Developing Professional Science Teacher Candidates' Teaching Skills Based on Next Generation Science Standards (NGSS)

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Abstract: This study aims to develop the teaching skills of science teacher candidates by integrating Indonesian standards with the criteria of the Next Generation Science Standards (NGSS) through innovative microteaching practices. A mixed-methods approach was used for this research, which targeted science teacher candidates enrolled in microteaching courses, partner teachers, and microteaching lecturers. A total of 20 teacher candidates from a single microteaching class were the subjects of this research. An innovation introduced in this study allowed each student to review and analyze videos of previous microteaching sessions prior to their own practice. Data was collected from the microteaching curriculum, microteaching videos, and effectiveness tests of two developed products. The instrument used was an open-ended observation sheet. Microteaching practices were found to develop the teaching skills of professional science teacher candidates in line with NGSS criteria. Partner teachers reported a variety of positive experiences related to the development of syllabi, lesson plans, teaching materials, student worksheets, and assessments. The positive practices of these partner teachers were used as material for collaboration with lecturers in microteaching courses. The findings of this research indicate that collaboration with teachers in microteaching courses to provide information and feedback to teacher candidates, from preparation and implementation to evaluation of learning, plays a significant role in developing teaching skills.

INTRODUCTION

The challenges in preparing science teacher candidates have become more complex because they face the millennial generation, characterized by instability, impatience, and a desire for instant gratification (Bhattacharya & Gandhi, 2020; Brailovskaja & Bierhoff, 2020; Hamm et al., 2020). Moreover, the weaknesses of the millennial generation in learning include a lack of patience and susceptibility to being easily influenced by digital content on social media. Teacher candidates from the millennial generation encounter difficulties in learning and practicing traits that contrast with their own. They tend to expect immediate results, while prospective teachers require a lengthy process to master certain skills. In this regard, not all teacher candidates pursue education based on their own choices and interests. Their motivations can vary, from aspirations and parental encouragement to keeping up with workplace trends or simply trial and error (Gozali et al., 2019). Thus, lecturers and educational program administrators are tasked with handling various
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challenges and addressing the declining trend in the quantity and quality of research on developing basic teaching skills. Teaching practice necessitates the development of learning tools, such as lesson plans, teaching media, teaching materials, and evaluation instruments. This also becomes one of the main reasons why research publications on basic teaching skills from Indonesian researchers in international journals are difficult to find. Research in various journals is predominantly focused on teacher skills in Indonesia.

In this context, our preliminary study focuses on two main indicators in preparing science teacher candidates: mastery of science material and teaching skills demonstrated during internships at partner schools. We analyzed student performance data from 40 science teacher candidates at the Universitas Negeri Semarang, who carried out teaching internships in those schools. Our findings suggest that the candidates have a good grasp of the subject matter. The average score, evaluated by supervising lecturers and teachers in 2022, was 84 out of a maximum of 100. Knowledge aspects were evaluated through learning observation using material mastery instruments. The implementation of micro-teaching has proven to be an effective strategy for developing teaching skills in our candidates (Murphy Odo, 2022; Pekdağ et al., 2021; Sezen-Barrie et al., 2014). These sessions allow prospective teachers to practice skills such as lesson opening, classroom management, evaluation, and closing in a controlled environment with their peers.

The lecture curriculum, designed to provide knowledge and insight into scientific fields, aligns with the competencies graduates needed by our science teacher candidates. Sixty percent of these courses contribute to their material mastery. However, exceptional material mastery needs to be accompanied by strong teaching skills. One of the challenges worth noting for our candidates is sparking curiosity in students at the beginning of learning. Achieving this not only motivates students but also facilitates teachers in reaching learning objectives. Research indicates that students become more engaged when lessons relate to their prior knowledge (Yang et al., 2021; Yeo et al., 2022; Younis et al., 2021). Classroom management skills pose another significant challenge in preparing science teacher candidates. Effective classroom mastery involves not only academic aspects but also creating a comfortable and conducive learning atmosphere. Such mastery relies on teachers’ ability to adapt the learning process (Schweder, 2020; Vedder-Weiss & Fortus, 2018). Finally, we emphasize the importance of variation in teaching strategies, considering the diverse characteristics of students, while maintaining the same learning objectives (Andrews et al., 2022; Nouri et al., 2019).

For the same material in a contextual learning setting, teachers can choose different learning strategies based on the environment and student learning skills. Preparation for professional science teacher candidates is expected to equip the graduates to teach not only in schools in Indonesia but also abroad. The standard for preparing science teacher candidates refers to Permendiknas Number 16 of 2007 about Teacher Competence, which consists of pedagogical, personal, social, and professional competence. These competencies can be trained at the university through microteaching. The problems faced by science teacher candidates mostly lie in pedagogical and personal competence, while the preparation for professional science teacher candidates falls short of meeting all four competence criteria. It is certainly necessary to integrate standards for the future generation of science in Indonesia.

The Next Generation Science Standard (NGSS) is an international educational standard integrated to create a
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generation that incorporates science into daily life (Duschl & Bybee, 2014; Ndumanya et al., 2021). The goal of the NGSS is to improve science education for all students. The NGSS provides an opportunity for teachers to design a classroom learning process that can stimulate students' interests and prepare them for higher levels of career and social life. The preparation of science teacher candidates under the NGSS standards includes skills such as setting clear goals for all students, ensuring accurate scientific learning, establishing specific material limitations, delivering material based on investigation results, and meeting the diverse learning needs of students (Christian et al., 2021; Drew & Thomas, 2018).

The future of science education heavily relies on preparing teacher candidates who understand standard criteria in the NGSS (Granucci et al., 2017; Krajcik et al., 2014). The NGSS criteria are assessed through teaching education, teaching practice in small classes (microteaching), and teaching internships in partner schools. Microteaching serves as a platform for teacher candidates to practice the NGSS criteria. However, not all NGSS criteria can be directly practiced through this activity. Teacher candidates are trained to develop learning tools, including the syllabus, lesson plans, teaching materials, and assessments that integrate the NGSS criteria. The profiles of science teacher candidates require deep and broad mastery of content, proficiency in teaching with information technology, the ability to integrate science in a multidisciplinary manner, and a scientific spirit and human literacy by applying concepts to meet life's needs (Parmin & Khusniati, 2021). The NGSS, as an international standard for future science generations, can be actualized through science learning.

Standards for science teachers in Indonesia, as per Permendiknas Number 16 of 2007, need to be aligned with the Next Generation Science Standards (NGSS) criteria. The new standard, which refers to the NGSS, indicates that education for preparing science teacher candidates continues to produce thousands of new graduates. The nature of science, according to the NGSS, includes eight aspects: (1) Investigation using various methods, (2) Knowledge based on empirical evidence, (3) Knowledge that is open to revision, (4) Models, laws, mechanisms, and theories that can explain phenomena, (5) A way of understanding, (6) Knowledge that assumes an orderly and consistent system, (7) Human effort, and (8) Constant curiosity about nature and the world (Bybee, 2014; Weinstein, 2017). NGSS can be achieved through science learning and teaching activities in schools. Preparing teacher candidates in Indonesia requires adjustments to keep pace with other countries. The competency standards for science teacher candidates can merge the Permendiknas standards with the NGSS.

The preparation of professional science teacher candidates necessitates collaboration with diverse parties. The technical collaboration between lecturers and teachers at partner schools is intended to address the issue of inadequate teaching skills. Basic teaching skills in teacher education are acquired through teaching courses, microteaching, and teaching internships at the partner schools. Collaboration among educators can be fostered through sharing experiences related to best practices mutually implemented in learning (Nguyen & Dang, 2021; Nielsen & Jensen, 2021). Lecturers play a strategic role in preparing science teacher candidates, acting as subject lecturers and academic supervisors. Every teacher candidate requires information about best practices from experienced teachers in schools. Collaboration between lecturers and teachers from partner schools (partner teachers) is also needed because both play...
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a key role in the teaching internships for the teacher candidates. The success of microteaching is measured by the basic teaching skills of teacher candidates, from initiating to concluding lessons (Hong et al., 2017). Some partner teachers have excellent teaching skills and experience as internship supervisors. Selected teachers can partner to address the issue of teaching skills of teacher candidates in microteaching.

The best practices in learning innovation in schools are upheld by teachers with a strong commitment to teach professionally (Du Plessis, 2020; Kaasila et al., 2021). The teachers' positive experiences in fulfilling professional assignments can serve as best practices to be adopted as models in microteaching lectures. Partner teachers and lecturers, acting as observers with structured observation instruments, are expected to find solutions to the problems in the basic teaching skills of teacher candidates. The collaboration between lecturers and partner teachers in microteaching can be enhanced by analyzing recordings from videos of teacher candidates' teaching practices. Improving the implementation of microteaching lectures is crucial to produce science teacher candidates who meet both Indonesian and NGSS teacher standards.

Therefore, this study focuses on preparing science teacher candidates through innovation in microteaching courses, considering the lack of teacher involvement in this course. Teachers' experiences in best practices are not fully utilized in shaping teacher candidates skilled at teaching. Merely involving teachers as supervisors in internships is insufficient because they function only as mentors. This study aims to develop science teacher candidates' basic teaching skills that integrate Indonesian standards and NGSS criteria through innovative best practices in microteaching. The results of this study are expected to contribute meaningful recommendations for innovations in preparing professional science teacher candidates. Research outcomes play a role in achieving quality education in line with the Sustainable Development Goals (SDGs) targets in Indonesia by improving science teacher candidates' teaching skills.

METHOD

This research used mixed methods (Creswell, 2013). The microteaching tools for science teacher candidates were developed in accordance with Dick and Carey (2001). The basic teaching skills used in this study referred to Permendiknas Number 16 of 2007 and the NGSS. A unique advantage was the involvement of partner teachers in microteaching as active observers and resource persons in discussing and providing feedback from observations. Each teacher candidate analyzed videos of other candidates' teaching before their practice. The microteaching tools in this study were developed by identifying lecture objectives, analyzing the lecture process, developing lecture implementation strategies, formulating the lecture material, and conducting evaluations and reflections at the end of the lecture.

The research participants were science teacher candidates who attended microteaching courses, partner teachers, and microteaching lecturers. The research group comprised 20 science teacher candidates from the same learning environment. The sample for this research was drawn from a class of students who attended microteaching courses. Five partner teachers and five lecturers were also involved in this study. The teachers were from partner schools of varying status, including public schools, nationalist private schools, and religious private schools. The research participants wore microteaching uniforms, namely white shirts, black pants or skirts, and ties for male students. Each science teacher
candidate practiced teaching twice, taking on the role of a teacher in one session and a student in others. A key innovation developed in this study was that each student could listen to and analyze videos of the previous microteaching session before their practice. From this innovation, it was hoped that each teacher candidate would learn from and improve upon the strengths and weaknesses identified in previous implementations. This pattern continues and repeats, leading to the creation of teaching skills development products through repeated recording. This research produced a video showcasing the best microteaching practices for science teacher candidates. The stages conducted during one year of research are depicted in Figure 1.

![Figure 1. Research Process.](image)

The data collected included the microteaching curriculum, microteaching videos, and effectiveness tests for the two developed products. The curriculum product in this study was confined to the syllabus and the microteaching lesson plan. Both the curriculum and videos were innovative because the course design involved teachers from partner schools experienced in implementing best teaching practices. The innovations in the two products were oriented towards teaching skill standards that reference the NGSS. The tests for product effectiveness were conducted in microteaching lectures at the Science Education Study Program of Semarang State University. The primary data were obtained from questionnaires distributed to the three research target groups. The instrument was novel as it was developed to elaborate on the Ministry of National Education Regulation and NGSS standards. The instruments used consisted of validation sheets for the two products and observation sheets for the microteaching and teaching skills of science teacher candidates. Curriculum product validation involved curriculum experts, while video product validation involved learning media experts. Product validation data were analyzed by processing the contents of the validation sheets, which used a Likert scale. The percentage of product validity was calculated by obtaining the percentage of validators (results were rounded up to an integer) relative to the total score of each selected criterion.

**RESULT AND DISCUSSION**

The experiences of partner teachers used as best practices are derived from superior schools. This is because these schools display a variety of positive teaching practices which are executed by partner teachers in accordance with the NGSS criteria, as presented in Table 1.
Table 1. Partner Teachers’ Positive Teaching Practice.

<table>
<thead>
<tr>
<th>Positive Teaching Practice (NGSS Criteria)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience</td>
<td>The longer teachers teach at school, the more unique and interesting experiences they have.</td>
</tr>
<tr>
<td>Learning Resources</td>
<td>Partner teachers’ positive learning practices are needed as learning resources for teacher candidates.</td>
</tr>
<tr>
<td>Ease of Teaching</td>
<td>Carrying out teaching in a real class is not as easy as a conceptual study of how to teach.</td>
</tr>
<tr>
<td>Adaptivity</td>
<td>Adaptive teachers can use varied and fast methods of learning.</td>
</tr>
<tr>
<td>Empirical Evidence</td>
<td>Students more easily acquire scientific knowledge by being given empirical evidence from everyday life.</td>
</tr>
<tr>
<td>Knowledge Revision</td>
<td>Science knowledge is revised after students carry out experimental activities.</td>
</tr>
<tr>
<td>Scientific Phenomena</td>
<td>Science phenomena are not easily explained by applying models, laws, mechanisms, and theories.</td>
</tr>
<tr>
<td>Material Understanding</td>
<td>Science is easy to understand but difficult to apply in everyday life.</td>
</tr>
<tr>
<td>Teaching Skills</td>
<td>Positive teaching practices in schools can be utilized in microteaching learning for science teacher candidates.</td>
</tr>
<tr>
<td>Teachers' Presence</td>
<td>Partner teachers must be present in microteaching courses for science teacher candidates.</td>
</tr>
</tbody>
</table>

The longer teachers teach at school, the more unique and interesting experiences they accumulate for science teacher candidates. Teachers do not necessarily need deep and broad knowledge of the teaching content to meet teaching needs. Adaptive teaching skills are essential because each class has a diverse group of students, necessitating modifications in teaching methods. It is insufficient for teachers to rely solely on textbook teaching materials, as students need a direct connection with concepts learned and their application in real life within society. As such, it is necessary to supplement teaching materials, particularly those related to local wisdom. The diverse experiences of partner teachers should be shared with science teacher candidates who take microteaching courses.

The program of visiting partner schools corroborated the questionnaire results that combined closed-ended and reasoned essay questions. This study reveals teachers’ opinions about positive practices: (1) not all material learned at universities can be applied during school internships; (2) the diversity of student characteristics makes the application of learning theory not as straightforward as one might imagine; (3) a variety of teaching methods are needed due to the diverse learning styles of students; (4) science material should encourage students to connect discussions of practical results with real-life experiences; (5) teachers must have the courage to develop their teaching materials to accommodate local potential. Selected teachers in the partner schools, who were also research targets, expressed their willingness to attend and share teaching experiences in the university microteaching courses.

From the validity test results of the questionnaire data, a significance value of less than 0.05 was obtained. This value indicates that the resulting data are valid for use. The analysis of item validation is presented in Table 2.

Table 2. Validity Test of Questionnaire Item.

<table>
<thead>
<tr>
<th>Total Pearson Correlation</th>
<th>Sig.(2-tailed)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>.318</td>
<td>.617</td>
<td>30</td>
</tr>
<tr>
<td>.428</td>
<td>.561</td>
<td>30</td>
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<tr>
<td>.561</td>
<td>.270</td>
<td>30</td>
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<tr>
<td>.439</td>
<td>.697</td>
<td>30</td>
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<tr>
<td>.503</td>
<td>.569</td>
<td>30</td>
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<tr>
<td>.444</td>
<td>.004</td>
<td>30</td>
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<tr>
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<td>.018</td>
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<td>30</td>
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<tr>
<td>.014</td>
<td>.014</td>
<td>30</td>
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</tbody>
</table>
From the reliability test, a Cronbach's Alpha value of 0.712 was obtained, satisfying the requirement of being more than 0.70. Thus, this indicates that the variables used are reliable. An analysis of the responses from three groups of respondents towards the four statements regarding the approval to involve teachers in the microteaching course, allowing teachers to provide suggestions, acting as observers, and involving teachers in reflecting on the microteaching course is depicted in Figure 1.

![Figure 1. Comparison of Statements from Teacher Candidates, Partner Teachers, and Lecturers about Teacher Involvement in Microteaching Course.](image)

The results of the questionnaire analysis, as a key finding in this study, indicated that the target groups of teacher candidates, partner teachers, and lecturers strongly agree on the importance of utilizing the diverse experiences of teachers from partner schools through the micro-teaching course. The three respondent groups generally shared the same views on: the longer teachers teach, the more positive practices they acquire, the adaptive teaching styles they need due to student diversity, and the importance of introducing selected teachers into micro-teaching learning. Almasri (2022) and Gomes et al. (2023) argued that learning in schools has different levels of complexity due to variances in students' geography, culture, and socio-economic backgrounds. The basic teaching skills gained through micro-teaching act as a provision for science teacher candidates to become professional teachers. During teaching internships, they are trained to solve classroom management problems. Based on the experiences of supervising teachers during internships, science teacher candidates often struggle with optimal classroom management because their teaching methods lack adaptability to students' learning styles. This finding aligns with the NGSS criteria in which the process of science uses diverse methods. The presence of supervising teachers remains essential, particularly in providing examples of classroom management for science teacher candidates.

Knowledge of basic teaching skills is obtained from discussions between lecturers and students in teaching education. The basic teaching skills analyzed in this study include opening lessons, managing classes, assigning
tasks, guiding, evaluating, and closing lessons. Students practice applying teaching skills through micro-teaching courses, a prerequisite for teaching internships in partner schools. Lecturers often have limited school teaching experience; some don't even have any. This study's findings reinforce the importance of collaboration between lecturers, who have theoretical knowledge of teaching skills, and partner teachers, who have practical school teaching experience. Faisal & Martin (2019) stated that preparing professional science teacher candidates requires collaboration with various parties to provide knowledge, skills, and teaching capabilities. In this study, selected teachers from top-ranking schools expressed their readiness to participate in micro-teaching courses. Teachers from partner schools, who clearly understand their role as partner teachers, are invited through the lecturers' initiative. The involvement of teachers from partner schools provides feedback for learning tools used by each teacher candidate in micro-teaching, such as syllabus documents, lesson plans, teaching materials, student worksheets, and assessment tools. Feedback is based on the best actual experiences in schools. The presence of a partner teacher in micro-teaching serves as an observer to gather data and facts about student learning. The findings in the teacher notes are used as reflection material after the micro-teaching attended by all students. Rahayu et al., (2012) revealed that reflection on learning is essential to improve the quality of teaching in the next meeting. The findings during observations were reinforced by videos to present authentic evidence needed in carrying out the reflection. The collaboration between lecturers and teachers can impact the preparation of teacher candidates before teaching internships begin.

Teacher candidates, teachers from selected top-ranking partner schools, and micro-teaching lecturers shared the same statement about the importance of presenting teachers. The presence of partner teachers, with a real impact on improving the quality of micro-teaching, can be used as an institutional policy. Science education study programs in Indonesia can collaborate with top-ranking partner schools in preparing prospective teachers because they undoubtedly have professional teachers. According to the findings of this study, collaboration is needed because the initiative of lecturers alone is insufficient to bring in teachers. Program managers should initiate this as well. Partner teachers should act beyond merely being supervisors during teaching internships. Basic teaching skills learned and practiced by student teacher candidates in micro-teaching courses can be developed in line with the NGSS criteria. The presence of teachers is needed since teacher candidates begin to practice basic teaching skills, improving their acceptance at school.

CONCLUSION

The best microteaching practices can develop the teaching skills of professional science teacher candidates who meet NGSS criteria. Partner teachers that are presented have various positive experiences in carrying out practices regarding syllabus development, lesson plans, teaching materials, student worksheets, and assessments. Partner teachers' positive practices are used as material for collaboration with lecturers in microteaching courses. The important finding of this research is that the collaboration by presenting teachers in microteaching courses to provide teacher candidates information and feedback, such as the preparation, implementation, and evaluation of learning is certainly indispensable. For future research, it is
recommended to involve a larger and more diverse sample to ensure more representative results. Additionally, further research can focus on other aspects of teaching and learning, such as student motivation, parental involvement, and the use of technology in teaching.

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