# Astronomy Education in the United States of America

This overview is part of the project "Astronomy Education Worldwide" of the International Astronomical Union's Office of Astronomy for Education.
More information: https://astro4edu.org/worldwide

**Structure of education:** Throughout the United States, education is compulsory spanning the K-12 grades (ages 5-18). Many states now require Transitional Kindergarten (TK) or Pre-Kindergarten (PK). A mix of public, private, and charter schools can be found in all 50 states and the 5 populated territories. The public schools are funded by a combination of taxes at the district, state, and federal levels – with most of the funding provided at the district level (often property taxes). Charter schools are publicly-funded experimental or mission-oriented schools; they often lack the accountability and public transparency of public schools. Private schools are tuition based. English is the primary language instruction throughout the United States, with English as a Second Language (ESL) programs being offered in most schools.

**Education facilities:** Class sizes average about 20 students per classroom. However, this average is taken over all of the 13,000+ school districts in the country. The larger urban school districts have significantly larger class sizes, with the breakdown by grade span more like K-3: 15-20 students; 4-6: 25-30; students; 7-12: 32-40 students. Most schools have internet access and have expanded their wifi capabilities in recent years. Disparities in class size and internet access exist, some of which are dependent on the socio-economic and racial makeup of the hosting communities. Schools vary in their amounts of available technology; some have one device per student, while others have rollable carts or no technology. Buses are provided for students who need them. There is much greater access to bussing in urban compared to suburban areas. Conditions of buildings and the availability of nutritional meals are typically adequate, but with disparities that again depend on the socio-economic and racial makeup of the hosting communities.

**Governance and organisation:** Most states (37 of 50) follow the Next Generation Science Standards (NGSS) that were established in 2013. However, not all of the national standards are adopted word for word, with some states relegating some of the national standards to “appendix” status. Implementation amongst adopting states varies from beginning the adoption process to full implementation state-wide. Some state frameworks, though often based on the NGSS, have modified their arrangement of standards for science content and skills. Most state credentialing requirements follow the previous requirements from the No Child Left Behind (NCLB) Act that was instituted in 2002 as a means toward measuring high qualification, and have not changed to reflect new standards.

**Teacher Training:** The US lacks a national standard on teacher credentialing, and relies on each state department of education to determine the requirements for teachers. Many U.S. colleges and universities have teacher education and certification programs. These, however, vary by state and even within states. For example - there are 113 certifying programs in California of lengths that vary from 9-24 months. California has the most strict credentialing requirements in the Country. Culminating requirements also vary -- from a summative portfolio to a lengthy document detailing all aspects of a lesson plan’s execution. In California, the two University families’ (the California State

University and University of California) credential programs vary in both length and depth; CalState programs are generally 2 years without a Master's degree, while UC is 13 months leading to a Master's degree. The coursework is similar, with the exception that CalState programs focus on more depth of pedagogical preparation and cost significantly less.
Some teacher education programs contain embedded certification in the 5th year of a specific education bachelor's program (as in Physics Education in Texas) or as part of an undergraduate major focused on teaching (as in Oklahoma). Other states have more rigorous and specific additional certification programs beyond the Bachelor's degree, which is attainable for those with any academic background. Most states have a required assessment to prove subject matter competency, if this qualification was not satisfied by coursework. In high need subjects, such as physics, many teachers opt for the test in lieu of taking additional coursework. The test, however, is extremely difficult and has a substantial fail rate. As previously mentioned, the credentialing tests do not reflect the new content determined by NGSS.
Some states offer mentoring programs, however these are typically provided by current teachers, who are often too overworked to provide much mentorship. For this reason, accompanied by consistently low pay, teacher retention is an issue in every state. In most states, a significant number of new teachers have left the profession by year 5. In Arizona, as many as 25% of positions remain unfilled this year in some locations. Master's degree programs in Earth and Space Science Education are offered at very few universities, such as Mississippi State and the University of Michigan. Both are remote options. Columbia University offers a PhD option in Earth and Space Science Education, and a very small number of schools offer an Earth and Space Science Education Bachelor's degree (such as Temple University and Arizona State University). Other institutions provide similar education programs but under more specific titles, e.g. Geoscience Education, Earth Science Education, Astronomy Education,etc. Most collegiate institutions provide teacher preparation programs, where the students choose their own science content courses. Meanwhile, an alarming proportion of Earth science (and presumably space science) teachers have never taken courses in these particular subjects

**Astronomy in the curriculum:** Explicit instruction in Astronomy as a stand-alone course in high school is spotty at best. This situation exists despite the NGSS and state standards' emphasis on Earth & space sciences having the same priority as the physical and life sciences across the K-12 grade sequence. Astronomy often appears as a small part of physics courses, while the Earth sciences are often relegated to small parts of geography or environmental science courses. This situation could be changing, however, as science education in the United States is under going a paradigm shift in content, practice and pedagogy. Unfortunately, most school districts are ill-prepared for this transition. During the previous educational era, Earth and Space sciences were a "catch-all," low-level course, which was not recognized by the College Board. After decades of demotion, Earth and space sciences now are to comprise the backbone of all science courses, across every grade band from 6-12. Students learn about plate tectonics through the lens of the fossil record in Biology, to investigate Earth's interior in Chemistry, and to investigate two dimensional motion and collisions in Physics. Starting 2020, states which were early adopters of the new standards will begin their annual student assessments. These will measure student understanding of concepts, through the lens of Earth and Space; These states, and eventually all, will have integrated Earth and space sciences into Biology, Chemistry, and Physics – yet no support, materials or coursework exist to support teachers in this transition. Furthermore, there are no support positions to assist in Earth and space science integration. In this absence, many teachers may choose to skip these requirements.
California, an early adopting State and model for the country, has not issued a new Geoscience credential (required to teach Earth and Space sciences) since 2015. Statewide, there are less than 100 credential holders; the second largest district in the nation has only 2 and a moratorium on hiring more. Most districts previously offering Earth science, in which astronomy would be an integral component, have cancelled these courses in favor of an integrated model. Such integration requires

all teachers to be Earth and Space experts. Finding overlaps within newly available texts is critical to identifying learning sequences to support teachers and learners as they embark upon this journey of integrated learning. Incorporating activities to support this new content and overlap however, is vital to the success of this integration. Having never taught this content, teachers and school sites are less likely to have materials, or experience facilitating lab activities focused on the Earth and space sciences. Developing innovative, adaptive, relevant and culturally responsive activities ,based upon the overlaps in the texts , will allow teachers to facilitate content they may lack familiarity in. This will ultimately assist in preparing the next generation of learners and leaders to make the most vital decisions for our environment, our nation, and our future.

**Astronomy education outside the classroom:** Pre-Covid Generally, since astronomy is either an elective or an embedded standard, field trips or extracurricular activities would be required to visit science museums, planetariums, observatories, or other public science centers. A few schools in the country have obtained funding to have their own small planetariums and/or observatories, but these are quite rare, and would require a very dedicated teacher and funding source. Field trips require either donations or student fees, which are increasingly difficult due to legislation prohibiting student payment. In many areas, busses for field trips are not covered, and are quite expensive. School field trips are site dependent, but more often consist of class field trips. There are a few youth programs that have astronomy activities. For example, the Girls Scouts of America offer a Junior Space Level Badge for girls in grades 4 and 5. The Astronomical Society of the Pacific offers mentor training called “Girls on the Scope”. This training encourages amateur astronomers to conduct public outreach with girls to increase their interest. NASA offers many opportunities for student competition and participation in national solicitations, but these require a very committed teacher (or school) to elicit large-scale participation. Many private organizations have sprung up offering opportunities for student space experiments, such as plants in space on cubesats and ISS analog missions. Some observatories have field trip programs, which generally cater to younger grades (5-7).In addition, a few science museums/centers have distance learning astronomy programs. These are available on a limited basis, and schools are responsible for booking and any associated fees. During the COVID-19 pandemic, NASA and the Astronomical Society of the Pacific have rapidly adapted content for remote settings, and remotely operated telescopes will likely fill the niche of star parties for coming years. Many planetariums have provided remote resources to their immediate and global communities. Outreach events through planetariums are also being conducted online.

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