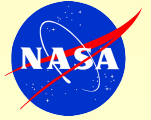


High School and Middle School Students Experience Authentic Science Research Investigating Active Galactic Nuclei



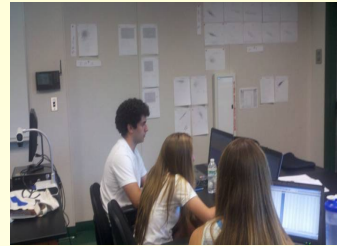
Thomas Doyle¹, Varoujan Gorjian⁶, John Blackwell⁴, Rajiv Chanda¹, Wendy Curtis², Ana Glidden⁴, Anna E. Gruen³, Colin Laurence², Jacob Llamas⁵, Mary McGeeney³, Zander Majercik², Jean-Christophe Mauduit⁵, Tressa Mikel³, Abdisalan Mohamud², Amelia Neilson², Adrian Payamps¹, Rebecca Robles¹, Pamela Thompson³, Gabriel Uribe³

¹ Freeport Public Schools, Freeport, NY, ² Wayne School, Portland, ME, ³ Monrovia High School, Monrovia, CA, ⁴ Phillips Exeter Academy, Exeter, NH, ⁵ Spitzer Science Center/Caltech, Pasadena, CA, ⁶ JPL/Caltech, Pasadena, CA



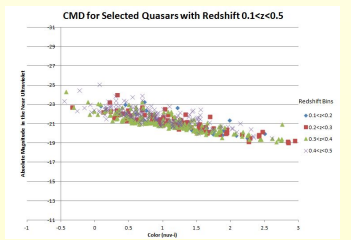
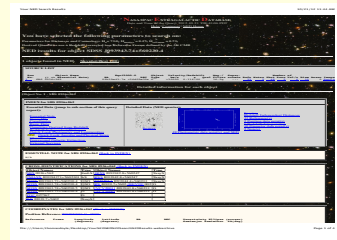
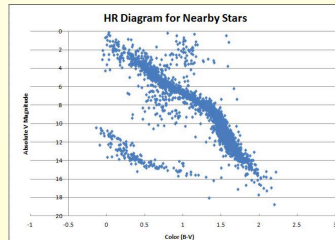
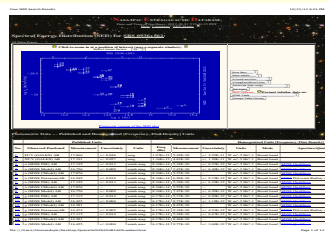
Abstract

As part of the NASA/IPAC Teacher Archive Research Program (NITARP), four teachers and 12 students from public and private middle schools and high schools across the US participated in authentic scientific research with guidance from a research scientist from NASA's Spitzer Science Center. The goal of this program is to help teachers incorporate research into middle and high school science classes. The team used data from the Sloan Digital Sky Survey (SDSS) and the Galaxy Evolution Explorer (GALEX) to analyze the relationship between temperature and luminosity of quasars with redshifts from $z = 0.1$ to $z = 0.5$. In order to work effectively on the project, the team held weekly teleconferences starting in January 2012 and met for a week in July of 2012 at the Spitzer Science Center located at California Institute of Technology where they learned how to access the data from the telescopes, how to manipulate the data into graphs of the appropriate information, and how to make judgments about the quality of the correlation observed. For example, students made plots of color vs. luminosity, used redshift values to calculate distance, created SED's for quasars, and plotted light curves for variable stars. After participating in the program, students reported that the field of astronomy is far more varied than they previously believed, and observed that astronomers do far more than "look through telescopes." Other students were able to create labs based on archived data to find black hole masses, to create HR diagrams, to derive power laws, and to create SEDs for quasars. Students are also learning better methods to mentor each other, while teachers are now more likely to incorporate authentic research experiences within their classrooms having been a part of this project.



The NITARP Experience

In January 2012 teachers attended the AAS conference in Austin and met with their mentor scientist and were introduced to their project. For the next several months the teachers communicated through teleconference and email. In July the teachers and students met for four days at Caltech where through the guidance of their mentor scientist the team was instructed in the science of quasars, the use of archived data from NASA, and data manipulation using Excel to create color-magnitude diagrams.



Through the NITARP experience students were able to think logically through complex problems and apply science to real-life situations and appreciate a sense of belonging to the scientific community, increase their collaboration and research skills, and develop and deepen their scientific literacy. For details regarding the science conducted by our team please see the poster # 339.39, "Color Magnitude Diagrams for Quasars Using SDSS, GALEX, and WISE Data", W. Curtis et al. at this meeting.

Education

Students have been given access to the data from SDSS, GALEX, and WISE and have embarked on their own projects to discover relationships within the data sets. Students have created SED's, derived power laws, calculated luminosity and calculated the mass of black holes from luminosity using the Eddington limit. Curriculum for informal study is being developed using the guidelines of the New K-12 National Science Education Standards. The activities will be intended for use by small groups in Earth science and astronomy classes. The curriculum will be made public and shared with other local science teachers.

"The best thing about being a part of the program was being able to work with students from completely different schools and areas who had the same passion for astronomy as I do. It not only created a successful group environment, but it also helped me to further my learning in astronomy."

Outreach

This project has been presented to three groups to date: Visitors to the McAuliff-Shepard Discovery Center (Concord, NH), visitors to the University of New Hampshire's NH Fall Astronomy Festival, and to the residents of the Riverwoods retirement community in Exeter, NH. In addition talks to Phillips Exeter Academy alumni and the public will be given at events in London, England and Paris, France as part of the Academy's ongoing outreach programs. Additionally, in partnership with The Cradle of Aviation Museum in Uniondale, New York, which has implemented a multi-disciplinary approach to teaching that incorporates Astronomy. We have been part of a number of professional development meetings and students have taken part in museum activities. Currently an article is being written about this experience to be published in the Los Angeles Astronomical Society newsletter, and to present the project and the NITARP program to the general meeting at Griffith Observatory.

"The best thing about this program is essentially allowing kids who want to dabble in this field to do research and collaborate with scientists on a real, un-canned project. The NASA part is also pretty cool."

"The best thing about this program was getting first hand experience from a NASA scientist. I felt that I learned more, and my prior knowledge was put to the test and my knowledge expanded greatly."

"The program made me realize that even though I am still only a senior in high school, I am capable of being able to interpret data and research in the same way as most astronomers."

"Made me want to do more research and confirmed my interest in majoring in astrophysics."



We gratefully acknowledge funding via NASA Astrophysics Data Program funds and NASA/IPAC Archive Outreach funds.

