culture. Although the book is USA-centered, many of the activities require students to think about how the sun appears in other parts of the world.

There is a website (www.nsta.org/solarscience) where teachers can view or download resources such as worksheets. The book also comes with a 16-page *Observer's Guide to Viewing the Eclipse*, and with eclipse glasses which conform to international

standards. The observer's guide can be downloaded, free of charge, from the NSTA website (www.nsta.org/publications/press/extras/files/solarscience/SolarScienceinsert.pdf). The guide and the book will be useful to those formal and informal educators who are blessed with totality, and to the rest of us who will have to settle for a partial eclipse. That includes the AAVSOers who observe the sun, and who engage in public outreach—which is almost all of us.

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