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Profile of Celestial Object Identification Skills of Junior High School Students in Indonesia

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Abstract
The ability to identify celestial objects provides significant benefits for improving students' motivation, understanding of the subject matter, reasoning, and skills, yet this area remains underexplored by researchers. This study aims to describe the profile of junior high school students' ability to identify celestial objects in science learning, particularly in the Solar System topic, focusing on their experiences in recognizing the names of celestial objects at night. Using a qualitative approach, this research involved semi-structured interviews with three science teachers and a survey of 31 7th-grade students who had not been taught the Solar System topic. The research instruments included student characteristics, availability of learning resources, challenges faced by students, teaching methods, and responses to the idea of outdoor learning with the assistance of an Augmented Reality (AR) application. The results indicate that, generally, students are not yet able to identify celestial objects other than the Moon due to limited prior experience and knowledge. Although teachers have attempted to introduce identification methods through instructional videos and direct explanations, this method is considered less accurate due to discrepancies between classroom learning and field experiences. However, both teachers and students recognize that identifying celestial objects can enrich understanding of the subject matter, increase motivation, and stimulate gratitude for God's creation. The positive response to the idea of outdoor learning with an AR application indicates high interest from both teachers and students in this approach.

Keywords: *Celestial object, Solar system, Augmented Reality, Outdor learning*

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1. Introduction

Science learning at the junior high school level plays a crucial role in providing understanding of celestial objects, especially in the Solar System material. Through a science approach, students not only acquire scientific facts about planets, stars, and celestial phenomena but also develop scientific skills such as identification, classification, and systematic observation [1], [2]. Discussion of celestial objects opens up horizons of knowledge, allowing students to understand the dynamics of the universe and stimulating them to investigate scientific questions regarding their origin and characteristics. Therefore, science learning serves as a solid foundation for exploring the wonders of the sky, providing in-depth understanding of the Solar System, and promoting the development of scientific skills applicable in various knowledge contexts [3].

The gateway to a deep understanding of the Solar System lies in observational skills and knowledge of the names of celestial objects, followed by an understanding of their conditions and regular motion [4].

Involving students in active observation of the night sky allows them to identify planets, stars, and moons, forming the basis for comprehensive understanding of the Solar System concept [5]. By knowing the names of celestial objects, students can broaden their understanding of the universe and build a foundation for critical scientific observation [6]. This identification serves as a preliminary step for further exploration of the characteristics, movements, and complex interactions among celestial objects in the Solar System.

The identification of celestial objects serves as a crucial focal point in enhancing students' understanding of the Solar System and astronomy as a whole. Although Solar System topics are already integral parts of the middle school curriculum, attention to students' abilities in scientific observation and identifying celestial objects remains minimal. Further research is needed to understand the extent to which students can apply the concepts learned in practice, identify potential barriers they may face, and formulate effective teaching strategies to enhance their understanding and skills in observing and recognizing celestial objects. By addressing this gap, research can provide valuable contributions to the development of teaching methods and a better understanding of students' scientific skill development in the context of the Solar System.

Surveys conducted to explore students' understanding of the Solar System and astronomy have involved various student groups, ranging from elementary [1], [7] to high school [8], [9] and university levels [8], [10], [11], [12]. However, attention to students' ability to identify celestial objects through astronomical observation has not been adequately covered. This represents a significant gap in the scientific literature that needs to be addressed. By focusing on this aspect, this research aims to fill this knowledge gap, with the hope of making a significant contribution to deepening students' understanding of the Solar System and astronomy as a whole. Thus, this study not only highlights the need for further research in this field but also provides a foundation for the development of more effective teaching strategies in understanding astronomical concepts.

Identifying celestial objects not only benefits learning about the Solar System and astronomy but also plays a crucial role in developing various skills and in academic assessments such as the National Astronomy Olympiad at the high school level [13]. This identification process serves not only as an initial foundation for comprehensively delving into the Solar System [14] but also aids in developing students' reasoning abilities [15] and spatial thinking [16]. Through this identification practice, students' interest and motivation in learning science, particularly in the context of the Solar System, can be enhanced [17]. The ability to recognize celestial objects also becomes an essential key in navigating time periods and directional cues, especially in the context of navigation [18].

Exploring students' knowledge and skills in observing and identifying celestial objects can begin by investigating science teachers' teaching methods in addressing the Solar System material [11]. Observing how teachers integrate celestial concepts into learning, including the introduction of objects visible at night, can provide insights into the approaches used and their effectiveness. Additionally, interviews or surveys with students can provide an overview of their experiences related to previous celestial object introductions. Questions about whether they have conducted their observations, whether they have a specific interest in particular celestial objects, and to what extent prior knowledge influences their current understanding can provide additional insights into how students interact with the Solar System material [11].

By combining analysis of teacher teaching methods and student experiences, research can detail how much the Solar System material motivates students to develop celestial object identification skills, and to what extent this approach can be reinforced to enhance students' understanding and scientific skills in the context of celestial observation.

2. Methods

This study aims to describe the profile of junior high school students' ability to identify celestial objects within the context of science learning, specifically the Solar System material. The profile of celestial object identification ability refers to the extent to which students have prior experience or knowledge in identifying the names of celestial objects visible at night [19]. These celestial objects include various planets, stars, and constellations observable with the naked eye. The research was conducted at SMP Negeri 6 Jember, East Java, Indonesia, chosen because it is where the head of Middle Jember District Musyawarah Guru Mata Pelajaran/ MGMP IPA (Indonesian version of Science Teachers Association) is located. Being an accredited "A" school situated in the city center, this junior high school serves as a model for others in the Jember district.

This study adopts a qualitative approach using data collection techniques such as interviews and surveys. Semi-structured interviews were conducted with three 7th-grade science teachers who had taught the Solar System material (referred to as G1, G2, and G3), while a survey was administered to 31 students from one 7th-grade class who had not yet undergone Solar System material instruction. The sample selection aimed to promptly identify solutions and follow up on the findings obtained. Data collection took place in January 2024. Both interviews and surveys explored the general science learning process conducted and then focused on the Solar System material.

The interview instrument consisted of a series of questions adapted from the research by Najib [20]; Marsa and Desnita [21] which were subsequently modified to fit the research context. These questions encompassed four main aspects: 1) student characteristics, 2) availability of media and learning resources, 3) challenges faced by students, and 4) teaching methods for the Solar System material and introduction to celestial objects. Additionally, we obtained teachers' responses to the idea of using Augmented Reality (AR) applications for celestial object identification, adapted from Qorimah [22].

Meanwhile, the survey instrument comprised 15 "Yes" and "No" questions along with their reasons, adapted from the same sources as the interview questions. This dichotomous scale encouraged respondents to provide clearer binary answers, without a neutral option. The question framework included: 1) learning motivation, 2) response to the availability of media and learning resources, 3) challenges faced by students, 4) learning experiences with the Solar System material and introduction to celestial objects, and 5) response to the idea of outdoor learning aided by AR applications for celestial object identification. The similarity in content between the interview and survey instruments indicates data triangulation in data collection. Once the data were collected, a process of reduction and condensation was undertaken. Data from interviews were presented comprehensively, while data from the survey were presented by grouping answers with similar tendencies from the students.

3. Results and Discussions

Before discussing the science learning process in the Solar System material, it is important to explore the availability of learning resources, completeness of facilities, teaching methods, student characteristics, and challenges experienced by students in science learning in general. Through interviews with the three science teachers at SMP N 6 Jember, it was found that all three teachers utilized various learning resources, including textbooks, Student Worksheets (LKS), practical videos, laboratory equipment, reference books from the library, the internet, YouTube, and social media. Additionally, SMP N 6 Jember is equipped with science laboratory buildings and equipment, LCD projectors, and internet access.

The teachers also implemented diverse methods in science teaching, such as discussions, question-and-answer sessions, and games (G1); problem-solving activities linking concepts to daily life (G2); as well as lectures and discussions (G3).

Regarding the teachers' views on student characteristics in science learning, G3 acknowledged that not all students have the same interest in science/physics, so it is important for teachers to recognize students' talents and interests. This view is supported by G2, who observed that students enthusiastic about mathematics tend to be more engaged in science learning. Conversely, G2 also emphasized that science learning related to daily life is more appealing to students.

In terms of challenges in science learning, all three teachers agreed that the challenges generally stem from students' potential and interests. According to G1, the biggest challenge is students' difficulty in mathematics, especially for those with weak foundations since elementary school. G3 also highlighted students' difficulties in memorizing formulas, determining units, and performing calculations. The results of interviews with science teachers regarding the learning process in the Solar System material, especially related to identifying celestial objects, are presented in Table 1.

After discussing the results of the teacher interviews, the survey results from 31 students will now be presented. As discussed in the interviews with teachers, the presentation of survey results will begin by explaining students' experiences in the science learning process. Regarding the preference for science lessons, the survey results indicate that 21 students enjoy them. The reasons for their enjoyment include engaging and easy-to-understand teachers, interesting and fun lessons (as reported by 18 students), while 3 students are interested in the universe.

Table 1. Interview Results with Science Teachers on Teaching Celestial Object Identification

No	Question	Core Answer
1	*Do students face difficulties when learning material about the Solar System, especially in identifying celestial objects?*	First, because the material relates to objects in outer space, students have difficulty seeing them with the naked eye because these objects cannot be observed directly on Earth (G1). In addition, proving phenomena that cannot be seen directly, such as using the internet, is also a challenge (G2). In addition, students showed varying levels of understanding; some quickly grasped the material, while others had difficulty. This indicates that students' level of understanding varies according to their individual learning abilities and pace (G3).
2	*Should students studying Solar System material be able to recognize or identify the names of celestial objects visible at night?*	All three teachers agreed. However, G1 disagreed that this skill should be used as a test.
3	*Please explain the benefits of knowing the names of celestial objects visible at night.*	Make us more grateful to know the greatness of God for his creation (G1 and G2). Add insight into the types (G2) and functions of celestial objects (G1).
4	*How do students feel if the teacher discusses or teaches the introduction of celestial objects at night?*	All three teachers answered with certainty that students would feel happy and enthusiastic. G2 added that students are indeed happy if Solar System learning is related to their daily experiences.
5	*Please explain the learning that you have done to introduce or identify the names of celestial objects to students.*	G1 and G2 answered that they used a learning video, while G3 gave an explanation of the characteristics of the celestial object. For example, the color, location, and time to observe it.
6	*In teaching Solar System material, do you carry out outdoor activities to introduce celestial objects, such as a visit to the Planetarium?*	All three teachers answered that they had not. G2 gave the reason that there were no supporting facilities.
7	*Do you agree that in science subjects, especially in the topic of the Solar System, effective and efficient learning activities are necessary to introduce the names of celestial objects?*	All three teachers agreed, with the addition from G1 that not only the names of celestial objects should be taught, but also their functions.
8	*After reviewing the lesson plan that we (researchers) propose, do you think that using augmented reality-based smartphone applications, such as Star Walk 2, for learning about celestial objects is an effective and efficient solution?*	All three teachers agreed, with the addition of G1 that something new would be good and interesting, in addition to the discussion and question and answer activities.

However, 10 other students are not interested, citing the difficulty of the material and too many formulas. Regarding the need for learning resources, 25 students consider student worksheets (LKS) and textbooks to be sufficient learning resources for them. However, 6 students believe that science lessons require observation and research, thus additional learning resources are needed. The majority of students, 30 out of 31, agree that the use of additional teaching media by teachers can enhance their learning motivation. The reasons vary, with 26 students expressing that learning becomes more engaging, active, less boring, and easier to understand. Three other students mentioned that they gained new experiences, while one student stated that seeing the teacher explain while using additional media also helped. Only one student disagreed with the statement. The survey results regarding the learning process in the Solar System material, specifically related to identifying celestial objects, with the participation of 31 7th-grade students, will be presented in Table 2.

Table 2. Survey Results on Learning Celestial Object Identification in The Solar System Material

No	Question	Core Answer
1	*Do you have difficulty understanding Physics material, especially those related to the Solar System?*	Yes: (26) • Yes, because physics material is difficult, but it is different from the solar system which is one of my favorite materials. (15) • Yes, because there are too many formulas and it is difficult to calculate. (11) No: (5) • Because the material is easy and I like it, and I understand it quite well. (5)
2	*Are you able to identify celestial objects other than the Moon when observing the night sky?*	Yes: 5 Because there are celestial objects that I know besides the moon (5) No: 26 • Because it is far away, it cannot be recognized with the naked eye (14) • The shape is indistinct, and requires a telescope to see. (11) • B ecause I rarely see the sky (1)
3	*You are eager to be able to identify celestial objects visible at night, such as recognizing the planet Mars, the star Sirius, or the constellation of Orion.*	Yes: 27 • For wanting to know more about planets, make it easier and distinguish the names of planets, along with other celestial objects in space (25). • Because one of my dreams is to become an Astronaut (1). • Because the Solar System material includes curious science learning (1). No: 4 Because there are too many planets in space (4).
4	*If you have been taught or are able to recognize the names of planets or stars in the night sky, describe your experience!*	Learning the names of the planets but only in theory, either taught directly through the teacher or looking at references from the internet.
5	*Do you agree that the ability to recognize celestial objects when studying Solar System material is very important?*	Yes: 29 • Since recognizing celestial objects is part of studying the Solar System, it is very useful and important. (19). • Because it expands the lessons in the Solar System material (8). • For wanting to know the power of Allah SWT (1). • Penting untuk yang memiliki cita-cita menjadi astronot (1).
6	*Do you agree that outdoor activities for celestial object recognition are enjoyable?*	Yes: 25 • Essential for aspiring astronauts (7). • Outdoor activities are fun, not boring (11). • For gaining new experience (6). • Can see the outside scenery (1). No: 6 Because it is very difficult and I really can't distinguish celestial objects (6).

No	Question	Core Answer
7	*Did you know that there are apps that can help in observing and identifying celestial objects?*	Yes: 8 I've heard of it, but I haven't downloaded it and haven't tried it yet. (8). No: 23 Never knew, and no one has ever explained about the application of observing celestial objects. (23).
8	*Do you agree that conducting celestial object observation activities outdoors using Augmented Reality applications is effective?*	Yes: 19 • To learn more about outdoor activities (5). • Because you want to see it in real life, or know its shape (4). • Because it can make students more enthusiastic because the learning is fun (6). • For wanting to know about celestial objects (1). • To make it easier to understand (2) • To know the Solar System online (1). No: 12 I never knew about it (12).
9	*Do you agree that observing or introducing celestial objects based on a practical and structured practicum module is effective?*	Yes: 27 • To make learning less boring (11). • Because in order to add insight baru (5). • I want to try to learn it (8). • Because to get smarter (1) • Because it's more practical (2) No: 4 Disagree (4)
10	*Do you agree that using the practicum module for observing celestial objects with the Star Walk 2 application as a new learning resource in your class is good?*	Yes: 25 • To know more about the celestial objects, because knowing the celestial objects is very important. (18). • Because to get smarter (1). • Because it adds a new learning experience (2). • Can enjoy the view (1). • Out of curiosity about the Star Walk 2 app (1). • It looks fun and exciting (2). No: 6 Because you can't bring a cell phone and don't know (6).

The analysis of interview and survey results reveals several significant findings. Based on the interviews, it was revealed that this school has sufficiently comprehensive facilities to support science learning. However, there are facility shortages, particularly concerning the presence of telescopes, which are essential tools in supporting understanding of the Solar System material. This finding is consistent with research by Liliawati [23] which found that most science laboratories lack telescopes, and their utilization is suboptimal. Authors speculate that this is due to the perception that telescopes are not considered essential equipment for schools to have, as well as their relatively high cost.

The interview results highlight that challenges in science learning often stem from students' potential and interests. Therefore, it is suggested to implement differentiated learning approaches in science subjects, where teachers need to identify and develop students' potential [24], [25]. Additionally, constraints also arise from students' mathematical abilities formed since elementary school, which significantly impacts their achievement in science subjects at the junior high school level. This finding consistently reinforces the significant positive relationship between mathematical ability and achievement in science [26], [27]. Teachers also explained that students' difficulties in understanding the Solar System material are caused by its connection to outer space objects that are difficult to directly observe with the naked eye on Earth, in line with reports from Supeno [28] and Putri [29]. Additionally, there are challenges in proving phenomena that cannot be directly observed.

Through the interviews, it was found that teachers have attempted to introduce methods of identifying celestial objects to students through instructional videos and direct explanations of their characteristics, directions, and observation times. However, authors found that this method is less effective due to the lack of accuracy in the explanations provided. Most planets or stars have similar characteristics and directions in the sky, making accurate identification difficult. Additionally, simulating celestial objects in videos or textbooks with a 2-dimensional approach does not reflect the actual observation experience outdoors, as suggested by Zhang *et al*. [14]. Teachers often use descriptions in the classroom assuming the direction and position of stars, which can result in different outcomes in actual observations. Limitations in observing actual stars outdoors can lead to a gap between classroom learning and practical experience, hindering effective knowledge transfer.

The usefulness of identifying celestial objects is not only to cultivate insight, motivation, and practical skills, as previously revealed by authors. Based on the interview results, it was found that identifying celestial objects can also cultivate gratitude for realizing the greatness of God. This is in line with the achievement of the spiritual core competency (KI-1) outlined by the 2013 Curriculum. Some references also emphasize the importance of science learning, especially Solar System material, in increasing gratitude as part of God's creation [30]-[32].

Survey results indicate that teachers' performance is a dominant factor influencing students' interest in science lessons, in addition to their relevance to nature-related topics. In this study, it is concluded that students tend to like science lessons because teachers provide explanations that are easy to understand, have attractive appearances, and present enjoyable learning experiences [33]. Furthermore, the use of teaching media other than textbooks and student worksheets (LKS) can enhance students' learning enthusiasm. The use of teaching media makes learning more engaging, active, less boring, and easier to understand, rather than just applying lecture methods.

Physics category science material is indeed less favored by some students because it is considered difficult and full of formulas, a finding consistent with research conducted by Azizah *et al*. [34], Yusup [35], and Astalini *et al*. [36]. However, the Solar System material is actually one of the favorites among students. We speculate that students' interest in the Solar System material is influenced by their learning experiences during elementary school, which strongly embeds a mental model of the Solar System in their minds. Students have realized that Earth is one of the planets orbiting the Sun, along with the seven other planets they easily memorize. They also realize that the Moon is the closest celestial object orbiting Earth, with its appearance changing every day. Although further research is needed to test various student conceptions related to the Solar System, strong learning experiences during elementary school are believed to be the key to students' interest in this material [7].

However, when students were asked about their ability to identify any celestial objects visible at night other than the Moon, almost all of them could not do so. Although they have memorized the names of planets like Mercury, Venus, Mars, Jupiter, and Saturn, none of the students succeeded in finding these planets among the many points of light in the night sky. Reasons given by students include their distance, making them unrecognizable with the naked eye, their unclear shapes, and the need for a telescope to see them. From these answers, we can assume that some characteristics of celestial objects have been known by students (such as Saturn being a planet with rings, Mars being red, etc.), so they consider it necessary to use aids to identify them. However, if students are not aware of these characteristics, the presence of a telescope will not help them identify celestial objects. Thus, answers about this reason are not in line with the question asked.

Nevertheless, the survey results indicate that students are highly enthusiastic about being able to identify celestial objects visible at night, such as recognizing Mars, Sirius, or the constellation of Waluku.

The main reasons mentioned are because they perceive the importance and usefulness of this knowledge, especially in studying the Solar System material, as well as to cultivate gratitude and satisfy their curiosity. This is due to the fact that students who feel capable of identifying celestial objects acknowledge that they have learned the names of planets, both theoretically from teacher instruction and through internet references. High curiosity tends to make students pay more attention, process information more deeply, and remember information better, ultimately helping them gain a better understanding in learning [37].

Teachers explain that there have never been outdoor activities to introduce celestial objects to students, either in open environments or in planetariums, due to a lack of supportive facilities. We also note that gathering students for outdoor learning at night can be relatively complicated, especially since learning activities are typically conducted during the day. However, despite this, students show enthusiasm for the concept of outdoor learning with the reason of wanting to overcome boredom and curiosity about new experiences, as summarized by Ayotte-Beaudet [38].

Based on the interview results, teachers agree with our proposal to implement outdoor learning using assignments outside of school guided by AR-based mobile applications. These applications work by directing the smartphone towards the celestial object being targeted, such as planets, stars, or constellations, and will automatically display the name of the celestial object in real-time. Some applications that work in this way include Sky Map, Star Walk 2, Stellarium Mobile, SkyView Lite, Night Sky, and others. Several studies have shown a number of positive impacts of using these applications in Solar System and astronomy learning [39], [40], [41], [42]. The implementation of these activities will certainly be supported by instructional materials and practical modules designed to facilitate students in completing tasks. This idea also receives positive responses from students due to its success and practicality in introducing celestial objects, in addition to the curiosity and entertainment aspects it offers.

4. Conclusion

The research analysis highlights the profile of students' ability to identify celestial objects. It is revealed that, generally, students are not yet capable of identifying celestial objects other than the Moon. Their initial knowledge of celestial objects is limited to previous learning experiences, with no outdoor learning experiences related to celestial object recognition. However, despite this, students show great interest in science learning, particularly in the Solar System topic. They are enthusiastic about being able to recognize the names of celestial objects visible at night and are interested in participating in outdoor learning activities that allow them to identify celestial objects.

The research analysis also reveals that in Solar System learning, science teachers have attempted to introduce methods of celestial object identification to students through instructional videos and direct explanations of their characteristics, directions, and observation times. However, this method is less accurate as it may lead to discrepancies between classroom learning and practical field experiences. Both teachers and students realize that identifying celestial objects in the night sky can enrich understanding of the subject matter, increase motivation, and stimulate gratitude for God's creation. Therefore, the positive response to our idea of conducting outdoor learning with assignments outside of school guided by AR-based mobile applications indicates that both teachers and students are interested in this approach. Furthermore, in the context of science learning in general, this research recommends the importance of optimizing methods, media, and learning resources beyond textbooks and worksheets, as this variation can enhance students' learning enthusiasm. Teachers are also advised to implement differentiated learning based on students' talents and interests, considering that one of the challenges in science achievement is the basics of mathematical ability.

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