Preface

For over a decade, Russ Genet has led astronomical research seminars for community college and high school students. Participants select a double star to study, plan their observations, analyze their data, and write papers describing their research and results. Through this process, students of the seminar learn science by doing science. Every student is required to be an author or coauthor of a paper published in an edited journal or book, which has historically set this research seminar apart from similar programs offered elsewhere. Sharing research with the scientific community is a hallmark of science and prepares novices for master's theses, doctoral dissertations, and, ultimately, STEM careers.

The research seminar, in its present form, largely follows a pedagogical model known as communities of practice. Broadly speaking, a community of practice is a group of people who share a common interest in collaboratively achieving a goal. In observational astronomy, the goal is to gather, interpret, and share data on stars, nebulae, planetary bodies, and galaxies. According to Etienne Wenger "…teachers need to 'represent' their communities of practice in educational settings." "…being an active practitioner with an authentic form or participation might be one of the most deeply essential requirements for teaching" (Wenger, Etienne. 1998. *Communities of Practice: Learning, Meaning, and Identity*. Cambridge: Cambridge University Press. pp 276-277).

Typically, the teacher is involved in some research group centered on a collaboration of professionals and experts. These professionals select the research topic and experimental design. The teacher makes the material accessible to students who can in turn make some modest contribution. Their contribution, though, may not be included in the data analyzed by the experts and, even if it is used, it is rarely cited in publications. Wenger admits that there are good reasons to shelter students from complexities (not to mention academic politics) and shelter professionals from students' "naiveté." However, Wenger also says that "When old-timers and newcomers are engaged in separate practices, they lose the benefit of their interaction." "Communities are thus deprived of the contributions of potentially the most dynamic, albeit inexperienced, segment of their membership—the segment that has the greatest stake in their future" (p 276).

The key difference between a traditional community of practice and the research seminar is that the research seminar inverts the roles of key players. Wenger believes that "unlike in a classroom, where everyone is learning the same thing, participants in a community of practice contribute in a variety of interdependent ways." "What they learn is what allows them to contribute to the enterprise of the community and to engage with others around that enterprise" (p 271). To that end, rather than professionals receiving support from teachers and occasionally inviting students to participate, the students direct the research effort themselves (albeit with some guidance) and receive support from professionals when necessary.

The research seminar has built a network of assistant instructors, experts, facilitators, and advisors. The instructor, Russ Genet, acts as commander-in-chief. He oversees the research process at the macroscopic scale and does not necessarily meet in person with every team. Rather he connects students with experts as needed and gives mostly general guidance in project management, although he does get into details when reviewing proposed research or draft papers. In the spring semester of 2015, a nucleated distance learning model was adopted in which students formed teams at a number of locations across the country. In all there were six schools in California, two in Hawaii, and one in Arizona. They were principally led by one or more local assistant instructors. The assistant instructors were high school science teachers, college professors, advanced amateur astronomers, and graduates of the seminar who continued their research and wanted to help new students learn the ropes. All of the assistant instructors are keen on promoting authentic science learning. The experts had been gathered from the visual double star and small telescope community over time.

For the last few years, the majority of observations have been of visual double stars. Finding their orbital parameters is one of the few ways that the mass of a star can be accurately determined. There are two parameters that, if measured over years, decades, or centuries, can reveal the orbital path of a binary

star system: 1) the distances between stars known as the separation and 2) the positions of stars relative to Celestial north called the position angle.

The research presented in this special issue of the *Journal of Double Star Observations* contains the work of each team organized by methodology. Part 1 includes papers written using a specialized eyepiece with a laser etched linear scale and a protractor. Most of these papers were written at Vanguard Preparatory School in Apple Valley, California during a long weekend student research workshop. Another team using this method included students from Cuesta College and nearby Atascadero High School.

Part 2 focuses on teams which used CCD cameras to capture images of double stars. These images were then processed digitally. This is the largest section, involving six teams at as many schools. A student at Maui High School in Kahului, Hawaii studied the effect colored filters might have on the precision and accuracy of astrometric measurements. The Crean Lutheran High School team in Irvine, California observed three double stars. Another Hawaii research team involved students from Waipahu High School and Leeward Community College, both of which are on the island of Oahu. They studied a multiple star system. Two teams from the Army and Navy Academy in Carlsbad, California observed double stars robotically with the iTelescope network. Students at The Harker School in San Jose, California made observations of several double stars.

Part 3 highlights two students from Arizona who used the more advance speckle interferometry technique to observe closely separated double stars. The students then compared their measurements to the accepted orbital plots. One student was from Basha High School in Chandler while the other was from Chandler-Gilbert Community College in Mesa.

Part 4 has a paper that describes a computer program developed by students at Lincoln High School in Stockton, California that finds pixel coordinates of new observations on an orbital plot. They applied this program to speckle interferometry observations previously made at Kitt Peak National Observatory.

Part 5 is a set of four short papers from a pilot program at the Army and Navy Academy held prior to the beginning of the seminar. These students analyzed data collected by Russ Genet and many others at Kitt Peak National Observatory.

This work would not have been possible without the often tireless effort of the assistant instructors who faithfully guided their eager, high-achieving students through the complexities of scientific research and scientific writing. These were: Pat and Grady Boyce at the Army and Navy Academy in Carlsbad, California; Chistine McNab at Crean Lutheran High School in Irvine, California, along with Bob Buchheim at Altamira Observatory; Babs Sepulveda at Lincoln High School in Stockton California; Rachel Freed at The Harker School in San Jose, California; Richard Harshaw for the Arizona students; Kakkala Mohanan at Leeward Community College, Pearl City, Oahu, Hawaii; and J.D. Armstrong at the Institute for Astronomy, University of Hawaii, Maui, Hawaii.

Many projects would also have been nearly impossible without the aid of expert advisors who contributed so much time and talent supporting authentic STEM education.

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Finally, all of the participants, however tangentially involved, give tremendous thanks to Russ Genet for founding the astronomy research seminar and crafting its innovative student-centered community of practice.

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