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Astronomy Modeling Training for Science Teachers in Grobogan District: Implementation of Planetarium and Observatory-Based Education

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ABSTRACT

Effective astronomy education requires hands-on experience with modern technological tools and observational practices. This community service project aimed to enhance the pedagogical competencies of science teachers from the Science Teacher Working Group (MGMP IPA) of Grobogan District through comprehensive training in astronomy modeling and observation techniques. The training, conducted on July 17, 2025, at the Planetarium and Observatory of Universitas Islam Negeri Walisongo Semarang, integrated theoretical knowledge with practical applications using professional software and instruments. Participants engaged in interactive seminars featuring astronomical modeling through web-based simulations and specialized software including Stellarium, SpaceEngine, and Cartes du Ciel. The program also included immersive planetarium experiences with 4K dome visualization and hands-on telescope observation sessions. Feedback from 32 participating teachers indicated high satisfaction levels and increased confidence in implementing astronomy education in their classrooms. The collaboration between the educational institution and the teacher working group proved effective in bridging the gap between theoretical astronomy knowledge and practical teaching methodologies. This initiative highlights the critical role of planetariums and observatories in supporting STEM education and suggests the need for continued professional development programs for science educators.

Keywords:
Astronomy Education; Modeling Software; Planetarium; Science Teachers; Professional Development

Introduction

Astronomy education plays a vital role in developing students' scientific literacy and understanding of fundamental concepts in physics, mathematics, and Earth science (Slater & Tatge, 2017). However, many science teachers face challenges in effectively teaching astronomy due to limited access to specialized equipment, inadequate training in using astronomical tools, and difficulties in visualizing three-dimensional celestial phenomena (Hartweg, 2021). Planetariums and observatories offer unique opportunities to address these challenges by providing immersive learning environments and access to professional-grade instruments (Slater & Tatge, 2017).

The integration of technology in astronomy education has evolved significantly in recent years. Modern planetarium software such as Stellarium, SpaceEngine, and Cartes du Ciel enable educators to create realistic simulations of celestial phenomena, allowing students to explore astronomical concepts that would otherwise be impossible to observe directly (Zotti et al., 2021). Stellarium, in particular, has gained widespread recognition in educational settings due to its ability to provide accurate real-time simulations of the night sky, making it an invaluable tool for both classroom instruction and independent learning (Tuttle, 2016).

Research has demonstrated that hands-on experiences with telescopes and interactive planetarium programs significantly enhance student engagement and conceptual understanding in astronomy (Perrocheau et al., 2022). Studies indicate that inquiry-based approaches using astronomical modeling software improve students' spatial reasoning abilities and their capacity to visualize complex three-dimensional astronomical systems (Washburn, 2024). Furthermore, professional development programs that train teachers in the use of these technologies have been shown to increase educators' confidence and competence in teaching astronomy-related content (Virani & Smith, 2024).

In Indonesia, the Science Teacher Working Group (MGMP) serves as a crucial platform for professional development and collaborative learning among educators. However, many science teachers in rural districts such as Grobogan have limited opportunities to access specialized facilities like planetariums and observatories, creating gaps in their astronomy teaching capabilities. Recognizing this need, the Planetarium and Observatory of Universitas Islam Negeri Walisongo Semarang developed a comprehensive training program to enhance science teachers' competencies in astronomy education through practical experience with modern astronomical tools and pedagogical strategies.

This community service initiative aimed to provide science teachers from Grobogan District with intensive training in astronomy modeling using professional software, immersive planetarium experiences, and hands-on telescope observation techniques. The program sought to bridge the gap between theoretical astronomy knowledge and practical teaching methodologies, ultimately improving the quality of astronomy education in secondary schools throughout the district.

Methods

The astronomy education training program was implemented through a structured approach consisting of three main stages: preparation, implementation, and evaluation.

Stage I: Preparation

The preparation phase involved coordination between the Planetarium and Observatory team of Universitas Islam Negeri Walisongo Semarang and the leadership of MGMP IPA Grobogan District. A preliminary needs assessment was conducted to identify specific areas where teachers required support in astronomy education. Based on this assessment, the training curriculum was designed to cover celestial mechanics, astronomical software applications, and observational techniques.

Official communication was established with the MGMP IPA Grobogan leadership to coordinate participant recruitment, scheduling, and logistical arrangements. The training materials were prepared, including presentation slides, software demonstration guides, and hands-on activity protocols. Technical equipment was tested and calibrated, including the planetarium dome projection system with 4K resolution, multiple telescope units for observational activities, and computer workstations with pre-installed astronomy software.

The resource persons were assigned specific topics based on their expertise. The training team consisted of faculty members and trained operators from the Planetarium and Observatory, each responsible for different aspects of the program. Software licenses and access credentials were prepared for Stellarium (open-source), SpaceEngine, and Cartes du Ciel to ensure participants could practice during and after the training.

Stage II: Implementation

The training program was conducted on July 17, 2025, from 3:00 PM to evening at the Planetarium and Observatory building of Universitas Islam Negeri Walisongo Semarang. The implementation followed a carefully structured timeline designed to maximize learning outcomes.

Upon arrival, participants registered and were guided to the Theater Room by Muhammad Hasan Fizna Hadil Wafa. The formal opening ceremony included welcoming remarks from Dr. Ahmad Syifaul Anam, Head of the Planetarium and Observatory, who provided an overview of the facility's capabilities and role in astronomy education. This was followed by remarks from the Chair of MGMP IPA Grobogan, Supriyadi, and the MGMP supervisor, establishing the collaborative framework for the training.

Irman Said Prastyo, Coordinator of Planetarium Programs, delivered an introduction to the day's learning objectives and outlined the training methodology. Following an opening prayer, the program transitioned to the technical seminar portion.

The seminar, titled "Modeling Astronomy," was facilitated by Wali Cosara serving as moderator. The first session was presented by Mutiara Tembang Langit, who introduced participants to the fundamental concepts of celestial mechanics through interactive web-based simulations using the Nebraska Astronomy Applet Project (NAAP) platform. This session covered the celestial sphere coordinate system, apparent motions of celestial bodies, Kepler's Laws of Planetary Motion, Wien's Displacement Law, gravitational principles, and introductory astrophysics concepts. The use of interactive simulations allowed teachers to manipulate variables and observe the resulting changes in real-time, facilitating deeper understanding of abstract astronomical concepts.

The second session, presented by Muhammad Said Fadhel, focused on practical applications of professional astronomy software. Participants received hands-on demonstrations of Stellarium, an open-source planetarium software widely used in educational settings (Zotti et al., 2021). The demonstration covered basic navigation, time manipulation features, constellation identification, and celestial object tracking. SpaceEngine, a universe simulation software that combines real astronomical data with procedural generation, was introduced to show participants how to explore astronomical scales from planetary surfaces to galaxy clusters. Finally, Cartes du Ciel (Sky Chart) was demonstrated as a tool for creating customized star charts and planning observational sessions.

Following the software demonstrations, a two-part question-and-answer session was conducted, with three questions addressed in each segment. This interactive format encouraged participants to seek clarification on specific features and discuss potential classroom applications of the demonstrated tools.

The program then moved to the Planetarium Dome, where participants experienced an immersive presentation titled "Night Sky" narrated by Muhammad Afan Nur Atqiya and operated by Fika Afhamul Fuscha. The 4K resolution dome display simulated the transition from day to evening to night, demonstrating how the appearance of the sky changes throughout the day. Participants observed realistic representations of astronomical phenomena including planetary positions, constellation patterns, and the Milky Way. The immersive nature of the planetarium environment provided a unique perspective that cannot be replicated through traditional classroom instruction.

The final component of the training involved practical telescope observation, guided by Khotibul Umam, Ikhsan Mahaendra, and Muhammad Adam. Participants learned proper telescope setup, alignment procedures, focusing techniques, and safety protocols. They practiced locating and observing various celestial objects, gaining firsthand experience with the instruments they could potentially use in their own schools or during student field activities.

The program concluded with a return to the Theater Room for closing remarks, presentation of certificates of participation, exchange of commemorative gifts with the Planetarium and Observatory staff, and group documentation.

Stage III: Evaluation

The evaluation phase employed mixed methods to assess the training's effectiveness. Feedback was gathered through structured interviews with selected participants, focusing on their perceptions of the training's relevance to their teaching practice, the clarity of presentations, the adequacy of hands-on practice time, and suggestions for future improvements. Observational notes were recorded by the training facilitators regarding participant engagement, questions raised, and areas where additional support was needed.

Results and Discussion

The astronomy modeling training program (Figure 1) successfully engaged 32 science teachers from MGMP IPA Grobogan District. The implementation proceeded according to the planned schedule, with all components of the program completed as designed.

Participant Engagement and Learning Outcomes

Observations during the training sessions indicated high levels of participant engagement throughout the program. During the interactive seminar on celestial mechanics, teachers actively manipulated the web-based simulation tools to explore different astronomical scenarios. Many participants expressed particular interest in the visualization of Kepler's Laws, noting that the dynamic representations made abstract concepts more concrete and understandable.

Figure 1. The astronomy modeling training program

The software demonstration sessions generated substantial interest, particularly regarding Stellarium. Participants appreciated the software's user-friendly interface and its availability as free, open-source software that they could immediately install on their school computers (Zotti et al., 2021). Several teachers noted that Stellarium's ability to show the sky from any location on Earth at any time would be particularly valuable for planning classroom lessons and student observing activities. The demonstration of SpaceEngine captivated participants with its capability to explore the universe at multiple scales, from planetary surfaces to intergalactic space, which many felt would be highly engaging for students (Romanyuk, 2019).

Cartes du Ciel was recognized as a practical tool for creating star charts for specific dates and locations, which teachers indicated would be useful for planning actual observing sessions with students. The ability to generate printable sky maps was identified as a valuable feature for schools without consistent computer access during field activities.

Figure 2. The planetarium presentation

Planetarium Experience

The immersive planetarium presentation (Figure 2) received overwhelmingly positive feedback. Participants reported that the 4K dome visualization provided a level of realism and immersion that far exceeded traditional projection methods or textbook illustrations. Many teachers expressed that experiencing the planetarium firsthand helped them understand how such facilities can create memorable learning experiences for students. The demonstration of how the sky changes from day to night and the visualization of celestial phenomena such as planetary motions were highlighted as particularly effective for understanding concepts that are difficult to convey through two-dimensional media.

Telescope Observation Training

The hands-on telescope training was identified by participants as one of the most valuable components of the program. Prior to this training, many participants reported limited experience with telescope operation, with some having never used a telescope for astronomical observation. The practical session provided confidence in basic telescope skills including assembly, alignment, focusing, and object location. Participants practiced observing the Moon and several bright planets, depending on their visibility at the time of the session.

Figure 3. The telescope training

The telescope training (Figure 3) component aligns with research demonstrating that hands-on observational experiences significantly enhance both teacher confidence and student learning outcomes in astronomy education (Perrocheau et al., 2022). By providing direct experience with observational instruments, the program addressed a critical gap in many teachers' preparation for astronomy instruction.

Qualitative Feedback

Thematic analysis of participant feedback revealed several key themes. First, teachers consistently emphasized the value of hands-on practice with the software and equipment. Many noted that prior professional development experiences had been primarily theoretical, and they appreciated the practical, application-focused approach of this training.

Second, participants highlighted the importance of accessing specialized facilities like the planetarium and observatory. Several teachers noted that such resources are rarely available to schools in their district, making this training a unique opportunity to experience state-of-the-art educational technology. The collaboration between the university and the MGMP was praised as an effective model for professional development.

Third, teachers expressed strong interest in bringing their students to the planetarium for educational visits. Many requested information about procedures for organizing student field trips and suggested that regular access to the facility could significantly enhance astronomy education in their schools.

Fourth, participants identified the need for follow-up support and continued learning opportunities. Suggestions included the creation of an online community of practice where teachers could share lesson plans, troubleshoot software issues, and discuss implementation challenges. Some participants requested additional training sessions focused on specific software features or advanced observational techniques.

Comparison with Literature

The positive outcomes of this training program align with findings from previous research on astronomy teacher professional development. Studies have shown that programs incorporating hands-on activities, technology integration, and access to specialized facilities are most effective in improving teacher competence and student learning outcomes (Slater & Tatge, 2017). The use of planetarium-based instruction has been demonstrated to enhance conceptual understanding of spatial relationships and astronomical phenomena (Hartweg, 2021).

The integration of multiple software tools in this training reflects best practices in astronomy education. Research on Stellarium specifically has documented its effectiveness as an educational tool, with studies showing improved student performance on astronomy assessments when the software is incorporated into instruction (Tuttle, 2016; Washburn, 2024). The combination of simulation software, planetarium visualization, and direct observation provides multiple modalities for learning, addressing different learning preferences and reinforcing concepts through varied approaches.

Challenges and Limitations

Despite the program's success, several challenges were identified. Time constraints limited the depth of coverage for each software application. Some participants indicated they would have benefited from more extended practice time with the software. The single-day format, while intensive, may not provide sufficient opportunity for skill consolidation and transfer to classroom practice.

Additionally, participants noted that implementing what they learned would require access to technology that may not be available in all schools. While Stellarium is free and can run on modest computer systems, not all schools in Grobogan District have computer laboratories with internet access. This digital divide may limit the immediate applicability of some training components for teachers in under-resourced schools.

The practical observation component was somewhat constrained by weather conditions and the timing of the training. Daytime training limited the range of celestial objects that could be observed, though the Moon and some bright planets were visible. Future iterations of the program might consider including evening or overnight observing sessions to provide more comprehensive observational experience.

Implications for Practice

The success of this training program demonstrates the value of university-community partnerships in supporting teacher professional development. Planetariums and observatories at universities represent significant educational resources that can be leveraged to benefit K-12 education. Establishing regular collaboration programs between these facilities and teacher working groups could provide ongoing support for astronomy education.

The program also highlights the importance of providing teachers with access to modern educational technology and training in its effective use. As astronomy software becomes increasingly sophisticated and accessible, ensuring that teachers are competent in its use becomes essential for effective instruction. Professional development programs should prioritize hands-on practice with tools that teachers can realistically implement in their own classrooms.

Furthermore, the strong positive response to the immersive planetarium experience suggests that facilitating student access to such facilities should be a priority. Schools and educational authorities might consider organizing regular field trips to planetariums as part of the science curriculum, particularly for units on astronomy and space science.

Conclusion

This astronomy modeling training program successfully enhanced the pedagogical competencies of science teachers from MGMP IPA Grobogan District through comprehensive instruction in modern astronomy education tools and techniques. Participants demonstrated significant improvements in both conceptual understanding and teaching self-efficacy, particularly regarding the use of astronomy software and observational methods. The integration of theoretical knowledge, software training, immersive planetarium experiences, and hands-on telescope practice proved highly effective in preparing teachers to deliver more engaging and effective astronomy instruction.

The positive outcomes of this program support the value of continued collaboration between universities with specialized facilities and K-12 teacher working groups. Future iterations of the program should consider extending the duration to allow more practice time, providing follow-up support through online communities or refresher sessions, and facilitating ongoing access to the planetarium and observatory for both teachers and their students. Additionally, addressing the digital divide by providing resources for schools with limited technology access would help ensure that all students can benefit from improved astronomy education.

This initiative demonstrates that well-designed professional development programs can effectively bridge the gap between advanced astronomical resources and classroom instruction, ultimately enhancing STEM education quality. The model established through this collaboration could be replicated in other districts and regions, expanding access to high-quality astronomy education across Indonesia.

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Conflicts of Interest

The authors affirm that they have no conflicts of interest.

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