"2nd Workshop on Astronomy Beyond the Common Senses for Accessibility and Inclusion (2022)"
Revista Mexicana de Astronomía y Astrofísica Serie de Conferencias (RMxAC), **54**, 61–65 (2022)

https://doi.org/10.22201/ia.14052059p.2022.54.13

NASA'S NEURODIVERSITY NETWORK (N3)

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ABSTRACT

NASA's Neurodiversity Network (N3) is a five-year program that has been funded as part of NASA's Science Activation Network. N3's main goal is to provide a pathway to NASA participation and STEM employment for neurodiverse learners, with a focus on those on the autism spectrum. Through the N3 program, we are enabling STEM education for a segment of the population that is significantly underserved through a process in which existing NASA education resources are redesigned with significant input from autistic learners and their instructors. The co-design process occurs primarily in informal environments, including high school summer programs, and camps and activity sessions for middle school students sponsored by the New York Hall of Science. N3 also offers a mentored summer internship program for at least ten neurodiverse high school students each year. Mentoring is provided by NASA Subject Matter Experts, individuals who collectively possess expertise that spans NASA's Science Mission Directorate.

RESUMEN

La Red de Neurodiversidad de la NASA (N3) es un programa de cinco años que ha sido financiado como parte de la inicitiva Science Activation Network de la NASA. El objetivo principal de N3 es proporcionar un camino para la participación de la NASA y el empleo STEM para estudiantes neurodiversos, con un enfoque en aquellos en el espectro del autismo. A través del programa N3, estamos posibilitando la educación STEM para un segmento de la poblacón que está significativamente desatendido, a través de un proceso en el que los recursos educativos existentes de la NASA se rediseñan con aportes significativos de estudiantes autistas y sus instructores. El proceso de co-diseño ocurre principalmente en ambientes informales, incluyendo programas de verano, campamentos y sesiones de actividades para estudiantes de primaria y secundaria patrocinados por el New York Hall de Ciencia. N3 también ofrece un programa de pasantías de verano con mentores para al menos diez estudiantes de secundaria neurodiversos cada año. La tutoría es proporcionada por expertos temáticos de la NASA, personas que colectivamente tienen experiencia que abarca la Dirección de Misiones Científicas de la NASA.

Key Words: STEM — science inclusion

1. INTRODUCTION

NASA's Neurodiversity Network (N3) is a five-year collaboration between experienced NASA education and Subject Matter Experts (SMEs) at Sonoma State University (SSU), autism education specialists from the Education Development Center (EDC) and informal education experts from the New York Hall of Science (NYSCI). N3 provides a pathway to NASA participation and STEM (Science, Technology, Engineering and Mathematics) employment for neurodiverse (ND) learners, with a focus on those on the autism spectrum. Our project aims to enable STEM education for a segment of the population that is significantly underserved by providing authentic NASA experiences for autistic STEM learners.

2. AUTISM SPECTRUM DISORDER AND STEM

Autism Spectrum Disorder (ASD) is defined by social-communication difficulties and repetitive patterns of behavior and/or focused interests (American Psychiatric Association 2013). ASD is also associated with strengths, including heightened attention to detail (Mottron et al. 2006) and the ability to recognize and create patterns (Baron-Cohen 2009). Focused interests can serve as powerful motivators that help autistic people obtain expertise and achieve meaningful roles in society (Grandin & Duffy 2008, Kanner 1971). Autistic people often express their focused interests through a systematic approach to

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learning and a strong affinity for computers (Baron-Cohen 2009, Gillespie-Lynch et al. 2014, Murray & Lesser 1999) and their skills and interests make many autistic people well-suited to careers in STEM fields (Baron-Cohen 2009). As autistic individuals [6] enter adulthood, they struggle with establishing independence, self-advocating, under-employment and developing relationships (Kapp et al. 2011).

Autistic young people remain chronically underemployed (Nord et al. 2016, Taylor & Seltzer 2011) despite their heightened interest in STEM fields (Wei et al. 2013) and the growing need for STEM professionals (West 2012). Data drawn from a nationally representative sample of youth receiving special education services in the US revealed that 44.9% of autistic youth never obtained paid employment in the six years after high school (Shattuck et al. 2012). Rates of unemployment among autistic youth were substantially higher than unemployment rates of youth with other disabilities. Rather than viewing autism as a disability or impediment to STEM success, N3 views these issues in neurodiversity education with a *strength-based* approach that incorporates the central tenet of the autism self-advocacy movement: **Nothing for us or about us without us**. To this end, input from and participation by autistic learners are included in all stages of resource and program development.

3. THE N3 PROGRAM

The main objective of the N3 program is to provide a pathway to NASA participation and STEM employment for neurodiverse learners, with a focus on those on the autism spectrum. To achieve this objective, we are implementing the following program elements:

- Enable STEM education for a segment of the population that is significantly underserved by co-redeveloping existing NASA resources with autistic learners.
- Improve scientific literacy for this underserved population by providing authentic NASA experiences.
- Provide internships, mentored by NASA Subject Matter Experts (SMEs) to selected neurodiverse learners.
- Partner with autism-focused organizations to leverage our efforts to create a sustainable pathway that provides autistic learners with the social and technical skills needed for successful STEM careers
- Work with autism experts to provide professional learning for SMEs and the NASA community around neurodivergence and best practices for working with autistic learners.
- Build on existing NASA-funded informal programs to create astronomy-focused after-school programs at schools that serve neurodiverse students and inclusive museum-based summer camps, workshops, and drop-in programs.

[6] Throughout this proposal we use identity-first language (i.e. autistic person) instead of person-first language (i.e. person with autism). Recent literature indicates that identity-first language is preferred by autistic individuals (Gernsbacher, 2017; Kenny et al., 2016; Sinclair, 2013).

4. PROGRESS DURING N3'S PILOT YEAR

The N3 program began in January 2021. Our main goals for the pilot year were: a) to launch the summer internship program with a limited pool of applicants; b) use the co-design process to redevelop a series of activities for teens that taught the fundamentals of observing astronomical objects using robotic telescopes; and c) use the co-design process to redevelop hands-on activities in a museum setting to engage a mixed audience of neurotypical and neurodivergence pre-teens. We also conducted extensive evaluation of our initial work.

4.1. *N3 2021 Summer Internships*

Applications opened for the 2021 Summer Internships in March 2021. Although we did not advertise widely, we received over 30 applications for our ten funded internship positions. However it was very difficult to narrow down the pool as there were so many great applicants from which to choose. Ultimately, we selected 16 interns: most were from partner schools in California or New York, but we also had a few interns from other states including Kentucky and Florida.

As part of the application process, we asked about special interests in one of the four scientific themes within NASA's Science Mission Directorate: Astrophysics, Heliophysics, Earth and Environmental Science, and Planetary physics. We then carefully matched each intern with a NASA SME in his or her area of interest, and helped the teams to define their initial research projects for the summer work. During a two-month period, each intern was expected to work the equivalent of at least one month (160 hours). Regular check ins with mentors were encouraged, and training was provided to the SMEs so that they would better understand the challenges

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in working with their neurodiverse intern, as well as gain an appreciation of their strengths. On September 10, 2021, all 16 interns presented reports on their accomplishments. These talks were recorded using Zoom, and for those interns from whom we have permission, we have posted the talks on the N3 website. We were most impressed with the wide variety of interesting NASA research topics that were explored by our neurodiverse teens, and with the depth and breadth of their studies. All together, eight interns (6 SMEs) studied topics in Astronomy using data acquired from ground- and space-based telescopes; three interns (3 SMEs) engaged in building Space Technology, including building a rocket and payload and testing antenna performance for a future CubeSat; two interns (2 SMEs) studied topics in Earth Science related to climate change; two interns (2 SMEs) analyzed solar physics data studying flares and ion distributions, and one intern (1 SME) worked on devising a new numerical method for data analysis.

4.2. *Remote Astronomy Co-Design Process*

The initial draft of the Remote Astronomy Activities was written by Dr. Bryan Mendez. These activities were divided into five sections:

1. Cosmic Perspective

   a. Your cosmic address and the scale of the Universe. b. Requesting your own images from a robotic telescope

2. What are images?

   a. Eyes, cameras, and telescopes

3. Making Pretty Pictures

   a. Exploring digital images. b. What is color? c. Constructing color images

4. Light Detectives: Measuring stellar brightness

5. Astronomy from Home: Monitoring light variations

   a. Exoplanets. b. Pulsating Stars. c. Exploding Stars.

The activities were presented via series of Zoom-based professional learning sessions to teachers at our four partner high schools, each of which specializes in educating neurodiverse learners. The teachers in turn decided the optimum way to engage groups of students in these activities during summer sessions or special, project-based learning time during the normal academic year. In all, nine teachers were involved in the professional learning sessions and 46 students were engaged in the student-learning sessions that followed. After the completion of the activities, four teachers and seven students, including representatives from each school, participated in approximately six to eight hours of debriefing sessions that explored how well they understood, engaged with and enjoyed the various activities. An additional codesign session was held with an instructor who worked with an individual student. Detailed notes were taken and provided to Mendez, who has now revised the activities in response. Our next step will be to review the revisions with our original codesigners, and to do professional layout and illustrations for the entire activity portfolio.

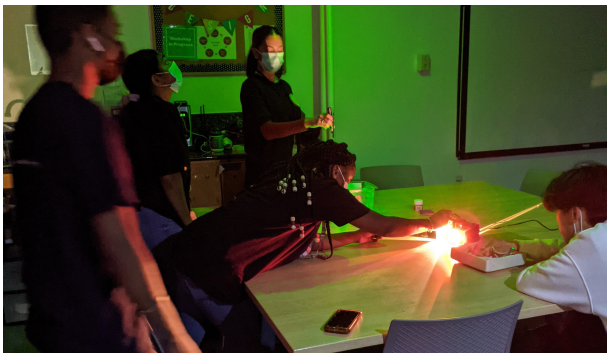

Fig. 1. Learners at the New York Hall of Science testing out an astronomy activity.

4.3. *Informal Activities Co-Design at NYSCI*

Despite many unanticipated hurdles and museum closures posed by COVID-19 precautions and then by damage due to Hurricane Ida, the New York Hall of Science (NYSCI) has undergone testing of some of the hands-on activities that were introduced to older teens during the high-school-based codesign process. The goal of the NYSCI work is to test a subset of the astronomy activities, and others already developed by NASA's Informal Science Education Network (NISENET) with a mixed audience of neurotypical and neurodivergent pre-teens. During 2021, nearly 400 museum visitors were engaged in prototyping these activities. A Saturday co-design session with high school age students and a middle school camp during winter break week in 2022 will provide additional input to the process.

5. EVALUATION OF PILOT YEAR ACTIVITIES

WestEd researchers have evaluated many of the activities that occurred during N3's pilot year, including the summer internship program, and the Astronomy activities codesign process with the partner high schools in Northern California.

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5.1. *Evaluation of Codesign Process for Astronomy Activities*

All the results in this section are excerpted from (Nguyen et al. 2021a), an external evaluation report created for the N3 project by WestEd.

To evaluate the codesign process for informal astronomy activities, WestEd conducted interviews with the instructors of the program, communicated with the neurodiverse youth who experienced the pilot implementation, and analyzed observation data of the resources. All nine instructors involved in the process were asked to participate in interviews: five instructors agreed and data were also collected from four neurodiverse students.

All interviewed instructors highly valued the resource redevelopment process. Instructors appreciated the access to NASA education resources and the other supplementary resources shared by other participants. They reported learning a lot about the subject matter and content as some of them did not usually teach astronomy. One instructor shared that they gained implementation ideas that worked for their neurodiverse students. The process of N3 program staff sharing the main focus of the resources and allowing the instructors agency in how they implement in their classrooms worked well for instructors. Overall, instructors reported that their students had positive experiences with the resources. Instructors reported their students learned a lot of content knowledge, a couple of their students received NASA internships, gained experience with data science hardware and software, gained a glimpse into STEM career pathways, gained an appreciation of science, and some gained a sense of belonging in the science community. Student response and observation data report that neurodiverse youth had overall positive experiences with the pilot implementation. Specific activities that were explicitly mentioned as their favorite part of the implementation included the communication and collaboration with peers aspect, the Crash Course videos, and the online telescope image activity. Most students reported that they felt very much supported by their educators during the activities and could think of no other additional supports they would have liked.

Challenges that students reported facing during implementation were personal non-academic related issues such as difficulty focusing and losing interest. To combat these challenges, students recommended including more hands-on activities that involve physical movement such as moving outside or incorporating a field trip. Based on the feedback from the educator interviews, the email responses from the students, and the observation data, the resource redevelopment process of the N3 program was engaging and productive for both teacher and student. Instructors expressed that they were well supported by the program and felt they could reach out to program staff if they had questions or issues about the resources. In turn, their students also reported feeling supported by their instructors.

5.2. *Evaluation of N3 Internship Program 2021*

All the results in this section are excerpted from (Nguyen et al. 2021b), an external evaluation report created for the N3 project by WestEd.

For the internship program, WestEd conducted interviews with the SMEs, neurodiverse youth interns, and their parents. Interviews focused on the overall internship experience, supports and challenges of the program, perceptions of neurodiverse youth learning and experience, and the presentation showcase. Seven SMEs were interviewed and data were collected from seven interns and six parents; two interns and one parent responded via email rather than a Zoom interview.

Overall, interns and their parents reported a positive experience with the internship program, and interns described their interactions with their mentors, program staff, and other research staff as helpful. Interns shared that the process of preparing for the internship showcase, learning new technical skills, and being part of the scientific community, and overcoming challenges all contributed to a memorable internship experience. Interns reported having liked their mentors and reported the mentors were knowledgeable and encouraging. Similarly, all parents shared that their child's mentor was responsive and patient.

Interns and parents shared their perceptions of what interns gained or learned from the program. Interns reported learning new software, 21st-century skills such as communication, collaboration, creative thinking, problem-solving, content knowledge, and technical skills. Similarly, parents shared that their child learned new software, understood the research process, learned about different pathways for programmers and researchers, and also noted seeing improvements in their communication skills and self-study skills. Interns also reported learning about what NASA scientists do, the different backgrounds you could have to work at NASA, and about more opportunities for neurodiverse youth such as themselves, while parents shared that the internship reinforced their existing interests and clarified career pathways for their child.

In preparation of the internship showcase on September 10, 2021, we employed a best practice

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in which interns were allowed to record their presentation ahead of time, and not require "live" presentations. Interns appreciated this accommodation as many of them were nervous to present in real time.

During the internship showcase, interns reported learning a lot about what others in their cohort were doing for their projects, including some who were surprised to the types of projects, such as hands-on building of a rocket. Interns reported learning a lot of new content knowledge from other presentations and other skills, such as how to present and how to create a PowerPoint presentation deck. When asked specifically about the internship showcase, all parents were impressed and positive about what they heard, even though they did not fully comprehend the different topics discussed. Mentors were pleased with the N3 presentation showcase and noted the variation in the communication styles of the students and the level of rigor of their projects. Mentors also shared challenges they faced during the internship, including some that were attributed to the neurodiverse aspects of their mentees, e.g., managing their mentees time, troubleshooting with their mentees online, and differences in communication styles.

Overall, interns, parents and mentors were pleased with the program and grateful for the opportunity to participate.

6. NEXT STEPS FOR N3

N3's pilot year has been a rewarding and challenging experience for everyone involved. We have learned valuable lessons that will be applied going forward. The focus of the second year's efforts will be on using the codesign process to redevelop rocketry and payload-building activities originally created by SSU for NASA's Rising Data program (PI Prof. Erin Quealy, Napa Valley College). The astronomy activities will be revised, reviewed and distributed through NASA's SciAct program. Training in working with neurodiverse students will be offered to the entire SciAct community. And the N3 internship program will be open to students nationwide. Applications open January 27, 2022, and close March 7, 2022 for summer 2022 internships.

7. ACKNOWLEDGMENTS

This presentation is based on work supported by NASA's Neurodiversity Network under award number 80NSSC21M0004. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Aeronautics and Space Administration. We gratefully acknowledge the work of Casey Lewiston in developing N3 website and also the beautiful illustrations drawn by Aurore Simonnet.

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