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Designing a Child Friendly and Sustainable Science Olympiad Program for Science Talent Development

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Abstract: 21st-century education emphasizes the development of higher-order thinking skills, creativity, problem-solving abilities, collaboration, and digital literacy. Science education plays a vital role in fostering these competencies. However, participation in competitive programs such as the National Science Olympiad (OSN) in Indonesia can place considerable cognitive and psychological demands on students. This study aims to explore and describe the implementation of a structured, sustainable, and student centered OSN coaching program at SMAN 1 Cepu. A descriptive qualitative approach was employed, using in-depth interviews and field observations. The findings indicate that the program incorporates internal and external mentoring, intensive training sessions, hands on learning, and collaborative activities. These components effectively strengthen students' scientific reasoning, problem solving capacity, and higher order thinking skills. Despite challenges related to training intensity, facility constraints, and selection processes, systematic execution and evaluation ensure a holistic approach that supports students' psychological well-being alongside their academic development. Ultimately, this study contributes to science education by proposing a science talent development framework that can serve as a scalable model for other schools, emphasizing a balance between academic performance and student well-being.

Keywords: Child friendly learning, higher order thinking skills, science education, National Science Olympiad, talent development

Introduction

In the context of twenty-first century education, the development of higher order thinking skills, creativity, problem-solving abilities, collaboration, and digital literacy is crucial to enable students to address increasingly complex global challenges (Yunita & Mandasari, 2025; Dinova & Mustika, 2025). Science and mathematics education play a fundamental role in fostering critical thinking, abstract reasoning, and problem-solving skills while simultaneously cultivating students' curiosity about natural phenomena and logical principles (Kemendikbudristek, 2022). Therefore, learning processes should ideally be exploratory, interactive, and engaging (Tirtawati et al., 2025). Early development of creativity and scientific talent has been shown to enhance students' ability to solve Higher Order Thinking Skills (HOTS) and problem-solving tasks flexibly, highlighting the importance of systematic science talent development programs (Dinova & Mustika, 2025; Krischler et al., 2021). Teachers play a central role in guiding students and creating adaptive, child-friendly learning experiences that optimize scientific reasoning, problem-solving abilities, and science talent development (Darling-Hammond et al., 2024; Ramadhan & Faradilah, 2026).

The National Science Olympiad (Olympics National Science, OSN) serves as a strategic platform for nurturing scientific talent through a structured progression from school-level to national-level competitions (Puspernas, 2024). Olympiad preparation and academic enrichment programs are designed not only to improve competitive achievement but also to train students in solving non-routine problems through HOTS-oriented activities involving analysis, evaluation, and the development of critical and creative thinking skills (Rochayati & Rochayani, 2024). Best practices implemented in high-performing schools indicate that intensive mentoring, periodic simulations, and structured training programs integrating both academic and soft skills such as time management and stress regulation can significantly improve academic performance while also preparing students psychologically for competitive environments (Gül & Ayık , 2024; Suarso et al., 2025).

Despite their effectiveness in enhancing academic achievement, OSN training programs often impose substantial cognitive demands and psychological pressure on students, potentially leading to academic stress and mental fatigue (Chadha & Chauhan, 2025). This challenge highlights the need for program designs that balance academic excellence with children's right to learn in environments that are safe, supportive, and conducive to mental well-being (Fitrianto , 2025). In this context, the principles of the Child-Friendly School (CFS) approach are highly relevant for integration into OSN coaching programs. This approach emphasizes the creation of learning environments that are safe, participatory, inclusive, and supportive of students' academic and psychological development. Consequently, science talent development should not focus solely on competitive achievement but also on students' overall well-being.

The Child Friendly School framework and student-centered school models have been demonstrated to enhance student well-being and learning effectiveness (Mangestuti et al., 2022). Within the context of National Science Olympiad coaching programs, these principles are particularly important because they promote psychological well-being, meaningful participation, and the sustainable development of students' potential. This perspective aligns with the Child Friendly School concept, which emphasizes the establishment of educational environments that are safe, comfortable, inclusive, and capable of safeguarding children's rights throughout the learning process (Chairiyah et al., 2021). Therefore, the implementation of child friendly school principles can provide a strong foundation for designing OSN coaching programs that effectively balance academic demands with students' developmental needs and rights.

Although previous studies have demonstrated the effectiveness of Science Olympiad coaching programs in fostering higher-order thinking skills and academic achievement, while other studies have highlighted the contribution of Child Friendly School principles to students' well-being and holistic development, these strands of research have largely evolved in parallel. Consequently, limited attention has been given to how science talent development programs can simultaneously pursue academic excellence and uphold child centered educational principles. Addressing this gap is essential for designing sustainable Olympiad coaching programs that not only nurture scientific talent but also support students' well-being and developmental needs

Based on the literature review and the identified research gap, this study aims to explore and describe the implementation of a sustainable and child-friendly National Science Olympiad coaching program at SMAN 1 Cepu. The study focuses on coaching strategies, program implementation, strengths and challenges encountered, and the program's contribution to the development of students' scientific reasoning, problem solving abilities, and learning motivation. The findings are expected to provide valuable insights for other schools seeking to develop effective, sustainable science talent development programs that align with child friendly school principles.

Methods

This study employed a descriptive qualitative approach. A qualitative approach was chosen to gain a deeper and more comprehensive understanding of empirical phenomena in the field and to describe them based on natural conditions (Oranga & Matere, 2023). Through a descriptive research design, this study does not focus on hypothesis testing through statistical analysis. Instead, it seeks to explain the design, implementation, and overall dynamics of the National Science Olympiad (OSN) preparation program as implemented in practice. To support these objectives, the study was conducted at SMAN 1 Cepu. This school was selected because it possesses a structured OSN coaching program, making it a relevant setting to explore innovations and implementation practices in olympiad coaching at the senior high school level.

In the data collection process, this study employed three primary methods: observation, interviews, and documentation. The selection of these techniques aligns with qualitative research characteristics that emphasize in-depth data collection to understand phenomena, experiences, and contexts through diverse information sources (Ardiansyah et al., 2023). Direct observations were conducted to examine the

interactions between coaching teachers and students, the teaching methods employed, and the learning atmosphere during coaching sessions. Semi-structured interviews were conducted with three key informants selected through purposive sampling based on their direct involvement in the OSN program, comprising one coaching teacher and two student participants. These interviews aimed to gather comprehensive information regarding coaching strategies, program implementation, challenges encountered, and the overall experiences of both the teacher and the students. To complement and triangulate the findings from observations and interviews, documentation was used as an additional data source. The researchers collected and reviewed relevant documents, including school profiles, program structures, coaching schedules, and evaluation reports, which served to strengthen and verify the empirical data.

After all the data were collected, data analysis was carried out using the interactive analysis model developed by Miles et al. (2014). This model consists of several interrelated stages that allow data to be analyzed systematically, as shown in Figure 1 below.



Figure 1. Data Analysis Model

As shown in Figure 1, data analysis was carried out through three interrelated stages. The first stage is data reduction, which is the process of selecting, categorizing, simplifying, and focusing the raw data obtained from observations, interviews, and documentation according to the research focus. Furthermore, during the data presentation stage, the reduced data were organized into systematic descriptive narratives and structured using a SWOT framework (Strengths, Weaknesses, Opportunities, and Threats). The SWOT framework was specifically integrated to systematically map and categorize the internal dynamics (strengths and weaknesses) and external factors (opportunities and threats) of the coaching program, facilitating a comprehensive interpretation of the empirical findings presented in Table 1. The final stage is conclusion drawing and verification, during which the researchers interpreted the synthesized findings and continuously verified them to ensure contextual accuracy, descriptive rigor, and validity.

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Results and Discussion

The OSN coaching program at SMAN 1 Cepu is designed in a structured and intensive manner, with routine activities that intensify as the competition approaches, aiming to prepare students academically and psychologically. Coaching is led by a supervising teacher from the school, who provides intensive practice on science concept mastery, scientific reasoning, problem solving, and HOTS. On certain occasions, the program is supplemented by three consecutive days of guidance from external tutors, such as university lecturers, who add scientific perspectives and deeper learning experiences. This approach combines theory and practice, hands-on learning, and collaborative activities so that students can practice actively and build mental readiness for competition. As explained in the Methods section, the data were organized in a SWOT matrix at the data presentation stage Table 1, and each component is discussed below in relation to previous studies.

Table 1. Main Findings

SWOT Components	Key Findings
Strength	The coaching is structured, with competent internal and external mentors and periodic simulations; the use of facilities and technology supports students' critical thinking and HOTS.

Weakness	Coaching is not conducted continuously throughout the year, participant selection is not yet fully systematic, and mentor limitations combined with high training intensity may cause student fatigue.
Opportunity	School support, access to digital learning resources, and opportunities for collaboration with universities, alumni, and external institutions open the way for wider program development.
Threat	Increasingly competitive OSN competition, growing complexity of material and questions, and potential student boredom due to academic workload challenge the sustainability of the program.

Program Strengths

The OSN coaching program at SMAN 1 Cepu shows several strengths that contribute to students' success. The clear training structure, the combination of internal and external mentoring, and periodic simulations enable students to master scientific concepts and to develop scientific reasoning and problem-solving skills systematically. This pattern is consistent with best practices reported in the gifted and STEM education literature, where intensive mentoring, periodic simulations, and structured training are associated with improved academic performance and psychological readiness for competition (Gül & Ayık, 2024; Suarso et al., 2025). The combination of intensive practice and HOTS-oriented problems in this program also resembles enrichment programs for gifted students that train non-routine problem solving (Rochayati & Rochayani, 2024). In addition, collaborative group work and team discussions improved students' motivation, involvement, and teamwork, which supports holistic learning and reflects the participatory character of child-friendly learning environments (Chairiyah et al., 2021; Mangestuti et al., 2022).

The program also makes optimal use of classrooms, and supporting technology, enabling students to engage in hands-on practice and experimentation interactively. Another strength is the teacher's flexibility in adapting learning methods to student characteristics, which supports HOTS and analytical skill development. This flexibility echoes the central role of teachers in creating adaptive learning experiences that optimize scientific reasoning and problem solving (Darling-Hammond et al., 2024) and the importance of teachers' diagnostic competencies in STEM talent development (Krischler et al., 2021). Taken together, these factors make the OSN coaching program at SMAN 1 Cepu effective and provide a model that other schools can adapt to develop scientific talent in a sustainable and child-friendly manner.

Program Weaknesses

Several weaknesses were also identified, although the program runs effectively overall. First, coaching is generally conducted only as the competition approaches, so training is not continuous throughout the year. This limits students' opportunities to develop scientific reasoning and problem-solving abilities gradually, and it falls short of the argument that science talent development benefits from early and systematic programs (Dinova & Mustika, 2025; Krischler et al., 2021).

Other weaknesses relate to participant selection and limited resources. The process of selecting students to represent the school is still limited and not fully systematic, while the number of mentors and available laboratory facilities is not always sufficient to guide all participants individually. This is a notable gap, because individual diagnosis and guidance are central to talent development (Krischler et al., 2021). In addition, the training rhythm during the three days with external tutors is very busy, running from morning until afternoon. Although students receive comprehensive material, they risk physical and mental fatigue. This finding resonates with evidence that academic pressure can lead to burnout (Chadha & Chauhan, 2025) and shows that the intensity that benefits academic performance (Suarso et al., 2025) must be balanced with schedule arrangements and strategies that keep the coaching effective and child-friendly (Fitrianto, 2025; Mangestuti et al., 2022).

Opportunity Program

The OSN coaching program at SMAN 1 Cepu has several opportunities that can be used to improve its quality and sustainability. School support for the development of academic performance provides room for a sustainable program. Moreover, technological progress and easier access to digital learning resources, such as question banks, learning videos, and scientific discussion platforms, give students opportunities to broaden their knowledge and improve their abilities independently. This is in line with recent arguments that technology-supported learning strategies can foster students' scientific thinking skills (Ramadhan & Faradilah, 2026).

Another opportunity comes from potential collaboration with universities, alumni, and external coaching institutions, which can enrich materials, learning experiences, and students' outlook on science competition. The tiered structure of the OSN, from school level to national level (Puspernas, 2024), also allows the school to develop a more directed coaching system while raising its academic reputation through student achievement.

Program Threats

Several threats require attention to keep the program effective and sustainable. Increasingly strict competition between schools demands that the coaching program keep adapting and improving its quality in order to produce competitive participants. In addition, the continuing development of OSN material and the rising difficulty of the questions require regular updates to learning materials and mastery strategies. This is consistent with the view that olympiad preparation should train students to solve non-routine problems through HOTS-oriented activities (Rochayati & Rochayani, 2024), which implies that coaching content must evolve alongside the competition.

Another threat is potential student boredom and declining motivation due to the high academic demands students face during coaching on top of their regular school activities. This threat is closely related to the academic stress and mental fatigue that intensive training can produce (Chadha & Chauhan, 2025), and it underlines why student well-being needs to be treated as a design principle of the program rather than a by-product (Fitrianto, 2025; Mangestuti et al., 2022). Changes in education policy or in the competition system may also affect the coaching pattern that has been applied. An adaptive and sustainable strategy is therefore needed so that the program remains effective in facing these challenges.

Strategic Implementation and Evaluation

The implementation of the program combines intensive practice, periodic simulations, and individual guidance tailored to participants' abilities. External tutors add deeper academic perspectives, while the integration of hands-on learning and collaborative activities helps students develop analytical skills and HOTS. Taken together, these elements correspond to the integration of academic and soft-skill training that previous studies describe as good practice in olympiad and gifted education programs (Gül & Ayık, 2024; Suarso et al., 2025).

Evaluation is carried out through pretest–posttest, teacher observation, student interviews, and digital monitoring to assess concept mastery, analytical skills, and participants' mental readiness. This systematic evaluation allows strategies, materials, and coaching methods to be adjusted so that they are more effective, sustainable, and supportive of student well-being. The evaluation results indicate that the approach is effective in improving students' academic and non-academic competence. By monitoring mental readiness alongside concept mastery, the program also goes beyond a purely achievement-oriented focus and brings together academic excellence and child-friendly principles, two strands that the literature has largely treated separately (Mangestuti et al., 2022; Suarso et al., 2025). In this respect, the study offers a coaching model that other schools can adapt.

Contributions and Implications for Other Schools

The National Science Olympiad (OSN) training program at SMAN 1 Cepu provides a practical overview of science talent development through structured training, a combination of internal and external

mentoring, as well as collaborative and hands-on learning activities. These components support the balanced development of students' academic and non-academic skills. However, since this study was conducted at a single school using a descriptive qualitative approach, the findings reflect the specific context and characteristics of SMAN 1 Cepu and cannot be directly generalized to all secondary schools. Consequently, this training model is best viewed as a contextual reference rather than a universally applicable framework.

Nevertheless, this model offers adaptable insights for other educational institutions. Other schools can adjust the number of mentors, facility usage, and training schedules to align with their respective institutional conditions and resource capabilities. Overall, the structured OSN coaching at SMAN 1 Cepu demonstrates that combining internal and external mentorship with hands-on and collaborative methods can effectively enhance students' academic competence, critical thinking, and Higher Order Thinking Skills (HOTS). Thus, this study serves as a holistic reference for fostering scientific talent and contributing to sustainable, high-quality, and inclusive science education.

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Conclusion

Based on the research findings, it can be concluded that the structured and sustainable National Science Olympiad (OSN) coaching program at SMAN 1 Cepu, which integrates internal mentoring, external guidance, intensive practice, hands-on learning, and collaborative activities, successfully enhances students' academic competence, scientific reasoning, problem-solving skills, and Higher Order Thinking Skills (HOTS). Although the program faces operational challenges such as intensive training schedules, facility constraints, and a selection process that is not yet fully systematic, planned implementation and ongoing evaluation allow the program to run effectively, holistically, and in alignment with child-friendly principles. This study contributes to science education by offering an OSN talent development framework that serves as a practical model for other schools, demonstrating how academic performance can be balanced with students' psychological well-being to foster sustainable science talent development in 21st-century education.

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