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ASTROCOM: A Global Astronomy Community for Telescopes in Education and Outreach

Rachel Freed[1, 2*]

Abstract

For 20+ years robotic telescopes in education have been the subject of many programs which have come and gone over the years. Long-term sustainability has yet to be achieved. However we are now at a point in technological development and global communication abilities where sustainable programs can be developed and implemented and the community can gather to communicate successes and failures and to share knowledge and ideas. As education is changing with the rapid growth in technology, working actively within the new paradigm to bring together the various stakeholders in a sustainable manner is important. Stakeholders include telescope network owners and operators interested in providing telescopes for education, the educators, the curriculum designers, and the program evaluators. There is a need for an active and dynamic online community meeting space, as the developing community constructs its collective knowledge base and networks of people, technologies and pedagogies. This paper presents a framework and rationale for such an endeavor.

[1] *Sonoma State University, Sonoma, CA, USA*
[2] *Institute for Student Astronomical Research (InStAR), USA*
***Corresponding author**: r.freed2010@gmail.com

Introduction

Since the development of robotic telescopes in the 1980s, many people and organizations have recognized their potential value in education, in many arenas (Gomez and Fitzgerald, 2017). For example, they could be used to teach students about technology, to inspire students in the field of astronomy and physics, or to provide a means whereby students can contribute to research. Numerous research studies have looked at many of the programs that have come and gone over the years (see Fitzgerald et al. 2014) and there are currently a number of programs bringing astronomy and telescopes into the classroom with varying degrees of authentic research experiences associated with them (Rebull 2018).

Several factors are contributing to the potential for the development of new sustainable programs utilizing robotic telescopes in education. A large part of this is the potentiality of embedding such programs into the curriculum (Salimpour et al. 2018) Others include the implementation of the Next Generation Science Standards (NGSS, 2017) in the United States (Schleigh et al., 2015), the way we are collectively thinking about science education in the 21st Century (Bybee, 2011), the importance of student driven community of practice programs (Genet et al. 2017, Wenger 1999), the integration of 21st-century skills and technology (such as that discussed at the International Society for Technology in Education: ISTE[1]) and the interplay between the educational systems and the local and global communities they serve.

Another important factor is the rapid growth of educational technology and the changing pedagogical approaches that this enables and

[1] http://www.iste.org

requires. For example, Google Apps for Education summits and EdTechTeam summits held globally are changing the face of education and looking at how technology can drive education forward.

Up until now, there hasn't been a great shared communication of lessons learned, approaches and honest evaluations surrounding the use of robotic telescopes in education. Many projects have been working independently of each other for a long time without having a formal place to meet and discuss problems and potential solutions to issues of incorporating telescopes into education. In order to facilitate the more rapid and continued development of the field, there is a need for a formal place to meet and communicate outside of physical meetings, workshops and conferences. In this paper the ASTROCOM[2] community, as a way of tackling these problems, is introduced and the rationale for such an online community is explored.

Overview of ASTROCOM

ASTROCOM is intended to serve as an online community platform to meet, connect and plan virtually. Members of the community can include:

- Educators
- Individual telescope owners and operators
- Observatories and telescope networks designed in part specifically for educational purposes
- Students and/or teachers/instructors looking for potential projects
- Astronomers looking for citizen science participants for follow-up observations
- Education evaluators and researchers
- Telescope and software manufacturers

If there was anything learned from the 2017 RTSRE Conference it is that there are many researchers and practitioners working in a variety of different fields at different levels that really needed to communicate but had yet to have the opportunity to do so. The conference, while for the time being an annual event, is a great place to meet up but we require a more sustained online network to continue the conversations and collaborations over time.

The benefits of us all collaborating online are that we can maintain the discussion of ideas begun at the conferences, workshops and events we attend. Additionally, we can continue to develop programs working together combining the expertise of those with the telescopes and research background, with the needs of students and educators looking for programs, projects and guidance. Mentorship and the relationships within the community-of-practice are going to be key factors in creating sustainable and scalable programs.

ASTROCOM at the outset will provide the following functionality:

- Low Key social network-like interactivity and conversation tools
- A discussion forum for more detailed conversation on ideas, tools and events.
- A place to connect educators, scientists and telescope operators
- An Event Diary for relevant conferences and upcoming events
- A (intended-)monthly news blog on current activities within the RTSRE community
- Monthly video conference networking meetings and talks

Numerous educators and instructors jumped at the opportunity to connect with each other at a central location during discussions at RTSRE. ASTROCOM is a resource where they could find research projects and connect their students with remote robotic telescopes. High school and community college physics and astronomy teachers are regularly looking for research projects and

[2] http://www.astrocom.org

telescope access for their students. However, these alone are not enough to engage students in meaningful research. They must also have access to the expertise relevant to their projects. Additionally, telescope companies see education as a realm in which they have potential stakeholders. The time is ripe to create a community network. We are perfectly poised to support these and other educators in bringing the knowledge and expertise of not only experienced telescope and observatory owners, but also that of Subject Matter Experts, to students and the public around the globe.

Furthermore, keeping educational designers and evaluators in the loop of what is actually going on in classrooms is invaluable in helping to create sustainable programs. Too often, curriculum designers are too far removed from the classroom to be aware of the needs of the teachers and students. ASTROCOM could provide a regular meeting and network space to help bridge the gap between theory and practice in designing programs that work for the educators. Bringing all of these inter-related groups together has the potential to provide sustainable relationships and programs that are better than the sum of their parts.

While there are numerous online and social media communities to support astronomy education, such as the Astronomy Education Facebook Group[3], and the Center for Astronomy's Improving Astronomy Education Yahoo Group[4], ASTROCOM would serve rather as a dynamic community meeting space with both curated current and relevant resources as well as moderated discussion forums, bringing together the multitude of stakeholders within the robotic telescopes and astronomy education communities. It would be a space that could connect educators looking for telescopes for their students, with those who have telescopes to provide for education, with the additional connections to the network of people who can help students and educators optimize their use of telescopes in their various educational settings. An important aspect of developing a Community-of-Practice is creating a sustainable manner in which to construct and store knowledge and ASTROCOM can serve in this capacity.

[3]https://www.facebook.com/groups/astronomyeducation/

[4]https://groups.yahoo.com/neo/groups/astrolrner/info

Why astronomy as the content area for a global science education and research community?

The special case of Astronomy in global science and science education

The question could be asked as to why Astronomy should be the focus of solving well-known science and STEM education issues on a global scale in modern day education. Just because we can have a global science education community based on astronomy, does not mean that we should or that it is even the best way to go about things. In essence, as Slater (2018) asks, "To telescope or not to telescope?". The astronomy enthusiast will always say "Telescope!" but a biologist may beg to differ and say "Microscope!". Here we suggest that Astronomy has unique benefits when trying to tackle science education *globally*.

As noted in the astronomy attitude change study of Bartlett et al. (2018), the idea that we should think of students' interest towards science as a whole is problematic. Students do not generally think of science as a coherent unit but rather think differently about its branches and subdivisions (Havard, 1996). Typically, astronomy has by far the strongest attraction for students of any of the context areas in science. Other sciences have their own qualities to bring to the science education table, but Astronomy also has distinct advantages over all other branches of science for the case of global distributed homogeneous classroom use.

Astronomy is a heavily observational science, largely outside the Solar System. Its common close partner, Earth Sciences or Geosciences, is also an observational science where experiments cannot be done in the traditional school science lab manner. Both present very aesthetically pleasing phenomena to the senses (mostly visual in Astronomy, but also touch and smell in

Geosciences)... crystal formations can be just as spectacular as nebulae as anyone who has been down a cave will attest.

However, for Geosciences, to do new research, students would need to go out into the 'field' to make measurements. Disregarding the difficulty of field trips in the current age, the 'field' would invariably be in the nearby geography surrounding the school or local area. This means that each school will have a unique geology to explore, which is wonderful! But it offers distinct disadvantages when trying to scale up an inquiry-based project beyond the local environment. Each new environment would require its own type of expertise.

Students understanding their local environment is a very important educational goal in itself and can even be beneficial in sharing differences between students across the globe but this localization puts Geoscience at a serious disadvantage when considering the 'global' 'shared' homogeneous nature of our intended explorations. The sky is *largely* the same the world over, aside from the differences arising from being positioned North or South of the Equator and the entire *available* sky is accessible from the numerous robotic telescopes located around the globe. Any object within the celestial sphere is available for exploration by the student provided sufficient instrumentation.

Biology partially overcomes some of Geosciences' problems in that experiments *can* be done within a lab. Then again, biology still tends to be attached to the local environment surrounding the school and local area if questions of ecology, botany or agriculture are concerned. Biology also retains part of observational science in the arenas of evolution and genetics, where "experiments" are designed more to unravel the history and details of these, as opposed to manipulating them, at least at the high school and undergraduate level. True genetic experiments are unlikely to be undertaken at a school level.

Authentic scientific research that makes a truly new contribution to our sum of scientific knowledge in the classroom is unlikely to happen in Chemistry Education. The idea that students could be mixing strange liquids together to create strange, and potentially explosive, odors within the science lab would unlikely get past Occupational Health & Safety requirements. Chemistry teachers are all too aware of the dangers of letting students "experiment" outside the carefully constructed confines of established laboratory experiments. In contrast, using a robotic telescope, safety barriers are either well programmed in by the designer and/or it isn't the school or students fault if they do not!

This really only leaves Physics and Mathematics as viable contenders. Due to the iterative and proof-laden development of mathematics, it is unlikely we are going to produce any Fields medal winners in high school and there is a distinct aversion to the purely mathematical by the typical student, so this is likely ruled out as a potentiality. This leaves Physics.

Astronomy tends to be seen as a subbranch, side-branch or sibling of Physics at the tertiary level. However, students perceive them markedly differently. It would not be an objectionable statement to say that students, even those of very low ability or interest in science, are excited by astronomy, especially its aesthetic appeal and impressive scale. Physics, with much of its knowledge being very abstract and non-intuitive in a sense, is less directly accessible to a novice student. The accessibility of research-grade data from premier facilities in astronomy is very high and the conceptual tools to use them, while not trivial, are relatively straightforward. Access to research-grade instrumentation in astronomy is also very high. While physics, like astronomy, is also 'global' in the sense that we have the same physics everywhere, it is not as accessible, understandable and aesthetically pleasing in the same way as astronomy.

Rationale for a local AND global astronomy teaching and research community

Global

Our ability to communicate in real-time across the globe and our abilities to build increasingly advanced remote robotic observatories in the most remote locations make it possible for students in almost any location to collect their own data in real-time from elsewhere on the planet. What prevents this from happening is that people typically don't bump into people from across the globe at their local or national teachers' meetings. An online community can make these connections happen! Having a larger, global community allows us to combine to have a larger impact. We can bring higher-level professionals and experts into the classroom. However, to create a lasting impact, there needs to be a dynamic, actively engaged Community-of-Practice, supporting educators in the long-term. The community can capitalize on teachers, schools, and districts that embrace the idea but don't have a plan or concept for follow-through, and don't have the technical and content knowledge to implement projects on their own.

Local

On a local, regional or national level, ASTROCOM can also facilitate regional groups to come together to form a local astronomy Community-of-Practice. This could be a resource for students to learn and do what is required for astronomical research projects with partners near and far. This may eliminate, or at least reduce, the significant requirement for externally training teachers on the use of telescopes, image processing and analysis software. Part of the Community-of-Practice can be that teachers can develop into facilitators of research rather than the distributors of knowledge.

Students could also pair up with local astronomers and/or advanced amateurs that are involved in projects supporting larger science missions. For instance, TESS follow-up, AAVSO observing campaigns or following up many objects from missions such as Kepler, GAIA or LSST, could be facilitated by connecting students with local astronomers. Local communities and community partnerships could also be facilitated through ASTROCOM. This could be local advanced amateurs, college or professional observatories, and clubs with research-grade equipment.

Teaching

As the educational landscape shifts towards more student-centered and globally connected classrooms, opportunities for students to engage in real-world problems and research are expanding and a community such as ASTROCOM can bridge the gap between what traditional teachers are able to provide within their isolated classrooms and what students need to participate in larger scale endeavors. There are several mechanisms that provide an easy entry point for student research within the classroom.

One example mechanism is the Genius hour, or 20% time, that is gaining a foothold within some educational communities. This is based on Google's idea of giving employees 20% of their time to develop their own pet projects. Actually, the 3M Corporation originally did this in the 50's, but Google is more recently credited with the practice. Many teachers and schools now integrate this into to their classrooms, and if students knew they could access remote telescope networks and a Community-of-Practice, many would choose astronomy projects.

An additional target audience that would likely be enthusiastic to participate in astronomical research are students within project-based schools where the curriculum is based on learning content as it applies to real-life problems and projects, rather than specific course sequences. The ASTROCOM community can specifically reach out to districts implementing these sorts of programs to make them aware of the global resources available to students.

How ASTROCOM will help incorporating robotic telescopes into the curriculum

One of the goals of ASTROCOM is to help incorporate robotic telescopes into the K-12 and community college curriculum. A driving force

necessitating the development of these sorts of programs is the way in which they can motivate and inspire students. It has long been documented that science education in the United States and other places is on the decline and there is a growing crisis in terms of people really understanding science, technology and engineering practices. Astronomy has always been known as a gateway science. It's the one science class where you almost never hear people say "I hated that class."

As a chemistry teacher for 10 years and a chemistry education researcher it is the author's experience that this is not the case for most other sciences. Informal studies by the author showed that nine out of 10 people when the subject came up stated how much they hated their chemistry class and, while the results for biology we're not so dramatic, there was a stark contrast between astronomy and the rest of the sciences in terms of how it draws people in and captures their imagination and interest. For this reason alone, we need to think about the value of astronomy in education as we try to develop a citizenry that understands the nature of science and can communicate effectively about science, enabling them to participate intelligently and actively in their democracy.

ASTROCOM can serve as not simply a repository for evidence-based, impactful curricula, but as a dynamic community of educators that interacts with each other around implementation within educational settings, and with all the other stakeholders in the larger community, the observatory networks, individual observatory owners, evaluators, and educational designers.

Why have programs come and gone?

There are a few fundamental aspects of telescopes in education that over the past 2 1/2 decades have caused them to lack sustainability. One is the technical challenges of building, maintaining and upgrading the telescopes and observatories themselves. In addition, maintaining quick and reliable connections to observatories has been and continues to be a challenge. However we are in a time where these challenges are being overcome, with improved technologies for network capabilities, and communications speeds and reliability.

Those who create these facilities, typically non-educators, have tended to be somewhat unrealistic in their expectations of what can be done by the educators with just the simple provision of equipment. The 'build [the telescope] and they will learn approach' (Slater et al., 2014) is attractive and readily apparent in the RTSRE literature. Percy (2003) also emphasized this issue when he envisioned a "national (or international) facility, consisting of a large farm of robotic telescopes, and a *carefully-developed* set of curriculum-connected projects, which would serve tens of thousands of students at any one time". The italics is an emphasis from the original paper. Also equally deserving of consideration for italics would be "curriculum-connected" in the sense that most teachers do not have the spare time or freedom to do anything outside of the mandated curriculum (Fitzgerald et al., 2017) in a field that is far outside the typical classroom science teachers' area of expertise which is more often than not, biology. In this section we focus on the much trickier situation of the K-12 science teacher and their problems with participating in our projects.

Lack of teacher preparation

Science teachers don't have science experience… Science teachers typically haven't done astronomy at any formal level either. A 2010 study found that according to high school principals surveyed in 15 states, the primary obstacle to providing an astronomy course was the lack of teachers that could teach it (Krumenaker, 2010). This same study also asked teachers, and for them as well the biggest need was for more teachers and training. In general, science teacher education programs don't have real science experiences for educators. In other words, those who go on to teach science have rarely actually conducted scientific research. One of the biggest obstacles for many teachers in California is passing the CSET Science tests created by the California Commission on Teacher

Credentialing[5]. These tend to test content knowledge, mainly, although now there is an increased focus on interpreting results of experiments. However, the entire experience of coming up with a research project, collecting and analyzing data, and then communicating that data to one's peers is significantly lacking in those who are teaching science.

Difficulties for teachers participating in authentic astronomy education projects

In addition to lack of scientific research experience, there are two main problems for integrating astronomy and telescopes into educational settings: 1) teacher's don't have the time to learn and develop new things and 2) there is no room in the curriculum. Teachers are generally over-worked and underpaid. Most teachers will tell you they do not have time to learn new programs or change their curriculum. Many professional development programs recognize this, explicitly acknowledge this to their teachers in the programs and work to incorporate the necessary time for teachers to create and develop new materials or tools within the time constraints of the program itself.

Incorporating telescopes into education comes with a host of challenges, including the new astronomy content, data analysis tools and of course the technology learning curve for using the telescopes and the software programs for image manipulation and data analysis. Again, ASTROCOM could provide not only access to educational materials and connection to telescopes but, importantly, also the network of experienced individuals and experts who are interested and able to help students and teachers through the process. As we attempt to move further into an educational system that truly capitalizes on the ability to engage and collaborate with the community outside of the classroom, ASTROCOM can provide an important service for educators as they step out of their role as the knowledge provider into their new role as facilitator.

The second difficulty can hopefully be addressed by focusing on the Next Generation Science Standards, at least in the US, which were developed with the intention of reducing required specific content for students and providing a new focus on developing an understanding about the nature of scientific inquiry, scientific and engineering practices, and learning how to clearly communicate science. These all create an environment perfectly situated to accommodate and utilize robotic telescopes in education as a way to motivate and engage students in the processes of conducting scientific research and communicating their results both in writing and in giving presentations. Furthermore, bringing the use of telescopes into the classroom can thoroughly address the significant number of disciplinary core ideas in earth and space science within the new standards in conjunction with truly modeling scientific and engineering practices that are fundamental to the standards.

What does this mean for our community?

What this means is that it is not so much the teachers that need to learn about how to do astronomy but also us as project runners, facilitators, observatory operators and researchers that need to learn from each other AND from teachers what works and does not work. One of the main problems at the moment might be that everyone is trying to reinvent the wheel or are trialling programs that haven't incorporated known best practices and avoided known poor practices before beginning. It is this where the conversation about our projects and approaches on ASTROCOM can help all of our projects succeed in changing our students' lives for the better.

Conclusion

One of the big themes to emerge from presentations and discussions at the inaugural RTSRE conference was that the many different stakeholders in the world of robotic telescopes and education felt that the conference represented the beginning of addressing a long-standing need to come together to determine how to move forward cohesively and productively. Many attendees

[5] https://www.ctc.ca.gov/

talked about how these conversations and opportunities to connect have been missing for the past decade or more, each group working in rather isolated environments, all striving to achieve the same general goals of bringing robotic telescopes and research into the realm of education in a sustainable manner.

While it is clear from the sentiments expressed by many folks attending the conference, that continuing these meetings and conversations is necessary moving forward, having simply an annual meeting will not create the dynamic, continuous interactions that can provide real support for sustaining programs that educators can confidently and successfully implement. In this paper, the outline and rationale for a local and global community, ASTROCOM, based on astronomy education, particularly focusing on the authentic uses of telescopes, was outlined.

References

Bartlett, S., Fitzgerald, M. T., McKinnon, D. H., Danaia, L., and Lazendic-Galloway, J. (2018). Astronomy And Science Student Attitudes (ASSA): A Short Review And Validation Of A New Instrument. *Journal of Astronomy & Earth Sciences Education–June*, 5(1).

Bybee, R. W. (2011). *The teaching of science: 21st century perspectives*. NSTA press.

Center for Best Practices & Council of Chief State School Officers (2010). Common Core State Standards for English language arts and literacy in history/social studies, science, and technical subjects.

Fitzgerald, M., Danaia, L., and McKinnon, D. H. (2017). Barriers inhibiting inquiry-based science teaching and potential solutions: perceptions of positively inclined early adopters. *Research in Science Education*, pages 1–24.

Fitzgerald, M. T., Hollow, R., Rebull, L. M., Danaia, L., and McKinnon, D. H. (2014). A review of high school level astronomy student research projects over the last two decades. *Publications of the Astronomical Society of Australia*, 31.

Genet, R., Armstrong, J., Blanko, P., Boyce, G., Brewer, M., Buchheim, R., Calanog, J., Castaneda, D. C., Clark, R. K., Collins, D., et al. (2017). Student Scientific Research within Communities-of-Practice. In *Society for Astronomical Sciences Annual Symposium*, volume 36, pages 143–150.

Gomez, E. L. and Fitzgerald, M. T. (2017). Robotic telescopes in education. *Astronomical Review*, 13(1):28–68.

Havard, N. (1996). Student attitudes to studying A-level sciences. *Public Understanding of Science*, 5(4):321–330.

ISTE (2017). ISTE Standards for Students. https://www.iste.org/standards/for-students.

Krumenaker, L. (2010). What It Would Take to Increase the Number of High School Astronomy Courses: A Survey of Principals and a Comparison to Astronomy Teachers, and a Prescription for Change. *Astronomy Education Review*, 9(1).

NGSS (2017). DCI Arrangements of the Next Generation Science Standards. https://www.nextgenscience.org/sites/default/files/AllDCI.pdf.

Percy, J. R. (2003). Small Telescopes in Astronomy Education. In Oswalt, T. D., editor, *The Future of Small Telescopes in the New Millennium*, pages 113–123. Springer (Kluwer Academic Publishers), Netherlands.

Rebull, L. (2018). Authentic Research in the Classroom for Teachers and Students. In Fitzgerald, M. T., James, C. R., Buxner, S., and White, S., editors, *Robotic Telescopes, Student Research, and Education Proceedings*, volume 1(1), pages 21–31.

Salimpour, S., Bartlett, S., Fitzgerald, M. T., Cutts, K. R., James, C. R., Miller, S., Danaia, L., Cabezon, S., Faye, M., Baudouin, C., Anajos, S.,

Birkenvauma, D., Wu, Q., and Slater, E. (2018). Robotic Telescopes and Student Research in the School Curriculum around the OECD countries. In Fitzgerald, M. T., James, C. R., Buxner, S., and White, S., editors, *Robotic Telescopes, Student Research, and Education Proceedings*, volume 1(1), pages 33–40.

Schleigh, S. P., Slater, S. J., Slater, T. F., and Stork, D. J. (2015). The new curriculum standards for for astronomy in The United States. *Latin American Journal of Astronomy Education*, 20:131–151.

Slater, T. (2018). To Telescope, or Not To Telescope? In Fitzgerald, M. T., James, C. R., Buxner, S., and White, S., editors, *Robotic Telescopes, Student Research, and Education Proceedings*, volume 1(1), pages 41–45.

Slater, T. F., Burrows, A. C., French, D. A., Sanchez, R. A., and Tatge, C. B. (2014). A proposed astronomy learning progression for remote telescope observation. *Journal of College Teaching & Learning (Online)*, 11(4):197.

Wenger, E. (1999). *Communities of practice: Learning, meaning, and identity*. Cambridge university press.