Learning Astronomy through Minecraft

Teacher Manual on Enhancing Astronomy Education in Primary Schools

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1. Acknowledgments

'Learning Astronomy through Minecraft – Astronomine - A Teacher Manual on Enhancing Astronomy Education in Primary Schools', is the transformative product of a journey undertaken via a KA220-SCH - Cooperation partnerships in school education, led by Drumcondra Education Centre (DEC) Dublin, Ireland, in partnership with THEMISTOKLIS, Private School, S.A Greece, NUCLIO - Nucleo Interativo de Astronomia e Inovação em Educação, Portugal, ATERMON B.V. Zuid-Holland Rotterdam, Netherlands, ELHUYAR FUNDAZIOA USURBIL Spain, and HEARTHANDS Solutions Limited, Cyprus.

As a consortium of six European partners, our KA220-SCH - ***Learning Astronomy through Minecraft***, the 24 month project ***Astronomine,*** was sanctioned in 2022 by Ireland's National Agency, Léargas IE01, whose exceptional support, assistance and guidance is gratefully acknowledged. The continuous support of DEC's Director, Ms. Thérèse Gamble, with the backing of the Management Committee and its chairperson Fiona Gallagher, has been invaluable in leading the project. The support of the management authorities and leadership of all the partners has also been an essential element to the success of the project – thank you. Finally, we welcome Dr. Helen Heneghan as the new Director of DEC, who has embraced with enthusiasm our European journey into the Minecraft Worlds of Astronomy – Astronomine!

In summary, the mission and vision of synergising game-based learning with astronomy education was born from a simple idea to transform 21st century Education in K-12 classrooms throughout the European Union, and beyond. ***Astronomine*** became the battle cry for six dedicated and passionate partners who together, dared to ***Boldly Go,*** where very few others had ventured in education. This Teacher Manual is a work designed by students and teachers, for students and teachers, to uncover a most exciting, transformative, and meaningful pathway to explore the Universe. So, look up and outwards into the Universe, and be brave as our exemplar lessons, and Minecraft, Astronomine worlds challenge you to venture into the unknown. Onwards and Upwards.

https://ecdrumcondra.ie/
https://www.themistoklis.gr/
https://nuclio.org/en/
www.atermon.nl
https://www.elhuyar.eus/en
https://hearthands.solutions/

2. Introduction

Welcome to **Astronomine**, the exciting world of astronomy education, where the Universe becomes your classroom, and the stars your guiding lights! In this Teacher's Manual, we embark on a journey that combines the wonders of the cosmos with the power of Inquiry-Based Learning (IBL) to ignite curiosity, inspire critical and creative thinking, and foster a deep love for astronomy and STEAM education among K-12 students. We strive to design and build a bridge between ***Astrono***my education and ***Mine***craft, game-based learning, which we will refer to throughout the manual as **Astronomine**, to creatively and transformatively bring exciting and challenging lesson plans, and exemplars to your classrooms and to whole-school communities.

Astronomy is an essential and captivating branch of science that has a strong connection to our daily lives. It is a subject that is full of excitement, wonder and limitless possibilities. Astronomy education in primary schools provides a unique opportunity for students to learn about the Universe and to develop critical thinking and problem-solving skills.

Astronomy and STEAM (Science, Technology, Engineering, Arts and Mathematics) education in K-12 schools offer even a wide range of benefits to students, educators, and society as a whole. Incorporating astronomy and STEAM education into K-12 schools can help create well-rounded, informed, and prepared citizens who are ready to contribute to the scientific, technological, and cultural advancements of society. It also provides opportunities for students to explore their passions and potential career paths.

1. **Inspires Curiosity and Wonder:** Astronomy, with its exploration of the cosmos, can captivate students' imaginations and inspire a sense of wonder about the Universe. It encourages students to ask questions about the world around them.

2. **Promotes Critical Thinking:** Astronomy and STEAM subjects require students to think critically, analyse data, and solve complex problems. These skills are transferable to other areas of life and future careers.

3. **Encourages Interdisciplinary Learning:** STEAM education integrates various disciplines, helping students see how subjects like math, physics, art, and technology are interconnected. This fosters a holistic understanding of the world.

4. **Enhances Technological Literacy:** Astronomy often involves the use of advanced technologies like telescopes and space probes. Exposure to such technology helps students become technologically literate and prepared for future tech-driven careers.

5. **Develops Math and Analytical Skills:** Astronomy involves extensive mathematical calculations, which can help improve students' math skills and make abstract concepts more tangible.

6. **Cultivates Problem-Solving Skills:** Astronomers and STEM professionals often encounter complex, real-world problems. Engaging in astronomy and STEAM education helps students develop problem-solving skills that can be applied in various contexts.

7. **Encourages Collaboration:** Astronomy projects often require collaboration among students. This teamwork fosters communication skills and teaches students how to work effectively with others.

8. **Promotes Inclusivity and Diversity:** Encouraging interest in astronomy and STEAM from an early age can help break down gender and racial stereotypes. It can also promote diversity in STEM fields, which have historically been underrepresented by certain groups.

9. **Prepares for Future Careers:** As technology continues to advance, STEM-related careers are in high demand. Astronomy and STEAM education can provide a solid foundation for students interested in pursuing careers in these fields.

10. **Addresses Global Challenges:** Many of the global challenges we face, such as climate change and space exploration, require a strong foundation in science and technology. Astronomy and STEAM education can prepare students to contribute to solutions for these challenges.

11. **Fosters Environmental Awareness:** Astronomy education can instil a sense of environmental responsibility, as it often highlights the fragility of Earth in the vastness of the cosmos.

12. **Boosts Scientific Literacy:** A basic understanding of astronomy and STEM topics can help students become scientifically literate citizens who can make informed decisions on issues related to science and technology.

13. **Engages Learning:** The excitement and curiosity generated by astronomy can engage students in learning and make education more enjoyable, leading to higher levels of motivation and retention.

Minecraft: Education Edition is a specially designed version of the popular video game Minecraft that is tailored for educational use in K-12 schools, and which prioritizes student safety. It was developed by Mojang Studios in collaboration with educators to provide a unique and engaging learning experience for students. Overall, Minecraft: Education Edition leverages the popular game's immersive and creative aspects to engage students in learning while aligning with educational goals and standards. It has gained popularity in K-12 schools as a tool for interactive and experiential learning across various subjects.

Incorporating Minecraft and STEM, STEAM and STREAMS[i] education into K-12 schools requires careful planning, teacher training and continuous professional development (CPD), and alignment with curriculum standards. However, the benefits, including increased engagement and improved learning outcomes, make it a compelling approach to education in the 21st century. Minecraft and STEAM (Science, Technology, Engineering, Arts, and Mathematics) education offer several benefits when integrated into K-12 schools.

1. **Engagement and Motivation:** Minecraft is inherently engaging for students. Its open-world sandbox environment encourages creativity and problem-solving, making learning enjoyable. This motivation can extend to STEAM subjects, which can sometimes be seen as challenging or dull.

2. **Hands-On Learning:** Minecraft allows students to apply STEAM concepts in a hands-on manner. They can build structures, experiment with Redstone circuits (which resemble basic logic and engineering), and even simulate ecosystems or historical events, providing practical experiences.

3. **Collaboration and Communication:** Minecraft fosters collaboration among students. They can work together on projects, share ideas, and communicate effectively. These skills are crucial not only in STEAM fields but also in the modern workforce.

4. **Critical Thinking and Problem-Solving:** Minecraft encourages critical thinking and problem-solving. Students must plan, strategize, and adapt to challenges they encounter in the game. This type of thinking aligns with the problem-solving skills needed in STEAM disciplines.

5. **Creativity and Design Thinking:** Minecraft allows students to unleash their creativity by designing and building structures, mechanisms, and even entire worlds. This aligns with design thinking principles, a valuable skill in STEAM and many other fields.

6. **Cross-Curricular Learning:** Minecraft can be used to teach a wide range of subjects, including math, history, geography, and even art. Integrating it into the curriculum promotes interdisciplinary learning, showing students how STEAM subjects are interconnected.

7. **Real-World Application:** STEAM education in Minecraft can be designed to mimic real-world scenarios, making learning more practical and relevant. For example, students can use Minecraft to model urban planning, geological processes, or architectural design.

8. **Inclusivity:** Minecraft is a game that can accommodate different learning styles and abilities. It can be adapted for students with various needs, allowing for a more inclusive educational experience.

9. **21st-Century Skills:** Minecraft and STEAM education help students develop 21st-century skills such as digital literacy, adaptability, and information literacy, which are essential in today's rapidly changing world.

10. **Career Readiness:** Exposure to STEAM concepts through Minecraft can inspire students to pursue careers in STEM fields. It can help them see the practical applications of what they learn in the game to real-world jobs and industries.

11. **Global Collaboration:** Minecraft's multiplayer mode can facilitate global collaboration, allowing students to work on projects with peers from around the world, promoting cultural understanding and global awareness.

12. **Assessment and Data Analysis:** Minecraft can be used for assessment and data analysis, where students can collect and analyze data within the game, reinforcing their analytical and statistical skills.

In this manual, we will provide primary school teachers with innovative teaching strategies, resources and lesson plans based on the Inquiry-Based Learning (IBL) approach to enhance the teaching of Astronomy through Minecraft - Astronomine. We understand that curricula the world over weigh heavily on the daily teaching duties, expectations and tasks undertaken by teachers, and this is why our Astronomine manual attempts to integrate the lessons with your existing curricula and subject areas. This manual is designed and written by teachers for teachers in the knowledge that learning is a meaningful, mindful and soulful, shared journey of discovery. The sky is the limit, or is it? So Onwards and Upwards!

The first documented records of systematic astronomical observations date back to the Assyro-Babylonians around 1000 BCE. From this cradle of civilisation in Mesopotamia – in the southern part of present-day Iraq – astronomers had built up knowledge of the celestial bodies and recorded their periodic motions. But they had no idea how far away the stars and the planets were. It was much later, in the third century BCE, that Greek astronomers first attempted to use astrometry to estimate cosmic scales. Among other sciences, astronomy flourished at Alexandria, a Greek colony off the northern coast of Egypt, with a renowned library and museum. The dominant view of the cosmos among scientists was geocentric, with the Earth being at the centre of the Universe and everything else revolving around it, but there were some who were edging closer to the truth[ii].

Today, according to the literature, educators and citizens globally, seem to perceive astronomy education either as an enabler or as unnecessary, in K-12 schools. We will of course focus on the positive in this manual[iii].

Projects such as **Astronomine** address the teaching of astronomy and physical science by linking professional and amateur astronomers with local educators [iv]& others[v]. The European Association for Astronomy Education (EAAE) provides links and opportunities for educators to again positively engage with astronomy[vi]. Finally, there are readily available, open-source, free Apps to explore astronomy in a safer and secure online environment and again they are worth exploring[vii]. There are so many more areas we could mention here, but enable and empower your classrooms and communities to do the exploring for you! Let them become the astronomers that seek out new horizons.

3. Summary view of the chapters

Our manual is divided in 10 chapters which cover the pedagogical framework of the project and its objectives, astronomy topics present in school curricula and how to approach them in the context of Astronomine and Minecraft Education Edition, and lesson plans that will support the project implementation in the classroom.

Astronomine's pedagogical approach is based on Inquiry-Based Learning (IBL). One may ask: "Why Astronomy and IBL?". The answer is simple: Astronomy, with its captivating celestial phenomena, offers a unique opportunity to engage young minds. Through this manual, we will not only explore the universe but also demonstrate how the IBL approach can be a powerful tool to transform traditional teaching into a dynamic, student-centred experience.

Imagine students stepping into a virtual Minecraft Astronomy world, where they actively participate in constructing knowledge, experimenting, and exploring the mysteries of the cosmos. This immersive approach synergizes with IBL, creating an educational experience that is out of this world! So, let's embark on this celestial adventure and discover how to enhance astronomy education in K-12 by integrating IBL with Minecraft Astronomy.

In this context, the manual aims to introduce Inquiry-Based Learning (IBL) as an effective approach to teaching astronomy in primary schools. It will discuss how the IBL approach can promote critical thinking and creativity among students, while also developing their scientific knowledge and skills. Additionally, the manual will examine the benefits of using IBL in astronomy education and how it aligns with innovative 21st-century teaching and learning skills.

Inquiry-Based Learning (IBL) in Astronomy Education Inquiry-Based Learning is an educational approach that encourages students to actively engage in the learning process by asking questions, investigating phenomena, and making observations. The IBL approach in astronomy education involves presenting students with a problem or question and allowing them to explore it through inquiry and experimentation. This approach promotes critical thinking and creativity by allowing students to make their own discoveries and draw their own conclusions.

Examples of how IBL can promote critical thinking and creativity IBL in astronomy education can promote critical thinking and creativity in several ways.

For example:

1. **Asking questions:** Students are encouraged to ask questions about astronomical phenomena, such as "Why does the Moon change shape?" or "What causes eclipses?" This encourages students to think critically about the natural world around them and develop their scientific curiosity.

2. **Investigating phenomena:** Students can engage in hands-on activities such as observing the phases of the Moon or constructing a model of the Solar System. This allows students to explore astronomical phenomena and develop their scientific understanding of the world.

3. **Drawing conclusions:** Students can analyse their observations and data to draw conclusions about astronomical phenomena. This promotes critical thinking and helps students develop their scientific reasoning skills.

The benefits of using IBL in astronomy education are numerous.

Some of the benefits include:

1. **Developing scientific skills:** IBL encourages students to engage in hands-on activities, make observations, and draw conclusions. These activities help students develop scientific skills such as problem-solving, data analysis, and critical thinking.

2. **Encouraging creativity:** IBL allows students to explore astronomical phenomena in a creative and imaginative way. This encourages students to think outside the box and develop their creative problem-solving skills.

3. **Fostering curiosity:** IBL encourages students to ask questions and explore the natural world around them. This fosters a sense of curiosity and wonder in students, which can lead to a lifelong love of learning.

Alignment with innovative 21st-century teaching and learning skills IBL in astronomy education aligns with innovative 21st-century teaching and learning skills in several ways. For example:

1. **Collaboration:** IBL encourages students to work together in groups to explore astronomical phenomena. This promotes collaboration and teamwork skills, which are essential in the 21st century workplace.

2. **Technology:** IBL in astronomy education can incorporate technology such as computer simulations, telescopes, and virtual reality tools. This allows students to engage with technology in a meaningful way and develop their digital literacy skills.

3. **Self-directed learning:** IBL encourages students to take ownership of their learning and become self-directed learners. This aligns with 21st-century teaching and learning skills, which prioritize student-centred learning and personalized instruction.

In conclusion, Inquiry-Based Learning is an effective approach to teaching astronomy in primary schools. It promotes critical thinking, creativity, and scientific skills development while fostering curiosity and a love of learning. Additionally, IBL aligns with innovative 21st-century teaching and learning skills, making it a valuable addition to any astronomy education curriculum.

Now, moving to the astronomical content: Astronomy is a fascinating field that can captivate students' imaginations and provide them with a deeper understanding of the universe. When teaching astronomy in K-12 schools, it's important to start with fundamental concepts that lay the foundation for more advanced topics. The manual will cover the fundamental concepts of astronomy that primary school, or K-12 teachers need to know to effectively teach the subject.

In this manual, we will discuss the Solar System, the planets, the Moon, stars and galaxies. We will also provide links to authentic resources that teachers can use to enhance their knowledge of astronomy. Here are some key fundamental concepts of astronomy suitable for K-12 students:

1. **Celestial Objects:**
    - Stars: Exploring the characteristics of stars, including their size, temperature, colour, and life cycle.
    - Planets: Learning about the planets in our Solar System, their orbits, and basic characteristics.
    - Moons: Understanding the natural satellites of planets and their roles.

2. **Solar System:**
    - The Sun: Discussing the Sun's role as the central star of our solar system and its importance for life on Earth.
    - Planetary Orbits: Introducing the concept of orbits and how planets move around the Sun.
    - Asteroids and Comets: Exploring the characteristics of these celestial bodies and their orbits.

3. **The Moon:**
    - Phases of the Moon: Understanding the lunar phases and how they relate to the Moon's position relative to the Earth, the Sun and the tides.
    - Lunar Surface: Learning about the Moon's geology and the impact of space exploration on our understanding of it.

4. **Cosmic Phenomena:**
    - Eclipses: Understanding solar and lunar eclipses and their causes.
    - Meteor Showers: Learning about meteor showers and their connection to comets.

5. **Earth's Rotation and Orbit:**
    - Day and Night: Explaining how the rotation of the Earth causes day and night.
    - Seasons: Understanding how the tilt of the Earth's axis leads to the changing seasons.

6. **Constellations and Stars:**
    - Constellations: Identifying some of the major constellations and their cultural significance.
    - Stellar Brightness: Exploring how stars vary in brightness and what factors influence their visibility.

7. **Telescopes and Observations:**
    - Telescopes: Learning about the history and importance of telescopes in astronomy.
    - Observing the Night Sky: Encouraging students to engage in stargazing and basic sky watching activities.

8. **The Milky Way Galaxy:**
    - Galaxy Basics: Introducing the concept of galaxies and explaining that the Milky Way is our home galaxy.
    - Galaxies and Stars: Discussing the billions of stars in the Milky Way and their distribution.

9. **Space Exploration:**
    - Human and Robotic Missions: Exploring key missions to study the planets, Moon, and beyond.
    - Space Technology: Discussing the technology used in space exploration and its impact on our daily lives.

10. **The Expanding Universe:**
    - Big Bang Theory: Introducing the concept of the Big Bang and the origin of the Universe.
    - Cosmic Expansion: Discussing the idea that the universe is expanding and its implications.

These fundamental concepts provide a solid starting point for K-12 students to explore the wonders of astronomy. As students progress, they can delve deeper into more complex topics such as astrophysics and cosmology, as well as the search for extra-terrestrial life.

Pedagogical Practices in Astronomy Education

In addition to the pedagogical framework and astronomical content, the manual presents pedagogical practices that teachers can use to engage their students in astronomy. We will provide examples of how to use inquiry-based approaches, project-based learning, simulations and Minecraft games, to make astronomy education more exciting and interactive. We will also discuss how teachers can use real-world examples and practical activities to teach astronomy effectively.

Among the pedagogical practices are:

1. **Hands-on Activities:** Engage your students in hands-on activities that allow them to explore astronomy concepts. Activities could include creating a model of the Solar System, building a telescope, or conducting experiments to understand the properties of stars.
2. **Technology Integration:** Incorporate technology into your lessons to provide interactive and engaging learning experiences. Technology resources could include digital simulations, videos, and online games.
3. **Cross-curricular Connections:** Astronomy can be integrated into other subject areas, such as math, literacy, and art. For example, students could write a story about a journey to space, create a math project that involves calculating the distance between planets, or create an art project based on a particular astronomical phenomenon.

The manual will also discuss the importance of continuous professional development (CPD) for teachers in astronomy education cannot be over emphasised. We will provide links to online courses, webinars, and workshops that teachers can attend to enhance their knowledge and skills in astronomy. We will also provide examples of how teachers can collaborate with other educators to share resources, ideas and best practices in teaching astronomy. As CPD Training examples we highlight:

1. NASA Education: NASA provides free online professional development resources for teachers, including webinars, workshops, and classroom activities. These resources cover a range of topics related to astronomy and space science. (https://www.nasa.gov/education/for-educators)
2. National Science Teachers Association (NSTA): NSTA offers a variety of professional development resources for science teachers, including online courses, webinars, and conferences. Their website also provides a wealth of resources and lesson plans for teaching astronomy. (https://www.nsta.org/)
3. European Space Agency (ESA) Education: ESA provides a range of teacher training opportunities and resources, including workshops, online courses, and classroom activities. Their website also provides a library of resources for teaching astronomy. (https://www.esa.int/Education)

Finally, this manual provides links to authentic resources and lesson plans, designed and written by our Astronomine schools, which teachers can use to teach astronomy in their classrooms. We will include links to websites, videos, simulations, games and other resources that teachers can use to engage their students in astronomy. We will also provide sample lesson plans, which teachers can modify to suit their teaching styles and the needs of their students.

Lesson 1: Astronomy in Ancient Civilisations.

Lesson 2: Solar System

Lesson 3: Exploring the Seasons

Lesson 4: Moon Phases and Tides

Lesson 5: Lunar and Solar Eclipses

Lesson 6: Exploring the Marvels of Tides

Lesson 7: Exploring Aurorae, A Celestial Light Show

Lesson 8: Tools of the trade

Lesson 9: Stars and Nebulae

Lesson 10: Galaxies and the Universe

Lesson 11: Are we alone?

Resources:

1. Stellarium: A free open-source planetarium software that can be used to simulate the night sky and explore astronomy concepts. (https://stellarium.org/)
2. NASA Kids Club: An interactive website for students to explore space and learn about astronomy. (https://www.nasa.gov/kidsclub/index.html)
3. Astronomy Picture of the Day: A daily updated website featuring stunning astronomical images and explanations. (https://apod.nasa.gov/apod/)

4. Theoretical approach

4.1 Inquiry-based learning

Inquiry-based learning is a pedagogical approach that places students' questions, ideas, and observations at the centre of the learning experience. Educators play an active role in guiding and facilitating this process, which encourages students to engage in the scientific process, develop critical thinking skills and understand concepts deeply. In the context of the Astronomine project, inquiry-based learning allows students to explore the wonders of astronomy, ask their own questions about the Universe and seek answers through observation, research and discussion.

Game-based learning is an additional pedagogical principle that complement inquiry-based learning. It uses games to support learning and engagement. In the Astronomine project, Minecraft serves as the game-based learning platform, providing a fun, interactive and immersive environment, where students can explore astronomical concepts and phenomena. Combining these three pedagogical principles, the Astronomine project aims to create an inclusive, engaging and effective learning experience for all students.

Building on these pedagogical principles, the subsequent module will delve deeper into the practical application of game-based learning using Minecraft Education Edition. Minecraft provides a dynamic and interactive platform that can bring the wonders of astronomy to life for students. In the Astronomine project, Minecraft serves not just as a tool for engagement, but as a virtual laboratory where students can explore, experiment and learn about the Universe. The game-based learning module will equip teachers with the knowledge and skills to effectively use Minecraft in their astronomy lessons, from navigating the game environment to integrating it into their teaching strategies.

The Astronomine project provides a series of structured lesson plans that guide teachers in implementing this innovative approach to astronomy education. Each lesson plan follows a consistent structure: an introduction that sets the stage and objectives for the lesson, a detailed plan for the lesson itself, and a Minecraft game that reinforces and extends the lesson content. These lesson plans are designed to be flexible and adaptable, allowing teachers to tailor them to their students' needs and interests. The module will familiarize teachers with these lesson plans and provide guidance on how to implement them in their classrooms, ensuring a seamless integration of inquiry-based learning and game-based learning in their astronomy teaching.

4.2 Game-based learning (GBL)

This section will introduce tutors to the fundamentals of game-based learning (GBL), its characteristics and provide some examples of its application in the classroom. In an effort to modernize teaching in the EU and bring it to the 21st century previously and also foster the motivation of young learners for school subjects, the concept of game-based learning in education has grown tremendously over the past decade.

The need for alternative and up-to-date teaching methods has grown, as learners' needs are constantly changing in the 21st century. Game-based learning is essentially the incorporation of game-based activities in an educational environment with a view to teaching a specific topic or training learners on specific skills. Through game-based learning, fun and entertaining activities, learners become familiar with difficult subjects, train in 21st century soft skills, and communicate with each other. GBL often involves games inside the classroom environment that encourage students to cooperate with each other in order to achieve a specific goal. Through teaching with GBL methods, learners not only effectively reach the predetermined educational objectives, but are also encouraged and guided to develop important and useful 21st century soft skills such as critical thinking, problem solving and team-working towards a specific goal, as well as technology skills and digital literacy. Creativity and collaboration are key factors for teachers to keep in mind when designing a GBL course or just wanting to enrich their curriculum with GBL activities. Also, another main objective of GBL is to encourage students to engage more intensively in the lesson and make learning that much more enjoyable and specifically tailored to the learners' age and needs. “Game” and “play” have a crucial difference, which is the existence of an “objective”. Games have a clear objective and a set of rules, while the essence of just playing does not involve a specific goal. Nevertheless, play-like elements in classroom activities contribute beneficially to the outcome of the learning process. There are five distinct kinds of freedom that enhance learning through play. The child at play is exercising freedom along five distinct axes:

1. freedom to fail.
2. freedom to experiment.
3. freedom to fashion identities.
4. freedom of effort.
5. freedom of interpretation, (Klopfer et al., 2009 p.4)

There is a fine balance between game elements and the educational effectiveness of GBL. This is the challenge for teachers when implementing GBL in the classroom; to strike the right balance between an enjoyable game that learners are interested in but also make sure that the educational objectives are met during this process.
Minecraft provides the opportunity to teachers to create their own game tailored to their learner's needs and to the educational objectives of their lesson. Digital Game-based learning environments, such as Minecraft have been introduced the past decade in education organizations all over the world and they are one of the most popular ways to design a digital GBL activity with a view to teach a specific subject or concept.
Game-based learning can be implemented in the classroom to teach hard-to-understand concepts such as Astronomy, Math, Science, etc., through actively engaging the student in games designed or adapted specifically to achieve the predetermined learning goals.

4.2.1 Game-based learning vs Gamification

At this point, the difference between game-based learning and gamification is essential to be mentioned. These two terms have been very popular in education and sometimes have been used interchangeably, but they are completely different notions in terms of how game elements are incorporated in an educational environment. “Gamification is turning the learning process as a whole into a game, while GBL is using a game as part of the learning process” (Al-Azawi et al. 2016, p.134).

As mentioned in the previous section, Game-based Learning is the act of using an actual game as a teaching tool with very specific learning objectives.

Examples of game-based learning:

- **Card games**
- **Board games**
- **Adaptation of popular games that kids are familiar with**
- **Computer games (Digital Game-based Learning/ DGBL), such as Minecraft: Education Edition, Astronomine World in Minecraft**

Gamification is the addition of game elements in an otherwise non-game activity, and it is also used outside the classroom as a marketing strategy in many companies. *"Gamification is using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning and solve problems"* (Kapp, Karl M. 2012, p.10). *"Gamification is the practice of using game design elements, game mechanics and game thinking in non-game activities to motivate participants. […] There are many examples of how gamification motivates behaviour in loyalty programs, marketing and even recycling programs"* (Al-Azawi et al. 2016, p.133). There are many examples of gamification in marketing strategies, e.g., large supermarkets that use badges or coins to attract more customers and engage them into buying more products and so on. Gamification in education follows the same concept but in an educational carefully planned way and can include much more than coin collection. The following techniques add an element of play in a learning activity, but also help the instructor organize the classroom and encourage learners to engage more actively:

- **Separating Students into groups**, assigning them with specific tasks or assignments, in order to create healthy competition inside the classroom and let them compete and work as a team in order to achieve their goal.
- **Use of learning badges** to reward excellent performance or improvement in skills.
- **Point systems**, through which learners can monitor their improvement and keep record of their progress on a subject or skill.
- **Levels/ check points** as methods of monitoring progression.
- **Use of dice, bingo cards and other game elements**.

4.2.2 Minecraft Education Edition as teaching tool

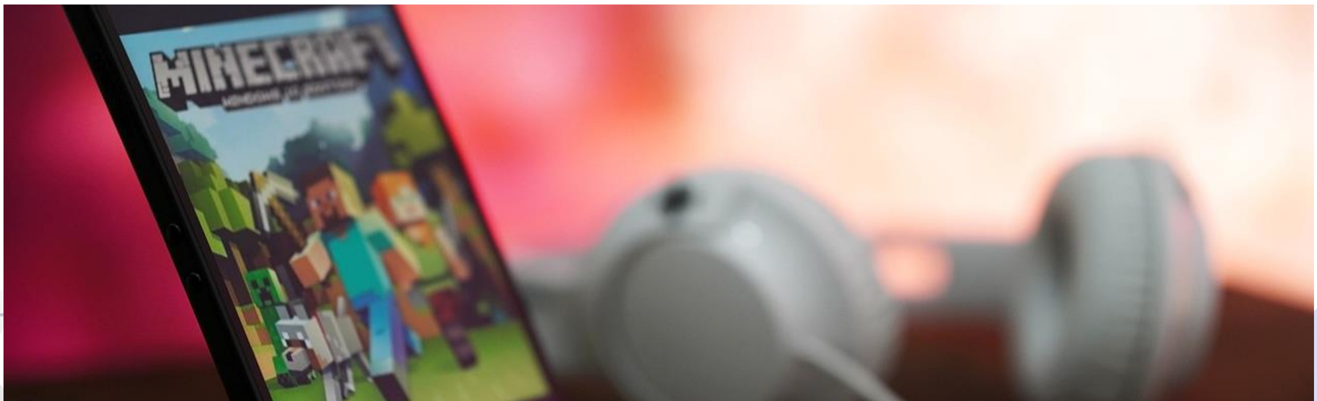


Fig. 1 - source: www.pixabay.com

Minecraft Education Edition is a game-based platform where learners can achieve specific educational objectives through creative, inclusive play. It is an educational edition of Minecraft specifically designed for classroom use. It was created by Mojang Studios and Xbox Game Studios and has features that make Minecraft easy to use in a classroom setting. The full game was released on November 1, 2016. Minecraft is an open-world game, where players can create and build, solve problems together, and explore amazing worlds.

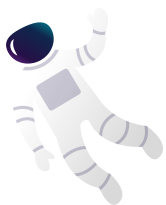
Minecraft Education Edition provides teachers and learners with the possibility to create a whole world custom-made to enhance learning and application of various concepts in science or other fields, through playing games in a digital environment, that students are already familiar with. Teachers can create a unique simulated world placed either on earth or a different planet by using Minecraft interface and all the different features it provides in terms of customization. Minecraft Education Edition can be used in the actual classroom or enhance distance learning, since learners can have access to Minecraft activities from practically anywhere.

Minecraft Education Edition provides students with the opportunity to get ready for the future, by helping them develop future-ready soft skills like creativity, problem solving, and systems thinking, while at the same time nurturing a passion for play. Game-based learning with Minecraft Education Edition encourages meaningful learning. Learners can explore real-world issues by carrying out activities in immersive, imaginative worlds with specific learning objectives. It helps learners develop computational thinking with in-game coding and curriculum and it enhances social-emotional skills, by building empathy and exploring digital citizenship. Learners get ready for a digital future while gaining knowledge and implementing it in simulated tasks.

Minecraft can:

- **Drive meaningful learning** through exploration of real-world issues in immersive, imaginative worlds
- **Prepare for digital future** through computational thinking with in-game coding and curriculum
- **Help learners build social-emotional skills** such as empathy and become familiar with digital citizenship[viii].

Several studies have been conducted on gamification; in the study conducted by Gutierrez & Lopez on *Game-based learning and gamification in initial teacher training in the social sciences*, the study population was formed by university students in the second year of their Master's degree in Primary education and it was published in the *International Journal of Educational Technology in Higher Education* in 2016. The results of the study showed that in the question "What programs or applications offers a game-based learning approach?", Minecraft was ranked first in comparison to other platforms. The results of the study also showed that the use of gamification in the classroom enhanced motivation greatly among students. Other benefits of implementing this game-based learning approach were interest, meaningful learning and participation.



Minecraft provides the user with the opportunity to be the creator of a whole new world. You can customize the game depending on your students' age, the subject, and the teaching objectives and outcomes that the teacher has set. Also, other preferences can be set such as difficulty, script and world types (survival or more creative and adventure world types).

Teachers can create a world from scratch or use one of the available **templates**:

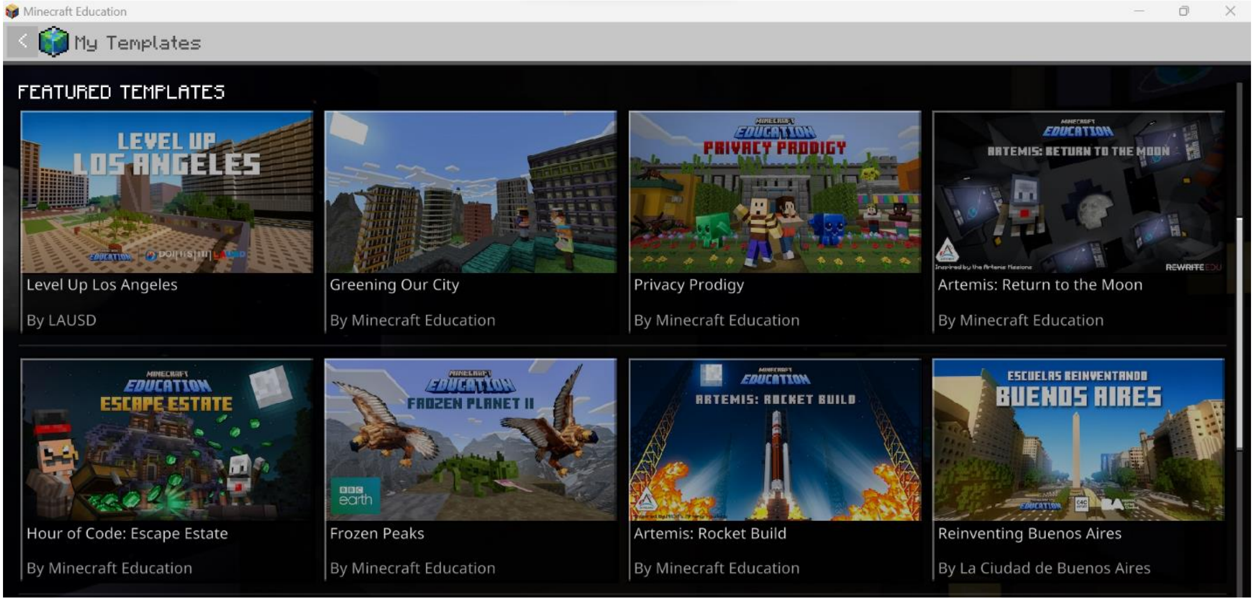


Fig.2 - Templates in Minecraft Education Edition

There are **templates for different genres and teaching subjects**. Below you can see an example of an astronomy-related template:

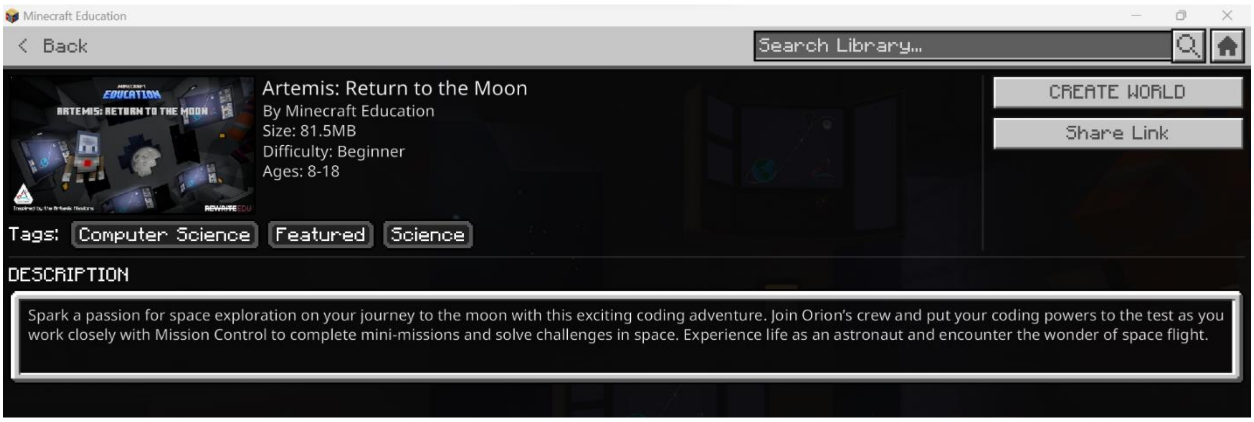


Fig.3 - Astronomy-related template in Minecraft Education Edition

Minecraft's Library includes a great variety of **subject kits** the user can choose from:

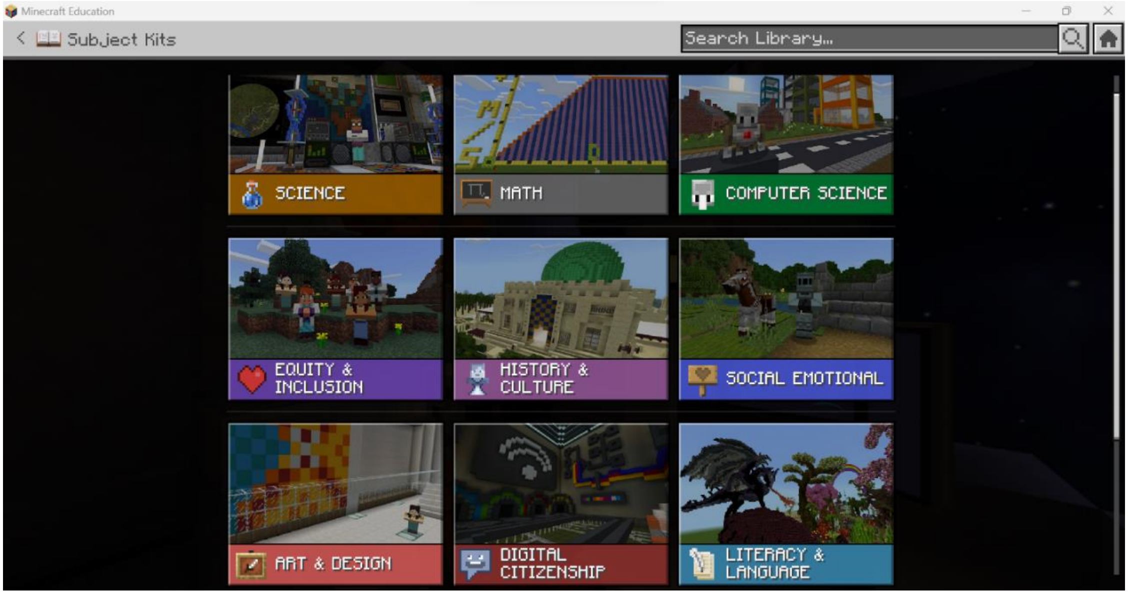


Fig.4 - Subject Kits in Minecraft Education Edition

The user, who chooses to create their own world form a template can use either Blocks or Python to develop the activity in Minecraft:

Fig.5 - Options for coding language

4.3 Astronomy as part of STEM, STEAM and STREAMS Education

Astronomy has influenced humanity and sciences throughout history. It is an integral part of our lives even if we don't realize it on a day-to-day basis, but it has a great impact on our worldview. It has shaped cultures and enhanced the application of science, math, and physics in human civilization from very early on. Therefore, it is an integral part of **STEAM**, which stands for science, technology, engineering, arts, mathematics. Astronomy has proved to have helped humans in agriculture, keeping track of calendars and time, and even today we still measure significant celebrations and religious observances according to the route of celestial objects, like the Moon for instance. Nevertheless, astronomy is part of the compulsory school curriculum in very few countries around the world and the EU.

Teaching astronomy in school can be quite challenging for teachers and it is one of the most hard-to-grasp subjects for young students. The conventional method of using textbooks and exercises is of course necessary, in order to organize the information in the curriculum and also assess what students have actually learned in the classroom. However, there are many more methods to teach this subject that enhance learning, but also make the learning experience for student much more fun, understandable and kinaesthetic, while increasing students' performance and engagement:

Incorporating games in classroom activities

- **Card games** to expand vocabulary related to astronomy such as: star and planet names, identifying constellations, names of astronauts and space expeditions
- **Set the scene** by hanging posters with pictures of the Solar System or bring in magazines with articles relevant to the lesson
- **Audiovisual material** such as YouTube videos and presentations
- **Games in a digital game-based learning environment such as Astronomine World in Minecraft:** where students will perform tasks in a virtual world, while learning about the cosmos at the same time!

Astronomy is a key subject in the development of ***STEM skills*** since it is the "ultimate interdisciplinary subject" as J. Percy very eloquently mentions in his work on Teaching Astronomy. It combines concepts from Physics, such as gravity, relativity, as well as Math, Chemistry, Biology and even some aspects of History. Therefore, science is introduced more wholistically into the classroom through astronomy. It intrigues young students to learn more about the cosmos and put theoretical knowledge into useful practice, reinforcing this way information from other subjects and connecting the dots between different disciplines and their usefulness in everyday life. Teaching astronomy while enhancing and applying knowledge from other fields of science is the ultimate terrain to let students explore elements of the Universe, while enhancing the understanding of the physical world and its principles. "In the classroom, astronomy provides a useful alternative to the experimental mode in the scientific method – namely, the observational mode. It also provides many examples of the use of simulation and modelling in science. These processes are increasingly important as part of the "scientific method" (Percy, 2006, p.249)".

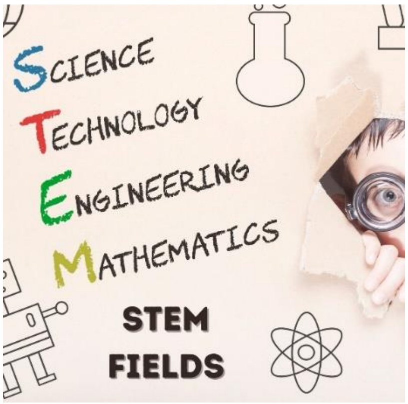


Fig. 6 STEM fields

Furthermore, Astronomy is also a key subject in the study of ***STEAM Skills***. This was very much brought to the fore during the Covid Pandemic when educationalists and scientists alike, looked again to extend the scope of STEM education to embody the creativity of 'Arts' education through STEAM innovation. In *"Reframing Pedagogy: Teaching Astronomy through STEAM Innovation",* (Exodus Chun-Long Sit, 2020), we see how the author explores the framing of promoting Astronomy as popular science to include the 'A' in STEAM Education.

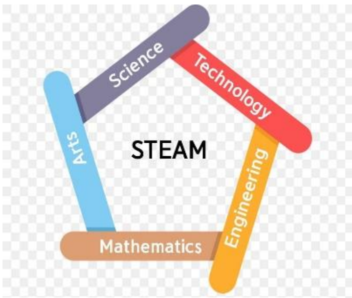


Fig. 7 STEAM fields

Through STEAM Innovation, integrating science and 'Arts', such as Astro-Music and Space Art, is a case in point of 'forced association'. It redefines the 'creative' methodology of Astronomy education and encourages the engagement of teachers from other disciplines beyond STEM. "*Supported with, and through user-centred design thinking, this pedagogy contributes effectively to the interactive teaching for solving real-life problems related to Astronomy" (IBID, 2020, pg. 381)*.

Again, Astronomy is, and will continue to transform, and become a key subject area in the study of ©***STREAMS Education and skills.*** (Ó Murchú, 2019). STREAMS education is an extension of STEAM (Science, Technology, Engineering, Mathematics, and Arts and Social Studies) education that includes two additional components: 21 century Multi-literacies and Sustainability.

Fig. 8 STREAMS fields

When applied to astronomy in K-12 schools, STREAMS education can offer several benefits:

1. **Interdisciplinary Learning:** STREAMS education encourages the integration of various subjects, enabling students to see how astronomy connects with other fields such as literacy, climate and environmental education, art, history and social studies. This holistic approach promotes a deeper understanding of the subject matter.
2. **Engagement:** Incorporating arts and social studies elements into astronomy lessons through the eyes of sustainability and multi-literacies like film literacy, emotional and empathetic literacy, etc., can make the subject more engaging and accessible to a wider range and ability of students. Creative projects, such as, making astronomy-related art, film or studying the cultural and historical significance of celestial objects, to inform climate action/ climate crisis, can spark students' interest.
3. **Real-world Applications:** STREAMS education emphasizes the practical application of meaningful, mindful and 'soulful' knowledge. In astronomy, this can mean engaging students in hands-on and empathetic activities like building models of the Solar System, designing space missions, or studying the societal impact of astronomical discoveries on our Planet.
4. **Critical Thinking:** Astronomy offers opportunities for critical and creative thinking and problem-solving, which are essential skills for students to develop. Analysing data, making predictions and understanding complex celestial phenomena can enhance these skills.
5. **Cultural Awareness:** Incorporating social studies in a diverse and inclusive and equitable manner into astronomy education empowers students to explore the historical, empathetic, cultural and societal aspects of astronomy. They can learn about how different cultures have observed and interpreted the night sky, fostering cultural awareness and empathy.
6. **Creativity:** Arts integration can inspire creativity in students. They can express their understanding of astronomical concepts through artistic projects, such as creating space-themed artwork, writing poetry about the cosmos, or composing music inspired by the stars.

7. **Improved Retention:** The multidisciplinary nature of STREAMS education can enhance memory retention. When students engage with astronomy from different angles—science, technology, art, history, sustainability and more—they are more likely to remember and apply what they've learned.
8. **Career Exploration:** Exposure to various aspects of STREAMS education, including astronomy, can help students discover their interests and potential career paths. It can inspire future scientists, artists, disruptors, creatives, authors, historians, or educators.
9. **Inclusivity:** By incorporating diverse perspectives and approaches, STREAMS education can be more inclusive and reach a broader range of students of all abilities. It acknowledges that not all students learn the same way or have the same interests.
10. **Preparation for the Future:** As our society becomes increasingly reliant on science and technology, students with a well-rounded education that includes STREAMS principles are better prepared for future challenges and opportunities[ix].

To implement STREAMS education in K-12 schools effectively, teachers should collaborate across subject areas, design interdisciplinary lessons, and encourage students to explore and make connections between different fields of study. By doing so, they can help students develop a deeper and more holistic understanding of astronomy and its place in the world.

Finally, 'STEAM and Astronomy Education is further explored through 'Teaching Materials', from Bosscha Observatory (2021, Indonesia). This project developed distance learning infrastructure, human resources, materials and a proposed methodology to assist teachers, particularly in empowering rational capacity through astronomy. The learning material is enriched with other STEAM components, most importantly energy, water, and the need to care for Planet Earth. The facility and human resources built have already reached out to 137,985 school and university students, teachers, and citizens.

5. Learning Objectives

ASTRONOMINE: A JOURNEY THROUGH THE COSMOS

This Astronomine , immersive, game-based Minecraft experience is designed to introduce students and teachers to the wonders of astronomy while honing their creative and computational thinking skills.

Astronomine: A Journey Through the Cosmos is a unique and engaging introduction to astronomy and computer science. This interactive experience will provide students with a basic understanding of key astronomical concepts, while demonstrating how computational thinking can be used to solve problems and understand the Universe.

Through Astronomine: A Journey Through the Cosmos, students will:

- ***Explore fundamental concepts in astronomy:*** Students will delve into topics such as the celestial sphere, the Sun and planets, constellations, and the structure of the Universe. They will learn about the unique characteristics of the inner and outer planets, the role of telescopes and other tools in astronomy, as well as the search for life in the Universe.

- ***Apply computational thinking to solve astronomy-related puzzles:*** Students will use their computational thinking skills to navigate through the Minecraft world, solve puzzles related to astronomical phenomena and complete tasks that reinforce their understanding of the astronomy concepts they've learned.

- ***Create and manipulate virtual models of celestial bodies and astronomical tools:*** Using Minecraft's building blocks, students will create their own models of planets, stars, telescopes and more. This hands-on approach will help students grasp complex astronomical concepts in a more intuitive and memorable way.

- ***Understand the interdisciplinary nature of astronomy:*** Students will see how astronomy intersects with other fields, such as physics, chemistry and biology. They will learn how the skills and knowledge they gain in astronomy can be applied to other areas of study and problem-solving.

This Astronomine experience emphasizes the application of computational and creative thinking in the context of astronomy. Computational thinking is a problem-solving approach that involves using specific skills and practices, and it's a key component of computer science education. Creative thinking is not just about artistic talent or original ideas, but also about problem-solving, collaboration and curiosity. Creative thinking encourages students to use a variety of approaches to solve problems, analyse multiple viewpoints, adapt ideas and arrive at new solutions. Sometimes it is referred to as divergent thinking. Through Astronomine, students will see how computational and creative thinking can be used beyond computer science, and even in the ‘Arts’ and other disciplines.

6. Astronomine world in Minecraft Education

Fig. 9 Astronomine

6.1 Minecraft licenses and installation

The following is a document dedicated to outlining the solutions to the Astronomine DEMO activities and to provide more information for the setup of Minecraft Education Edition. To play the game, you must have Minecraft Education Edition installed on your computer. You can download the demo of Minecraft: Education Edition, using this link: https://education.minecraft.net/en-us/discover/what-is-minecraft.

Minecraft licensing: https://education.minecraft.net/en-us/licensing

After the Minecraft has been installed, you can download and install the Astronomine demo from here: http://Astronomine.erasmusplus.website/

Launching Minecraft

You do not have to first run the Minecraft: Education Edition app in order to open the DEMO, as the DEMO will automatically open the app if you double click on the file. Both Windows and Apple OS support .mcworld files. The only exception to this rule is if the user has an iPad device, when they should convert the ***.mcworld file*** with the instructions indicated here. After double clicking on the COSMIC DEMO.mcworld file, you will have to login using your Microsoft 365 account, or whatever other mean of logging in you have available.

6.2 Getting started with Astronomine

After the game loads, which can take up to a minute on the first try, you will be facing the barn where all the activities will take place. Please note that the scale and appearance of the world can alter to better fit the final scenario.
The basic controls of the game are the following:
W: Move Forward
A: Move Left
S: Move Backward
D: Move Right
[Mouse Move]: Adjust the Camera Angle

[Left Click]: Strike, [Hold] Break
[Right Click]: Interact, Place selected item.
[Wheel]: Shuffle through the hotbar.
E: Open Inventory
Q: Throw item forward.
[1-9]: Move to that position in the hotbar
H: Show Control Hints
C: Open Code Builder
[esc]: Open Menu
You can toggle the option to show the controls on screen on/off in the Settings.

6.3 Overview of Astronomine lesson plans

1. The Sky Above Us
    - **a.** The Celestial Sphere
    - **b.** The Sun, the Planets and the Moon
    - **c.** Constellations
    - **d.** Astronomy in Culture
2. The Sun and the Moon
    - **a.** Seasons
    - **b.** Moon Phases
    - **c.** Lunar and Solar Eclipses
    - **d.** Tides
    - **e.** Aurorae
3. Solar System
    - **a.** Inner Planets
    - **b.** Outer Planets
    - **c.** Minor Bodies
    - **d.** Meteors and Meteorites
4. Tools of the trade
    - **a.** Telescopes, Cameras and Detectors
    - **b.** Observatories and Space Telescopes
    - **c.** Human Exploration of the Solar System
5. Stars and Nebulae
    - **a.** The Sun as a star
    - **b.** Stellar Properties
    - **c.** Stellar Evolution
    - **d.** Exoplanets
    - **e.** Black Holes
6. Galaxies and the Universe
    - **a.** The Milky Way
    - **b.** Other Galaxies
    - **c.** Large Scale Structure of the Universe
    - **d.** Cosmology and the evolution of the Universe
7. Are we alone?
    - **a.** Astrobiology and the search for life in the Universe

6.4 Guidelines for using Astronomine in class

Astronomine is designed to be a comprehensive teaching tool that seamlessly integrates with your existing curriculum and lesson plans. Each session begins with an introduction where teachers present the astronomical concept of the day to the students. This introduction sets the stage for the lesson, providing students with a broad overview of the topic and sparking their curiosity. The introduction is followed by a detailed lesson plan that outlines a series of activities designed to delve deeper into the topic. These activities are carefully crafted to engage students and promote active learning.

The highlight of each session is the Astronomine Minecraft demo. This interactive, game-based learning experience is designed to reinforce the concepts taught in the lesson. The Astronomine Minecraft Demo(s) is/are not designed as lesson(s) to be taught. They are designed for further learning beyond the lesson plans, and as a means of exploring and re-enforcing the astronomical concepts already presented in the various lessons. Students are enabled to explore a virtual Universe, where they can see the astronomical phenomena come to life in a game-based environment. They are empowered and encouraged to build their own models of celestial bodies, solve puzzles related to astronomical phenomena, and even embark on space missions. This hands-on, immersive experience not only makes learning fun but also enables students to better understand and recall the concepts they have learned. Teachers can guide students through the Minecraft demo, facilitating their exploration and learning, and tying it back to the concepts discussed in the lesson.

7. Lesson plans

7.1 Astronomy in Ancient Civilizations

Introduction to the Chapter: Astronomy in Ancient Civilizations

Welcome to a fascinating journey through time, where we explore the captivating realm of astronomy as it was understood and practiced in ancient civilizations. In this chapter, we will delve into the rich history of astronomy, tracing its origins to some of the most influential cultures of the past.

Long before the advent of modern telescopes and advanced scientific instruments, ancient civilizations looked up at the night sky with awe and wonder. They observed the celestial bodies, mapped the movements of the stars and planets, and developed intricate cosmologies that sought to explain the mysteries of the Universe. In this chapter, we will embark on an exploration of three remarkable ancient civilizations: the Egyptians, the Greeks, and the Mayans. Each of these cultures developed unique perspectives on astronomy, leaving behind a rich legacy that continues to inspire and intrigue us today.

We will begin our journey in the ancient land of Egypt, where the pyramids stand as enduring testaments to their deep astronomical knowledge. We will uncover the importance of astronomy in Egyptian religion, their precise calendar systems and their observations of celestial events that influenced their agricultural practices.

Next, we will travel to the land of ancient Greece, where great thinkers like Ptolemy and Hipparchus made ground-breaking discoveries about the motion of celestial bodies. From their geocentric models to their myths and legends associated with the constellations, the Greeks laid the foundation for much of Western astronomy. Indeed, many of the Greco-Roman constellations were inherited from ancient Egypt.

Our final destination will be the Mayan civilization, renowned for their exceptional achievements in mathematics, architecture and astronomy. We will unravel the Mayans' intricate calendar system, their celestial observations and the significance of astronomy in their religious beliefs and cultural practices.

Throughout this chapter, we will examine the remarkable advancements and achievements of these ancient civilizations, appreciating their ingenuity, their spiritual connection to the cosmos, and their enduring impact on the field of astronomy.

So, fasten your seatbelts and prepare to travel back in time as we uncover the mysteries of astronomy in the past. Let us embark on this enlightening journey that will broaden our understanding of the Universe and deepen our appreciation for the wisdom of those who came before us.

Theory to be taught in class

One of the key theories that should be taught when exploring astronomy in past civilizations is the Geocentric Model. This theory, which was widely accepted in ancient times, proposed that Earth was at the centre of the Universe, and all celestial bodies, including the Sun, Moon, planets and stars, revolved around it.

The Geocentric Model was developed by ancient Greek astronomers, notably Ptolemy, and it formed the foundation of astronomical understanding for many centuries. According to this theory, each celestial body moved along a complex system of concentric spheres, with Earth as the stationary centre.

Teaching the Geocentric Model allows students to understand how ancient civilizations perceived and explained the movements of celestial bodies. It provides insights into the cosmological beliefs of various cultures and the significance they placed on Earth's position in the Universe.

However, it is important to emphasize that the Geocentric Model was eventually replaced by the Heliocentric Model, which asserts that the Sun is at the centre of the Solar System. The shift from the Geocentric to the Heliocentric Model, spearheaded by astronomers like Nicolaus Copernicus and further developed by Johannes Kepler and Galileo Galilei, revolutionized our understanding of the cosmos.

By exploring the Geocentric Model and its subsequent evolution, students can appreciate the progress of human knowledge and the ongoing refinement of scientific theories over time. They can also reflect on the cultural and historical factors that shaped ancient civilizations' perspectives on astronomy.

It is crucial to present the Geocentric Model within the historical context of ancient civilizations, acknowledging its limitations and the advancements that followed. This approach helps students develop a comprehensive understanding of the theories that were prevalent in the past, while also fostering critical thinking skills and an appreciation for the iterative nature of scientific progress.

The pedagogical approach

When teaching about astronomy in past civilizations, incorporating a pedagogical approach that engages students actively and promotes critical thinking can enhance their learning experience.

Some key pedagogical approaches that can be effective are:

- **Inquiry-Based Learning:** Encourage students to ask questions, explore primary and secondary sources, and seek answers through research and investigation. Provide opportunities for them to analyse ancient astronomical texts, artifacts and artwork to develop their own understanding of how astronomy was perceived and practiced in different civilizations.
- **Hands-On Activities:** Design hands-on activities that simulate ancient astronomical observations or experiments. For example, students can create models of celestial spheres or use sundials to understand how ancient civilizations measured time and tracked celestial events. Such activities foster a deeper understanding of the practical aspects of astronomy in the past.
- **Collaborative Learning:** Facilitate group work and discussions where students can exchange ideas, share findings, and collectively construct knowledge about ancient astronomy. Assign group projects where students research and present on specific civilizations, promoting teamwork and fostering a sense of shared discovery.
- **Multidisciplinary Approaches:** Connect astronomy with other disciplines such as history, mathematics, art and literature. Explore how ancient astronomical knowledge influenced

architectural designs, religious practices and cultural beliefs. Analyse ancient astronomical instruments and relate them to mathematical concepts or engage with ancient myths and literature inspired by celestial observations.

- **Use of Technology:** Incorporate digital resources, interactive simulations and virtual tours, to provide students with immersive experiences of ancient astronomical sites and artifacts. Virtual reality or augmented reality tools can transport students to ancient observatories or allow them to explore ancient star maps, enhancing their understanding of astronomy in a more engaging manner.
- **Reflective and Experiential Learning:** Encourage students to reflect on their learning experiences, make connections to their own lives, and consider the significance of ancient astronomy in shaping our current understanding of the Universe. Engage students in discussions and writing activities that prompt them to think critically about the cultural, social and scientific implications of ancient astronomical knowledge.

By adopting these pedagogical approaches, educators can create an engaging and immersive learning environment that fosters curiosity, critical thinking and a deeper appreciation for the rich history of astronomy in past civilizations.

Activity Description

This is a three-lesson class proposal (50 minute each) for 12-year-old students.

It combines teachers' explanations, Minecraft exercises to carry out on computers, group activities without computers, and activities to assess students' understanding.

Lesson structure

1st 50-minute session

We introduce the topic to the students after creating the appropriate atmosphere to intrigue their curiosity, using the above-mentioned tools.

We form separate groups of students.

Assign students to prepare short presentations on specific ancient civilizations and their contributions to astronomy. Encourage them to include visual aids, such as images or diagrams, to support their presentations. Evaluate their ability to convey information accurately and effectively.

2nd 50-minute session

Presentations from students.

3rd 50-minute session

Evaluation and Activities. Minecraft Worlds on their computers.

Lesson guide

Description

This is a three-hour proposal (50 minutes each) for 12-year-old students.

It combines teacher's explanations, tools, activities and Minecraft exercises to carry out on computers.

Learning goals

The learning goals of teaching astronomy in the past can include:

Historical Understanding: Students will develop an understanding of the significant role that astronomy played in ancient civilizations and how it influenced their culture, beliefs and daily lives.

Cultural Appreciation: Students will gain an appreciation for the diversity of ancient astronomical practices across different civilizations, such as the Egyptians, Greeks, Mayans, or Chinese.

Scientific Knowledge: Students will learn about the basic principles of astronomy, including the movement of celestial bodies, the concept of constellations, the measurement of time and the development of astronomical instruments.

Observational Skills: Students will develop observational skills by studying ancient star charts, identifying constellations and understanding the methods used by ancient astronomers to observe and track celestial bodies.

Critical Thinking: Students will engage in critical thinking by analyzing the purposes and functions of ancient astronomical practices, considering the cultural and scientific significance behind them.

Historical Context: Students will gain an understanding of the historical context in which ancient astronomical knowledge was developed, including the available technologies, the cultural beliefs and the societal needs that influenced their observations and interpretations.

Connection to Modern Astronomy: Students will make connections between ancient astronomical practices and modern-day astronomy, recognizing the contributions and legacies of past civilizations to our current understanding of the Universe.

Communication Skills: Students will practice effective communication by discussing and presenting their findings, sharing their understanding of ancient astronomy, and explaining the significance of ancient astronomical practices to others.

Introduction to the topic

"Today, we are going to embark on a journey back in time to explore the captivating world of astronomy as it was understood by ancient civilizations. Imagine for a moment being in a time when technology and scientific knowledge were vastly different from what we have today. Yet, despite their limited resources, ancient cultures had a deep fascination with the stars and the mysteries of the cosmos."

"As we delve into this lesson, we will discover how ancient civilizations like the Egyptians, Greeks, Mayans and Chinese, peered into the night sky and unravelled its secrets. We will explore their rich astronomical traditions, innovative observations and the ways in which they integrated their celestial knowledge into their daily lives."

"We will learn about the significance of celestial bodies, such as the Sun, Moon and stars, in their cultures. We will unravel the stories behind the constellations they mapped in the sky and how they used them for navigation, agriculture, religious rituals and tracking time. We will uncover the extraordinary tools they developed, like sundials, astrolabes and observatories, which allowed them to make precise measurements and predictions."

"As we dive deeper into the lesson, we will examine their astronomical achievements, their pioneering thinkers and their astronomical records that have survived throughout the ages. We will explore the cultural beliefs and mythologies intertwined with their understanding of the cosmos, discovering how their worldviews shaped their interpretations of the celestial realm."

"By learning about astronomy in the past, we gain a greater appreciation for the interconnectedness of science, culture and history. We can explore how ancient knowledge laid the foundations for our current understanding of the Universe and how it continues to inspire and influence modern astronomy."

"Throughout this lesson, we will engage in hands-on activities, interactive discussions, and exciting explorations to bring the ancient world of astronomy to life. Get ready to step back in time and embark on an extraordinary adventure as we unravel the celestial wonders of the past!"

Teaching tools

1. **Captivating visuals** such as images, videos, or artifacts related to ancient astronomy. Pictures of ancient observatories, star maps, or astronomical instruments used by different cultures. These visuals help students visualize the context and the remarkable achievements of ancient astronomers.

2. **Musical suggestions** that capture the spirit of astronomy:

"The Planets" by Gustav Holst: This orchestral suite depicts each of the planets in our Solar System, providing a musical journey through space.
https://www.youtube.com/watch?v=Isic2Z2e2xs

"Also Sprach Zarathustra" by Richard Strauss: This powerful and dramatic composition is often associated with space exploration and was famously used in the film "2001: A Space Odyssey."
https://www.youtube.com/watch?v=Szdziw4tI9o

"Space Oddity" by David Bowie: This iconic song tells the story of an astronaut named Major Tom and his experiences in space. It captures the sense of awe and wonder associated with space travel.
https://www.youtube.com/watch?v=iYYRH4apXDo

"Clair de Lune" by Claude Debussy: This beautiful piano piece evokes a serene and dream-like atmosphere, often compared to the tranquillity of Moonlight.
https://www.youtube.com/watch?v=WNcsUNKlAKw

"Rocketman" by Elton John: This uplifting song speaks to the allure and magic of the stars, encouraging listeners to embrace the sense of wonder and adventure they inspire.
https://www.youtube.com/watch?v=DtVBCG6ThDk

"Fly Me to the Moon" by Frank Sinatra: This classic song, often associated with space exploration and the Apollo missions, expresses the desire to journey beyond Earth's confines and explore the wonders of the cosmos.
https://www.youtube.com/watch?v=ZEcqHA7dbwM

These musical pieces can be incorporated into lessons, presentations, or activities to enhance the atmosphere and spark curiosity about astronomy.

3. Some **relevant presentations** that could also be used

The history of Astronomy https://www.youtube.com/watch?v=RVXFrDYxm80

History of Astronomy Part 1: The Celestial Sphere and Early Observations
https://www.youtube.com/watch?v=M2M7zSh7YFI&t=75s

How the Greeks knew that the Earth is Spherical | Physical Science
https://www.youtube.com/watch?v=5PpyDRPvOYc

Minecraft activities about this lesson plan in Astronomine / Minecraft worlds:

World 1 - Observatory

Nº	Topics	Activity 1	Description
1	Astronomy in Culture	Building challenge	The player is asked to complete and Ancient Astronomy Observatory by the lead astronomer. The Observatory will be based on one used by ancient civilizations.

Ideas for evaluation

Quiz: Astronomy in the Past

Section 1: Multiple Choice

1.- Who improved the telescope and made many discoveries about the planets and stars with it?
A) Ptolemy
B) Copernicus
C) Galileo

2.- Which ancient civilization built huge stone structures called pyramids that aligned with certain stars?
A) Greeks
B) Egyptians
C) Romans

3.- The North Star, also known as Polaris, has been used for:
A) Navigation
B) Nothing
C) Painting

4.- Stonehenge, an ancient monument in England, was possibly used for:
A) Theatre plays
B) Observing the stars and Sun
C) Sleeping

5.- The ancient Mayans were known for their:
A) Hunting techniques
B) Songs
C) Advanced calendar system

6.- Which planet is named the Red Planet?
A) Mercury
B) Mars
C) Jupiter

7.- In ancient times, people believed that a Solar Eclipse meant:
A) The gods were angry
B) The Sun was taking a nap
C) The Moon disappeared

8.- The ancient Greeks named the planets after:
A) Their favourite foods
B) Animals
C) Gods and goddesses

9.- Which of these is NOT an object studied in astronomy?
A) Star
B) Planet
C) Rainbow

10.- Long ago, the Chinese used what to predict eclipses and the future?
A) Ancient calendars
B) Dragon tales
C) Magic mirrors

Answers:

1.- C) Galileo
2.- B) Egyptians
3.- A) Navigation
4.- B) Observing the stars and Sun
5.- C) Advanced calendar system
6.- B) Mars
7.- A) The gods were angry
8.- C) Gods and goddesses
9.- C) Rainbow
10.- A) Ancient calendars

Section 2: True or False

- *The ancient Greeks believed that the Earth was the centre of the Universe.*

Answer: True (Note: This refers to the geocentric model proposed by some ancient Greek astronomers, such as Ptolemy. However, it's worth noting that not all ancient Greeks believed this, as evidenced by the heliocentric model proposed by Aristarchus.)

- *The ancient Romans invented the telescope.*

Answer: False (The telescope was invented much later, in the early 17th century.)

- *Ancient Egyptian astronomy played a significant role in religious and mythological beliefs.*

Answer: True

- *The ancient Mayans believed that the Moon was made of silver.*

Answer: False

- *Ancient Chinese astronomers developed a sophisticated calendar system based on astronomical observations.*

Answer: True

Section 3: Matching

Galileo - (i) Used a telescope to look at the sky
Neil Armstrong - (ii) First person to walk on the Moon
Copernicus - (iii) Said the Sun is the centre, not Earth
Hubble - (iv) Has a famous space telescope named after him

Section 4: Short Answer

- Explain one practical application of ancient astronomy in daily life.
- Search for a name one ancient or new observatory and its significance.
- Briefly describe the purpose of the Mayan "Long Count" calendar.
- What was the significance of the astrolabe in ancient astronomy?

  Answers will vary.

Ideas of innovative activities besides Minecraft that could be used in this lesson

- A theatrical performance after the completion of the lessons.
- Creative Projects: Enable students to showcase their understanding of the topic through creative projects such as artwork, dioramas, or written stories inspired by ancient astronomy. Assess their creativity, originality, and the extent to which they effectively communicate their understanding of the subject.
- Observational Skills Assessment: Develop an activity where students are given images of ancient star maps or constellations and are asked to identify specific stars or patterns.

Evaluate their observational skills and ability to make connections between the images and their understanding of ancient astronomy.

- Discussions and Debates: Engage students in class discussions or debates about controversial or significant topics related to ancient astronomy. Encourage them to present evidence and support their arguments. Assess their ability to articulate their thoughts, listen to others, and construct well-reasoned arguments.

Lesson plans

7.2 Solar System

Activity Description

This is a six-lesson class proposal (2 X 50 minute lessons) for 10-year-old students.

It combines teachers' explanations, Minecraft exercises to carry out on computers.

In this chapter, we will embark on a fascinating journey through our Solar System. We will start by exploring the Inner Planets, including Mercury, Venus, Earth, and Mars, discussing their unique characteristics and features. Then, we will venture further out to the Outer Planets, such as Jupiter, Saturn, Uranus and Neptune, and learn about their intriguing atmospheres and Moons. We will also delve into the realm of Minor Bodies, like asteroids, comets and dwarf planets, and understand their role in the Solar System. Lastly, we will touch upon the phenomena of Meteors and Meteorites, explaining what they are, where they come from, and their impact on Earth. This chapter will provide students with a comprehensive understanding of our cosmic neighbourhood and its diverse inhabitants.

Lesson structure

Day 1: Introduction to the Inner Planets. Earth & Mars (50 minutes)

- Introduction (10 minutes): Start the class with a brief introduction to the Solar System and the concept of Inner Planets. Explain why they are called "terrestrial" or "rocky" planets.
- Earth (15 minutes): Begin with our home planet, Earth. Discuss its size, its atmosphere, and its ability to support life. Highlight the presence of water and the importance of its distance from the Sun.
- Mars (15 minutes): Introduce Mars, the fourth planet from the Sun. Discuss its size, its thin atmosphere, and its surface features. Talk about the possibility of past and future life on Mars.
- Activity (10 minutes): Comparison activity in Minecraft.

Day 2: Mercury & Venus and Review of Inner Planets

- Mercury (15 minutes): Introduce Mercury, the closest planet to the Sun. Discuss its size, its lack of Moons, and its extreme temperature changes between day and night. Use Minecraft to help visualize the planet.
- Venus (15 minutes): Move on to Venus, the second planet from the Sun. Discuss its size, its thick and cloudy atmosphere, and its surface features. Explain why it's known as Earth's "sister planet" but also why it's much hotter.
- Review (15 minutes): Review the key characteristics of all four inner planets. Use Minecraft to compare their sizes, number of Moons, and other unique features.

Day 3: Introduction to the Outer Planets. Jupiter & Saturn (50 minutes)

- Introduction (10 minutes): Begin the class with a brief introduction to the concept of Outer Planets, also known as the "gas giants". Explain their significant size and gaseous composition.
- Jupiter (15 minutes): Start with Jupiter, the largest planet in our Solar System. Discuss its size, its strong magnetic field, its many Moons, and its distinctive Great Red Spot. Highlight the importance of its distance from the Sun.
- Saturn (15 minutes): Introduce Saturn, the second-largest planet. Discuss its size, its ring system, and its many Moons. Talk about the unique features of some of its Moons, like Titan and Enceladus.
- Activity (10 minutes): Comparison activity in Minecraft, where students can explore models of Jupiter and Saturn, noting their sizes and unique features.

Day 4: Uranus & Neptune and Review of Outer Planets

- Uranus (15 minutes): Introduce Uranus, the seventh planet from the Sun. Discuss its size, its unusual tilt, its faint ring system, and its Moons. Use videos and illustrations to help visualize the planet.
- Neptune (15 minutes): Move on to Neptune, the eighth and farthest known planet from the Sun. Discuss its size, its strong winds, its dark spots, and its Moons. Explain why it's considered an "ice giant".
- Review (15 minutes): Review the key characteristics of all four outer planets. Compare their sizes, number of Moons, ring systems, and other unique features. Students can explore models of Uranus and Neptune, noting their sizes and unique features.

Day 5: Introduction to Minor Planets. Asteroids & Minor Bodies (50 minutes)

- Introduction (10 minutes): Begin the class with a brief introduction to the concept of minor planets, which include objects in the Solar System that orbit the Sun but are neither planets nor comets. Discuss famous minor planets like Eris and Pluto, and explain their characteristics and the controversy around their classification.
- Asteroids (15 minutes): Start with asteroids, discussing their composition, size, and location, primarily in the Asteroid Belt between Mars and Jupiter. Highlight some famous asteroids like Ceres and Vesta.
- Minor Planets (15 minutes): Introduce Minor Bodies in our Solar System. Explain what asteroids and minor planets are and where they are typically found.
- Activity (10 minutes): Activity where students can explore models of an asteroid and a minor planet, noting their differences in size and composition.

Day 6: Comets, Meteors, Meteorites, and Review of Minor Bodies

- Comets (10 minutes): Introduce comets, discussing their composition of ice and rock, their orbits, and the phenomenon of their tails when they approach the Sun. Search for famous comets like Halley's Comet and Comet NEOWISE.

- Meteors and Meteorites (10 minutes): Introduce the concepts of meteors and meteorites. Explain the difference between them, how meteors are the streaks of light we see in the sky when a small piece of asteroid or comet enters Earth's atmosphere, and how meteorites are the remnants of these that reach Earth's surface. Discuss meteor showers and famous meteorites.

- Review (20 minutes): Review the key characteristics of asteroids, minor planets, comets, meteors, and meteorites. Use Minecraft to compare their sizes, compositions, and other unique features. Students can explore models of a comet, a meteor, and a meteorite, noting their differences.

- Activity (10 minutes): Activity where students can simulate a meteor shower and find meteorites that have landed on the ground.

Learning goals

- **Identifying and Describing the Inner Planets:** Students should be able to name the four inner planets (Mercury, Venus, Earth, and Mars) and describe their basic characteristics, including their size, composition, and number of Moons. They should understand why these planets are called "terrestrial" planets and how they differ from the outer planets.

- **Understanding the Unique Features of Each Inner Planet:** Students should be able to identify unique features of each inner planet, such as Mercury's extreme temperature fluctuations, Venus's thick atmosphere and surface features, Earth's life-supporting conditions, and Mars's potential for past and future life. This goal will help students appreciate the diversity and uniqueness of each planet in our Solar System.

- **Identifying and Describing the Outer Planets:** Students should be able to name the four outer planets (Jupiter, Saturn, Uranus, and Neptune) and describe their basic characteristics, including their size, composition, and number of Moons. They should understand why these planets are called "gas giants" and how they differ from the inner planets.

- **Understanding the Unique Features of Each Outer Planet:** Students should be able to identify unique features of each outer planet, such as Jupiter's Great Red Spot, Saturn's ring system, Uranus's unusual tilt, and Neptune's strong winds. This goal will help students appreciate the diversity and uniqueness of each planet in our Solar System.

- **Identifying and Describing Minor Planets:** Students should be able to name and describe the basic characteristics of minor planets, including their size, composition, and location in the Solar System. They should understand the controversy around the classification of minor planets.

- **Understanding the Unique Features of Minor Planets:** Students should be able to identify unique features of minor planets, such as Eris's high orbital inclination and Pluto's heart-shaped glacier. This goal will help students appreciate the diversity and uniqueness of minor planets in our Solar System.

- **Identifying and Describing Minor Bodies:** Students should be able to name and describe the basic characteristics of minor bodies like asteroids, comets, meteors, and meteorites, including their size, composition, and typical locations.

- **Understanding the Unique Features and Phenomena of Minor Bodies:** Students should be able to identify unique features and phenomena associated with minor bodies, such as the tail of a comet, the flash of a meteor, and the impact of a meteorite. They should also understand how these phenomena are observed from Earth. This goal will help students appreciate the diversity and uniqueness of minor bodies in our Solar System.

Introduction to the topic

Welcome, young astronomers, to our exciting journey through the Solar System! Our Solar System is a vast, fascinating place filled with an array of celestial bodies, from our life-supporting home planet, Earth, to the gas giants like Jupiter and Saturn, and even to the icy realms of the outer Solar System. We'll explore rocky planets and gas giants, minor planets and comets, and the countless meteors and asteroids that zip around our cosmic neighbourhood. We'll learn about the unique features of each of these celestial bodies and understand their place in the grand scheme of the Solar System. So, buckle up and prepare for an adventure that's truly out of this world!

Minecraft activities about this lesson plan in Astronomine / Minecraft worlds:

World 2 - Solar System

Nº	Topics	Activity 1	Activity 2	Description
3	Solar System	Building challenge	Quiz	After fixing the observatory, the player is asked to build a small replica of the Solar System. In order to do so, they will get materials from the laboratory based on the elements that make the planets (Eg. They will gather red sandstone for Mars). They will be required to get multiple materials for planets that have multiple features (eg. One element for the body of Saturn, another for its rings). The elements could be showcased as unknown items and the player will have to run them through a detector to understand their nature. After creating all the planets (by combining the correct elements in a machine) they will have to position them in the correct spot of the Solar System model
4	Solar System	Quiz		The planets will be scaled and will feature their unique aspects such as rings and Moons. The player will have to observe those and answer to a serious of questions made by the astronomers (eg. How many Moons in Jupiter? Which planet is the closest to the Sun? Etc.)
5	Solar System Scales	Exploration		Solving the quiz, the astronomer will reward the student with a prize. After receiving and wearing a space suit, the student will click on a button that will teleport it next to the Sun. A dialogue coming from the astronomer will pop out, mentioning that at said distance the Earth would look so tiny that the student could hold it into their hand. The earth block will appear in the student hand to show comparison.

Ideas for evaluation

Genially presentation once they have finished this chapter, creating Bing Image generator or Ideogram to create the Solar System elements.

Ideas of innovative activities besides Minecraft that could be used in this lesson

- Genially presentation (or other) once they have finished this chapter, creating Bing Image generator or Ideogram to create the Solar System elements.
- NASA's Solar System Exploration website. It provides detailed information about each planet, including their size, atmosphere and unique features. https://solarsystem.nasa.gov/planets/overview/

Lesson plans

7.3 Exploring the Seasons

Approximately 60 minutes session

Lesson guide

Learning Objectives

1. Understand the concept of seasons and the factors that cause them.
2. Identify the four seasons and describe the characteristics of each.
3. Recognize the relationship between the Earth's tilt and the changing seasons
4. Comprehend the axial tilt of the Earth in its orbital path around the Sun, leading to the phenomenon of opposing seasons in the Northern and Southern Hemispheres.
5. Explain how the changing seasons affect weather, daylight, and activities.
6. Analyse the impact of seasons on plant and animal life.
7. The solstice and equinox events in the astronomical calendar.

Introduction to the topic

Welcome, young astronomers, to an exciting journey through the mysteries of the seasons! Have you ever wondered why the weather changes throughout the year? Why do we experience warm summers and chilly winters? Today, we will embark on an astronomical adventure to uncover the secrets behind these fascinating phenomena.

You see, our planet, Earth, is not just a simple rock floating in space. It is a magnificent celestial object with its own unique characteristics. One of the most captivating aspects of Earth is the way it interacts with the Sun, our nearest star, to create the magical dance of the seasons.

Imagine a beautiful cosmic ballet where Earth twirls and pirouettes around the Sun, bringing about the enchanting transformation of our environment. As we journey together, we will explore how this cosmic ballet shapes our daily lives and gives rise to the splendid seasons that we experience.

Throughout our lesson, we will learn about Earth's tilted axis and how this slight tilt plays a vital role in the changing of the seasons. We will discover how this tilt causes different parts of our planet to receive varying amounts of sunlight throughout the year, resulting in the diverse climatic conditions we observe.

Together, we will uncover the secrets of Earth's orbit around the Sun, understanding how its revolution creates a rhythmic cycle of spring, summer, autumn (fall) and winter. We will unlock the wonders of how sunlight interacts with Earth's atmosphere, influencing temperatures, daylight duration, and the behaviour of nature around us.

Are you ready to delve into the mysteries of the seasons? Prepare to explore the captivating relationship between Earth and the Sun, as we unravel the cosmic choreography responsible for the breath-taking transformations that shape our world.

Get ready to witness the mesmerizing ballet of the seasons, where science and nature merge into a captivating symphony. By the end of this lesson, you will have a deeper understanding of the astronomical forces at play and how they contribute to the ever-changing tapestry of our lives.

So, let us embark on this celestial adventure and unlock the secrets of the seasons together! Get ready to be amazed, inspired and awestruck by the marvellous wonders of our cosmic dance.

Lesson Outline:

1. Introduction (5 minutes)
   - Engage students by asking the following question: "Why when it is summer in the Northern Hemisphere, it is winter in the Southern Hemisphere, and vice versa?"
   - Discuss student responses and elicit their prior knowledge about seasons.
   - Explain that in this lesson, they will explore the concept of seasons and discover why they occur.

2. Seasonal Changes and the Earth's Tilt (15 minutes)
   - Show a short YouTube video that explains the Earth's tilt and its relation to the changing seasons. Recommended video: "Seasons and the Earth's Tilt" California Academy of Sciences (Link: https://www.youtube.com/watch?v=WgHmqv_-UbQ)
   - After watching the video, facilitate a class discussion to reinforce the key points and clarify any doubts or questions.

3. Characteristics of the Four Seasons (10 minutes)
   - Display images or short videos depicting the four seasons and discuss the distinctive features of each (temperature, weather, daylight hours, activities, etc.).
   - Use an authentic media link, such as a website or photo gallery, to explore examples of each season. Recommended resource: NASA's "Earth Observatory" website (Link: https://earthobservatory.nasa.gov/)
   - Encourage students to take notes or create a graphic organizer to record information about each season.

4. Impact of Seasons on Weather and Daylight (10 minutes)
   - Show a YouTube video that explains how seasons affect weather patterns and the amount of daylight. Recommended video: "Seasons: All about Weather" Harmony Square (Link: https://www.youtube.com/watch?v=XxELVix36tI)
   - Engage students in a brief discussion about the video's content, emphasizing the cause-and-effect relationship between seasons, weather and daylight.

5. Seasons and Plant/Animal Life (10 minutes)
   - Discuss how seasons influence the growth, behaviour and adaptations of plants and animals.

- Use an authentic media link, such as a wildlife documentary or an interactive website, to explore examples of seasonal changes in the natural world. Recommended resource: Harmony Square, "Climate and Seasons" webpage (Link: https://www.youtube.com/watch?v=o54YudenJn0)
- Facilitate a class discussion, encouraging students to share their observations and insights.

6. Differentiated Activities (10 minutes)
    - Provide students with differentiated activities based on their abilities and interests. These activities can include:
        - Drawing or colouring worksheets depicting each season.
        - Writing a short paragraph describing their favourite season and why they like it.
        - Creating a diorama or collage representing a particular season.
        - Conducting research on how different cultures celebrate the changing seasons and presenting their findings.
        - Encourage students to showcase their completed activities and share their work with the class.

Ideas for evaluation

Part 1: Multiple Choice

1. Why do we have different seasons on Earth?

    a) Because of the tides
    b) Because the Earth goes around the Sun
    c) Because the Moon goes around the Earth
    d) Because the Earth is tilted on its side

Correct answer: d) Because the Earth is tilted on its side

2. In which season does the Northern Hemisphere experience the longest days and shortest nights?
    a) Spring
    b) Summer
    c) Fall
    d) Winter

Correct answer: b) Summer

Part 2: Fill in the Blanks (search on the internet for the correct answers)

- The summer solstice in the Northern Hemisphere occurs on ___________.
  Correct answer: June 21st (or around that date)

- During the autumnal equinox, the length of day and night are approximately _______.
  Correct answer: Equal

- The tilt of the Earth's axis is about _______ degrees.
  Correct answer: 23.5 degrees

Part 3: Short Answer

- Explain why the seasons are reversed in the Northern and Southern Hemispheres.
- Describe the difference between the solstices and equinoxes.

Part 4: Practical Activity

- Create a visual representation (drawing, diagram, or model) showing the tilt of the Earth's axis and how it affects the seasons.

Note: For younger students, provide additional guidance and support as needed.

Minecraft activities about this lesson plan in Astronomine / Minecraft worlds:

World 1 - Observatory

Nº	Topics	Activity 1	Activity 2	Description
3	Constellations/Tools	Escape Room	Puzzle Solving	The player is provided with a camera as a reward for completing the previous activities. It is then asked to take pictures of the Constellations found in four different rooms that represents the 4 seasons and have therefore different constellations in it (eg. in the summer room the Constellation of Scorpius will be visible). To access each of the rooms they will have to answer to some questions about the constellations (when to observe them, in which hemisphere etc.). Some puzzles will also involve harvesting (for instance, a cultivation of a plant to be harvested in summer will have to be collected in the summer room to proceed to the next door.)

Ideas of innovative activities besides Minecraft that could be used in this lesson on Seasons.

Here are some more innovative activities related to seasons that can engage K-12 students:

1. Virtual Reality (VR) Experience: Create a virtual reality experience where students can explore different seasons in an immersive way. They can witness the changes in weather, foliage and activities associated with each season.

2. Interactive Weather Maps: Use interactive weather maps to teach students about the different weather patterns in each season. Students can analyse the maps, identify patterns and make predictions about the upcoming weather conditions.

3. Seasonal Art Project: Encourage students to create artwork that represents each season. They can use various mediums such as painting, collage, or digital art. The focus can be on capturing the colours, moods and elements unique to each season.

4. Seasonal Poetry Slam: Have students write and perform their own poetry about seasons. They can experiment with different poetic forms and techniques to express their thoughts, emotions and observations related to each season.

5. Seasonal Gardening: Set up a small garden or planter boxes where students can plant and observe seasonal plants. They can learn about the life cycle of plants, the effects of seasons on growth, and the importance of seasonal gardening practices.

6. Seasonal Photography Challenge: Encourage students to capture the essence of each season through photography. Provide them with basic photography tips and techniques. They can share their best photographs and explain how each image represents a particular season.

7. Seasonal Science Experiments: Conduct hands-on science experiments that demonstrate seasonal phenomena. For example, explore the melting rates of ice in different seasons or study the effects of temperature and sunlight on plant growth.

8. Seasonal Storytelling Podcast: Have students create a seasonal storytelling podcast where they share stories, legends or personal experiences related to each season. They can add sound effects and background music to enhance the storytelling experience.

9. Seasonal Fashion Show: Organize a seasonal fashion show where students design and showcase outfits inspired by different seasons. They can incorporate elements like colours, textures and patterns associated with each season into their designs.

10. Seasonal Cuisine: Introduce students to seasonal ingredients and recipes. Encourage them to prepare dishes using ingredients that are commonly available during specific seasons. They can learn about nutrition, culinary skills and the cultural significance of seasonal foods.

Lesson plans

7.4 Moon Phases and Tides

Approximately 60 minutes session

Learning Objectives

1. Understand the concept of Moon phases and their relationship to the positions of the Moon, Earth, and Sun.
2. Identify and describe the different Moon phases: new Moon, crescent Moon, quarter Moon, gibbous Moon, and full Moon.
3. Explain the causes and effects of lunar phases, including the tides.
4. Analyse authentic media and visual representations to deepen understanding of Moon phases.
5. Engage in differentiated activities to accommodate students of all abilities.

Introduction to the topic

Welcome again, young astronomers! Prepare to embark on a celestial adventure that will take you on a captivating journey through the mysterious world of Moon phases. Imagine gazing up at the night sky, where the Moon, our luminous companion, dances and transforms, revealing its ever-changing face. Have you ever wondered why the Moon appears different each night? Get ready to unlock the secrets of this celestial spectacle as we delve into the captivating realm of Moon phases in astronomy.

Buckle up as we embark on a lunar expedition like no other! We will explore the captivating interplay between the Earth, our home planet, and its faithful companion, the Moon. Just like a cosmic chameleon, the Moon undergoes a mesmerizing transformation, shifting its appearance from a dazzling full Moon to a mysterious crescent, and everything in between.

As we venture deeper into the realms of lunar magic, you will discover that the Moon's phases are intricately linked to its position in relation to the Sun and the Earth. We will unravel the cosmic dance between these three celestial bodies, uncovering the awe-inspiring phenomenon that causes the Moon's appearance to wax and wane.

Prepare to witness the majesty of a full Moon, bathing the night in an ethereal glow and illuminating the world below. But wait, there is more! Through our astronomical exploration, you'll learn the secrets behind the mystical half-Moon, the enigmatic gibbous Moon and even the elusive new Moon, when the Moon hides its luminous face from the Earth.

During our celestial expedition, we will unearth the hidden forces that shape the Moon's phases. You will discover the intriguing concept of lunar cycles, where the Moon's transformation repeats itself over a span of time, capturing the rhythm of the cosmos. We will decode the lunar language, demystifying terms like waxing and waning, and unveiling the celestial mechanics behind these enchanting lunar metamorphoses.

But the adventure does not stop there! We will also explore the cultural significance of Moon phases across civilizations. From ancient myths and folklore to the practical applications of lunar calendars, you will witness how humanity's fascination with the Moon has shaped cultures and guided our ancestors throughout the ages.

So, get ready to don your stargazing gear, young astronomers! Together, we will unveil the mesmerizing secrets of Moon phases in astronomy. Buckle up, as we embark on an astronomical odyssey through the cosmic ballet of the Moon, where celestial wonder awaits us at every phase. Let us embark on this captivating journey to unlock the secrets of our lunar companion and unveil the enchanting beauty of Moon phases!

Lesson Outline

Introduction (5 minutes):

- Begin the lesson by asking students if they have ever noticed changes in the Moon's appearance.
- Introduce the topic of Moon phases and explain that the Moon goes through different phases throughout its orbit around the Earth.
- Ask if they know about the relation between the Moon and the tides
- Share the learning objectives for the lesson.

Moon Phases Explanation (15 minutes):

- Present a concise explanation of Moon phases using visuals, diagrams and authentic media links. You can use the following resources:
    - NASA's Moon Phases Animation: https://Moon.nasa.gov/resources/94/grail-impacts-the-Moon/
    - Video: "Phases of the Moon" by Free School: https://www.youtube.com/watch?v=f4ZHdzl6ZWg
    - Video: Why does the Moon Change? By SCiShow Kids: https://www.youtube.com/watch?v=yXe0yxzYkjo

    - Encourage students to take notes and ask questions during the explanation.

Moon Phase Demonstration (10 minutes):

- Conduct a live demonstration using a flashlight, globe and small ball or sphere to represent the Moon.
- Mimic the positions of the Moon, Earth and Sun to show how different phases are formed.
- Allow students to participate by taking turns playing the role of the Moon, Earth, or Sun.

Authentic Media Analysis (15 minutes):

- Share authentic media such as photographs, images, or short videos showcasing different Moon phases.
- Provide a set of questions for students to analyse the media, such as:
    - What Moon phase is shown in the media?
    - What features can you identify in the Moon's appearance?
    - How does the media help you understand the concept of Moon phases?
- Encourage students to share their observations and interpretations.

Differentiated Activities (20 minutes): Note: Depending on the grade level, select appropriate activities from the following options or modify them as needed.

1. Artistic Expression:
   - Ask students to create a Moon phase flipbook illustrating each phase and labelling them accordingly.
   - Provide templates or guided worksheets for younger students.

2. Hands-On Exploration:
   - Provide materials for students to create 3D models or dioramas representing different Moon phases.
   - Alternatively, use Oreo cookies to represent the Moon phases, allowing students to eat their creations afterward.

3. Technology Integration:
   - Assign students interactive online simulations to manipulate the Moon, Earth and Sun to understand Moon phases.
   - Example: Phases of the Moon Simulator by Peekaboo Kids: https://www.youtube.com/watch?v=BQvo7vyCmuE

Wrap-Up and Quiz (10 minutes):

- Summarize the main points covered during the lesson.
- Conduct a brief quiz or Kahoot quiz (if technology is available) to assess students' understanding of Moon phases.
- Provide immediate feedback to reinforce learning.

Conclusion:

- Recap the key concepts and highlight the significance of understanding Moon phases in astronomy.
- Encourage students to continue observing the Moon and its phases in their daily lives.
- Offer suggestions for further exploration, such as stargazing or researching lunar missions.

Note: Please ensure that the authentic media links provided are active and up to date as liks change and are updated.

Minecraft activities about this lesson plan in Astronomine / Minecraft worlds:

World 2 - Solar System

Nº	Topics	Activity 1	Description
2	Eclipses/Lunar Phases	Escape Room	To go to the Power Plant, the player will have to trespass a tunnel/escape room. The puzzles of the escape room will be based on Eclipses and Lunar Phases (eg. Entering the room of the correct lunar phase, rotate mirrors and/or lights in order to project the shadow of an eclipse, etc.). When passing the escape room, the player will be able to fix the power plant and then go back to the lab.

Ideas for evaluation

Here is an astronomy quiz on the topic of Moon Phases, designed for K-12 students. The quiz includes differentiated activities for students of all abilities. The answers are provided at the end.

Moon Phases Quiz

Part 1: Multiple Choice

1. Which of the following best describes a lunar eclipse?
   a) When the Moon passes between the Earth and the Sun
   b) When the earth is positioned between the Sun and the Moon
   c) When the Moon's shadow falls on the Earth
   d) During the new Moon

Correct answer: b) When the earth is positioned between the Sun and the Moon

2. The phase of the Moon that occurs when the Moon is between the Earth and the Sun is called:
   a) New Moon
   b) Full Moon
   c) Crescent Moon
   d) First Quarter Moon

Correct answer: a) New Moon

3. What causes the different phases of the Moon?
   a) The Moon's distance from the Earth
   b) The Moon's rotation on its axis
   c) The Earth's rotation on its axis
   d) The Moon's position relative to the Sun and Earth

Correct answer:

e) The Moon's position relative to the Sun and Earth

Part 2: Fill in the Blanks

The Moon is Earth's natural ________.
Correct answer: Satellite

The Moon goes through different shapes in the sky, and these shapes are called ________.
Correct answer: Phases

The Moon's gravity affects the Earth's ________, causing them to rise and fall.
Correct answer: Tides

The Moon does not have its own light; it ________ the light from the Sun.
Correct answer: Reflects

The Moon has many holes or pits on its surface, which are known as ________.
Correct answer: Craters

The time it takes for the Moon to complete one orbit around the Earth is about ________ days.
Correct answer: 28 days (exactly 27.3)

Part 3: Diagram Labelling

Label the following phases of the Moon on the diagram provided:

1. New Moon
2. Waxing Crescent
3. First Quarter
4. Waxing Gibbous
5. Full Moon
6. Waning Gibbous
7. Third Quarter
8. Waning Crescent

[Choose the Northern or Southern Hemisphere and provide a diagram of the Moon with blank spaces next to each phase for labelling.]

Part 4: Short paragraph Question in teams or individuals depending on your differentiated programme:

Explain the difference between a solar eclipse and a lunar eclipse. Include a description of what causes each type of eclipse and why they do not occur every month.

Ideas of innovative activities besides Minecraft that could be used in this lesson on Moon Phases

Here are some differentiated ideas for innovative activities on Moon Phases for K-12 students, beyond using Minecraft:

1. Moon Phase Models: Have students create physical models of the Moon phases using craft materials like clay, Styrofoam balls, or paper plates. They can label each phase and explain their understanding of how the Moon transitions through these phases.

2. Lunar Calendar Art: Ask students to design and create their own lunar calendars. They can research the Moon phases for a specific year and create artistic representations for each phase. Encourage them to use different colours, textures and materials to showcase their creativity.

3. Moon Phase Mobiles: Have students design and construct mobiles that illustrate the Moon phases. They can use different-sized balls or cut-outs to represent the Moon and attach them to strings or wire. As they assemble the mobile, they can explain the order and appearance of each phase.

4. Moon Phase Flipbooks: Ask students to create flipbooks that show the transition of Moon phases. They can draw each phase on individual pages and then animate the flipbook to demonstrate the continuous cycle of the Moon's phases.

5. Moon Phase Observation Journals: Encourage students to observe the Moon's phases over a month and maintain a journal. They can sketch the Moon's appearance each night and note down any observations or questions they have about the Moon's changing shape.

6. Moon Phase Shadow Play: Set up a light source, such as a flashlight, and a small model of the Earth and Moon. Students can experiment with positioning the Earth and Moon model to cast shadows that mimic the different Moon phases. This hands-on activity helps reinforce their understanding of how the Moon's position affects its appearance.

7. Moon Phase Virtual Reality (VR): Use virtual reality technology or online simulations to immerse students in a 3D environment that demonstrates the Moon's phases. Students can explore the lunar landscape and observe how the Sun's light interacts with the Moon at different positions.

8. Moon Phase Stop-Motion Animation: Introduce students to stop-motion animation techniques using clay or paper cut-outs. They can create short videos showcasing the Moon's phases, moving the Moon model slightly in each frame to demonstrate the transitions.

9. Moon Phase Poetry or Storytelling: Ask students to write poems or stories that incorporate the concept of Moon phases. They can use metaphors and descriptive language to capture the essence of each phase and its significance.

10. Moon Phase Math Puzzles: Create math puzzles or problems related to Moon phases. For example, students can calculate the percentage of the Moon's surface that appears illuminated during different phases or analyse the average duration of each phase over a year.

Remember to adapt these ideas to suit the age and grade level of your students and provide support and guidance as necessary.

Lesson plans

7.5 Lunar and Solar Eclipses

Approximately 60 minutes session

Learning Objectives

1. Understand the basic concepts of lunar and solar eclipses.
2. Identify the differences between lunar and solar eclipses.
3. Recognize the factors that contribute to the occurrence of eclipses.
4. Appreciate the significance of eclipses in astronomical events.

Introduction to the topic

Attention, young astronomers! Prepare to embark on an extraordinary journey through the cosmic wonders of our Universe. Today, we shall unveil the mesmerizing mysteries of lunar and solar eclipses, events that captivate both the mind and the heart.

Imagine standing beneath a vast celestial theatre, where the Earth, Moon, and Sun become the stars of an extraordinary show. As we delve into the realm of astronomy, we uncover the enigmatic dance of shadows and light that creates these awe-inspiring phenomena.

Let us first turn our gaze towards our radiant Sun, a celestial beacon that bathes our world in warmth and light. Have you ever wondered what happens when the Moon decides to play hide-and-seek with our beloved Sun? Prepare to witness a solar eclipse, a breath-taking spectacle that mesmerizes all who dare to look up at the heavens.

During a solar eclipse, the Moon, like a cosmic acrobat, positions itself directly between the Earth and the Sun. As it gracefully moves across the Sun's fiery face, a magnificent shadow is cast upon our planet. The sky grows darker, the air cools, and a hush falls over the land, as if nature itself holds its breath in anticipation.

Observe closely as the Moon's silhouette perfectly aligns with the Sun, creating a moment of total solar eclipse. Darkness reigns, but fear not, for it is a wondrous darkness. The Sun's elusive corona—a delicate, shimmering halo of light—unveils itself, illuminating the heavens in an ethereal display. This rare cosmic phenomenon paints the sky with celestial brushstrokes, reminding us of the grandeur of our Universe.

But wait, there is more to this celestial spectacle! Let us now turn our attention to our celestial companion, the Moon, a celestial gem that graces our night sky. Have you ever wondered what occurs when our Moon takes a journey through Earth's shadow? Brace yourselves for the mesmerizing lunar eclipse, a celestial ballet of darkness and mystery.

As our Earth twirls on its axis, it occasionally aligns itself perfectly between the Sun and the Moon. This alignment creates a captivating scene in which our planet's shadow engulfs the Moon, transforming its radiant glow into a captivating shade of coppery red. The Moon, now cloaked in our planet's shadow, becomes a celestial canvas upon which the Universe paints its most profound secrets.

Gaze in awe as the Moon ventures deeper into Earth's shadow, gradually transitioning from its usual luminous self to a captivating spectacle of lunar eclipse. The sky becomes a celestial theatre, showcasing a radiant spectacle that mesmerizes stargazers and sparks the curiosity of astronomers young and old.

Lunar and solar eclipses, these cosmic spectacles, serve as reminders of the marvels that await us beyond our earthly bounds. They encourage us to explore, to question, and to never stop wondering about the Universe we call home.

So, young astronomers, let us embark on this cosmic journey together. Let us unravel the mysteries of eclipses and gaze upon the tapestry of our Universe, for it is within our reach to unlock the secrets of the stars.

Lesson Outline

1. **Introduction (10 minutes):**

Begin the lesson by showing an authentic media link or a short video introducing the concept of lunar and solar eclipses (see below). b. Ask students what they know or have heard about eclipses. c. Write their responses on the whiteboard or chart paper.

2. **Differentiating Lunar and Solar Eclipses (15 minutes):**

Present a brief explanation of the differences between lunar and solar eclipses using visuals and diagrams. b. Discuss the relative positions of the Earth, Moon, and Sun during each type of eclipse. c. Show a YouTube video that demonstrates the visual representation of both types of eclipses.

3. **Factors Influencing Eclipses (15 minutes):**

Explain the factors that contribute to the occurrence of eclipses, such as the tilt of the Earth's axis and the Moon's orbital path. b. Show an authentic media link or video illustrating the alignment of the Earth, Moon, and Sun during an eclipse.

4. **Real-Life Examples (15 minutes):**

Provide examples of famous lunar and solar eclipses throughout history. b. Discuss the cultural significance of eclipses in different societies. c. Show images or videos of notable eclipses, highlighting their impact on scientific knowledge and cultural beliefs.

5. **Hands-On Activity: Model Eclipses (20 minutes):**

Divide the students into pairs or small groups. b. Provide each group with materials such as a flashlight, a ball representing the Earth, and a smaller ball representing the Moon. c. Instruct the students to create their own model to demonstrate how lunar and solar eclipses occur. d. Allow time for students to present their models and explain the processes involved.

6. **Assessment: Quizzes and Worksheets (15 minutes):**

Distribute differentiated quizzes or worksheets based on students' abilities. b. The quizzes or worksheets should include multiple-choice questions, fill-in-the-blanks, and short answer questions related to the lesson content. c. Monitor students' progress and provide assistance as needed.

7. **Conclusion and Reflection (10 minutes):**

Recap the main points discussed during the lesson. b. Engage students in a reflective discussion, encouraging them to share any new insights or questions they may have. c. Provide additional resources or references for further exploration of the topic, such as books or websites.

Authentic Media Links and YouTube Videos:

1. NASA Eclipse Website: https://solarsystem.nasa.gov/eclipses/home/
2. National Geographic "Lunar Eclipse 101" video: https://www.youtube.com/watch?v=VW2xRR75lKE
3. NASA's "What's a Solar Eclipse?" video: https://www.youtube.com/watch?v=XfQI-wk5au8
4. Science ABC's "Solar and Lunar Eclipses explained" video: https://www.youtube.com/watch?v=n7tnHPDH5d8

Minecraft activities about this lesson plan in Astronomine / Minecraft worlds:

World 2 - Solar System

Nº	Topics	Activity 1	Description
2	Eclipses/Lunar Phases	Escape Room	To go to the Power Plant, the player will have to trespass a tunnel/escape room. The puzzles of the escape room will be based on Eclipses and Lunar Phases (eg. Entering the room of the correct lunar phase, rotate mirrors and/or lights in order to project the shadow of an eclipse, etc.). When passing the escape room, the player will be able to fix the power plant and then go back to the lab.

Ideas for evaluation

Here is an astronomy quiz on the topic of ***Lunar and Solar Eclipses***, designed for K-12 students. The quiz includes differentiated activities for students of all abilities. The answers are provided at the end.

Lunar and Solar Eclipses Quiz

Here is an astronomy quiz on the topic of Lunar and Solar Eclipses designed for K-12 students. The questions are followed by multiple-choice answers and, at the end, you will find the correct answers. The questions are ordered from easier to more challenging, allowing for differentiation among students of different abilities.

Quiz: Lunar and Solar Eclipses

1. What is an eclipse?
   a) A natural phenomenon where the Sun disappears.
   b) A natural phenomenon where the Moon disappears.
   c) A natural phenomenon where one celestial body casts a shadow on another.

2. What causes a lunar eclipse?
   a) The Earth blocking the Sun's light from reaching the Moon.
   b) The Moon blocking the Sun's light from reaching the Earth.
   c) The alignment of the Sun, Earth, and Moon in a straight line.

3. What is a solar eclipse?
   a) When the Moon casts a shadow on the Earth.
   b) When the Earth casts a shadow on the Moon.
   c) When the Moon passes between the Sun and the Earth, blocking the Sun's light.

4. During the totality phase of a lunar eclipse, the Moon appears:
   a) Dark and reddish.
   b) Bright and fully illuminated.
   c) Partially covered by the Earth's shadow.

5. Why don't we have an eclipse every month?
   a) The Moon's orbit is slightly tilted compared to the Earth's orbit around the Sun.
   b) The Sun's rays are too powerful and always reach the Moon.
   c) Eclipses only occur during leap years.

6. Which of the following statements is true about a total solar eclipse?
   a) It occurs when the Moon partially blocks the Sun.
   b) It is only visible from certain parts of the Earth.
   c) It happens more frequently than lunar eclipses.

7. What safety precautions should be taken when observing a solar eclipse?
   a) Staring directly at the Sun is safe during an eclipse.
   b) Using special eclipse glasses or filters to protect your eyes.
   c) No precautions are necessary since eclipses are harmless.

8. What is the term for the outer part of the Sun visible during a total solar eclipse?
   a) Solar flares.
   b) Corona.
   c) Sunspots.

9. How often do total solar eclipses occur at any given location on Earth?
   a) Every month.
   b) Once every few years.
   c) Once every few decades.

10. In what phase must the Moon be for a lunar eclipse to occur?
    a) New Moon.
    b) Full Moon.
    c) First Quarter.

Answers:

1. c) A natural phenomenon where one celestial body casts a shadow on another.
2. c) The alignment of the Sun, Earth and Moon in a straight line.
3. c) When the Moon passes between the Sun and the Earth, blocking the Sun's light.
4. a) Dark and reddish.
5. a) The Moon's orbit is slightly tilted compared to the Earth's orbit around the Sun.
6. b) It is only visible from certain parts of the Earth.
7. b) Using special eclipse glasses or filters to protect your eyes.
8. b) Corona.
9. c) Once every few decades.
10. b) Full Moon.

Feel free to adapt the quiz to fit your students' needs, and make sure to review the answers with them to reinforce their understanding of lunar and solar eclipses.

Ideas of innovative activities besides Minecraft that could be used in tit is lesson on lunar and solar eclipses

1. Shadow Play: Set up a light source and various objects (such as balls or blocks) to represent the Earth, Moon and Sun. Students can experiment with moving the objects around to simulate different eclipse scenarios and observe the resulting shadows.

2. DIY Eclipse Viewer: Have students create their own eclipse viewers using simple materials like cardboard boxes, aluminium foil and a pin. They can use these viewers to safely observe and understand the phenomena of solar eclipses.
3. Virtual Reality (VR) Experience: Use VR technology to simulate a virtual eclipse environment. Students can wear VR headsets and explore a realistic representation of a lunar or solar eclipse, allowing them to visualize the events from different perspectives.

4. Role-Playing: Assign to students different roles, such as the Sun, Moon, Earth and observers, and have them act out a solar or lunar eclipse. This interactive activity helps them understand the relative positions and movements of these celestial bodies.

5. Interactive Websites: Utilize interactive websites or educational apps specifically designed to teach about eclipses. These platforms can include animations, simulations, quizzes and explanatory videos to engage students and reinforce their understanding.

6. Artistic Representation: Encourage students to create artwork depicting lunar and solar eclipses. This can involve various mediums such as painting, drawing, or even creating sculptures. Artistic expression can help students internalize their knowledge and present it in a creative way.

7. Stellarium Software: Introduce students to Stellarium, a free open-source planetarium software. They can use this program to explore the night sky, identify celestial bodies, and simulate eclipses. It provides an immersive learning experience that allows students to interact with astronomical phenomena[x].

8. Astronomy Field Trip: Organize a field trip to a local planetarium or observatory, where students can observe actual celestial events or participate in astronomy-themed workshops. Hands-on experiences like these can deepen their understanding and spark a lifelong interest in astronomy.

9. Collaborative Research Projects: Divide students into small groups and assign each group a specific aspect of eclipses to research, such as the history of eclipses, cultural beliefs, or the science behind them. Have them create presentations or posters to share their findings with the class, promoting teamwork and comprehensive learning.

10. Guest Speaker or Video Conference: Invite a guest speaker, such as an astronomer or astrophysicist, to give a talk or conduct a video conference session with the students. This allows them to interact with experts in the field and ask questions, gaining insights beyond what can be covered in the classroom.

Remember to adapt these activities to suit the age and grade level of your students, ensuring they are engaging, age-appropriate, and aligned with the learning objectives.

Lesson plans

7.6 Exploring the Marvels of Tides

Duration: 1-2 class periods (45-60 minutes per class)

Learning Objectives.

By the end of this lesson, students will be able to:

1. Define tides and understand the factors that influence their occurrence.
2. Describe the relationship between tides and the gravitational pull of the Moon and Sun.
3. Explain the different types of tides (high tides, low tides, spring tides, and neap tides).
4. Identify the practical implications of tides, such as tidal energy and navigation.

Introduction to the topic

Welcome, young explorers, to a captivating adventure through the wondrous world of tides, where the mesmerizing dance between the Earth, the Moon and the Sun shapes the ebb and flow of our vast oceans. Prepare to embark on a journey that will unveil the secrets of these mighty forces that shape our planet.

Picture yourself standing on a sandy beach, the salty breeze caressing your face as you gaze out at the endless expanse of the ocean. Have you ever wondered what causes the tides to rise and fall, like a cosmic heartbeat that pulses across our planet?

Get ready to dive into the realm of astronomy, where we unravel the mysteries of tides and witness the celestial choreography that unfolds above and below the surface of our magnificent oceans.

At the centre of this celestial ballet is our gentle Moon, a celestial marvel that holds a mystical sway over our tides. As the Moon gracefully orbits our Earth, its gravitational pull creates an enchanting interaction with our planet's vast bodies of water.

Imagine the Moon, like a cosmic conductor, orchestrating the rise and fall of the ocean's waters. As it glides across the night sky, it pulls on the water with its gravitational force, causing the tides to swell and recede in a rhythmic symphony.

But the Moon is not alone in this celestial dance. Enter the radiant Sun, our nearest star, whose gravitational influence adds a fascinating twist to the tide's tale. When the Sun and the Moon align or oppose each other, their combined gravitational forces intensify, resulting in the phenomenon known as spring tides.

During a spring tide, the ocean's waters surge to their highest point, revealing the raw power of nature's symphony. It is a time of marvel and awe, as the shorelines are engulfed by waves that crash and roar, reminding us of the immense forces at play in our Universe.

However, the story does not end there. As the Moon continues its celestial journey, it transitions into a graceful waltz with the Sun, creating an intricate interplay of gravitational forces. This mesmerizing celestial dance gives rise to neap tides, a time when the difference between high and low tides is at its minimum.

Neap tides, like a gentle lullaby, calm the ocean's waters, allowing them to retreat and reveal hidden treasures along the shorelines. It is a moment of tranquillity, where the ebb and flow of the tides hold the promise of exploration and discovery.

So, young adventurers, let us set sail on this celestial voyage together. Let us uncover the marvels of tides, as we witness the captivating interplay between the Moon, the Sun and our mighty oceans. From the roar of spring tides to the tranquillity of neap tides, the ebb and flow of our tides beckon us to explore the wonders that lie beyond the horizon.

So, strap on your imagination and prepare to dive into the mysteries of tides, for an ocean of discovery awaits us, where science and wonder merge in a breath-taking display of nature's majesty.

Lesson Outline:

1. **Introduction (5 minutes)**
    - Begin the lesson by asking students if they have ever noticed the water at the beach or near a river rising and falling.
    - Explain that these movements are called tides and are caused by the gravitational pull of the Moon on Earth's oceans.
    - Share a brief video or animation that visually demonstrates the concept of tides. (Example: Brain Stuff - How Do Tides Work? - https://www.youtube.com/watch?v=5ohDG7RqQ9I

2. **Types of Tides (10 minutes)**
    - Introduce the two main types of tides: spring tides and neap tides.
    - Explain that spring tides occur during the full Moon and new Moon phases when the Sun, Moon, and Earth align, resulting in higher high tides and lower low tides.
    - Show a video or visual aid that illustrates the difference between spring tides and neap tides. (Example: How does the Moon control Earth's Tides? - Stargazing – ABC Science https://www.youtube.com/watch?v=8bSXuxjIACU
    - Engage students in a class discussion about the causes and effects of spring tides and neap tides.

3. **The Moon's Influence (15 minutes)**
    - Explain how the Moon's position affects the height and timing of tides.
    - Discuss how the Moon's gravitational pull causes bulges in the Earth's oceans, creating high tides.
    - Show a video or animation that demonstrates the Moon's influence on tides. (Example: Crash Course - Tides: Crash Course Astronomy #8 - https://www.youtube.com/watch?v=KlWpFLfLFBI
    - Conduct a hands-on activity where students use a globe or model Earth to simulate the Moon's gravitational pull and observe the formation of tides.

4. **Tides and Ecosystems (10 minutes)**
    - Explain the impact of tides on coastal ecosystems and their inhabitants.
    - Discuss how tidal patterns influence the distribution of marine life and adaptations of organisms living in intertidal zones.
    - Share images or videos showcasing diverse coastal ecosystems affected by tides. (Example: Ocean MOOC - Coastal ecosystems affected by tides - https://www.youtube.com/watch?v=zhO1BKl8p28
    - Facilitate a class discussion about the importance of tides for coastal ecosystems and the challenges they face due to human activities.

5. **Quiz and Differentiated Activities (15 minutes)- See below**
    - Distribute printed handouts with age-appropriate quizzes to assess students' understanding of tides.
    - Provide differentiated activities based on students' abilities and interests: a. For lower grades (K-2): Colouring sheets or simple drawing activities depicting tides and their effects on marine life. b. For middle grades (3-6): Crossword puzzles or word searches using key terms related to tides. c. For higher grades (7-12): Research assignments on the effects of tides on coastal communities or the connection between tides and lunar phases.

6. **Conclusion and Recap (5 minutes)**
    - Summarize the key points covered in the lesson.
    - Encourage students to continue observing and learning about tides in their everyday lives.
    - Provide additional resources for further exploration, such as books, websites, or documentaries.

Note: It is essential to adapt the activities, vocabulary, and depth of content to suit the grade level of the students. You can use the suggested videos or find alternative media resources suitable for your students' age group.

Minecraft activities about this lesson plan in Astronomine / Minecraft worlds:

World 2 - Solar System

Nº	Topics	Activity 1	Description
1	Tides	Building challenge	In a modern observatory, the player, after a small tutorial, is asked by the lead astronomer to go fix the Tidal Power Plant just outside the observatory as a black out is preventing them from working. Before taking on the quest, the astronomer will ask some questions about tides to be sure that the player knows why it is important to fix the power plant.

Ideas for evaluation

Here is an astronomy quiz on the topic of Exploring the Marvels of Tides, designed for K-12 students. The quiz includes differentiated activities for students of all abilities. The answers are provided at the end.

Quiz: Astronomy Quiz: Exploring the Marvels of Tides

Here is an astronomy quiz on the topic of Exploring the Marvels of Tides designed for K-12 students. The questions are followed by multiple-choice answers, and at the end, you will find the correct answers. The questions are ordered from easier to more challenging, allowing for differentiation among students of different abilities.

Instructions: Answer the following questions related to the fascinating phenomenon of tides.

Choose the best answer from the options provided. The answers will be provided at the end of the quiz.

1. What causes tides on Earth?
   a) The rotation of the Earth on its axis
   b) The gravitational pull of the Moon and the Sun
   c) The movement of water due to winds
   d) The Earth's magnetic field

2. How many high tides and low tides occur in a 24-hour period?
   a) 1 high tide and 1 low tide
   b) 2 high tides and 2 low tides
   c) 3 high tides and 3 low tides
   d) 4 high tides and 4 low tides

3. When do spring tides occur?
   a) During the spring season
   b) When the Moon is closest to the Earth
   c) When the Sun and the Moon are in line with the Earth
   d) When the Moon is farthest from the Earth

4. Which of the following best describes neap tides?
   a) Tides with the greatest difference between high and low tide levels
   b) Tides that occur during the neap season
   c) Tides that occur when the Moon is closest to the Earth
   d) Tides with the least difference between high and low tide levels

5. How long does it take for the Moon to complete one full cycle of its phases?
   a) 7 days
   b) 14 days
   c) 29.53 days
   d) 365 days

Answers:

1. b) The gravitational pull of the Moon and the Sun
2. b) 2 high tides and 2 low tides
3. c) When the Sun and the Moon are in line with the Earth
4. d) Tides with the least difference between high and low tide levels
5. c) 29.53 days

Differentiated Activities:

For students with lower abilities:

1. Provide visual aids, such as diagrams or pictures, to help them understand the questions better.
2. Simplify the language used in the questions and answer options.
3. Offer multiple-choice questions with fewer options to choose from (e.g., true/false questions).

For students with higher abilities:

1. Encourage them to explain their answers or provide additional information to support their choices.
2. Include more challenging questions that require deeper understanding of tidal phenomena.
3. Ask open-ended questions that prompt critical thinking and analysis.

Ideas of innovative activities besides Minecraft that could be used in this lesson on Exploring the Marvels of Tides

1. Tidal Wave Simulation: Create a hands-on activity where students can simulate the formation of tidal waves. Provide trays of water, small boats and objects like rocks or sand to represent the coastline. Have students make observations as they tilt the tray to mimic the gravitational pull of the Moon and the Sun and discuss how tidal waves are formed.

2. Tidal Zone Exploration: Take students on a field trip to a nearby beach or estuary with a diverse tidal zone. Provide magnifying glasses and identification guides to help them explore the different organisms inhabiting the area. Encourage them to make observations about how these organisms adapt to the changing tides and discuss the importance of tidal zones for biodiversity.

3. Tide Height Measurement: Have students track the daily changes in tide height using a tide chart for their local area. Provide them with simple measuring tools like rulers or measuring tapes and ask them to record the tide height at regular intervals throughout the day for several weeks. Help them analyse the data to identify patterns and understand the factors that influence tide height variations.

4. Tidal Energy Design Challenge: Introduce students to the concept of tidal energy and its potential as a renewable energy source. Divide them into small groups and challenge them to design and build models of tidal energy systems using materials like cardboard, tape and small motors. Encourage them to consider factors such as the tidal cycle, efficiency and environmental impact in their designs.

5. Tidal Art: Combine artistic expression with learning about tides by having students create tidal-themed artwork. Provide materials such as watercolours, acrylic paints, or coloured pencils, along with reference images of different tidal landscapes. Ask students to depict the beauty and dynamics of tides in their artwork and explain the scientific concepts behind their creations.

6. Virtual Tidal Simulation: Use interactive online simulations or virtual reality experiences to allow students to explore the marvels of tides virtually. Provide them with guided activities where they can manipulate variables such as the Moon's position, the Sun's influence, or

the shape of the coastline to observe the corresponding changes in tides. Facilitate discussions based on their observations and encourage them to make connections to real-world tidal phenomena.

7. Tidal Poetry or Storytelling: Engage students' creativity by assigning them to write poems or stories inspired by tides. Encourage them to use descriptive language to convey the rhythmic rise and fall of tides, the interactions between land and sea, and the impact on coastal communities. Allow them to share their creations with the class and discuss the emotions and imagery evoked by their writing.

Remember to adapt these activities to the appropriate grade level and incorporate age-appropriate resources to ensure optimal engagement and learning outcomes.

Lesson plans

7.7 Exploring Aurorae, A Celestial Light Show

Duration: 1-2 class periods (45-60 minutes per class)

Learning Objectives

By the end of this lesson, students will be able to:

1. Understand the concept of aurorae and their formation.
2. Identify the different types of aurorae and their characteristics.
3. Recognize the geographical locations where aurorae can be observed.
4. Explore the cultural significance and myths surrounding aurorae.

Introduction to the topic

Attention, young explorers of the cosmos! Prepare to embark on a thrilling journey through the shimmering wonders of our planet's skies as we delve into the captivating realm of aurorae! From the crackling dance of colours in the night to the breath-taking spectacle of nature's light show, we shall unravel the mysteries of these celestial wonders that have fascinated astronomers and poets alike for centuries.

Imagine a canvas of deep, velvety darkness studded with countless twinkling stars. Suddenly, a curtain of ethereal light unfurls across the heavens, casting an otherworldly glow that seems to defy the laws of nature. This mesmerizing phenomenon is none other than the aurora, a celestial display that leaves us spellbound and eager to understand its secrets.

Aurorae, also known as the Northern and Southern Lights, are extraordinary light shows that occur near the Earth's poles. These luminous spectacles are caused by the interaction of charged particles from the Sun with our planet's magnetic field. As these energetic particles collide with atoms and molecules in the upper atmosphere, they release energy in the form of shimmering lights of various colours – a breath-taking symphony of greens, reds, blues and purples painting the sky.

As we embark on our journey to explore aurorae, we will unravel the science behind these awe-inspiring displays. We will learn about the Sun's role as the ultimate cosmic artist, propelling its charged particles towards our planet at incredible speeds. We will discover the magnetic forces that shape Earth's protective shield, guiding the charged particles towards the poles and triggering the radiant dance of light we call the aurora.

But our adventure does not end there! We will delve into the rich cultural tapestry of legends and folklore surrounding the aurora, as ancient civilizations marvelled at this celestial phenomenon and wove enchanting stories to explain its existence. We will also explore how modern technology allows us to study aurorae in unprecedented detail, using satellites, telescopes, and cutting-edge scientific instruments.

Join us on this thrilling expedition through the realms of astronomy, where we will witness the breath-taking aurorae, unlocking their secrets and kindling the spark of curiosity within our minds. So, fasten your seatbelts, young astronomers, for we are about to embark on a voyage that will ignite your imaginations and unveil the dazzling beauty of the Universe's most captivating light show – the aurora!

Lesson Outline

1. **Introduction (5 minutes)**
    - Begin the lesson by capturing students' attention with a short video or a series of captivating images of aurorae. Here are some authentic and checked media links:
        - National Geographic: https://www.youtube.com/watch?v=Vdb9IndsSXk
        - NASA's Astronomy Picture of the Day: https://apod.nasa.gov/apod/ap130326.html
    - Facilitate a brief discussion about the images or video. Ask students if they have ever seen aurorae or heard about them. Encourage them to share their prior knowledge and observations.

2. **What Are Aurorae? (15 minutes)**
    - Use the projector or Smartboard to display an age-appropriate educational video about aurorae. Here is a YouTube video suggestion:
    - Title: "What is an Aurora? :NASA Space Place: https://www.youtube.com/watch?v=PgIKsuZ3RZU
    - After watching the video, lead a class discussion to ensure understanding and address any questions that may arise. Use the following prompts:
        - What are aurorae?
        - How are they formed?
        - What causes the different colours in aurorae?

3. **Types of Aurorae (15 minutes)**
    - Present information about the Aurora Borealis and the Aurora Australis. Explain their unique characteristics and the geographic regions where they can be observed. Free School: https://www.youtube.com/watch?v=nHn5OO1t1yc
    - Utilize a visual aid, such as a chart or diagram, to highlight the key differences between these types of aurorae.
    - Show images or videos that depict each type, emphasizing the distinctive colours and shapes associated with them.

4. **Geographic Locations (10 - 15 minutes)**
    - Display a world map on the projector or Smartboard.
    - https://www.youtube.com/watch?v=HdF6nYTmwvM : KidsMath TV
    - Indicate the regions where aurorae are most commonly observed, such as northern latitudes (Aurora Borealis) and southern latitudes (Aurora Australis).
    - Discuss why these regions are more likely to experience aurorae, mentioning the Earth's magnetic field and its interaction with charged particles from the Sun.

5. **Cultural Significance and Myths (15 – 30 minutes)**
    - Explain that aurorae have captivated people throughout history and are significant in various cultures. Seth Aam Smith: The Legend of the Northern Lights : Alaska https://www.youtube.com/watch?v=ljLbeISADzo
    - Share stories or legends from different cultures that associate aurorae with supernatural or mythical events. BBC Earth Unplugged: https://www.youtube.com/watch?v=lcKe9EI2Vfs
    - Encourage students to reflect on their own cultural perspectives and stories related to aurorae, if applicable.

6. **Differentiated Activities (20 minutes)**
    - Provide differentiated activities to cater to students of all abilities. Offer a variety of choices, such as: a) Artistic Expression: Students can create their own visual representation of aurorae using art supplies. They should consider colours, shapes and patterns seen in real aurorae.
    - b) Writing Assignment: Students can write a short paragraph describing their imaginary experience of witnessing an aurora.
    - c) Research Project: Assign older or more advanced students the task of researching the science behind aurorae or delving deeper into cultural beliefs and myths associated with them.
    - d) Quiz: Distribute age-appropriate quiz sheets to assess students' understanding of aurorae. You can create your own quiz questions based on the lesson content. (***See Below).***

7. **Conclusion (5 minutes)**
    - Gather students together and ask a few volunteers to share their artwork or written assignments related to aurorae.
    - Recap the key points discussed throughout the lesson, emphasizing the formation, types, geographic locations and cultural significance of aurorae.
    - Conclude by highlighting the awe-inspiring beauty of aurorae and their importance in appreciating the wonders of the Universe.

Note: It is recommended to adapt the lesson duration and activities according to the grade level and individual needs of the students. Additionally, ensure that the videos and media links provided are still active and appropriate at the time of the lesson.

Minecraft activities about this lesson plan in Astronomine / Minecraft worlds:

World 1 - Observatory

Nº	Topics	Activity 1	Activity 2	Description
2	Auroras	Puzzle Solving	Quiz	After building the observatory, the player is faced with a puzzle in which they have to put in chronological order pictures of the Aurora taken by the lead astronomer. They will also have to reply to a small quiz about auroras done by the astronomers.

Ideas for evaluation

Here is an astronomy quiz on the topic of Exploring Aurorae, designed for K-12 students. The quiz includes differentiated activities for students of all abilities. The answers are provided at the end.

Exploring Aurorae Quiz (use internet to find the correct answers):

1. **Multiple Choice:**

Where can you usually see the Northern Lights?
a) Near the equator
b) Near the North Pole
c) Near the South Pole

Correct answer: b) Near the North Pole

What is another name for the Northern Lights?
a) Aurora Australis
b) Aurora Borealis
c) Aurora Solaris

Correct answer: b) Aurora Borealis

Which color is NOT commonly seen in auroras?
a) Pink
b) Brown
c) Green

Correct answer: b) Brown

The Southern Lights are also called:
a) Aurora Borealis
b) Aurora Australis
c) Aurora Polaris

Correct answer: b) Aurora Australis

Auroras are caused by:
a) Clouds
b) Rainbows
c) Charged particles from the Sun

Correct answer: c) Charged particles from the Sun

The best time to see auroras is during:
a) A full Moon night
b) A cloudy afternoon
c) A clear, dark night

Correct answer: c) A clear, dark night

Auroras usually occur in a belt called the:

a) Aurora Zone
b) Ozone Layer
c) Equator

Correct answer: a) Aurora Zone

Which of the following can affect the intensity and frequency of auroras?
a) Solar flares
b) Lunar phases
c) Ocean tides

Correct answer: a) Solar flares

In which of these countries might you NOT expect to see the Northern Lights?
a) Norway
b) Canada
c) Mexico

Correct answer: c) Mexico

2. **True or False:**

a) Aurorae are only visible during the daytime. (True/False)
Correct answer: False

b) Aurorae occur in both the Northern and Southern Hemispheres. (True/False)
Correct answer: True

c) Aurorae are caused by interactions between the Earth's magnetic field and charged particles from the Sun. (True/False)
Correct answer: True

Design a poster that explains the science behind aurorae. Include illustrations, diagrams, and key information.

Note 1: The different colours observed in aurorae are caused by the interaction of charged particles from the Sun with atoms and molecules in the Earth's atmosphere. Oxygen atoms produce green and red light, while nitrogen atoms produce blue and purple light.

Note 2: For the creative activity, there are no fixed answers. Students are encouraged to use their creativity to design informative posters about aurorae, including key scientific concepts and illustrations.

Ideas of innovative activities besides Minecraft that could be used in this lesson on Exploring Aurorae

1. **Auroral Art Gallery:** Organize an art activity where students create their own interpretations of the Northern or Southern Lights using various art materials such as paints, pastels, or coloured pencils. Encourage them to explore different colours, patterns, and textures to capture the ethereal beauty of the aurora borealis or aurora australis.

2. **Science Fair Showcase:** Host a science fair focusing on auroras, where students can conduct experiments, create models, or prepare presentations to showcase their understanding of the phenomenon. Provide them with resources, such as videos and articles, to research and gather information about aurorae. Encourage them to explore different aspects, such as the science behind auroras, their impact on Earth's atmosphere, or the cultural significance in different regions.

3. **Virtual Field Trip:** Arrange a virtual field trip to a location where auroras are commonly observed. Collaborate with scientists, researchers, or photographers who specialize in aurora studies to guide the virtual tour. Students can ask questions, learn about the specific characteristics of aurorae, and understand the environmental conditions necessary for their occurrence.

4. **Auroral Storytelling:** Invite a guest speaker, such as a local indigenous elder or a writer, to share stories and legends about the aurora lights from different cultures. This activity will help students appreciate the cultural significance of auroras and understand how they have been perceived and interpreted throughout history.

5. **Aurora Photography Contest:** Organize a photography contest focused on capturing auroras. Encourage students to venture outside during night-time and take pictures of the night sky, especially in regions where auroras are more likely to occur. Provide resources and tutorials on basic astrophotography techniques and let them experiment with exposure settings and compositions to capture stunning images.

6. **Magnetic Exploration:** Create hands-on experiments to teach students about the connection between Earth's magnetic field and auroras. Provide magnetic compasses and demonstrate how the needle aligns with the Earth's magnetic field. Then, simulate the interaction between the solar wind and Earth's magnetosphere using magnets and a model of Earth. This activity will help students understand how charged particles create the colourful light displays we observe as auroras.

7. **Aurora Poetry Slam:** Encourage students to express their creativity by writing and performing original poems inspired by auroras. Host a poetry slam where they can share their works, exploring themes such as the beauty, mystery, and scientific aspects of the auroras. This activity not only fosters language and artistic skills but also encourages students to dive deeper into their understanding of aurorae.

8. **Dance of the Lights:** Introduce a movement-based activity where students can create dance routines or choreographies inspired by the fluid, dynamic movements of auroras. Encourage them to use their bodies to depict the swirling lights, the shifting colours and the undulating shapes of the auroras. This activity combines physical activity, artistic expression and scientific understanding.

Remember to adapt the activities based on the age and grade level of the students, ensuring that the content and complexity are appropriate for their developmental stage.

Lesson plans

7.8 Tools of the trade

Activity Description

This is a four-lesson class proposal (50 minute *2) for 10-year-old students.
It combines teachers' explanations and Minecraft exercises to carry out on computers.

Lesson structure

Day 1: Introduction to Astronomical Tools and Telescopes (50 minutes)

- Introduction (10 minutes): Begin with an introduction to the tools astronomers use to explore space. Explain that these tools are like our eyes and ears in space, helping us see and learn about faraway things.
- Telescopes (30 minutes): Introduce the concept of telescopes. Explain in simple terms how telescopes help us see things that are far away in space. Discuss the basic differences between telescopes that use lenses (like a magnifying glass) and telescopes that use mirrors. Use images or models to help visualize the concepts.
- Activity (10 minutes): End the class with a Minecraft game. If possible, simulate a telescope. Alternatively, give link to web about astronomy that show images of telescopes.

Day 2: Cameras and Detectors (50 minutes)

- Cameras (20 minutes): Begin explaining how cameras in space work. Explain that just like the cameras we use on Earth, space cameras capture pictures of faraway things in space. Use images taken by space cameras to illustrate the concept.
- Detectors (20 minutes): Introduce the concept of detectors. Explain that detectors are tools that help us learn more about the things we see in space. For example, they can help us find out how hot a star is or what a planet is made of.
- Review and Activity (10 minutes): Minecraft game to differentiate telescopes, cameras, and detectors. End the class with a fun game to reinforce the students' understanding of these astronomical tools.

Day 3: Introduction to Observatories and Space Telescopes (50 minutes)

- Introduction (10 minutes): Begin with an introduction to the concept of observatories and space telescopes. Explain that these are special places and tools that scientists use to observe the Universe and learn more about it.

- Observatories (20 minutes): Introduce the concept of observatories. Explain that these are places on Earth where scientists use large telescopes and other tools to observe space. Discuss some famous observatories like the Palomar Observatory and the Very Large Telescope (Paranal), the Hubble Space Telescope and the Chandra X-ray Observatory.
- Space Telescopes (20 minutes): Introduce the concept of space telescopes. Explain that these are like observatories, but they are in space! This allows them to see things that we cannot see from Earth because they are not blocked by our atmosphere.
- Activity (10 minutes): End the class with a handmade activity where students can build their own observatory or space telescope. Alternatively, provide links to websites that show images of different observatories and space telescopes.

Day 4: Human Exploration of the Solar System (50 minutes)

- Introduction (10 minutes): Begin with an introduction to the concept of human exploration of the Solar System. Explain that this involves sending people or robots to other planets and Moons to learn more about them.
- Human Exploration (30 minutes): Discuss the history of human exploration of the Solar System, from the first Moon landing to current missions to Mars. Discuss the challenges and benefits of exploring space.
- Review and Activity (10 minutes): Make a play where students can simulate a space mission, such as landing on the Moon or exploring Mars. Alternatively, provide links to websites that show images and videos of real space missions.

Lesson guide

Description

In the following set of lessons, we will introduce the essential tools astronomers use to explore the Universe. We will begin with Telescopes, Cameras and Detectors, explaining how they work and their importance in capturing images and data from celestial bodies. We will then discuss Observatories and Space Telescopes, highlighting their role in providing clearer and more detailed views of the Universe, free from Earth's atmospheric interference. We will also cover the exciting topic of Human Exploration of the Solar System, discussing past missions like Apollo Moon landings, current endeavours like Mars rovers, and future plans for human space travel. This chapter will equip students with an understanding of the technology and efforts that enable us to explore and learn more about our Universe.

Learning goals

- **Understanding the Role of Telescopes, Cameras, and Detectors:** Students should be able to explain in simple terms how telescopes help us see faraway things in space, how cameras capture pictures of these faraway things, and how detectors help us learn more about them. They should understand that these tools are like our eyes and ears in space, helping us explore and learn about the Universe.

- **Recognizing Different Types of Telescopes:** Students should be able to identify and describe the basic differences between telescopes that use lenses (like a magnifying glass) and telescopes that use mirrors. They should also understand that the biggest telescopes are on the ground, and there are also telescopes in space, and these different types of telescopes help us see different things in space.

- **Understanding the Role of Observatories and Space Telescopes**: Students should be able to explain in simple terms how observatories and space telescopes help us observe the Universe. They should understand that observatories are places on Earth where we use large telescopes and other tools to observe space, and space telescopes are like observatories but in space, allowing us to see things that we can't see from Earth.

- **Recognizing Different Types of Observatories and Space Telescopes**: Students should be able to identify and describe the basic differences between ground-based observatories and space telescopes. They should also understand that different observatories and space telescopes are designed to observe different things, from planets and stars to galaxies and nebulae.

- **Understanding the Concept of Human Exploration of the Solar System**: Students should be able to explain in simple terms what it means to explore the Solar System. They should understand that this involves sending people or robots to other planets and Moons to learn more about them.

- **Recognizing Key Milestones in Human Exploration of the Solar System**: Students should be able to identify and describe key milestones in the human exploration of the Solar System, from the first Moon landing to current missions to Mars. They should understand the challenges and benefits of exploring space, and the role of international cooperation in space exploration.

Introduction to the topic

Welcome, young astronomers, to our exploration of the "Tools of the Trade" used in astronomy! In this exciting part of our journey, we'll delve into the fascinating world of telescopes, cameras, and detectors, which serve as our eyes and ears in the vast expanse of space. We'll discover how observatories on Earth and space telescopes orbiting our planet provide us with stunning images and invaluable data from the farthest reaches of the Universe. Lastly, we'll embark on a thrilling adventure through the history of human exploration of the Solar System, from the first steps on the Moon to the rovers on Mars. These tools and endeavours have expanded our understanding of the Universe and our place within it, and now, it's time for us to learn more about them!

Minecraft activities about this lesson plan in Astronomine / Minecraft worlds:

World 3

Nº	Topics	Activity 1	Activity 2	Description
1	Stellar structure/ Nuclear Reaction	Quiz	Building challenge	In the same modern laboratory of the previous world, the lead astronomer will ask the player to go mine some proton blocks found inside the Sun. In order to do so, there will be a tunnel room with multiple gates, all based on the internal structure of the Sun; said gates will open when the player recognizes what they represent (namely, the first room will be the photosphere, the second the convective zone and so on until in the core are found the protons). Reaching the end of the tunnel, the player will mine 2 proton blocks and 2 neutron blocks, crafting a helium block and an energy block.
2	Stars	Puzzle		Having the block energy, players will insert it inside one wall and light up the different items present on a shelf. Said items will represent the different type of stars (protostar, red dwarf, solar type, hot supergiant, red giant, white dwarf, neutron star, black hole). Players will have to collect said items and re-order them by evolutionary status.
3	Galaxies	Building Challenge		Entering a new room, that could be the room from the previous world where the Solar System model is present, players will have to look around for pieces of the Milky Way. Collecting the nucleus, bulge, disk with spiral arms and the halo, they will be able to craft a Milky way item. They will then hand it to the astronomer, who will test the student knowledge.
4	Galaxies	Quiz		The astronomer will question students about galaxies, about the features of each part of the milky way and about the blue/red shift.
5	Galaxies	Puzzle		In a similar puzzle to the ones of the stars, on a shelf players will find different items (planets, comets, asteroids, Moons/satellites, Sun) - (stars, clusters (Messier 42/45/13), nebulae, pulsars, black holes), which will have to be sorted into two chests by being Solar System objects or Galactic objects.
6	Are we alone	Quiz	Puzzle	Solving the last puzzle, the player will be subjected to a final quiz about the necessary conditions for life on earth. Then, the student will be presented with three tiny stellar system models, one based on a cool star, the second on a solar-type star and the last on a hot star. Each model will have three circles around its star, representing zones. The player will have to put an earth-item inside the respective habitable zone of each system. Doing so, the game will finish.

Ideas for evaluation

Search the web to find the closest real telescopes, cameras and detectors from the school.

Ideas of innovative activities besides Minecraft that could be used in this lesson

ESA's Education Resources website: The European Space Agency (ESA) has a dedicated Education section on their website. It offers a variety of resources, including information about different space tools and technologies.

https://www.esa.int/Education

Calendars of astronomy and night sky events, for 2023 and beyond:

- In The Sky: https://in-the-sky.org/newscalyear.php?year=2023&maxdiff=7
- Star Walk: https://starwalk.space/en/news/astronomy-calendar-2023
- Sea Sky: www.seasky.org/astronomy/astronomy-calendar-2023.html
- Go Stargazing: https://gostargazing.co.uk/astronomical-events-calendar/
- Go Astronomy: www.go-astronomy.com/solar-system/event-calendar.htm
- Time and Date: www.timeanddate.com/astronomy/sights-to-see.html
- Royal Museums Greenwich: www.rmg.co.uk/stories/astronomy/guide-night-sky
- Photo Pills (Photography Guide): www.photopills.com/articles/astronomical-events-photography-guide

Lesson plans

7.9 Stars and Nebulae

Activity Description

This module presents the subject of stars, their properties, structure and evolution. The contents are based on the 7th grade science (age 12) science curriculum in Portugal, but it can be adapted to younger or older students.

The module is divided in three lessons. The first one concerns the initial knowledge of the students about the stars, presenting the Sun as an example of star, and then introducing the concept of light year. The second lesson explores the basic characteristics of stars such as sizes, masses, temperatures and composition. The internal structure of stars is also presented in this lesson, as well as the nuclear reactions that comprise their energy source. Finally, the third lesson presents stellar evolution, from star forming regions to red giants and supernovae.

The lesson plans also include suggestion of additional hands-on activities and digital tools that will enrich the learning experience, as well as outlines of the missions available in the Minecraft scenarios developed by the Astronomine project.

Introduction to the topic

Welcome, young astronomers! We will now start our exploration of stars. During a starry night you can see hundreds, if not thousands of stars in the sky, but did you know that stars are visible during daytime? Yes, the Sun is the closest star from us! All the other stars are more or less like the Sun, but so far away that they look like tiny specks of light even with the largest telescopes.

Be ready to explore the fascinating Universe of stars, get to know their main properties, understand what is the source of the light that make them so bright, and follow the different fates of stars during their evolution.

Lesson structure

Lesson 1: What are stars? (50 minutes)

1 - Introduction (10 minutes): The teacher starts the lesson by asking the students about their knowledge of stars. Among the possible answers given by the students we will find subjects like what stars are made of, how far and how big they are, and how hot/big they are.

Ask the students if they know any star names and where they are in the sky.

2 - The Sun as a star (15 minutes): Ask the students when they can see stars in the sky. Ask them if it is possible to see stars during daytime, and then mention that the Sun is the nearest star.

Ask the students about their knowledge on the Sun (how big, heavy, hot and far it is). Briefly describe the Sun's main characteristics (size, mass, distance, composition and surface temperature).

Then show a picture is scale of the Sun and the Earth. For instance, if the Earth is the size of a 1-euro cent coin, the Sun would be 177 cm in diameter, 162 meters away. Tell them that the average distance from the Earth to the Sun, the astronomical units, is 150 million km.

Finally, present an image showing the main characteristics of the Sun's surface such as sunspots and flares.

3 - Other stars (15 minutes): Tell the students that every star in the Universe is somewhat akin to the Sun, some larger, some smaller, some hotter and some cooler. The main point is to show that the Sun is an average star among the myriad of stars in the Universe.

Ask the students if they know how far stars are. Tell them that they are so far away that it does not make sense to measure the distance in kilometres and instead astronomers use light years.

Proceed to the definition of a light year and calculate how much a light year is in kilometres by multiplying the speed of light in km/s to the number of seconds in one year. The result is the number 9 followed by 11 zeroes, or more precisely 9.46 x 10^{12} kilometres.

Minecraft Activity (10 minutes): Activity in Minecraft. See suggestions for activities at the end of the lesson plan.

Lesson 2: Stellar structure (50 minutes)

Introduction (5 minutes): Ask students if they know what stars are made of, and what is their source of energy.

Stellar composition and properties (15 minutes): Tell the students those stars are made of hydrogen and helium, the two most common elements in the Universe. Tell those stars are very hot, with surface temperatures that range from 3000 to 100000 degrees. Tell them that at these temperatures matter exists at a state named plasma, which is a very hot and electrically charged gas.

Explain that star colours change according to temperature, with cooler stars being red-orange, and hotter stats being blue. Also explain that stars vary greatly in size, from regular stars like our Sun to giant stars like Betelgeuse which diameter is hundreds of times larger than the Sun's.

Explain that stars do not burn like a normal fire on Earth; instead, the energy source is located in the star's core, where the temperature and pressure are so high that allows spontaneous nuclear fusion reactions to take place.

Stellar internal structure (10 minutes): Present a diagram showing the main internal structure features of stars, including the core, radiative envelope, convective zone and photosphere. Tell the students that temperature and pressure increaser inwards, and that the stars' weight is supported by the energy generated by the core. Tell that the energy produced in the core takes thousands of years to reach the surface, where it can finally escape as starlight.

Stellar nucleosynthesis (10 minutes): Ask the students if they know what a nuclear fusion reaction is. Explain that this reaction is different from the atomic bombs. Then explain that nuclear fusion resembles a chemical reaction, where you have an initial set of ingredients that combine and result in a different element, and that during this process energy is released. Tell the students that the energy released is due to the fact that the final product mass is smaller than the initial mass, and that this difference in mass is converted to energy according to Einstein's famous formula $E = mc^2$.

Show a diagram representing the proton-proton chain reaction that happens in the Sun's core. Explain the in this reaction 4 hydrogen atoms combine to yield one helium atom, with the difference in mass converted to energy. Explain that this is the main nuclear reaction taking place in the stars everywhere in the Universe.

Finally, explain that as stars use the hydrogen in their cores, the core becomes depleted of hydrogen and eventually runs out of it, causing a lack of nuclear fuel leading to drastic changes in stellar structure.

Minecraft Activity (10 minutes): Activity in Minecraft. See suggestions for activities at the end of the lesson plan

Lesson 3: Stellar evolution (50 minutes)

Introduction (5 minutes): Ask the students if they think stars live forever, or if they have a beginning and an end. Then ask how stars can be "born" and "die". You'll probable hear something about stellar explosions and black holes during this initial conversation.

How stars form (10 minutes): Explain that stars are made mostly of hydrogen and helium, the two most abundant gases in the Universe. Show the students pictures of nebulae and explain that these are huge clouds of gas and dust scattered around the galaxy. Tell them that this gas and dust are the building materials of stars.

Show the students pictures of protostars in the Orion Nebula. Explain that the dark blobs are actually stars in the making, and the process takes millions of years to complete. Explain that some of the gas and dust in the nebula forms a spherical cloud about the size of our Solar System, that collapses due to gravity. As it collapses, the temperature in the centre increases, until the gas is so hot that the nuclear reactions start to take place. At this moment is said that a star is born. Explain that our Solar System was born in such a cloud about 4.5 billion years ago.

Stellar evolution (15 minutes): Ask the students if they think that there are planets around other stars. Then explain that planets are formed together with the stars, from the same material in the initial nebula. Show the students pictures of protoplanetary disks and explain that these disks around young stars are planetary systems in the making. Tell them that the material in the disk gradually dissipates leaving only the planets around the star.

Now ask the students if stars shine forever. Make them conclude that eventually all the hydrogen in the core of the star that is responsible for the energy generation will be used. When that happens, the star cannot support its own weight and will collapse, and as a consequence the internal temperature will increase, leading to a new set of nuclear reactions.

Present the students a slide with different nuclear reactions that take place in the core of stars. Explain that all chemical elements in the Universe apart from Hydrogen, Helium and Lithium were forged in the core of stars that no longer exist. Tell the students that the oxygen we breath was once inside a star. Make them understand that our planet is literally made of recycled stardust.

Dear of stars (10 minutes): Continue the description of stellar evolution by telling the students that there are different ends to the life of a star. First, describe the fate of low mass stars like our Sun. After the hydrogen in the core is exhausted, solar-type stars will inflate and become red giants. Our Sun itself will engulf the inner planets, may be even Earth. It will be the end of life on our planet, but this will happen in a very far away future, billions of years from now. After this red giant phase, the outer layers of the star will gradually be lost to space, forming a cloud of gas known as planetary nebulae, with the exhausted core in the centre - a white dwarf star. Show images of planetary nebulae and tell the students that this will be the fate of our Sun billions of years from now.

Now discuss the evolution of high mass stars. In these stars, nuclear reactions allow the production of heavier chemical elements, until Iron production is reached. This marks the endpoint of nucleosynthesis, as nuclear reactions involving iron do not release sufficient energy to counteract gravity. As a result, the whole star collapses very rapidly and try to compress the core, which rebounds causing a gigantic explosion - a supernova, that can briefly shine as bright as a billion Suns. Show images of supernova remnants to illustrate this.

Finally, tell the students that the core of a massive star can have two fates: a very dense compact core known as a neutron star, or an even more compact object which gravitational field is so strong that not even light can escape it - a stellar black hole. Tell students those supernovae are responsible for the production of heavy chemical elements and that eventually a explosion will result in a black hole.

Minecraft Activity (10 minutes): Activity in Minecraft. See suggestions for activities at the end of the lesson plan.

Minecraft activities about this lesson plan in Astronomine / Minecraft worlds:

World 2 - Solar System

Nº	Topics	Activity 1	Activity 2	Description
3	Solar System	Building challenge	Quiz	After fixing the observatory, the player is asked to build a small replica of the Solar System. In order to do so, they will get materials from the laboratory based on the elements that make the planets (Eg. They will gather red sandstone for Mars). They will be required to get multiple materials for planets that have multiple features (eg. One element for the body of Saturn, another for its rings). The elements could be showcased as unknown items and the player will have to run them through a detector to understand their nature. After creating all the planets (by combining the correct elements in a machine) they will have to position them in the correct spot of the Solar System model
4	Solar System	Quiz		The planets will be scaled and will feature their unique aspects such as rings and Moons. The player will have to observe those and answer to a serious of questions made by the astronomers (eg. How many Moons in Jupiter? Which planet is the closest to the Sun? Etc.)
5	Solar System Scales	Exploration		Solving the quiz, the astronomer will reward the student with a prize. After receiving and wearing a space suit, the student will click on a button that will teleport it next to the Sun. A dialogue coming from the astronomer will pop out, mentioning that at said distance the Earth would look so tiny that the student could hold it into their hand. The earth block will appear in the student hand to show comparison.

World 3

Nº	Topics	Activity 1	Activity 2	Description
1	Stellar structure/ Nuclear Reaction	Quiz	Building challenge	In the same modern laboratory of the previous world, the lead astronomer will ask the player to go mine some proton blocks found inside the Sun. In order to do so, there will be a tunnel room with multiple gates, all based on the internal structure of the Sun; said gates will open when the player recognizes what they represent (namely, the first room will be the photosphere, the second the convective zone and so on until in the core are found the protons). Reaching the end of the tunnel, the player will mine 2 proton blocks and 2 neutron blocks, crafting a helium block and an energy block.
2	Stars	Puzzle		Having the block energy, players will insert it inside one wall and light up the different items present on a shelf. Said items will represent the different type of stars (protostar, red dwarf, solar type, hot supergiant, red giant, white dwarf, neutron star, black hole). Players will have to collect said items and re-order them by evolutionary status.
3	Galaxies	Building Challenge		Entering a new room, that could be the room from the previous world where the Solar System model is present, players will have to look around for pieces of the Milky Way. Collecting the nucleus, bulge, disk with spiral arms and the halo, they will be able to craft a Milky way item. They will then hand it to the astronomer, who will test the student knowledge.
4	Galaxies	Quiz		The astronomer will question students about galaxies, about the features of each part of the milky way and about the blue/red shift.
5	Galaxies	Puzzle		In a similar puzzle to the ones of the stars, on a shelf players will find different items (planets, comets, asteroids, Moons/satellites, Sun) - (stars, clusters (Messier 42/45/13), nebulae, pulsars, black holes), which will have to be sorted into two chests by being Solar System objects or Galactic objects.
6	Are we alone	Quiz	Puzzle	Solving the last puzzle, the player will be subjected to a final quiz about the necessary conditions for life on earth. Then, the student will be presented with three tiny stellar system models, one based on a cool star, the second on a solar-type star and the last on a hot star. Each model will have three circles around its star, representing zones. The player will have to put a earth-item inside the respective habitable zone of each system. Doing so, the game will finish.

Ideas for evaluation

Genially (or other) presentation once they have finished this chapter, presenting what they learnt during the lessons.

Ideas of innovative activities besides Minecraft that could be used in this lesson

- Papercraft model of the Sun Earth system https://sunearthday.nasa.gov/2007/materials/solar_pizza.pdf
- Relative sizes of celestial objects https://neal.fun/size-of-space/
- Nucleosynthesis game https://dimit.me/Fe26/

Lesson plans

7.10 Galaxies and the Universe

Activity Description

This module presents the subject of galaxies, first introducing our own galaxy, the Milky Way, its structure and components, followed by a presentation of other galaxies in the Universe, its different types, how they are distributed, and its connection to the history of the Universe. The contents are based on the 7th grade science (age 12) science curriculum in Portugal, but it can be adapted to younger or older students.

The module is divided in three lessons. The first one concerns the initial knowledge of the students about our own galaxy, and what kind of objects we can find in it. The second lesson explores other types of galaxies, and how they are distributed. In this lesson, students will be presented to the Messier Catalogue of objects which congregates objects from our own galaxy and beyond. Finally, the third lesson presents a discussion of the large scale structure of the Universe, its expansion, and the Big Bang hypothesis.

The lesson plans also includes suggestion of additional hands-on activities and digital tools that will enrich the learning experience, as well as outlines of the missions available in the Minecraft scenarios developed by the Astronomine project.

Introduction to the topic

Hello again, space explorers! Are you ready for the biggest journey? Take a look at the sky and try to count how many stars you can see. What if I tell you that even in the darkest of nights, you could only see a few thousand stars, and that is not even 0,000001% of the stars in our Galaxy? And that there are way more galaxies in the Universe than stars in our own Galaxy? Isn't it mind-blowing?
Join us in this exploration of the Universe at large - from our cosmic backyard to infinity and beyond, racing back from today till the dawn of time.

Lesson structure

Lesson 1: Our Galaxy, the Milky Way (50 minutes)

1 - Introduction (10 minutes):

Ask the students where the Earth is located. You'll probably hear that it is in the Solar System. Then ask if the Solar System belongs to something larger. You'll probably hear "The Universe", but some students might answer "galaxy" or "milky way". Proceed explaining that the Sun is part of an immense stellar system, known as the Milky Way Galaxy.

Then ask your students what kind of of celestial objects can be find inside a galaxy. They will probably mention Solar System objects such as planets, comets, and asteroids, but will also mention others as black holes, nebulae, clusters etc.

2 - Our Galaxy (20 minutes):

It's time to organize the student's answers to the previous questions. First, organize the elements in two groups: Solar System objects (planets, comets, asteroids, Moons/satellites, Sun), and galactic objects (stars, clusters, nebulae, pulsars, black holes).

Mention that every star we can see at night is indeed a Solar System, and that astronomers agree that most, if not all, stars have planets (and comets, asteroids, Moons etc) around it.

Now show a picture of the night sky where the Milky Way is visible. Explain that the Milky Way has its name because it resembles a milky patch of stars through the sky, but that nowadays it is only visible from very remote locations devoid of artificial light. Explain that the Milky Way we see is in fact the light of millions of stars that form our own Galaxy.

Now show a picture of the Milky Way structure, describing its mains features: the nucleus, bulge, disk (with spiral arms), and halo. Mention that the Milky Way is a spiral galaxy, with the Solar System located in the disk, roughly midway between the galaxy centre and the disk edge.

Point out the main differences between the disk and the other regions of the Galaxy, namely that the disk concentrates most of the gas and dust (in form of nebulae) which therefore results in young, hot and blue stars, and open stellar clusters. On the other hand, the bulge and halo are devoid of gas and dominated by evolved, cool and red stars. Finally, mention that the nucleus is the most mysterious region of the Galaxy, but there is sound evidence that a supermassive black hole lurks in it.

3 - Nebulae and Clusters (10 minutes):

Show a picture of the Orion Nebulae (Messier 42). Recall from the previous lesson that stars are formed from gas in interstellar clouds. Explain that very large clouds such as the Orion Nebula have enough material to form thousands of stars. Mention that once the star forming process is over, after several millions of years, the end product is a star cluster.

Show pictures of two stellar clusters: the Pleiades (Messier 45) and the Great Hercules Cluster (Messier 13). Ask the students what are the differences between the two clusters. Explain that the Pleiades is an open cluster, formed of young stars less than one hundred million years old, and that the hottest and blue stars are still shining. Then explain that Messier 13 is a globular cluster, a much older structure formed billions of years ago, and composed of cool and red stars. Tell that open clusters are located in the galactic disk, where gas and dust is abundant, whereas globular clusters are scattered around the nucleus, on the bulge and halo regions

Minecraft Activity (10 minutes): Activity in Minecraft. See suggestions for activities at the end of the lesson plan.

Lesson 2: Other Galaxies (50 minutes)

Introduction (5 minutes):

Start the lesson asking the students if they think the Milky Way is the only galaxy in the Universe. If they answer yes, ask if they can name any other galaxies. Perhaps someone will mention the Andromeda galaxy. Ask if they know how many galaxies exist in the Universe.

Galaxy types (10 minutes):

Show pictures of two types of galaxies: a spiral galaxy (such as Messier 31), and a elliptical galaxy (such as Messier 87). Ask the students about the differences between the two galaxies.

Explain that galaxies can be classified in two groups according to their structures: spiral galaxies, that resemble our own Milky Way, and elliptical galaxies, which look like giant globular clusters without any particular structures.

Then, show pictures of some irregular galaxies (such as IC 4710 and IC 3583) and ask the students to classify them as spiral or elliptical. Tell the students that some galaxies do not fit in this simple scheme, and that are classified as irregular galaxies.

Interacting Galaxies (10 minutes):

Show pictures of Messier 51 and the Antennae Galaxies (NGC 4038/NGC 4039). Ask the students their impressions of what might have happened. Some students might say that the galaxies are touching each other.

Tell the students that galaxies are vey massive objects and, therefore, have very strong gravitational fields. Gravity from a galaxy influences its neighbour, attracting it and resulting in interaction. Tell the students that this process takes several millions of years, but scientists are confident that this interaction results in a merger between the interacting galaxies.

The Messier Catalogue (10 minutes):

It’s time to reflect on what was discussed. Show a picture of the Messier Catalogue. Ask the students if they can identify the different types of objects in the catalogue (clusters, nebulae, and galaxies). Tell the story of Charles Messier and how he assembled his famous catalogue, and then invite the students to further explore its components, using digital resources such as Stellarium or World Wide Telescope.

Minecraft Activity (10 minutes): Activity in Minecraft. See suggestions for activities at the end of the lesson plan

Lesson 3: The Universe at Large (50 minutes)

Introduction (5 minutes):

Start the lesson asking the students how many galaxies exist in the Universe. Show the students a picture of the Virgo Cluster of galaxies, and tell them this is a local gathering of thousands of galaxies, much alike an open stellar cluster. Then show a picture of the Hubble Deep Field and tell the students that the image show a very tiny patch of the sky, loaded with galaxies.Tell them there are more galaxies in the Universe than stars in our Galaxy.

Distances in the Universe (10 minutes):

Ask the students how it is possible to know the distance to other galaxies. Explain that measuring distances between stars is a very difficult task, and that the most reliable tool involves comparing brightness of objects.

Propose a simple thought experiment, where a small torch is moved away from the observer. Ask the students how they think the brightness of the torch will behave as it recedes. They will conclude that the further away the torch is, the fainter it appears. Explain that astronomers employ the same reasoning, that is, apparent brightness decrease with distance.

Continue explaining that if we know how bright an object is, and how bright it appears to us, then it is possible to calculate the distance to the object based on the difference of observed and real brightness. Tell the students that astronomers use stars as standards in this type of calculation, and when the detect a star in a distant galaxy, and they know how bright a star is, then it is possible to derive the distance to the host galaxy.

Redshift (10 minutes):

Ask the students if it is possible to know if a galaxy is moving away or towards us. They will probably answer it is impossible since they are so far away.

Tell the students it is possible to measure this, by examining the light emitted by galaxies very carefully. First, explain that light is a kind of wave, an electromagnetic wave, and it behaves much alike other waves such as sound waves.

Then, introduce a particular phenomena involving sound waves emitted by moving sources: the Doppler effect. Ask if the students have ever heard a police or ambulance siren moving by. Ask if the pitch of the sound changed as the car moved. With a simulator, reproduce the changing sound.

Explain that the pitch in sound waves are correspondent to frequency, and that light waves are likewise affected by the movement of the source, with the frequencies shifted from blue (high) to red (low) as the emitting source approaches and recedes. Finally, explain that it is possible to calculate the velocity of a light source, such as a star or galaxy, solely on analysing the shifts in light frequency.

The Expanding Universe and the Big Bang Model (15 minutes):

It's time to bring it all together. Tell the history of Edwin Hubble, the astronomer who realised that some of the nebulae in Messier Catalogue were indeed other galaxies. Explain that he measured not only the brightness of standard stars, from which he could derive the galaxy's distance, but as well measured the shifts in light frequency that led to velocity determination.

Explain that after years of observations, Hubble obtained a sample of galaxies with both distances and velocities accurately measured and, to his surprise, a trend was detected, with galaxies receding faster from us there farther away they were.

Ask the students what kind of conclusion can be obtained from this fact. There can only be two type of conclusions: either the Earth is standing still at the centre of the Universe and everything else is flying apart, or the whole Universe is expanding, like an inflating balloon.

Demonstrate this with a simple hands-on experiment where a balloon with galaxies drawn in is inflated. Make sure the students understand that the expanding conclusion is reached regardless of the observer's position.

Finally, ask the students what would happen if the process is reverted, that is, if the full balloon is emptied. The obvious answer is that the balloon will shrink and all galaxies drawn will approach each other. Explain that this observation is equivalent to reversing the flow of time, and that it implies that if the Universe is expanding now, then it was very small at the beginning. Explain that the initial moment of the Universe is called the Big Bang because it lead the Universe to expand from a very small structure (singularity) to what we observe today. Mention that scientists agree that this initial moment took place roughly 14.5 billion years ago.

Minecraft Activities : Activities in Minecraft. See suggestions below.

Minecraft activities for this lesson plan in Astronomine / Minecraft worlds:

Integrating Minecraft into a lesson on galaxies and the Universe can be a fun and engaging way to help K-12 students understand complex astronomical concepts. Here are several age-appropriate activities that can be used to bring this lesson to life in the classroom:

1. **Build a Solar System**: Have students work individually or in small groups to recreate the Solar System in Minecraft. They can build the Sun, planets, and their Moons to scale. This activity can help students understand the relative sizes and distances of celestial bodies.

2. **Create Alien Planets**: Encourage students to use their creativity to design and build their own alien planets in Minecraft. They can consider factors like gravity, atmosphere, and terrain. This activity can lead to discussions about the conditions necessary for life on other planets.

3. **Scale Models of Galaxies**: Students can work together to construct scale models of different types of galaxies, such as spiral, elliptical, and irregular galaxies. This activity helps them grasp the diversity of galaxies in the Universe.

4. **Space Exploration Missions**: Set up space exploration missions within Minecraft. Students can simulate launching rockets, exploring celestial bodies, and conducting experiments on other planets or Moons. This can teach them about space exploration and the challenges it involves.

5. **Celestial Navigation**: Teach students about celestial navigation by having them use Minecraft's day-night cycle and stars to find directions. They can learn how early navigators used the stars for guidance and how it's still used in some cases today.

6. **Astronomy Observatory**: Create an astronomy observatory in Minecraft, complete with telescopes. Students can learn about different types of telescopes, how they work, and use them to "observe" celestial objects like stars, planets, and galaxies.

7. **Constellation Mapping**: Have students work together to map out constellations in Minecraft's night sky. They can research the mythology behind the constellations they create and share their findings with the class.

8. **Black Hole Adventure**: Introduce the concept of black holes by creating a black hole simulation in Minecraft. Students can explore its properties, such as the event horizon, and learn about the effects of black holes on nearby objects.

9. **Space History Museum**: Encourage students to build a space history museum in Minecraft, showcasing key moments in space exploration, famous astronomers, and important discoveries. This can help them appreciate the history of our understanding of the Universe.

10. **Space-Themed Storytelling**: Challenge students to create and share space-themed stories or presentations within Minecraft. They can use the game's building blocks to illustrate their narratives and reinforce their understanding of the subject matter.

Ideas of innovative activities besides Minecraft that could be used in this lesson

Here are several age-appropriate activities that can help bring this lesson on galaxies and the Universe to life in a meaningful way:

1. **Star Gazing Night**: Organize a stargazing event where students can observe the night sky using telescopes or even just their naked eyes. Teach them to identify constellations, planets, and other celestial objects. You can use star charts or astronomy apps to assist.

2. **Create a Scale Model**: Have students work together to create a scale model of our Solar System, galaxies, or even the entire Universe. Use different objects to represent planets, stars, and galaxies to help them grasp the vastness of space.

3. **Guest Speaker**: Invite a local astronomer or astrophysicist to speak to the class. They can share their expertise, show images from space telescopes, and answer students' questions.

4. **Planetarium Visit**: Take a field trip to a planetarium if one is available nearby. Planetariums offer immersive experiences with breath-taking visuals of the Universe.

5. **DIY Solar Observations**: Safely observe the Sun using solar viewing glasses or DIY pinhole projectors. Teach students about sunspots, solar flares, and the importance of our Sun in the context of the Universe.

6. **Space-Themed Art**: Encourage students to create space-themed art, such as paintings, drawings, or sculptures. This allows them to express their understanding of the Universe creatively.

7. **Astronomy Books and Documentaries**: Assign age-appropriate astronomy books or documentaries for students to read or watch. Then, facilitate discussions or essays about what they learned.

8. **Galaxy Collages**: Provide magazines and materials for students to create collages of galaxies and other celestial objects. They can describe each object's unique characteristics.

9. **Astronomy Olympiad**: Organize an astronomy-themed competition where students can answer questions and solve puzzles related to the Universe. You can use resources like the Astronomy Olympiad papers for this purpose.

10. **Space History Timeline**: Have students create a timeline of significant events in the history of space exploration. This can include milestones like the first Moon landing, the launch of space telescopes, and more.

11. **Build a Rocket**: Depending on the age group, consider simple rocket-building activities. Students can design and launch water rockets or model rockets, learning about the basic principles of propulsion.

12. **Astronomy Journal**: Encourage students to keep an astronomy journal where they document their observations of the night sky, including Moon phases, planets, and any meteor showers.

13. **Science Fiction Writing**: Challenge older students to write short science fiction stories set in different galaxies or the Universe. This fosters creativity while tying into the theme.

14. **Virtual Space Tours**: Use virtual reality (VR) or online platforms like Google Earth to take students on virtual tours of the Solar System, galaxies, and famous astronomical landmarks.

15. **Astronomy Clubs**: Start an astronomy club at your school where interested students can meet regularly to discuss astronomy topics, share findings, and even plan observing sessions.

Ideas for evaluation

Prepare a presentation for other students, parents, and school community, to display what has been learned during the lesson on galaxies and the Universe.

More ideas of innovative activities besides Minecraft that could be used in this lesson

- Doppler Effect Demonstration https://www.youtube.com/watch?v=P8wx2ckyENk
- Hubble's Messier Catalog https://www.nasa.gov/content/goddard/hubble-s-messier-catalog
- Big Bang Balloon https://coyotescience.com/en/balloon-activity/

Lesson plans

7.11 Are we alone?

Activity Description

This module presents the subject of life in the Universe, and it is divided in two lessons. The first lesson deals with the emergence of life on Earth, and the second lesson presents the topic of life elsewhere in the Universe.

Introduction to the topic

Students will understand the scientific theories and hypotheses about the origin of life on Earth, and they will be able to explain the basic concepts related to the development of life.

Lesson structure

Lesson 1: Life on Earth (50 minutes)

Introduction (10 minutes):

Begin with a question: "Have you ever wondered how life on Earth began?". Show an image of Earth and ask students to share their thoughts on how life might have originated. Introduce the concept of the origin of life and explain that scientists have been studying this question for a long time.

The origin of Life on Earth (20 minutes)

Explain that Earth formed around 4.6 billion years ago. Discuss the harsh conditions of early Earth, such as high temperatures, volcanic activity, and a lack of oxygen. Show images and diagrams illustrating the early Earth's environment.
Now discuss the chemical evolution of life. Introduce the idea that life might have started from simple organic molecules. Discuss the Miller-Urey experiment and its significance in simulating the conditions thought to be present on early Earth. Show a simple diagram of the Miller-Urey experiment and its results.

Ask your students if they are familiar with the concept of a cell, and which components exist in it. Explain the RNA World hypothesis, where self-replicating RNA molecules are considered to be precursors to life. Highlight the ability of RNA to store genetic information and catalyze reactions. Show a visual representation of RNA molecules and their functions.

Then discuss the transition from simple molecules to cells. Introduce the concept of protocells - early, cell-like structures with a lipid membrane. Show images of protocells and compare them to modern cells.

Group activity (15 minutes):

Divide students into small groups. Provide each group with a worksheet containing a scenario related to the origin of life (e.g., "You are a scientist observing the early Earth environment. Describe the challenges and conditions for life to form.”). Ask each group to discuss and come up with a short presentation based on their scenario. Have each group present their findings to the class.

Conclusion (5 minutes):

Summarize the main points discussed during the lesson. Encourage students to think critically about the different theories and hypotheses. Highlight the ongoing research and advancements in our understanding of the origin of life

Lesson 2: Life Elsewhere (50 minutes)

Introduction (10 minutes):

Begin with a thought-provoking question: "Do you think life exists somewhere else in the Universe?”. Share a captivating image of a distant galaxy or an exoplanet, and explain that scientists are trying to answer this question. Introduce the term "astrobiology" and explain that it's the study of life beyond Earth.

Main Content (35 minutes):

Define astrobiology as the study of life's existence, evolution, and potential beyond our planet. Emphasize the interdisciplinary nature of astrobiology, involving biology, chemistry, astronomy, and more. Show images of diverse environments on Earth where life exists, such as extreme habitats.

Discuss the essential elements and molecules necessary for life (e.g., carbon, water, amino acids). Explain how these building blocks are common in the Universe and can be found in various space environments.

Introduce extremophiles and describe how they thrive in extreme conditions (e.g., extreme cold, heat, pressure). Show images of extremophiles and their habitats. Discuss the implications of extremophiles for the possibility of life on other planets.

Talk about space missions and telescopes (e.g., Mars rovers, telescopes like Hubble and James Webb) designed to find signs of life beyond Earth. Mention recent discoveries and missions related to the search for exoplanets. Introduce the concept of the habitable zone.

Conclusion (5 minutes):

Summarize the key points discussed in the lesson. Ask students to share one thing they find fascinating about astrobiology. Encourage them to continue exploring science and consider the possibility of contributing to the field in the future.

Minecraft Activities : Activities in Minecraft. See suggestions below.

Minecraft activities for this lesson plan in Astronomine / Minecraft worlds:

Using Minecraft as an educational tool to teach students about the question "Are we Alone in the Universe?" can be an engaging and interactive way to enhance their learning experience. Here are several age-appropriate activities that can be used to bring this lesson to life in the classroom:

1. **Build Extra-terrestrial Habitats:** Have students work in teams to design and build extra-terrestrial habitats on different planets or Moons within the Minecraft Universe. Encourage them to consider the unique challenges of each celestial body, such as gravity, radiation, and temperature.

2. **Solar System Exploration:** Create a scaled-down model of the Solar System within Minecraft, with planets and their Moons accurately placed. Students can explore and gather information about each celestial body as they move through the Solar System.

3. **Alien Life Simulation:** Challenge students to design and create their own alien life forms within Minecraft. They can think about the environmental conditions that might exist on other planets and adapt their creations accordingly.

4. **Spacecraft Design:** Have students research and design their own spacecraft within Minecraft. They can explore the principles of engineering and physics by building functional spacecraft and launching them into space within the game.

5. **Historical Space Missions:** Recreate historical space missions like the Apollo Moon landings or Mars rover missions within Minecraft. Students can work in groups to build mission control centres, spacecraft, and even simulate landings or rover exploration.

6. **Virtual Space Tours:** Create virtual tours of significant space-related locations, such as the International Space Station (ISS) or famous telescopes like the Hubble Space Telescope. Students can explore these locations and learn about their importance.

7. **Alien Language and Communication:** Challenge students to create their own alien languages and communication systems within Minecraft. This activity can help them think about the challenges of communicating with potential extra-terrestrial life.

8. **Space Quests and Challenges:** Design quests or challenges related to space exploration within the Minecraft world. These quests can include researching facts about planets, solving space-related puzzles, or completing missions to gather information.

9. **Exoplanet Exploration:** Create a series of Minecraft worlds representing different exoplanets that scientists have discovered. Students can explore these worlds and gather data about their suitability for life.

10. **Scientific Data Collection:** Develop Minecraft mods or plugins that simulate the collection of scientific data from space missions. Students can use these tools to gather data and analyse it to draw conclusions about the potential for life beyond Earth.

Remember to align these activities with age-appropriate content and learning objectives for each grade level. Additionally, encourage collaboration and critical thinking as students explore the mysteries of the Universe within the Minecraft platform.

Ideas of innovative activities besides Minecraft that could be used in this lesson

Here are several age-appropriate activities that can help bring this lesson on Are we Alone to life in a meaningful way:

1. **Build a Solar System**: Have students create a scale model of the Solar System using craft materials like clay, paper, or even balloons. Discuss the relative sizes and distances between planets and their potential for hosting life.

2. **Extra-terrestrial Life Research**: Divide students into small groups and assign each group a different celestial body (e.g., Mars, Europa, Enceladus). Have them research the potential for life on their assigned body and present their findings to the class.

3. **Alien Life Form Art**: Encourage students to use their creativity to design and draw their own imagined alien life forms. Discuss the various adaptations these life forms might need to survive on different planets.

4. **Planetarium Visit**: Take a field trip to a local planetarium where students can learn about the night sky, stars, and the possibility of extra-terrestrial life through interactive presentations and shows.

5. **Guest Speaker**: Invite a scientist or researcher who specializes in astrobiology or exoplanets to speak to the class. They can share their knowledge and insights, answer questions, and inspire students.

6. **Debate Extra-terrestrial Life**: Organize a classroom debate where students take on the roles of scientists and argue for or against the existence of extra-terrestrial life. This can help improve critical thinking and communication skills.

7. **Exoplanet Hunt**: Use online tools or apps to explore exoplanet data. Students can "discover" their own exoplanets and discuss the potential habitability of these distant worlds.

8. **Space News Analysis**: Assign students to follow current space exploration news and report on any developments related to the search for extra-terrestrial life. This encourages them to stay updated on scientific advancements.

9. **Design a Space Mission**: Have students work in teams to design their own space mission focused on the search for extra-terrestrial life. They can create mission plans, spacecraft designs, and even budget proposals.

10. **Alien Language Creation**: Challenge students to invent their own alien language or communication system. This activity can be both creative and thought-provoking, as they consider how alien life might communicate.

11. **Space-themed Creative Writing**: Encourage students to write science fiction stories or poems about encounters with extra-terrestrial life. This combines imagination with writing skills.

12. **Interactive Simulations**: Use online simulations or interactive tools that allow students to explore topics like the Drake Equation, the Fermi Paradox, or the habitable zone around stars.

13. **Extra-terrestrial Artifacts**: Create a hands-on activity where students simulate the discovery of an alien artifact or fossil. This can spark discussions about the implications of such a discovery.

14. **Documentary Screening**: Show age-appropriate documentaries about space exploration and the search for extra-terrestrial life. Follow up with discussions and reflections on what they've learned.

15. **Space-themed Board Games**: Introduce board games like "Exoplanets" or "The Search for Planet X" that teach students about the science and challenges of finding habitable planets.

These activities can help K-12 students engage with the concept of extra-terrestrial life in a meaningful way, fostering curiosity, critical thinking, and a love for science.

Ideas for evaluation

Prepare a presentation for other students, parents, and school community, to display what has been learned during the lesson on galaxies and the Universe.

More ideas of innovative activities besides Minecraft that could be used in this lesson

- Explore the activities in https://astrobiology.nasa.gov/classroom-materials/
- Play with the habitable zone simulator https://ccnmtl.github.io/astro-simulations/circumstellar-habitable-zone-simulator/

8. Conclusion

In conclusion, the journey we've embarked upon together in this Teachers Manual has been nothing short of extraordinary. We've explored the infinite wonders of the Universe through the lens of Minecraft Astronomy, or as we affectionately call it, Astronomine . The limitless possibilities of combining Inquiry-Based Learning (IBL) with this innovative educational tool have unveiled a cosmos of opportunities for K-12 astronomy education.

As educators, we understand the importance of sparking curiosity and nurturing a sense of wonder in our students. Astronomine allows us to do just that, by providing an immersive, interactive, and limitless canvas upon which to paint the wonders of the Universe. With each block placed and each star explored, our students are not merely learning about astronomy; they are becoming astronomers, explorers of the cosmos.

Through IBL, we empower our students to ask questions, seek answers, and develop critical thinking skills that will serve them well throughout their lives. Astronomine amplifies this process by enabling students to pose questions about celestial phenomena and then embark on quests to uncover the answers. It's a journey that turns passive learners into active discoverers.

But Astronomine offers more than just a gateway to the stars. It fosters collaboration, teamwork, and creativity among our students. In this virtual Universe, they build spaceships, design space stations, and collaborate on projects that stretch their imaginations and push the boundaries of what they thought possible. They are empowered to see the Universe as a crucial part of sustainability citizenship and explore their roles on Planet Earth as Climate activists. It's a testament to the boundless potential of combining technology and education.

As we conclude this manual, we encourage you to embrace the potential of Astronomine in your classroom. Whether you're a seasoned educator or just beginning your teaching journey, this innovative approach to astronomy education will inspire both you and your students. Together, we can ignite a passion for the cosmos and instil a sense of wonder that will last a lifetime.

In the end, the limitless possibilities of combining IBL with Astronomine are a testament to the power of education to inspire, transform, and shape the future. We invite you to embark on this educational voyage with an open heart and a curious mind. The stars await, and with Astronomine , the possibilities are truly limitless. So, let's set sail among the stars, for the Universe is our classroom, and the cosmos our curriculum. Together, we can reach for the stars and instill in our students the belief that they can touch them. The future of astronomy education is bright, and it's up to us to help our students reach for the stars and go beyond.

Remember, the Universe is waiting to be explored, and the journey begins in your classroom!

http://Astronomine.erasmusplus.website/

9. Additional Resources

Minecraft Education Edition
https://www.youtube.com/watch?v=vIgnOCBOGRA

https://education.minecraft.net/en-us/challenges/spaceships

https://education.minecraft.net/en-us/challenges/solar-model

https://education.minecraft.net/en-us/lessons/interplanetary-journey

https://education.minecraft.net/en-us/resources/classroom-build-challenge

https://education.minecraft.net/en-us/discover/artemis-missions

1. *Calendars of astronomy and night sky events, for 2024 – The Sky[xi].*

2. *Calendars of astronomy and night sky events, for 2024 -2100[xii]*

Date	Event
2024 March 25	March 2024 lunar eclipse
2024 April 8	A total solar eclipse will be visible in the Central Pacific Ocean, northern Mexico, eastern, southwestern and central US, southeastern Canada and northern Atlantic Ocean.
2024 September 18	September 2024 lunar eclipse
2024 October 2	Solar eclipse of October 2, 2024
2026 August 12	Total solar eclipse near lunar perigee
2027 February 6	Annular solar eclipse
2027 August 2	Total solar eclipse

2027 August 7	Asteroid (137108) 1999 AN_{10} will pass within 388,960 km (0.0026 AU) of Earth.
2028 January 12	Partial lunar eclipse
2028 January 26	Small annular solar eclipse
2028 July 22	A total solar eclipse will be visible across Australia, including Sydney, and New Zealand.[2]
2028 October 26	Asteroid (35396) 1997 XF_{11} will pass 930,000 km (0.0062 AU) from the Earth.
2029	NASA's *New Horizons* spacecraft is scheduled to leave the Solar System.
2029 April 13	Near-Earth asteroid (99942) Apophis will pass Earth at a relatively small distance of 31,200 km (19,400 mi) above Earth's surface, closer than some geosynchronous satellites.[3]
2029 June 26	Total lunar eclipse. With an umbral eclipse magnitude of 1.84362, it will be the largest total lunar eclipse of the 21st century.
2029 December 20	The December 2029 lunar eclipse, the second of two Metonic twin eclipses, will occur. The first of the twin eclipse pair happened from December 21 to 22 in 2010.
2030 June 1	An annular solar eclipse will be visible in Northern Africa, the Balkans, and Russia.
2030 November 25	A total solar eclipse will be seen in Southern Africa and Australia.
2031 March 17	Transit of Venus from Uranus
2031 May 7	Penumbral lunar eclipse[4]

2031 May 20	Comet 55P/Tempel–Tuttle (source of the November Leonids) comes to perihelion.[5]
2031 May 21	Annular solar eclipse[6]
2031 June 5	Penumbral lunar eclipse[4]
2031 October 29	Transit of Venus from Uranus
2031 October 30	Penumbral lunar eclipse[4]
2031 November 14	Hybrid solar eclipse[6]
2031 December 17	Transit of Earth from Uranus
2032 November 13	Transit of Mercury[7]
2032	Projected return to Earth orbit of object J002E3, the discarded S-IVB third stage of the Apollo 12 Saturn V.[8]
2033 October 8	SuperMoon lunar eclipse[9]
2034 March 20	Total solar eclipse[6][10]
2034 April 3	Penumbral lunar eclipse[4][11]
2034 September 12	Annular solar eclipse[6]
2034 September 28	Partial lunar eclipse[4]
2034 November 25	SuperMoon[12][13]

2036 April	A METI message Cosmic Call 2 sent from the 70-metre Eupatoria Planetary Radar on July 6, 2003, arrives at its destination, HIP 4872.
2036 March 27	The 99942 Apophis approach to Earth on March 27, 2036, will be no closer than 0.30889 AU (46.209 million km; 28.713 million mi; 120.21 LD).[14]
2038 January 5	An annular solar eclipse will occur in the Caribbean Sea, Atlantic Ocean and western Africa.[importance?]
2038 July 2	An annular solar eclipse will be visible in northern South America, the Atlantic Ocean and Africa.[importance?]
2038 December 26	A solar eclipse will be seen in Australia and New Zealand.[importance?]
2038 December	New Horizons passes 100 AU from the Sun.[15]
2038	The next triple ring plane crossing of Saturn will occur.[16][17][18]
2039 June 21	An annular solar eclipse will occur over the Northern Hemisphere.
2039 November 7	Transit of Mercury
2039 December 15	Total solar eclipse
2040 September 8	Planetary alignment of Mercury, Venus, Mars, Jupiter, Saturn and the crescent Moon[19]
2040	The Great Red Spot on Jupiter's atmosphere will become circular according to calculations based on its reduction rate at present.[20]
2044 May	A METI message Cosmic Call 2 sent from the 70-metre Eupatoria Planetary Radar arrives at its destination, 55 Cancri.

2044 September	Another METI message Cosmic Call 2 sent from the 70-metre Eupatoria Planetary Radar arrives at its destination, HD 10307.
2044 October 1	Occultation of Regulus by Venus. The last was on July 7, 1959, and the next will occur on October 21, 3187, although some sources claim it will occur on October 6, 2271.
2047 July	A METI message called Teen Age Message sent from the 70-metre Eupatoria Planetary Radar will arrive at its destination, 47 UMa.
2048 February 29	There will be a rare full Moon on a leap day; this event happens roughly once every century.[21] The next full Moon on a leap day will not occur until February 29, 2124.[22]
2052	December 6 – The closest superMoon of the century will occur.[23]
2053	August 29 – A Total Penumbral Lunar Eclipse will occur, the first since 2006.[24]
2057	This year will see the very rare occurrence of *two* total solar eclipses in a single calendar year (on January 5 and December 26). The last time this occurred was 1889. The next time it will occur is 2252. (Eclipse predictions by Fred Espenak, NASA/GSFC).
2060 October 22	Periodic comet 15P/Finlay will pass 0.0334 AU (5.00 million km; 3.10 million mi) from Earth.[25]
2061 July 28	Halley's Comet reaches its perihelion, the closest point to the Sun—the last return reached its perihelion on February 9, 1986.[26]
2062 May 10	Transit of Mercury.[27]
2063	Triple conjunction Mars-Uranus.[citation needed]
2065 November 11	Transit of Mercury

2065 November 22	At 12:45 UTC, Venus will occult Jupiter. It will be very difficult to observe from Earth, because the elongation of Venus and Jupiter from the Sun at this time will be only 7 degrees. This event will be the first occultation of a planet by another since January 3, 1818; however, the next will occur less than two years later, on July 15, 2067.[28][29]
2066	Triple conjunction Jupiter-Uranus.[citation needed]
2067 July 15	At 11:56 UTC, Mercury will occult Neptune. This rare event will be very difficult to observe from Earth's surface, because of the constant low elongation of Mercury from the Sun, and the magnitude of Neptune always under the limit of visibility with the naked eye.[29]
2067 October	A METI message Cosmic Call 1 sent from the 70-metre Eupatoria Planetary Radar arrives at its destination, HD 178428.
2069	A METI message, Cosmic Call 1, sent from the 70-metre Eupatoria Planetary Radar in 1999, arrives at its destination, 16 Cyg A.[30]
2070 February	The Teen Age Message, an Active SETI message sent in 2001 from the 70-metre Eupatoria Planetary Radar, arrives at its destination, the star HD 197076.[31]
2076 July	Dwarf planet 90377 Sedna will reach its perihelion of 76 AU from the Sun.[32]
2079 August 11	Mercury occults Mars, the first since at least 1708.[29]
2083	A star system known as "V Sagittae" is expected to go nova this year (+/- 11 years).
2084 November 10	Transit of Earth as seen from Mars, the first and the only one in this century.
2085 November 7	Transit of Mercury

2088 October 27	Mercury occults Jupiter for the first time since 1708, but very close to the Sun and impossible to view with the naked eye.[29]
2090 September 23	Total solar eclipse in the United Kingdom. The next total eclipse visible in the UK follows a track similar to that of August 11, 1999, but shifted slightly further north and occurring very near sunset. Maximum duration in Cornwall will be 2 minutes and 10 seconds. Same day and month as the eclipse of September 23, 1699.
2094 April 7	Mercury occults Jupiter; it will be very close to the Sun and impossible to view with the naked eye.[29]
2092	The dwarf planet (523794) 2015 RR245 will make its closest approach to the Sun of 34 AU.[33]
2100 March 24	Polaris appears furthest North. Polaris' maximum apparent declination (taking account of nutation and aberration) will be 0.4526° from the celestial north pole.[34]

https://ecdrumcondra.ie/

https://www.themistoklis.gr/

https://nuclio.org/en/

https//www.atermon.nl

https://www.elhuyar.eus/en

https://hearthands.solutions/

Drumcondra Education Centre
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NUCLIO - Núcleo Interativo de Astronomia e Inovação em Educação
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Atermon B.V.
Game-based Learning & Gamification Experts
More info

Elhuyar Fundazioa
NGO
More info

Hearthands Solutions
ICT Consultancy
More info

10. Bibliography

Al-Azawi, R., Al-Faliti, F. and Al-Blushi, M., 2016. Educational gamification vs. game based learning: Comparative study. *International journal of innovation, management and technology*, *7*(4), pp.132-136.
http://www.ijimt.org/vol7/659-CM932.pdf

Bosscha University Observatory, Indonesia, (2021). Empowering Rational Capacity Through Astronomy : A Distant Learning Approach.
https://www.astro4dev.org/category/australasia-oceania/

Cózar-Gutiérrez, R., Sáez-López, J.M. (2016). 'Game-based learning and gamification in initial teacher training in the social sciences: an experiment with MinecraftEdu. *Int J Educ Technol High Educ* **13**, 2 (2016). https://doi.org/10.1186/s41239-016-0003-4
https://educationaltechnologyjournal.springeropen.com/articles/10.1186/s41239-016-0003-4

Exodus Chun-Long Sit, (2020). *Reframing Pedagogy: Teaching Astronomy through STEAM Innovation*, in Education and Heritage in the era of Big Data in Astronomy. Pgs. 381-383, Proceedings IAU Symposium No.367,2020 R. M. Ros, B. Garcia, S. R. Gullberg, J. Moldon & P. Rojo, eds. doi:10.1017/S1743921321000375
https://www.cambridge.org/core/journals/proceedings-of-the-international-astronomical-union/article/reframing-pedagogy-teaching-astronomy-through-steam-innovation/877454D0B6A54B0E6C6A9E64A6A235C5

Kapp, Karl. (2012). *The gamification of learning and instruction: Game-based methods and strategies for training and education*. San Francisco, CA: Pfeiffer.
https://books.google.ie/books?id=M2Rb9ZtFxccC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

Klopfer, Eric & Osterweil, Scot & Salen, Katie. (2009). Moving learning games forward.
https://www.researchgate.net/publication/281885031_Moving_learning_games_forward

Ó Murchú, D. (2019). STREAMS Education.
https://www.biomebioyou.eu/streams.html

Percy J.R. (2006). *Teaching Astronomy? Why and How?'*. The Journal of the American Association of Variable Star Observers, Vol. 35, No. 1, p. 248-254 2006JAVSO..35..248P
http://www.astro.utoronto.ca/~percy/useful.pdf

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[i] STREAMS education is an extension of STEAM (Science, Technology, Engineering, Mathematics, and Arts and Social Studies) education that includes two additional components: 21 century Multi-literacies and Sustainability.

[ii] https://sci.esa.int/web/gaia/-/53196-the-oldest-sky-maps#:~:text=The%20first%20documented%20records%20of,and%20recorded%20their%20periodic%20motions

[iii] https://nap.nationalacademies.org/read/9839/chapter/7

[iv] https://astrosociety.org/education-outreach/k-12-science-teachers/project-astro.html

[v] https://astrosociety.org/education-outreach/education-activities/grades-k-12.html

[vi] https://www.eaae-astronomy.org/

[vii] https://opensource.com/article/21/1/kstars

[viii] https://education.minecraft.net/en-us/discover/impact

[ix] https://www.biomebioyou.eu/streams.html

[x] https://stellarium.org/

[xi] *http://www.seasky.org/astronomy/astronomy-calendar-2024.html*

[xii] https://en.wikipedia.org/wiki/List_of_future_astronomical_events