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Network Astronomy for School Education: An Ethnophysics-Based Literature Review

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Abstract: The research reported in this article aims to review the available literature on integrating ethnophysics-based network astronomy for school education (NASE) on the understanding and trust of teachers, students, and society. The method used in this study is a literature review from 2010-2022. The literature included in this review was chosen from journals with international reputations to ensure high-quality and widely recognized sources by searching for relevant literature in the databases of Mendeley and Google Scholar. The keywords used in the search included "astronomy learning difficulties, NASE or Network Astronomy School Education, and Ethnophysics", which strictly discuss the challenges in learning astronomy and astronomy in local wisdom with four questions: (1) What kinds of challenges are faced in astronomy learning? (2) Does NASE affect astronomy learning? (3) Does local wisdom relate to astronomical learning? (4) How are the community's understanding and beliefs related to Ethnophysics? The literature review results show that NASE has a positive effect on the challenges of learning astronomy, and NASE has a relationship with local wisdom that discusses astronomy. The finding also shows that the relationship between local wisdom and astronomy with NASE can increase people's understanding and trust in ethnophysics from each culture they have. This article recommends that astronomy-based NASE integrated learning with local wisdom be applied in various countries, especially in Indonesia concerning astronomy learning so that the culture owned is preserved due to the times and can be used for learning.

Keywords: ethnophysics, learning, NASE

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INTRODUCTION

Astronomy is one of the branches of the National Student Competition, whose interest increases annually. The National Science Competition K (KSN K) 2022 in astronomy with 19,612 participants increased compared to KSN K 2021 with 12,880 participants. However, education in Indonesia still needs to be improved to channel the interests and talents of Indonesian students in astronomy. This is seen when we look at the astronomy content in the school curriculum. In this school curriculum, there are no special lessons in astronomy (Julianti et al., 2022). Astronomy material is discussed only to a limited extent within physics lessons. The material taught includes optical instruments, Newton's Law of Gravity, and electromagnetic radiation. Meanwhile, the material needed for the Astronomy Olympiad Competition is much broader and more in-depth, covering celestial mechanics, electromagnetic radiation, the celestial sphere, concepts of time and calendars, the solar system, astronomical phenomena, stellar photometry, and cosmology. In addition, limited astronomical facilities and mentors

hinder the equitable distribution of astronomical knowledge and *skills* (Elzulfiah et al., 2015). This resulted in the need for special attention related to astronomy material in schools.

Astronomy has a pending role in education to increase understanding of the universe and encourage interest in science and technology. Knowing and studying astronomy can make people qualified both in the fields of technological development and education (Azizi et al., 2024). The presence of astronomy, which has a vital role in natural knowledge, cannot be separated from the living part of a culture. Indonesia consists of several ethnic tribes familiar with natural science, the sky, and stars. Some of the things discussed in ethnophysics related to astronomical material include cosmology, the concept of time and calendar, the movement of the moon, the movement of the sun, and the movement of stars (Pebrian, 2017). However, along with the times, ethnophysics is less widely known by modern society, especially students. Previous research by Pebrian (2017) reveals that of 72 respondents in the West Bandung area, only 13.9% know Sundanese ethnophysics, while the rest 86.1% do not know it.

Local wisdom and wealth are unique potentials the Indonesian nation possesses. This potential is an opportunity to popularize astronomy. However, knowledge about astronomy in the archipelago's culture has yet to be studied much and more deeply (Webmaster, 2015). A program based on International Astronomical Union-Network for Astronomy School Education (NASE) guidelines has been developed, including workshops, classroom learning, and astronomy-related excursions (Permana, 2021).

In Indonesia, the Network for Astronomy School Education (NASE) program is not widely known among teachers and students in schools and universities. This indicates that the program has not received broad exposure or acceptance among teachers and students. NASE aims to enhance the quality of astronomy education by providing relevant training and resources. The lack of recognition and implementation of this program may be due to several factors, such as limited information, insufficient support from educational institutions, or differing priorities within the education curriculum. For example, only a few universities, such as the Bandung Institute of Technology (ITB) and Ahmad Dahlan University, have conducted basic NASE training virtually, demonstrating that efforts to introduce the program remain limited (Pratiwi et al., 2021). Based on previous problems and research, this article aims to review the available literature related to the effect of integrating ethnophysics-based NASE on the understanding and trust of teachers, students, and the community by answering the following research questions:

1) What challenges are faced in astronomy learning?
2) Does NASE affect astronomy learning?
3) Is local wisdom related to astronomical learning?
4) How are the community's understanding and beliefs related to ethnophysics?

METHOD

The research questions were addressed by searching for relevant literature in the following databases: Mendeley and Google Scholar. The search was concentrated on journal articles published between 2010 and October 2022. The keywords used in the search included "astronomy learning difficulties, NASE, Network Astronomy School Education, and ethnophysics". The literature included in this review was selected from journals with international reputations to ensure high-quality and widely recognized sources. The selection process involved analyzing the research based on several criteria, including the publication year, the context of the study, the research objectives, the methods used, and the results obtained. This approach ensures that the themes discussed are covered by reputable sources and that the findings are relevant and credible.

The ability of researchers to limit boundaries and identify or create strategies or work criteria is one of the essential skills in having a comprehensive review of the literature. The sought literature is entered or excluded for analysis based on criteria. Studies were selected following inclusion criteria, as shown in Table 1.

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Table 1. Inclusion Criteria

Criterion	Meaning
Time interval	Studies conducted between 2010 and October 2022
Types of interventions used to explain astronomy	This study rigorously discusses the challenges of learning astronomy and astronomy in local wisdom.
Study design	Astronomical studies on NASE and local wisdom
Research results	A study that produced its effect on the learning of astronomy

Studies outside the scope of this research discuss astronomy without having anything to do with the challenges of learning astronomy, discuss astronomy learning but are not associated with *Network Astronomy Student Education*, and discuss astronomy without relating it to local wisdom. Literature that does not conform to the criteria is abolished. Subsequently, some of the same literature published on different sites was written off due to duplication of literature.

The total number of journal literature that makes up the entire dataset is 11,220 pieces of literature. A search for "astronomical learning difficulties" yielded 5,170 pieces of literature. The keyword "*Network Astronomy for Student Education*" resulted in 3,760 pieces of literature. The keyword "*ethnophysics*" yielded 2,290 pieces of literature. Some of the same literature was published on different sites, so 3,324 pieces of literature were obtained. This literature was sorted based on the level of relevance of literature, so 1,548 pieces of literature were obtained. In the next stage, based on the specific reasons of the researcher, from the 1,548 pieces of literature were sorted 259 pieces of literature. Thus, at the last stage of the elimination process, the rest of the existing literature was read one by one by researchers to reveal the years of research, research context, research objectives, research methods, and research results and the final result was that the literature to be studied in this study consisted of 25 pieces of literature

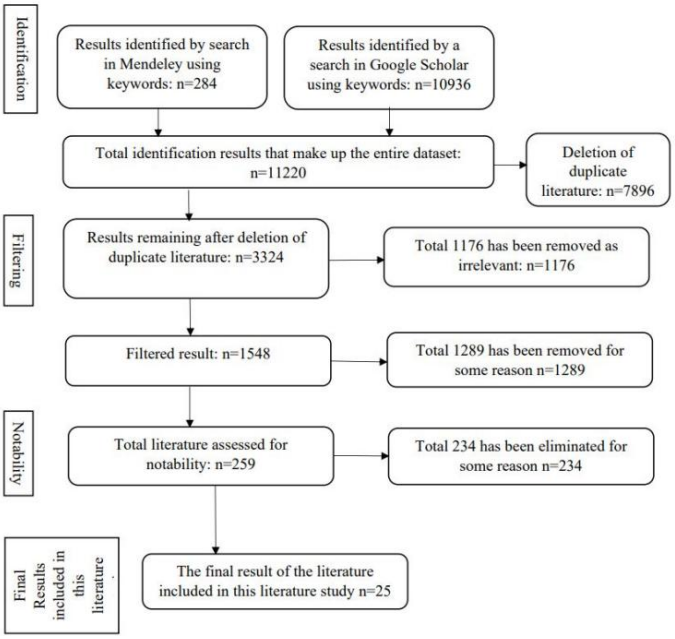

Figure 1. Preferred Reporting Items for Systematic Review and Meta-Analysis

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RESULTS AND DISCUSSION

The total journal literature that makes up the entire dataset on Mendeley and Google Scholar amounts to 11,220 pieces of literature. They were sorted out and it resulted in 25 pieces of literature studied in this research. The results will be discussed one by one, divided into two topics as follows.

What challenges are faced in astronomy learning and does NASE affect astronomy learning?

In this section, 11 pieces of literature discuss the challenges faced in astronomy learning and whether NASE affects astronomy learning. Each piece of literature will be discussed one by one as follows.

Astronomy education is an effort to realize the desire to pass on astronomical knowledge and traditions to the next generation. Each country has different policies in addressing astronomy education. In Indonesia, astronomy education is specifically not taught to students. However, students acquire basic knowledge of astronomy from natural sciences subjects at the elementary level and physics subjects at the intermediate level. In Spain, astronomy education is taught in primary education on knowledge subjects about the natural, social, and cultural environment, then it is also taught in secondary education on natural sciences subjects by following three cycles based on the age of learners (Solbes & Palomar, 2013). Astronomy education in each country also has its challenges and this can be seen from some literature that reveals challenges in learning astronomy. The following paragraphs discuss what kind of challenges are faced in learning astronomy.

A study conducted on the development of astronomy education for high schools in Indonesia shows that interest in astronomy in Indonesia is increasing from year to year (Elzulfiah et al., 2015). It can be seen from the increasing number of Bandung Institute of Technology (ITB) astronomy students and the achievements of Indonesian students at the international level in astronomy. However, the content of the material in the curriculum is not supportive. Coupled with the challenge of the National Science Olympiad (OSN) Astronomy as a prestigious event that should provide equal opportunities for all students in Indonesia, limited facilities, and coaches are obstacles to the equitable distribution of astronomical knowledge and skills. This situation can be improved with support and cooperation from various parties, such as school officials, universities, communities, and institutions engaged in astronomy.

Solbes & Palomar (2013) conducted a study to determine the difficulty of learning astronomy by high school students and the teaching of astronomy. The results showed that some students did not understand or did not know the basic aspects of astronomy even though the teaching was repeated. They conclude that verbal and theoretical teaching of astronomy does not contribute to learning improvement because it does not consider the difficulties of its students, and the teaching of astronomy is not carried out by direct observation. Another study conducted by Eriksson (2019) aims to introduce and discuss a new learning framework related to astronomy: Sky reading, when viewed through the lens of academic disciplines, necessitates both confirming disciplinary principles and applying them to interpret observations. This involves connecting observation, experience, and specialized knowledge to decipher visual information through disciplinary representations.

Lelliott & Rollnick's (2010) study reviewing astronomical education research conducted among school students, teachers, and museum visitors over a 35-years yielded implications for future teaching and research in the discipline. The research finding shows that the concepts of the earth and the day-night cycle are relatively well understood, especially by older learners, while the moon phase, seasons, and gravity are concepts that are difficult for most people to understand and explain. Research conducted by Cole et al., (2018) reports that spatial thinking is important in astronomy learning. For intermediate students, it is difficult to visualize the earth-moon-sun system in explaining astronomical phenomena. Teachers are expected to be aware of students who may lack spatial skills to learn astronomy well.

The study conducted by Bretones & Neto (2011), which aimed to reveal the characteristics and tendencies of published research to determine whether researchers should consider and take new directions, reports that the teaching and learning process appropriate for the field of astronomy at various levels of school grades and theoretical frameworks is indispensable. The study suggests continuing the International Astronomical Union (IAU)'s support for presenting hands-on work related to astronomy education to the public and encouraging research participation in the education field.

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Research indicates that teaching astronomy presents difficulties. To overcome these, experts recommend building strong connections with the Network for Astronomy School Education (NASE) to improve learning effectiveness. NASE was developed in response to the International Astronomical Union's 10-Year Strategic Plan to enhance school IAU efforts. The aim is to educate teachers and help them develop astronomy education in their countries (Ros, 2012). NASE provides teachers with facilities to create instruments to understand astronomical concepts. In addition, NASE also promotes an active learning process by practicing using homemade instruments (Ros & Garc, 2015). The following paragraphs discuss the effect of NASE on astronomy learning in schools.

A study discussing the empowerment of science teachers in Indonesia through NASE workshops held by IAU (Malasan et al., 2019) states that NASE positively impacts teachers' and instructors' attitudes toward teaching astronomy at the secondary level. Then at the space panorama seminar on NASE for Indonesia Teachers, Pratiwi et al., (2021) state that NASE can improve teachers' understanding of concepts and practices in astronomy, NASE makes progress in teaching skills so that teachers can increase students' interest in learning astronomy, NASE provides teachers with facilities to make instruments to understand astronomical concepts, and NASE promotes an active learning process by practicing using self-made instruments for teachers and students.

A study conducted by Garcıa (2017) on the presentation of the development of IAU Astronomy and the role of professional astronomers, including educators in achieving the proposed goals for the future, reports that with education about astronomy, NASE can help maintain knowledge about astronomy for the future and has been able to publish astronomy books, and NASE can create tools that can explain how the universe works and can establish local NASE groups in different countries. Then, a study discussing the organization of NASE courses for middle school and elementary school teachers (Ros & Garc, 2015) shows that after NASE astronomy working groups and visits, teachers understood that astronomy was part of everyday life and thought that they might discover some aspects of astronomy in their cities with their learners and teachers were interested in offering new approaches to astronomy through the heritage of ancient cultures, buildings, or monuments that have an orientation towards astronomy.

Ros (2012), who reviewed the NASE training course in astronomy for teachers around the world, states that NASE created a group of teachers in each country, who repeated the educational course every year. Indonesia's Ministry of Education recognizes the NASE course as an official course to train teachers in astronomy. In this course, astronomical material is integrated into mathematics and physics, and teachers are allowed to improve their knowledge of two other branches of science. The list of the literature under study is presented in Table 2.

Table 2. Top 11 in the challenges faced in astronomy learning and the effect of NASE on astronomy learning topics

Writer	Educational Context	Year	Purpose	Method	Result
(Elzulfiah et al., 2015)	Indonesia	2015	Studying the development of astronomical education in upper secondary school	Literature review	Interest in astronomy in Indonesia continues to increase, but the content material in the curriculum is not supportive, and the limited facilities and guidance are obstacles to the equitable distribution of astronomical knowledge and skills.
(Solbes & Palomar, 2013)	Spanyol	2013	Revealing the difficulties of learning astronomy for high school	Questionnaire questionnaire with a sample of 113 students	Most students do not understand and know the basic aspects of

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Writer	Educational Context	Year	Purpose	Method	Result
			students and their teaching		astronomy, despite the repeated teaching.
(Eriksson, 2019)	Sweden	2019	Introducing and discussing a new learning framework related to astronomy: reading the sky	Empirical data analyzed through qualitative research methodology	Astronomy-related sky reading requires two competencies, namely discipline affirmation and extrapolating three-dimensionally, to be associated with observation, experience, and knowledge of the discipline.
(Lelliott & Rollnick, 2009)		2009	Reviewing astronomical education research conducted among school students, teachers, and museum visitors over 35 years.	Literature review	The concept of Earth and the day-night cycle is relatively well understood, especially by older students, while the phases of the moon, seasons, and gravity are concepts that are difficult for most people to understand and explain.
(Cole et al., 2018)	Nevada	2018	Describing traditional and contemporary approaches to characterizing and measuring spatial thinking skills in astronomy education	Literature review	In intermediate students, it is difficult to visualize the Earth-Moon-Sun system in explaining astronomical phenomena. Teachers are expected to be aware of students who may have less spatial abilities to learn astronomy well.
(Sergio Bretones & Megid Neto, 2011)	Brazil	2011	Determining whether the researcher should consider and take a new direction.	Literature review	The study suggests continuing IAU's support for the presentation of hands-on work related to astronomy education to the public and encouraging the participation of researchers in the field of education.
(Malasan et al., 2019)		2019	Empowering science teachers in Indonesia through NASE workshops	Lectures dan Workshops	The existence of NASE for four years in Indonesia has had a positive impact on the attitude of teachers and instructors to the

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Writer	Educational Context	Year	Purpose	Method	Result
					teaching of astronomy at the secondary education level.
(Pratiwi et al., 2022)	Indonesia	2022	Providing teachers and students with basic training related to astronomical material.	Basic astronomy-related training	1. NASE can improve understanding of concepts and practices in astronomy for teachers 2. NASE is making progress in teaching skills so that teachers can increase students' interest in learning astronomy.
Garcıa (2017)	Mexico	2017	Presentation of the development of IAU astronomy and the role of professional astronomers, including educators to achieve the proposed goals for the coming years.	Presenting the purpose of NASE	Education on astronomy through NASE can help maintain knowledge about astronomy for the future, and has published astronomy books.
(Ros & Garc, 2015)	Argentina	2015	NASE organizes courses for secondary and primary school teachers and creates a team of teachers—a Local Work Group	Form a working group, visit several places, and find some ways to teach "Astronomy in the City"	1. After working groups and astronomy visits, teachers understand that astronomy is part of their daily lives and think that it is possible to find some astronomical aspects in the city with their students. 2. Interested in offering new approaches to astronomy through cultural heritage—ancient cultures or oriented buildings or monuments.
(Ros, 2012)		2012	NASE aims to develop and improve astronomy education at all levels around the world	Courses and workshops	Indonesia's Ministry of Education recognizes NASE as an official course for training teachers in astronomy.

Based on several related to the challenges faced when learning astronomy along with advice provided by researchers, astronomy learning has a connection with the Network Astronomy for School Education (NASE). Therefore, NASE has a positive effect on astronomy learning in facing astronomy learning challenges, so there is a need for equitable expansion related to NASE in various countries, especially in Indonesia.

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Does local wisdom have a connection with astronomy learning and how is people's understanding and belief related to ethnophysics?

In this section, 14 pieces of literature discuss the connection between local wisdom and astronomy learning, as well as people's understanding and beliefs related to ethnophysics. Each piece of literature will be discussed one by one as follows. The study that discussed the organization of NASE courses for middle school and elementary school teachers (Ros & Garc, 2015) shows that after working groups and visits to NASE astronomy, teachers understood that astronomy was part of everyday life and thought that it was possible to discover some aspects of astronomy in their cities with their learners and they were interested in offering new approaches to astronomy through the heritage of ancient cultures, buildings, or monuments that have an orientation towards astronomy. The study shows that there is a link between ancient cultural heritage and the study of astronomy. This is in line with a study conducted by Cotte (2015), which presents the situation on astronomical and *archaeoastronomical* heritage related to world heritage conventions over the past few years, which states that astronomy represents a rich and significant cultural and natural aspect of the world heritage. The following paragraph discusses the relationship between local wisdom and astronomy learning.

A study conducted by Zainuddin et al., (2021) discusses astrophysics, religion, and local wisdom education and reports that astrophysics education is very worthy to be studied with religious content based on the Qur'an and local wisdom, not only among national institutions but also international institutions. Then, the study of Wiyanarti & Holilah (2017), which utilizes nautical traditional values of Indonesian coastal communities in social science learning focusing on the richness of nautical traditions through ethnophysics, reports that social sciences can utilize the values of nautical traditions through learning implementation plans among achievement indicators, materials, methods, sources, media, and learning evaluation. The ethno-physics approach allows the content of daily life to become an important study in social science culture-based learning that can equip students with knowledge, attitudes, and skills in solving problems in society.

Based on some of the research that discusses the relationship between astronomy and local wisdom, the people of Indonesia as *one* of the countries that have many cultures certainly have attitudes and beliefs towards astronomy from the perspective of each culture which can be used as culture-based astronomy learning. The following paragraphs discuss the Indonesian people's attitudes and beliefs regarding astronomy from each culture's perspective.

A study by Putri & Qodir (2022), which aims to see how Sheikh Abbas Kutakarang formed local wisdom in the method of determining the classical Hijri calendar in Aceh, reports that there are characteristics of local wisdom in determining the classical Hijri calendar in Aceh with methods and algorithms that are different from the classical Javanese *hisab*. These differences have an impact on differences in determining the beginning of the Hijri year. Then, a study conducted by Putri (2020) traced how Sheikh Abbas Kutakarang's contribution to the *hisab* in determining the beginning of the Hijri month resulted in Hisab Urfi Sheikh Abbas Kutakarang unique and some with the above *hisab* in determining the Hijri month. He used the rules of science not only for worship purposes but also for counting good and bad days, for agriculture, and for counting seasons. Hisab urfi Shaykh Abbas Kutakarang in the study of science belongs to the study of ethno-physics, which is a study that connects astronomy in the use of the rules of *falak*.

Research conducted by Prabowo et al., (2019) aims to trace the course of the use of this time dimension and complete it with samples of statues in several inscriptions from the Majapahit or previous era and propose it as the ethnophysics of the archipelago resulting in archipelago inscriptions use the Saka calendar and Javanese calendar in recording the passage of time. Previously, in the Majapahit era, the dating elements used included the year in the Saka calendar, *tithi in suklapaksa* and *kresnapaksa* format, the name of the month, *saptawara, sdwara* and *pancawara*, and tribe. In the Majapahit era, dating elements were added, including *naksatra, yoga,* and *karana*. Arisafitri & Izzuddin (2021) conducted a study to determine the Nias dating system in terms of science and astronomy in the perspective of science and astronomy showing that this traditional Nias calendar refers to the lunar cycle which consists of the first 15 days called the bright moon and the last 15 called the dead moon. In addition, it is also affected by the sun's location concerning the Star of Orion. From an astronomical perspective, this dating system is classified as the Luni-Solar calendar with astronomical calculations.

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Research by Madjowa et al., (2020), which discusses the inventory of Gorontalo local wisdom related to astronomy and the movement of pelagic fish in Tomin Bay, shows that there is local wisdom that is still maintained and trusted by Gorontalo offshore fishermen Tominis in determining seasons and currents using astrology. Another study conducted by Venia (2020) discusses how fishing communities in Bonang Village, Lasem District, Rembang Regency use natural phenomena to facilitate their work associated with astronomical analysis, resulting in compatibility and disagreement related to constellations between the beliefs of fishing communities and astronomical concepts, in terms of the time of appearance, direction, and formation of constellations. This belief is a belief passed down from their ancestors.

Jesajas & Tumiwa (2013) conducted a study on local wisdom and practices of smallholders on Kisar Island related to rain forecasting through observations of the Pleides star or Seven Brothers stars resulting in farmers forecasting rainfall by observing the onset and appearance of the Pleides star or seven brothers and measuring size and brightness to determine the characteristics of rainfall. A brighter luster and better appearance means more rain to come while a dim and small appearance means less. Another study by Iskandar & Iskandar (2016) discusses how the cultural practices of Baduy farming are based on the traditional calendar and report that the agricultural cycle in the Baduy community is fixed every year by referring to the agricultural calendar. The Baduy community has developed several strategies, such as organizing a traditional calendar and implementing traditional agroforestry whose production can be used for subsistence and commercial purposes.

An education conducted by Khusnani et al., (2022) regarding astronomy learning with a cultural approach in the Waipare community resulted in the Waipare community being enthusiastic about ethnophysics-based NASE workshops related to the understanding of astronomy related to cultural beliefs that have existed for generations there. Another study conducted by Jufriansah et al., (2022) aims to introduce astronomy and provide astronomical training through NASE constellation props related to the local culture of the Bajowuring Tribe resulting in an understanding of constellations and the relationship between the cultural beliefs of the Bajowuring Tribe with astronomy related to navigation, and skills in the form of making NASE constellation props and being able to use the Stellarium and SkySafari applications. Based on several studies that have been conducted by researchers, there is a relationship between local wisdom and astronomy through NASE learning, which can be used for astronomy learning by teachers, students, and the community, and can increase people's understanding and trust in ethnophysics from their culture.

CONCLUSION

This study presents a systematic review of research studies investigating the linkage of local wisdom with astronomy. This article discusses two research questions that resulted in the finding that NASE has a positive effect on astronomy learning challenges for teachers and students. Then, NASE has a relationship with local wisdom that discusses astronomy. Therefore, there is a relationship between NASE based on local wisdom and astronomy which can be used for astronomy learning by teachers, students, and the community. This research also shows that the relationship between NASE based on local wisdom on astronomy can increase people's understanding of and trust in ethnophysics from each culture they have.

This article recommends learning astronomy with the relationship between NASE based on local wisdom to astronomy, which can be applied in various countries, especially astronomy learning in Indonesia so that the culture owned is preserved due to the times and can be used for learning. This study notes the need for research on the effect of the relationship between local wisdom-based NASE to astronomy for learning on other students' cognitive engagements, such as critical thinking.

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