Improvement of high school biology teacher understanding on the national science competition subject through technical guidance

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Abstract. There has not been a single high school student in Brebes District who has successfully represented Central Java Province in the National Science Competition (NSC) in the last three years. The main problem is the teacher's weak mastery of the subject to provide guidance to students, caused the mentoring process is not optimal. The purpose of this study was to improve the teacher mastery of subjects for teachers who were accompanying students in the NSC. This study used a one-group pretest-posttest design with a sample of 23 high school biology teachers who attended Technical Guidance (TG). The TG subjects were Ecology, Animal Physiology and Metabolism; Plant Anatomy and Physiology; and Genetics. The data obtained were pre-test and post-test scores, which were then analyzed using T-test and N-gain. The average result of the pre-test score was 40.22, and the post-test score was 70.27. There is an indication of teacher weaknesses in the application of the concept and data analysis. The results showed (1) there was a difference in the results of the participants' post-test scores, which higher than the pre-test, (2) there was a significant increase in the scores between before and after technical guidance, (3) the N-gain was 0.51 in the moderate category. It could be concluded, Technical Guidance on NSC subjects is effective in improving the understanding of high school biology teachers in Brebes district.

1. Introduction
Brebes district has 19 public high schools and 48 private high schools. Unfortunately, many high schools have not been able to support the achievement of students in Brebes District to excel in the National Science Competition (NSC). It has even been recorded that in the last three years, no one has made it into the top 10 for the Central Java Province level [1]. Based on discussions with biology teachers, one of the problems is their low mastery of NSC subjects. This condition could cause the process of mentoring in NSC's preparation at the district level is not optimal. The teachers understood that the difficulty level of the NSC selection questions was high because of many questions with higher-ordered thinking (HOT) characteristics. Many teachers stated that they experienced difficulties in guiding students due to the NSC questions’ difficulty level. Based on these conditions, it is necessary to provide technical guidance in dealing with NSC's district-level problems.

There are many factors affecting student achievement. One of them is teacher quality. Most studies have shown a relationship between teacher quality and student achievement [2-4]. Quality teachers contribute to student learning outcomes. Therefore, teachers need to be facilitated to improve their qualifications in sustainable professional development. One of the challenges in many developing
countries supporting teacher development is weak subject content and pedagogical knowledge and classroom skills [5]. Teacher training is one of the fundamental areas for teacher development and improving the quality of teachers [5]. A lack of professional development will jeopardize the achievement of Sustainable Development Goals (SDGs) as set under the 2030 Development Agenda in education [6].

The National Science Competition (NSC) is a prestigious competition carried out in stages, starting from the selection at the school, district, provincial and national level. The winner of the NSC at the national level will represent Indonesia at the international level [7]. The NSC covers nine scientific fields: Mathematics, Physics, Chemistry, Informatics/Computers, Biology, Astronomy, Economics, Earth, and Geography. NSC Biology subjects were: Cell Biology (Molecular, Microbiology, and Biotechnology); Plant Anatomy and Physiology; Animal Anatomy and Physiology; Ethology; Genetics and Evolution; Ecology Biosystematics. The NSC question sets have a high level of difficulty, which requires the ability to analyze data. Some questions used tables, graphs, pictures, or numbers that require in-depth understanding when answering questions. Therefore, the supervising teacher needs to give adequate knowledge and skills to support student preparation for the selection. This research aims to study the teacher improvement of NSC Biology subjects after following technical guidance.

2. Methods
The research design used One-Group Pre-test and Post-test and 23 Biology teachers as a sample involved. There were four subjects of the technical guidance: Ecology, Animal Physiology and Metabolism, Plant Physiology and Anatomy, and Genetics. Each subject is handled by lectures from the Biology Department Faculty of Mathematics and Sciences Universitas Negeri Semarang, who have experiences in NSC guiding for more than five years. The technical guidance was conducted for four weeks, every Thursday, from 9 am to 3 pm. The pre-test and post-test used the sample test of NSC at the district level, with multiple choice types of problems. The limit of the average score after technical guidance was 70. We used the T-test to determine the average difference score of the pre-test and post-test data and N-gain to measure the course's effectiveness in improving conceptual understanding before and after technical guidance. Some sample problems were analyzed based on the answer sheet of the participant.

3. Results and discussion
Biology teachers' understanding of the NSC subject was successfully improved after following technical guidance, as shown in Table 1. The average score in pre-test and post-test shows a striking difference with an increasing trend. Participants showed an increase in understanding between before and after following technical guidance. The average of pre-test and post-test scores were significantly different based on the T-test. The overall N-gain value is in the medium category.

| No. | Data         | Pre-test | Post-test |
|-----|--------------|----------|-----------|
| 1.  | Highest score| 71       | 90        |
| 2.  | Lowest score | 25       | 50        |
| 3.  | Average      | 40.22    | 70.27*    |
| 4.  | N-Gain       | 0.51 (moderate) |         |

*significance at t<0.05

Although there was an increase in the pre-test mean score compared to the pre-test, the average pre-test scores only slightly exceeded the minimum completeness criterion, namely 70.22 from the limit (70). Only 21% of teachers achieved an average score of 80> for all subjects, and there are 26% of teachers who got an average score of 60<=, the others with an average score between 60-80. Some teachers said they need more practice in solving higher-level questions. When this data compared to student selection results in district level year 2019, there is an indication of a relationship between
teacher achievement and student achievement. This result is in line with previous studies that the quality of teachers affects the quality of students [2][3][4]. In Indonesian teachers' case, their understanding of HOTS is broad enough, and HOTS needs to be trained. However, it has not been implemented in their teaching activities because the HOTS aspect tends to be neglected [8]. Other research findings indicated that teachers' knowledge about HOTS, their ability to improve students' HOTS, solve HOTS-based problems, and measure students' HOTS is still low [9]. This weakness must be corrected immediately by conducting ongoing HOTS training for teachers. Participant teachers must receive guidance and monitoring in its application in the classroom, not just knowledge. However, this effort must be made in synergy between district education offices, education quality assurance institutions, and higher education institutions.

The effectiveness of the technical guidance is indicated by the N-gain score, which reaches the medium category. This indicates that technical guidance is effective in increasing teachers' understanding of the NSC subject. All teachers have a positive N-gain, ranging from 0.23-0.89. Teachers with participant numbers 2, 3, and 16 showed relatively higher N-gain scores compared to others. This is in accordance with the data from the Biology NSC selection results at the Brebes District level in the year 2019.

Based on the individual subject of Biology NSC (Figure 1), the N-gain average ranged from 0.49 to 0.55, and there is no significant difference among them. Each subject has characteristics that participants need to understand. For example, Genetics requires numerical abilities (numerical literacy). Animal physiology and metabolism and plant physiology and anatomy subject require an understanding of biochemistry and how to implement the understanding in everyday life. Ecology subject needs the ability to connect between data and interpret it based on the questions' context. Understanding each subject's characteristics must be mastered by the teacher so that they can teach well to students.

As mentioned earlier, the Biology NSC selection problem set requires analyzing and thinking critically, not just the ability to know facts and concepts. Framework for 21st Century Program emphasized that students in the 21st century must master higher-order thinking skills (HOTS). They use complex ways to think about what they are learning [10]. Teachers must help students understand what HOTS is, connect concepts, teach students to infer, encourage questioning, use graphic organizers, teach problem-solving techniques, encourage creative thinking, use mind movies, teach students to elaborate their answers, and teaching question-answer-relationships [10]. Biology teachers in Brebes District, through this technical guidance, began to practice and learn how to think critically in answer to
questions. Indeed, not all teachers have experienced good development, but teachers begin to learn how to solve HOT questions. Nevertheless, LOTS is still needed as a foundation to move up to the HOTS stage. However, the teacher's experience in following this technical guidance is very valuable because it would determine the success in helping students to master HOTS. This is according to the finding of Geritse et al. [12] that all students' test performance improves with teacher experience.

In Bloom's taxonomy, skills involving analysis, evaluation, and synthesis (creation of new knowledge) are thought a higher order than the learning of facts and concepts (low order thinking skills, LOTS), which requires different learning and teaching methods (Figure 2). The LOTS involve memorization, while HOTS requires understanding and applying that knowledge [13]. Higher-order thinking emphasizes analyzing (differentiating, organizing, attributing), evaluate (checking and critiquing), create (generating, planning, producing). Teachers who would teach HOTS should understand all about HOTS: how to design, implement and evaluate. Therefore, continuous professional development is needed to progress in education, especially in the Disruptive 4.0 Era. Teacher professional development could be achieved by deepening the scientific field (cognitive) through postgraduate education, short-term training; improve psychomotor and affective abilities through training, workshops, seminars, discussions, academic and academic activities [14]. In the case of teachers involved in the technical guidance, some teachers stated that they had attended HOTS training in education quality assurance institutions (LPMP). Still, most had never participated in such activities, especially teachers from private schools. Thus, higher education institutions' participation is needed to assist The Ministry of Education and Culture to equalize access to quality improvement of teachers.

Figure 2. Categories in the cognitive domain of Bloom's Taxonomy [11].

From this activity, information was obtained that 26% of teachers were still weak in the mastery of the material, especially in Genetics. In Mendel's genetic problems, for example, questions are usually started with the parent's genotype data and asked for the offspring's genotype and phenotype. Participants have no difficulty in solving this kind of problem (LOT). However, when the questions started with progeny data and were asked to determine the parents' genotype or phenotype (HOT), almost all participants experienced difficulties (Table 2).

The results of this technical guidance can be used as a reflection for teachers, both those who have succeeded in reaching the minimum limit and those who have not. Teachers who participate in this technical guidance that have not achieved optimal results become aware of improving their academic abilities to provide better services for their students. They could learn from other teachers or experts to complete their skills. Therefore, they could help their students to better understanding and skills about HOTS. On the other hand, teachers who have succeeded in technical guidance can further sharpen their ability to solve questions at the HOT level and help the students in easier ways of thinking. They can even develop their abilities, so they no longer feel anxious when following a teacher competency test because they are well prepared and trained. If the teacher masters the subject material and learning
techniques, it is very beneficial for their students. This is in accordance with the findings of Oleshinde et al. [15] that pedagogical and subject content knowledge of teachers were found to be significant predictors of students' academic achievement. The role of teachers in teaching HOT is an important aspect of teaching HOT effectively [16]. Teachers' understanding of HOTS and creativity in teaching are important aspects in supporting the success of learning. Teachers suggested employing strategies such as activating prior knowledge, graphic organizers, questioning, and brainstorming [17]. Some researchers report the effectiveness of teaching HOTS using INSTAD [18], serious games [19], comics [20], or using module [21]. This shows that there are many techniques or strategies that the teacher can choose to develop students' HOTS.

### Table 2. Example of LOT and HOT problems in Genetics.

| Example of LOT problem | Example of HOT problem |
|-----------------------|-----------------------|
| It is assumed that the mango skin color is controlled by a pair of alleles (A for orange color, dominant to a for yellow). At different loci, fruit taste is controlled by a pair of alleles (B for sour taste, dominant to b for sweet taste). If we crossed two types of mango with genotype: AaBb x Aabb, determine the progeny's genotype and phenotype. | It is assumed that the mango skin color is controlled by a pair of alleles (A for orange color, dominant to a for yellow). The fruit taste is controlled by a pair of alleles at different loci (B for sour taste, dominant to b for sweet taste). The results of crossing two types of parent mangoes are as follows: orange, sour = 301; yellow, sour = 99; yellow, sweet = 102; orange, sweet = 298. Determine the most likely genotype of both parents! |

After receiving technical guidance, 30.43% of teachers stated that they are confident in guiding their students in preparation for district Biology NCS selection. As many as 52.17% are still in doubt. The remaining 17.50% stated that they are not ready to guide their students. However, in general, the teacher stated that they really felt the benefits of this technical guidance activity and hoped that it would be continued for other subjects.

### 4. Conclusion

Technical guidance on the National Science Competition subject effectively improves the understanding of high school biology teachers in Brebes District. There is a difference between pre-test and post-test scores during Technical Guidance. The N-gain average score of technical guidance was 0.51 in the medium category. N-gain among subjects showed no difference, which is 0.49 to 0.55 in range, with medium category. Some teachers still have difficulty solving problems at the level of analysis and require repeated practice with a more challenging set of questions.

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