The Homeschool Audience and NASA Science:
Audience background, analysis, and possible strategies for engaging homeschoolers in NASA Science

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I. Introduction

The modern homeschool movement started to boom in the 1970s, but the practice has been present in the United States since its founding. As states began to add compulsory schooling laws at the turn of the 20th century, they were challenged to define and permit alternative schooling options including private religious schools and schooling at home. With the Sputnik generation, an increasing number of families left public school for religious reasons. Then research during the mid-century on the effects of compulsory schooling on children gave rise to a more humanist and secular group of homeschoolers in the 1970s. This motivation shifted in the 1980s with a dominant number of families homeschooling for religious reasons which was also reflected the available curriculum for this audience.

According to the National Center for Educational Statistics, the number of students home schooled has grown by 61.8% from 1.096 million in 2003 to 1.773 million in 2012[1] and remains consistent in 2016 according to the NCES "First Look" report.[2] Homeschoolers are still traditionally decentralized and localized into their own support groups, but families are seeking out instructional materials and programming from sources ranging from the internet to local libraries and museums. They are looking for real world connections to science and programs that engage their children's interest.

NASA content is uniquely positioned to serve homeschoolers in their quest for STEM resources. Parents seek out resources other than packaged curriculum for a variety of reasons, from encouraging a child to follow their own interests, to building science content knowledge while struggling in other content areas, to laying the groundwork for research skills.[3] The excitement of NASA can engage kids' interests in STEM subjects and content. This real-world connection can provide greater depth to learning activities and encourage kids to make connections and develop critical thinking. There are a variety of channels that NASA and the SciAct partners can leverage to bring NASA science to this audience including social media, existing networks, and conferences.

II. State Regulation of Homeschooling

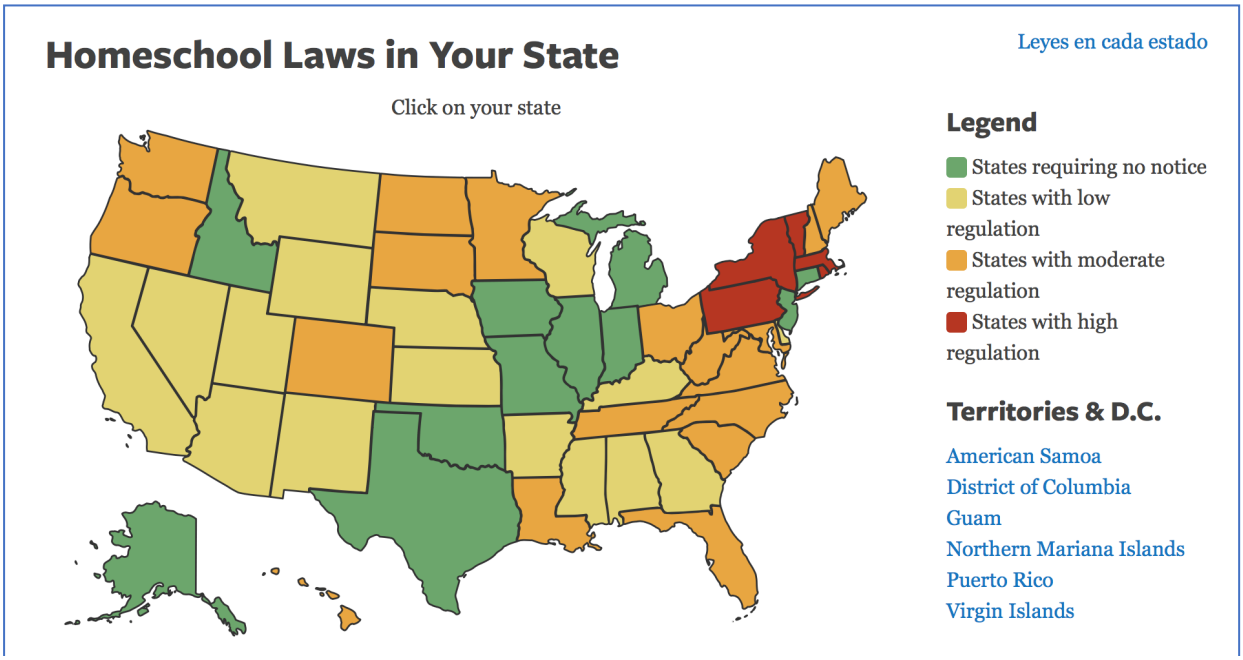
Governmental authority to regulate education, as well as all other issues not mentioned specifically in the Federal Constitution, is left up to the states. Massachusetts was the first to enact compulsory education in 1852 and other states began passing similar statutes for various reasons such as to discourage child labor, assimilate immigrants, and improve literacy rates.[4] The court system was full of child labor disputes in the early 1900s and compulsory education laws were quickly enacted in the name of protecting children's welfare such that by 1918, every state had a compulsory attendance law on the books.[5] Many Americans embraced public schools, but others preferred not to send their children to these government regulated schools.

As more and more states adopted compulsory attendance laws, conflicts between parents and states led to a surge of court cases from parents wanting to school their children at home. Massachusetts (1893) and Indiana (1904) courts found that their state laws permitted instruction at home, but with caveats that were not exactly clear such as the instruction provided must be "in faith and sufficient in extent." Washington (1912) ruled that home instruction was not a private school and thus illegal, and the New Hampshire (1929) court rejected home schooling because of "inadequate socialization" and that "regulating it would be a burden to the state." Even after the 1925 U.S. Supreme Court decision in Pierce v. Society of Sisters "forbidding a state from prohibiting private schooling" left the question whether a homeschool is a school unanswered.[6]

Court cases continued through the 20th century as more and more families decided to homeschool and in some places homeschooling was treated as a crime and parents faced jail time and loss of their children. One of the homeschooling pioneers, Rousas Rushdoony, believed that "religions that fail to

dominate education and law quickly become relics of the past." His protégé, John Wayne Whitehead, established the Rutherford Institute which took on homeschooling cases *pro bono* and laid the groundwork for Christian legal activism that would be built on by the Home School Legal Defense Association (HSDLA) in the 1980s.[7]

FIGURE 1: Map of Homeschooling Laws from HSLDA[8]



The HSLDA continues to monitor state regulation of homeschooling which varies widely along a continuum from "requiring no notice" (low regulation) to "high regulation." Their web site provides parents details of the law in each state, process and forms for removing a child from school, and options for compliance – such as keeping your own student records for review by the state, or working through an umbrella school or cooperative (co-op) who reviews student portfolios on behalf of the state. Source: Home School Legal Defense Association (HSDLA)

Every state in the U.S. has its own unique homeschooling law and different requirements on notification, evaluation, and recording keeping of students' progress. The HSLDA monitors these regulations as a service for their members, see Figure 1. The concentration of high regulation in the Northeast, shown above, may reflect the historical rise of compulsory education and public school that started in states like Massachusetts that opened the first public school. In 1837, the Massachusetts secretary of education created a statewide system of professional teachers and introduced a model of 'common schools' where students were placed in grades by age regardless of differences of aptitude.[9] A comparison of states that have high and low regulation of homeschooling shows how different the requirements are for families who want to educate their children at home; see Table 1.

The HSDLA formed in 1983 and offered homeschooling-related legal advice and representation for a nominal membership fee.[10] By 1992, homeschooling was recognized in every state[11] partly because HSLDA virtually won every legal battle, but also because homeschooling had support of conservative legislators.[12] Bhatt, 2014, found that the probability a young child is homeschooled increases significantly, by 1.4 percentage points, following the passage of homeschool rights in their state.[13] National Home Educator Research Institute (NHERI) estimated that in 2002-2003, there were 1.7 million

to 2.1 million homeschoolers in the United States[14] and by early 2016 there were 2.3 million homeschoolers increasing at a rate of 2-8% a year.[15] However, the institute's research may be of limited value given many criticisms of found Dr. Brian Ray's methodologies[16] including his studies on socialization[17] and academic achievement of homeschoolers[18] in addition to the possible bias with the institute's connection to HSDLA who funds many of their studies.[19]

The most reliable estimates of homeschooler demographics are from the National Center for Educational Statistics (NCES) and their National Household Education Survey (NHES) "which uses a rigorous random sampling design wedded to enormous sample sizes to obtain statistical data on all aspects of the education of children in the United States."[20] NCES defines homeschooled students as school-age children (ages 5–17) in a grade equivalent to at least kindergarten and not higher than 12th grade who receive instruction at home instead of at a public or private school either all or most of the time. The survey first added questions about homeschooling in 1999 with results estimating the number of homeschooled students at 800,000. As of the latest survey, there were 1.7 million homeschooled students in the United States in 2016.[21]

TABLE 1: Comparison of state regulation of homeschool instruction.[22]

	Alaska	Pennsylvania
Requires notification of Homeschool registration	no	yes
Requires instruction in English	no	yes
Requires parents to meet educational qualifications (teacher certification or level of education)	no	yes
Requires minimal instructional time	no	yes
Requires attendance records	no	no
Mandates subjects	no	yes
Requires maintenance of test scores and/or student work	no	yes
Requires annual review or evaluation of child's performance (e.g., portfolio review)	no	yes
Requires standardized testing	no	yes
Requires certification that none of adults in the home have been convicted of a criminal offense	no	yes

The FindLaw website, run by Tomson Reuters, provides a listing of homeschooling laws by state. Table 1 illustrates an example of the disparity among states by comparing Alaska, with no requirements, versus Pennsylvania regulating a high level of requirements for homeschooling families.

It is important to note that even though Alaska state policies are less stringent, the state has a correspondence school network (Connections Program) that provides a formal structure and support for participating homeschools, including individualized learning plans, assessment plan, and quarterly reviews of student work to monitor progress. Participating homeschool students in grades 3-10 are required to take Alaska state testing in science at the same time as students in traditional schools.[23]

III. Reasons for Homeschooling

Homeschoolers are a difficult demographic to study. By nature, homeschooling is deinstitutionalized with a very diverse population.[24] Additionally, the distrust with which many homeschoolers regard external surveillance[25] and one subgroup of homeschoolers is those parents that are "particularly wary of government institutions and the notion of professional expertise."[26] However, there is a considerable

body of work on the history of homeschooling that helps us understand the origins of motivations and perhaps why these motivations shift.

The rise of homeschooling in the 1970s and 1980s reflected a broadening dissatisfaction with formal education in the United States that began in the late 1950s.[27] The launch of Sputnik sparked federal investment into math and science education that resulted in federally funded Biological Science Curriculum Study (BSCS) series of textbooks that included evolution. By the end of the 1960s almost half of the nation's public school districts had adopted the evolution-heavy BSCS textbooks.[28] In 1962 and 1963, the Supreme Court rulings that state-written prayer and Bible readings in public schools were unconstitutional worried many fundamentalists.[29] Conservative evangelical parents began pulling their children out of public schools for religious reasons, which led to a burst of new private Christian day schools. Soon, more curriculum options with a fundamentalist Christian worldview would come on the market to meet the needs of this Christian Day School movement, and later, homeschoolers. In 1967, the Christian Liberty Academy Satellite Schools (CLASS) correspondence school offered an inexpensive and pervasively Christian curriculum that was also marketed to Christian homeschoolers.[30]

Also in the 1960s, multiple authors including Dr. Raymond Moore and John Holt, published works on the negative effects of compulsory education and criticisms of institutional and tax-funded schooling. John Holt was a humanist and critic of the compulsory nature of schooling. Based on his experience as a classroom teacher, he detailed complaints in his 1967 book *How Children Learn* in which he recounts observations of "well-meaning but overworked teachers, who program children to recite right answers and discourage self-directed learning, often retard children's natural curiosity." Holt's philosophy for a home-based education is "learning by living," which was later described by his followers as "unschooling."[31] Holt's *Growing Without Schooling* publication was the first homeschooling periodical, and appealed to those who desire educational activities outside a traditional school framework.[32] Holt became a cult figure of sorts to the wing of the homeschooling movement that drew together New Age devotees, ex-hippies, and homesteaders—the counter-cultural left.[33]

In 1969 Dr. Raymond Moore, a former U.S. Department of Education employee, Ed.D. from the University of Southern California, and former Christian missionary, laid the groundwork that would legitimatize homeschooling. Dr. Moore and his wife studied the effects of institutionalized schooling on young children. Dr. Moore concluded that "development problems, such as hyperactivity, nearsightedness, and dyslexia, were often the result of prematurely taxing a child's nervous system and mind with continuous academic tasks, like reading and writing." They began to advocate that formal schooling should be delayed until at least age 8 or 10, or even as late as 12 and wrote books that offered practical advice to parents on how to successfully school young children at home from a Christian perspective.[34]

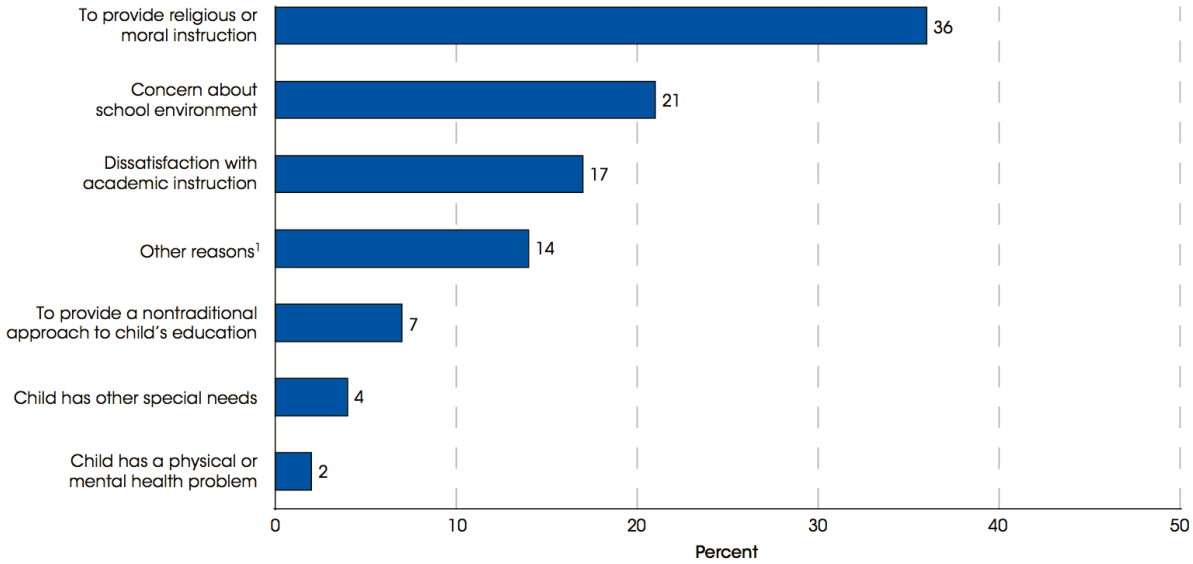
There are various reasons why parents homeschool, but Holt and Moore influenced the two historical strains of homeschooling.[35] In the 1970s, the bulk of families homeschooling were the countercultural-left who responded more strongly to Holt's philosophy. Then in 1972, a condensed version of Dr. Moore's essay on "The dangers of early schooling" was published in *Reader's Digest* and reached millions of readers. Because of Dr. Moore's Christian perspective, he earned a sizable following among parents who chose homeschooling primarily to impart traditional religious mores to their children—the Christian right. James Dobson has called Dr. Moore the "father of the modern homeschool movement."[36]

However, this movement would take a turn to the far-right in the 1980s with the help of the advocacy of Michael Farris and Greg Harris. Prior to establishing the HSLDA, Farris was legal counsel to the Concerned Women of America[37] and is now the president, CEO, and general counsel for the Alliance Defending Freedom (ADF).[38] Greg Harris, with the support of HSLDA, started the National Center for

Home Education (NCHE). Along-side Dr. Moore, Farris and Harris made the rounds at homeschool conventions with a message that "would change the nature of homeschooling from a crusade against 'the establishment' to a crusade against the secular forces of modern-day society."[39] There was some controversy over this shift as detailed in Dr. Moore's white paper "The Ravage of Home Education Through Exclusion by Religion."[40]

By 2007, when the number of homeschoolers reached 1.43 million students, the most important reason given by parents for homeschooling was for religious or moral instruction.[41] See figure 2 below. Farris continued his influence on the homeschool movement by founding the Patrick Henry College, the Homeschool Foundation (charitable arm of HSLDA), and Generation Joshua–a youth civics program with the goal "to ignite a vision in young people to help America return to her Judeo-Christian foundation."[42]

FIGURE 2: Percentage of school-age children who were homeschooled, by reasons parents gave as the most important reason for homeschooling: 2007[43]



SOURCE: U.S. Department of Education, National Center for Education Statistics, Parent and Family Involvement in Education Survey of the National Household Education Surveys Program (NHES), 2009.

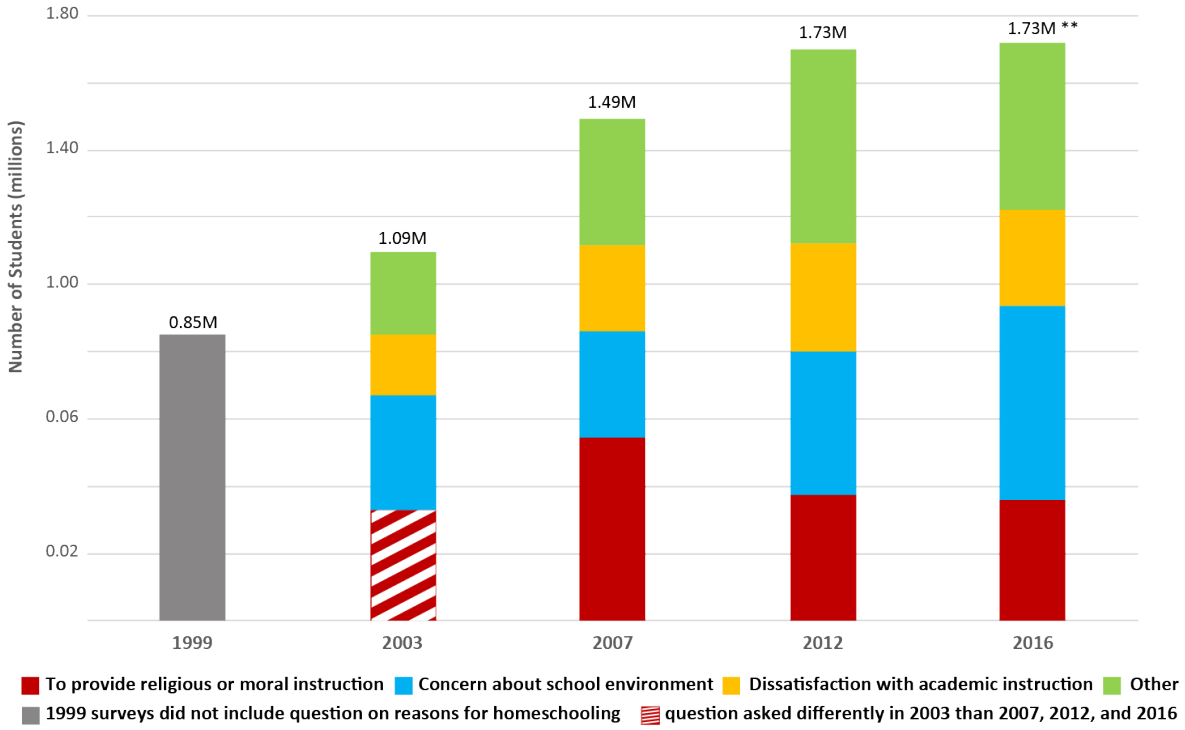
IV. Changing demographics

Primary motivators for homeschooling have changed over time. While the modern day Homeschool Movement has its roots in fundamentalist Christian teachings, the practice is gaining in popularity among secular groups. In 2007, 36 percent of parents said they desire to provide religious or moral instruction. As the total number of homeschooled children increased from 1999 to 2016, the responses to the question of what is the "most important" motivator for homeschooling have changed. By 2016, 80 percent of parents said school environment (e.g., safety, drugs, negative peer pressure) as an important reason for homeschooling their child with 34 percent of parents indicating that this was the most important reason. This compares to only 16 percent of parents who said that providing religious instruction was their most important reason for homeschooling.[44] Figure 3 shows the change in the "most important" reason for homeschooling as number of students increased.

The rapid growth in the number of students homeschooled from 1999 to 2012 could be the result of the widespread access to the internet for inexpensive home instruction materials and social media for support and networking. Together, they could provide the confidence for more parents to take their

children out of public school. However, numbers have remained steady in 2016 at 1.7 million according to NCES's "First Look" report of 2016 data.[45] There could be a connection with charter schools as those are sometimes considered connected to public schools since they use tax funds. For example, the Charter-Homeschool hybrid is very robust in Oregon and parents can choose charters such as Alliance Charter Academy and Paisley Charter School, where they can use public funds to fulfill their requirements across the curriculum. However, this model requires additional accountability such as using curriculum that adheres to education standards. [46]

FIGURE 3: Total number of homeschooled students and "most important" reason for homeschooling



*** Data for 2016 is only preliminary from the "First Look" publication in September 2017.*
SOURCE: U.S. Department of Education, National Center for Education Statistics, Parent and Family Involvement in Education Survey of the National Household Education Surveys Program (NHES), 2016 and 2017.

A broader look at this changing demographic over time shows the number of homeschooled students growing, but the number of those who homeschool for religious reasons is somewhat steady. This could mean a shift from a primarily non-secular audience to a growing secular audience when it comes to selection of curriculum and support materials. This is significant for NASA and our SciAct partners as there appears to be a growing audience of those who homeschool for reasons other than religion; many of the available, pre-packaged science curricula are grounded in specific religious teachings (e.g., creationism). Homeschools are an audience whose needs might be well supplemented with NASA STEM education resources and programming.

V. Methods of Homeschooling

Homeschooling does not imply that all learning takes place exclusively in the home; homeschoolers use libraries, visit and participate in activities at museums and science centers, compete in state and national competitions, and attend both public and school-related educational events. They also meet in groups (or cooperatives) where parents share in the role of teaching various classes (often based on their expertise). In some states or school districts, they may take a limited number of classes at a local school, partner with a charter school, or enroll in an online school specific for homeschoolers (e.g., Bob Jones University, Keystone Online School). They may enroll in a specialized homeschooling program affiliated and run by a school district that allows them access to additional resources and teaching personnel.[47] Regardless of where instruction takes place, there are a variety of methods for organizing homeschool instruction from highly-structured correspondence courses to using no curriculum at all. It is common to see an eclectic combination of methods used by parents meet the needs of their child.

FIGURE 4: Sample homeschool plan for 10th grader

Subject Area	Course Title	Curriculum Used
Language Arts	10th grade Literature	Co-op Instructor: Linda Hickman Classics – see attached reading list
Mathematics	Algebra 2	Teaching Textbooks – DVD lecture, workbook, tests Tutor: Pete Barrow (AP Calculus teacher, Blair HS Mont. County)
Science	Biology	Holt, Rinehart, Winston's "Modern Biology" http://www.biologycorner.com/ Fall Labs: UMBI Zebrafish Embryology Patuxent River Park - Goose Dissection
Social Studies	Ancient History	The Teaching Company. World History DVD lecture
Bible	Old Testament – Documentary hypothesis	Text: New American Bible Teacher: Mr. Folks, Coptic Greek Masters from Catholic Univ.
Fine Arts		
PE	Biking	Summer Camp 2007 Washington DC – Pittsburgh, PA 357 miles
Health	Nutrition & Safety	USDA nutrition materials / CPR course Girl Scout Health & Nutrition Badges
Practical Arts		
Foreign Language	Japanese	Classes at Japan-America Society (Washington, DC)
Christian Service Hrs.		
Electives & Work Study/ Apprenticeship	Drama	Winter 2008 Youth Musical - Greenbelt Community Center
	Music	Piano Lessons. Instructor: Ms. Lauren

An example of homeschool subjects for a 10th grade homeschool student with an eclectic mix of curriculum and methods: packaged homeschool curriculum for math; traditional text plus labs at local science centers for science; traditional class at a co-op for English; summer and winter youth camps for PE and Drama; private piano lessons for music; and a mix of internet resources from USDA, local Red Cross CPR course, and Girl Scout badge activities for health class. SOURCE: Ginger Butcher

The most familiar method is a traditional model of educator and student using a planned curriculum, a school-at-home model. While this could be led by a parent-educator at home, it could also be implemented via distance learning, as correspondence courses, or by instructors at classes attended

outside the home such as a co-op or community college. These tend to include packaged curriculum developed specifically for a specific grade level and includes all materials needed for instruction, lectures, student practice, and assessment. Curriculum can be specifically designed for homeschoolers but also include secular publishers providing traditional classroom instructional materials (e.g., those used in public school) for homeschooled families— Pearson Homeschool and Houghton Mifflin Harcourt. (See more in the next section on Curriculum.)

Unit studies organize the child's learning experiences within a framework of a single topic or theme. For example, a unit study on "horses" might include reading fiction about horses, studying horse breeds and anatomy, calculating grazing acreage and feed needed to keep horses, reading about the history of horse racing or horses in combat, a museum visit centered around horses in artwork, viewing movies about horses, writing poems and stories about horses, and drawing horses. This method is a common choice for parents who need to teach multiple children at different grade levels because the children can read and do activities together but complete assignments at their own level. Younger children can also learn from the older children.

Unschooling focuses learning around the child's interests and is based on Holt's philosophy of "learning by living." Parents encourage the child to investigate their own interests and guide the child's learning during experiences. For example, if a child is interested in cooking, the parent may teach math as part of making a recipe, encourage the child to research the history of a particular type of food that interests them, compose a letter to a chef, or post a recipe review on a web site. Opportunities are everywhere; a new subscription box, RaddishKids cooking club, includes homeschooling lessons with their monthly boxes. This method does not use traditional curriculum products but rather focuses on hands-on activities and teachable moments. This is often popular with younger children similar to the Montessori approach to learning, but can also be employed for some high school subjects such as art, history, or literature. The key is that the content appeals the child's interests.

VI. Curriculum

Throughout the growth of Christian day schools in the 1970s and 1980s, there were three leading producers of curricula: A Beka, Accelerated Christian Education (ACE), and Bob Jones University (BJU) Press.[48] These were also leading choices for homeschool curriculum in the 1980s and featured prominently in homeschooling conventions.[49]

A Beka curriculum started in 1954 and set out to meet the needs of Christian-school leaders who wanted traditional texts with traditional themes. The curriculum took out-of-print textbooks that emphasized traditional teacher-directed and rote memorization, and republished them with scriptural passages and traditional Protestant religious imagery. The A Beka curriculum gained popularity, particularly with the Christian Liberty Academy's CLASS correspondence school, and then started their own correspondence school in 1975. By 1998, they had over 23,000 students enrolled in their school and 225,000 more families purchasing their curriculum for home.[50] Today, available A Beka homeschool materials include complete parent and child curriculum packages for K-12 and supplemental video-homeschooling resources.

Accelerated Christian Education (ACE) was developed in 1970 and promoted an individualized, child-centered pedagogical method. ACE offered graded series that include 12 Packets of Accelerated Christian Education (PACEs) for students to complete independently, in cubicles, at their own pace. PACEs are based on a mastery approach and formatted for students to complete the exercises found throughout the workbook, then take a final test to measure understanding. The pedagogical goal was to increase student's responsibility with daily accountability goals with rewards and consequences. While

PACE's educational pedagogy was criticized, most fiercely from secular critics, the curriculum remained popular for its combination of novelty, low cost, and promise of increased academic achievement.[51] The ACE curriculum gained a following with the CLASS correspondence schools (popular with homeschoolers) and by 1987, was in 5,000 schools.[52]

The faculty at Bob Jones University (BJU) were not satisfied with the traditional textbook approach from A Beka, nor did they consider ACE's self-paced workbooks an adequate form of instruction. BJU educators relied on Bloom's Taxonomy for their curriculum with a focus higher-order thinking skills. In 1974, two faculty members published *Physical Science for Christian Schools*. The strength of the university's educators and researchers to develop coherent, literate curriculum that has proven popular to this day.[53] Today, BJU Press offers homeschool parents a complete set of textbooks for K-12 as well as a distance learning program.

While they differ in pedagogy, the leaders of all three publishers are alumni from BJU and held the same guiding theology and cultural philosophy that: the Bible contained God's truth as revealed through human authors; the Bible contained no error or falsehood; and, any discrepancy between the Bible and scientific facts must result from an error in science or a mistaken understanding of the Bible.[54]

Another aspect of this cultural philosophy was a focus on the home-based business. As a result, a cottage industry of Christian curriculum developers emerged. [55] Alpha Omega Publications (AOP) is similar to ACE, is also workbook based, and also offers computer-based instruction called Switched On Schoolhouse. Christian Light Education offers an adapted Mennonite version of AOP. Mott Media reprints nineteenth century textbooks such as McGuffey readers. Rod and Staff Publishers produce a traditional line of textbooks with a conservative Mennonite theology.[56] By late 1980s, homeschool conventions included hundreds of curriculum options, most from a Biblical worldview. [57]

Apologia Educational Ministries began a homeschool science curriculum with just one chemistry text in the early 1990s and now publishes a series of creation-based science texts across all science subjects and offers distance learning courses for grades K–12. An account of their success from the Apologia website offers the best description about the popularity of creation-based science in homeschooling:

> "Part of Apologia's success in the years that followed was the result of the books' unabashedly Christian worldview. The Greek word *apologia* is a legal term the apostle Peter used when he commanded Christians to be 'ready to give a defense' to inquirers about the faith (1 Peter 3:15). Apologia textbooks have helped families defend the faith by holding to a solidly creation-based worldview. At the time, other Christian textbooks often just added a veneer of Bible verses over a basically secular curriculum. But Apologia textbooks represented a fresh approach inspired by James Clerk Maxwell, one of the founders of modern physics, who started every lecture and every experiment with prayer. Maxwell approached science with an attitude of '"Here's how the Creator did it' rather than 'Here is science—let's see how it fits with Scripture.[58]'"

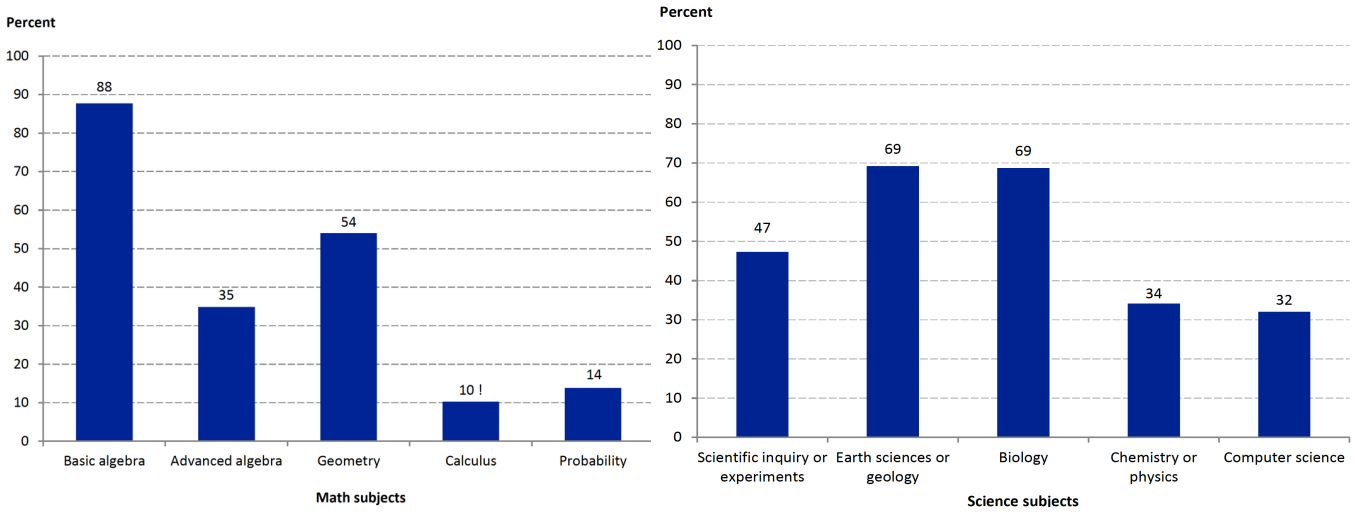
In 2006, few traditional secular science textbook publishers marketed directly to homeschoolers (personal experience, author Butcher). However, NCES surveys showing rapid increase in this audience from 1.09 million in 1999 to 1.49 million in 2003 may have influenced these publishers to get into the homeschool market. In 2002, McGraw Hill published The McGraw-Hill Homeschooling Companion. Pearson registered Pearsonhomeschool.com in 2004[59] and now offers a complete suite of curriculum for homeschoolers.

VII. Homeschooling STEM

The NHES survey in 2012 asked homeschooling parents what math and science subjects their children were taught in 9th-12th grades; see figure 5. Basic algebra (88%) and geometry (54%) were the most taught math subjects. For science, biology and Earth sciences/geology were both taught for 69% of homeschooled students.[60] Notable is that almost half of homeschoolers are taught science inquiry or conduct experiments. Bob Jones Sr., founder of BJU, believed in a traditional pedagogy and warned that classrooms had been "silenced by the babble of foolish questions arising out of the perversion of the so-called mind of science-inquiry."[61] This could be another indicator that this audience is changing their views on science, or that they have a naïve understanding of scientific inquiry.

Homeschool parent and coordinator for the Oregon Homeschool Science Club Jilene Modlin, says that science is often the most difficult subject to teach for homeschool parents. They don't have lab equipment, often science was poorly presented to the home educator as a student, and they want something more but don't know how to design or develop it. They desire science experiences beyond vinegar and baking soda experiments in the kitchen. Thus, unlike any other subject such as math, language arts, or history, they turn to the community for their science instruction.[62] Homeschool families often seek out programs at museums (like Air and Space Museums), outdoor schools (like at a marine science center), university programs (such as the Portland State University Saturday Academy), outdoor opportunities, homeschool co-ops, and homeschool Facebook groups.[63]

Figure 5: Percentage of homeschooled students with a grade level equivalent of 9-12 who had been taught specific math and science subjects during home instruction: 2012



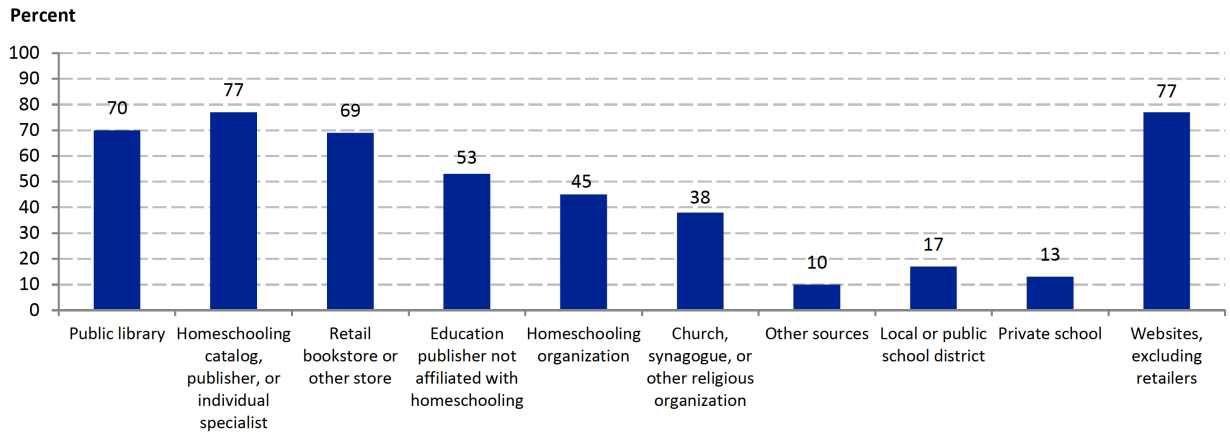
SOURCE: U.S. Department of Education, National Center for Education Statistics, Parent and Family Involvement in Education Survey of the National Household Education Surveys Program (NHES), 2016.

A 2017 study on STEM teaching and learning strategies by parents of high school students shows parents employ a variety of strategies including prepared curriculum and self-directed study. They also focus on collaboration - both student-student as well as student-parent. Programs at science centers and museums often offer labs and group programs that provide collaboration. A key difference between teachers in a traditional setting and homeschoolers is that parents see themselves as learners.[64] Thus, there is an opportunity to reach parents with new science knowledge in addition to students.

The majority of packaged science curriculum for homeschool is largely creation-based, which can be problematic for some homeschooling families (even those of faith) when teaching biology and Earth science topics such as geology. With the changing demographics and shifts in motivations, there is an opportunity to provide curriculum support in these areas. But sensitivities to both sides must be taken into account when providing programming. Some are concerned about faith-based and other approaches they may not want; others do want a faith-based approach and are concerned about curriculum that isn't compatible. Providing a clear description of what is being taught can assuage these concerns.[65]

The NHES survey asked respondents to identify their sources of homeschooling curricula and books; see Figure 6. It is clear that homeschoolers are resourceful and use multiple sources to successfully meet the needs of their homeschooled children. There are two data points that are particularly relevant to NASA and SciAct partners. First, websites are reportedly the primary source (77%) of curricula and books for homeschooling parents (tied with homeschooling catalogs). Next, public libraries are the second most accessed source (70%) of curricula and books for homeschoolers.

Figure 6: Percentage of homeschooled students, ages 5 through 17 with a grade equivalent of kindergarten through grade 12, by parent-reported sources of curriculum and books: 2012.[66]



SOURCE: U.S. Department of Education, National Center for Education Statistics, Parent and Family Involvement in Education Survey of the National Household Education Surveys Program (NHES), 2016.

The prominence of websites as a source of homeschooling curricula offers both a nearly free distribution method for the provider of online educational resources such as Khan Academy, and Time4Learning Science, as well as convenient and unlimited access for the homeschooling consumer. Among those students that homeschool for their K-12 years, Hanna (2011) found that as children age, their homeschooling experience is increasingly characterized by reliance on networks outside the home, especially co-ops and internet resources.[67] Many accredited universities are now offering online courses for homeschoolers such as Stanford's Online High School and Johns Hopkins Center for Talented Youth who offer courses for Pre-K to 12th grades. The NSF has also recognized the internet as a dissemination channel and invested in the development of the National STEM Education Distributed Learning (NSDL) and its pathway collections for specific audiences.[68] One such portal that was started as an NSDL pathway collection is HowtoSmile.org – a digital library designed to bring the best educational STEM content to school-age kids in non-classroom settings (such as homeschoolers) and out-of-school educators (e.g., museums, aquariums).[69]

Many parents choose to use resources other than pre-packaged curriculum.[70] Home educators value the application and the connection of knowledge to the in real world (e.g., robotics competitions).[71] This was echoed in the interview with Jilene who says homeschoolers "want an emphasis on *real science* not crafts. Not just reading from a book or doing an activity for the sake of doing an activity." She says another motivating factor is linking to something beyond science and learning such as a merit badge in scouting.[72]

Many libraries offer free programs to the public and some offer programs specific for homeschoolers during the school day. Chad Mairn at Seminole Campus Library in St. Petersburg, Florida, runs a Maker Bootcamp program out of their Innovation Lab maker space. The interest from homeschoolers was so overwhelming that they opened an additional session and both are consistently booked. The kids are motivated and often return to the library to finish their projects. Chad says that future technologies for the workforce, projects students can do on their own, and learning about coding are all in high demand with seven homeschool groups he works with.[73]

Museums are becoming places for families who are looking for more in-depth science learning for their students by offering out-of-class components to their homeschooling, such as labs.[74] Elizabeth Andanen from Oregon Museum of Science and Industry (OMSI) attended a session at the 2012 annual Association of Science and Technology Centers (ASTC) about how to adapt programs to meet the unique needs and challenges of homeschooled children with presentations from seven different centers across the country. Elizabeth says that "things may have changed in the past five years, but from my notes it seemed like almost all of these groups were offering drop-in, ticketed programs for individual homeschooling families."[75]

OMSI partners with the Oregon Homeschool Science Club on the development and delivery of science programming. Since this homeschool group also partners with a charter school, they can use public funds to pay for programs at the museum. OMSI beta-tests and refines the programs with the homeschoolers and then offers the same programs to the public and school groups. Additionally, this arrangement is collaborative. The museum offers the facilities and materials needed for the programs and the homeschool groups are flexible so they can work around the museum's low volume schedule, avoiding dates when visitation at the museum is high. Parents also volunteer at the museum.[76]

Some homeschoolers have a preference for packaged curriculum because it is self-contained and includes assessments. Even with this decidedly Christian focus, many parents in the Oregon Homeschool Science Club who are not homeschooling for primarily religious reasons use Apologia because it has reputation for being a solid curriculum and includes assessments.[77] Discovery Education's Streaming service offers videos to supplement curriculum that also include worksheets and assessments. SciAct partners such as WGBH's Learning Media are well positioned to curate NASA science content and package it as support modules with assessments as a way to meet this need.

VIII. Suggested Strategies and Channels

Reaching homeschoolers with NASA content is somewhat challenging given that homeschooling is very de-centralized and grassroots in its structure and organization. Yet, as illustrated in this paper, homeschools find and share resources from the internet, their communities, local libraries, and museums. They use a variety of channels to communicate including Yahoo groups, online bulletin boards, Facebook, and email lists. A good strategy is to forge a connection and relationship within the community and have this champion be your "voice" in the community.[78] Additionally, many states have state homeschool associations that conduct annual conventions. The following are a few suggested strategies and channels to reach the homeschooling audience with NASA science.

Strategies:

- Curate collections of materials to supplement curriculum – track stats of views
  - Example: Eclipse Resources for Home Schools webpage created for NASA Eclipse site and received 76,000 page views in a little over a month (from July 20-Aug. 29, 2017) and an additional 3,711 views after the eclipse (through Oct. 30, 2017).
- Provide webinars to introduce curated lists and demonstrate activities – track viewership and residuals
- Promote curated content with current events or other "hooks" on social media – track stats
- Work with partners to promote archived lists, webinars, and events
- Present at homeschool conventions and professional conferences with homeschool reach (ASTC, NSTA, ALA) – record attendance and track residuals

Suggested Channels:

Social Media

An analysis of Facebook (Sept 2017) revealed that 975,502 users self-identify as a homeschooled student, 55,898 self-identify as being employed as a home educator, and 5,797,670 Facebook users say they are interested in homeschooling. Pinterest has a thriving array of boards and pins focused on homeschool. It is difficult to collect Pinterest statistics on number of followers by topic; a preliminary search shows boards have followers of more than 100,000. While these statistics are international, having a robust strategy for reaching homeschoolers via social should provide significant results.

NASA can build on an existing NASA Education Facebook presence, and create one if one doesn't exist, to target the homeschool community via groups, outreach, and targeted communications, and can leverage SciAct partners' social presence. Some partners may even be able to participate in paid social promotion activities, a practice currently unavailable to government social accounts. NASA can also create Pinterest boards off NASA's Pinterest account.

Homeschool support groups and cooperatives

A survey of Yahoo groups found over 225 active groups for home schools across the U.S. in 2015-2016 totaling over 75,000 members. Many of these groups are closed or invitation-only, but their contact information is accessible via Yahoo groups and homeschool support websites such as Homeschool World. The Seminole public library has had good success in forging connections and relationships within these communities by finding someone "on the inside" to be their "voice" in the community and promote programming.[79] NASA and SciAct partners could employ this strategy to reach out to some of the more popular groups and establish contacts to act as mavens promoting the excitement of NASA science via the grassroots base.

Homeschool conventions

Homeschooling conventions at the national level such as Great Homeschool Conventions, and at state level such as the Homeschool Conference hosted by the Homeschool Association of California can draw large numbers of homeschoolers. These conventions are places where homeschoolers come to find curriculum, activities, and support for their homeschooling efforts. Historically, many of the popular homeschool curricula and philosophies have grown through exposure at the conventions over the years.[80] A strategic NASA presence at some of the more largely attended events could prove advantageous in introducing NASA science to this audience and establishing a network of mavens to reach smaller homeschool groups.

Professional conferences

Some national conferences already host sessions specific to homeschool programming, or reach out to promote their conferences on homeschool resources sites. As mentioned, ASTC has offered sessions specifically about homeschool programming. The National Science Teachers Association (NSTA) promotes their annual conference and encourages "homeschooling parents to register for the conference to learn new science teaching techniques, experience new hands-on learning options, and more."[81] NASA and SciAct partners are already attending these and other conferences where they can present and promote NASA science content for homeschoolers.

Libraries & SciAct Partner NASA@My Library

As mentioned earlier, 77% of homeschoolers say they use libraries to find curriculum and books for their education. SciAct partners such as SSI's NASA@ My Library is uniquely positioned to promote NASA science programming to homeschoolers through their existing network of libraries. Presentations at library conferences such as the American Library Association could promote NASA content and programming available through SSI, but are also a venue to teach librarians how to access and promote NASA data for patrons doing research.

Maker spaces

Community maker spaces are becoming the shop class for homeschool as well as resources to materials they don't have at home. Classes offered at maker spaces for homeschoolers are in high demand. These spaces are in need of programming that not only leverages the resources in their space, but also brings real-world connections to technology, engineering, and science. Well-designed programs that leverage or adapt existing NASA science content would be popular. NASA and SciAct partners could host webinars that would play during a session at a maker space or one that provides professional development. It may also be advantageous for NASA to look into partnering strategically with MAKE to get NASA-related activities into their summer Maker Camps that are run across the country.

Museums and Science Centers - see NASA Museum Alliance under Leveraging SMD infrastructure.

Leveraging SMD Infrastructure:

NASA Museum Alliance

SMD and SciAct partners can leverage NASA's Museum Alliance to curate and/or develop NASA science programming that will meet the needs of homeschoolers. There is potential to review existing successful programs, such as OMSI and other members of ASTC, and leverage successful programming models with NASA science content.

NASA Centers

NASA Centers are already working directly with or coordinating with local institutes that work with homeschoolers. For example:

- NASA Langley Science Education Team participates in an annual homeschool day at the Virginia Living Museum (see http://smdepo.org/post/9085). The Langley team also celebrated Earth Day 2017 with Homeschool Families at Slover Library located in Norfolk, VA, and is part of the STAR-NET libraries organization.
- NASA Stennis Space Center also participated in an eclipse event with homeschoolers in collaboration with the Infinity Science Center (which serves as NASA's official visitors center for Stennis Space Center), who has a strong homeschool network from their a Homeschool

Monday events. (see http://www.visitinfinity.com/programs-events/solar-eclipse-day/266/)

- Johnson Space Center/Space Center Houston hosts exclusive activities and guest speakers for home schools at the annual fall Home School Day. They have held these events at least since 2014, with the latest on Oct. 19, 2017 (see https://spacecenter.org/home-school-day/)
- NASA Jet Propulsion Laboratory (JPL) education specialist Lyle Tavernier, presented via virtual connection to a homeschool association in Fall Creek, Ore. This connection was the opening event of a month-long unit on space studies during fall 2016. Students learned about the solar system, and how JPL utilizes robotics to explore space.
- All NASA Centers have events for the public at their Visitor's Centers, or partnering institutions, that could be promoted to homeschools (e.g., NASA GSFC recently celebrated International Observe the Moon Night on October 28)

Additionally, homeschool events at NASA Centers could be promoted through the NASA Science WoW! eNews and blog.

NASA Wavelength and learning resources from the NASA SMD SciAct Collective

NASA SMD and the SciAct community can provide homeschool educators and out-of-school providers with access to NASA resources through NASA Wavelength digital library for educators. This could be done through Featured banners linking to blog posts or featured Wavelength lists highlighting relevant resources for homeschools. These could be a regular feature – establish a schedule (e.g., quarterly) that calls out resources and upcoming mission and science events (e.g. upcoming science events that will be I the news, like Mission launches, celestial events, the 2017 eclipse Ginger Butcher created a Wavelength list of homeschool resources).

Wavelength should also consider whether "Homeschool" should be added as an audience, with search strategies and curated resources identified for homeschool audiences. For example, the new Earth and Space Science Education Toolkits developed by the Science Museum of Minnesota CAN award include online digital versions of their toolkits with hands-on, active learning resources with excellent scaffolding for educators who may not have a strong background in the science presented, including short video demos and explanations from subject matter experts about the science behind the activity. (http://www.nisenet.org/earthspacekit-2017).

NASA Science Wow!

NASA SMD's weekly science education eNews and blog could be promoted to homeschools, homeschool networks. NASA Science Wow! could also feature resources or events that specifically target home school (e.g., NASA Center events for homeschools, Wavelength lists or featured blog posts, etc.).

Citizen Science

Outreach to homeschoolers via citizen science campaigns is a strong opportunity to provide the real-world science activities they crave. They want a real science experience, a well-rounded experience, and an experience for the whole family.[82] These activities can provide solid curriculum supplement as well as engage the student's interest for further study, which a homeschool parent is ready to help foster. For example, the NASA Langley team shared MY NASA DATA and GLOBE resources with parents at Slover Library in June 2017 (follow-on to the earlier Earth Day event) and at VASC's Homeschool Day in May 2017. They signed up participants for future training opportunities and helped students complete the Estimation of Cloud Cover Learning Activity and learned about data entry on the GLOBE Observer App.

Discussion
Organizations that provide STEM programming and resources for homeschools (libraries, museums, science centers, planetaria, etc.) are popular for homeschool activities and extra-curricular programming. Our SciAct partners are well poised to reach this audience through their broad networks.

How can we best leverage NASA SMD Infrastructure to meet the needs of this audience?

- NISE Network – The National Informal Science Education (NISE) Network is a national community of informal educators and scientists dedicated to fostering public awareness, engagement, and understanding of current science, technology, engineering, and math (STEM).
- STAR Net's NASA@ My Library program could help libraries bring NASA science into homeschool programming
- Other CAN awardees – identify where/who serve large homeschool communities
- Infrastructure such as NASA Museum Alliance and presentations at ASTC conferences.
- WGBH and PBS Learning Media

IX. Measuring success

Depending on which suggested strategies are implemented, measuring success will include a variety of approaches. This may be best to address as a discussion with the SciAct partners as they may have established mechanisms for collecting feedback, metrics, and evaluations. Thus, working closely with SciAct partners, some of the feedback and metrics that can be collected on the effectiveness of homeschool programs with NASA science may come from sources such as:

- facilitators providing activities for homeschooling through museums, science centers, or libraries
- NASA Center events and educator resource centers
- Facilitators presenting or conducting workshops at conferences and homeschool conventions
- Webinar viewership and post-surveys
- Networks of homeschool groups or parents willing to try out materials and provide feedback (e.g,, Oregon Homeschool Science Club).

Metrics can be collected on the distribution of NASA materials to this audience:

- Social media stats
- Website analytics
- Webinar residual views
- Feedback on curated collections on channels such as NASA Wavelength

More detailed feedback from facilitators and participants can be evaluated for:

- how valuable facilitators find the resources
- who is adopting/adapting these resources to use with homeschools
- how well the content meets the needs of homeschoolers

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