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Train the Skills of Making HOTS-based Physics Questions to Physics Teachers in Mojokerto

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Train the skills of making HOTS-based physics questions to physics teachers in Mojokerto

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Abstract. Higher-order-thinking skills (HOTS) are skills that must be possessed to be globally competitive in the 21st century. Therefore, HOTS should be trained and assessed in learning, including learning physics. To measure HOTS, you need questions that agree with the HOTS criterion. Not all physics teachers understand the characteristics of HOTS. This study aimed to practice the skills of making HOTS-based physics questions for physics teacher in Mojokerto. The method used is a one-shot case study. Physics teachers understand HOTS characteristics and trained on how to make HOTS questions starting from fundamental competency analysis in the curriculum to creating HOTS questions for physics. The results showed that 60% of the teachers who were able to complete the task of making HOTS-based physics questions from all the participants who attended the training activities. It shows that efforts are still needed to improve teachers' quality and capacity in preparing HOTS questions for physics subjects.

1. Introduction

The development of science and technology takes place very rapidly in the 21-st century. The world makes progress very massive in the global paradigm, including society, work, and lifeways. Future generations need Higher-order thinking skills (HOTS) to deal with complex situations like this so that everyone can solve problems, think critically, have creativity, and collaborate to find solutions to the issues they face. To be more intellectual and competitive in facing every problem in their real life, it is better if the teacher trains students in higher-order thinking through learning and learning assessment so that students are used to doing higher-order thinking processes.

HOTS-based assessment is an assessment that uses test questions that can hone students' higher-order thinking skills. Based on international study results, the Program for International Student Assessment (PISA) shows that the achievement of reading literacy, mathematical literacy, and scientific literacy achieved by Indonesian students is still low. In general, the ability of Indonesian students is deficient in (1) understanding complex information, (2) theory, analysis, and problem-solving, (3) use of tools procedures and problem-solving, and (4) conducting investigations [1]. HOTS has been poorly trained and accommodated by the teacher during learning, which affects all aspects of knowledge [2]. Based on the facts, it is necessary to change the system in learning assessment. The assessment developed by the teacher expected to encourage HOTS, increase creativity, and build the independence of students to solve problems.

HOTS questions' characteristics include measuring HOTS, based on contextual problems, and various forms of items [3-4]. HOTS problems aim to hone the skills of students in carrying out higher-order thinking processes. Judging from the dimensions of knowledge, generally, HOTS questions measure metacognitive dimensions, not just measuring factual, conceptual, or procedural dimensions [5]. The metacognitive dimensions describe the ability to connect several different concepts, interpret, solve problems, choose problem-solving strategies, discover new methods, reasoning, and make the right decisions [6]. The dimension of the thought process in Bloom's



Taxonomy as refined by Anderson and Krathwohl consist of the ability on remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6) [6]. HOTS questions generally measure the ability in the realm of "analyzing", "evaluating", and "creating" [5].

The results of a review of the question items conducted by the Directorate of Senior High School (SHS) Coaching in the 2018/2019 school year National Standard School Exam (NSSE) Assistance to 26 subjects in 136 Reference SHSs spread across 34 Provinces, most of them were at Level-1 and Level-2. From the 136 referred SHSs, only 27 schools compiled HOTS questions as much as 20% of all the NSSE questions made, 84 schools compiled HOTS questions below 20%, and 25% schools said they did not know whether HOTS questions were compiled or not [7]. It is not in line with the demands of the 2013 curriculum assessment, which further improves the HOTS assessment model's implementation.

Considering that the assessment in curriculum 13 refers to the HOTS type, teachers must compile HOTS questions themselves that tailored to the learning context of students, including physics teachers. Assessment of learning outcomes is expected to help students improve HOTS because higher thinking can encourage students to think broadly and deeply about the material lesson [8]. Besides, in this century's learning, students must master 21-st century skills that consist of critical thinking, creativity and innovation, collaboration, communication and learning to learn (usually called 4Cs). These skills are essential for students to face in the post-school world [9].

Based on these facts, the higher education lecturers need an effort to train HOTS-based question preparation skills to teachers, including high school physics teachers. Physics teachers are supported by Subject Teachers' Deliberation (STD) management who have paid attention to the importance of having skills in arranging the right questions to accommodate the thinking skills possessed by students. STD administrators have attempted to facilitate training on NSSE questions preparation through the National Examination Grid Surgery activity in early 2018.

However, more efforts are still needed to train the skills of teachers in composing HOTS-based physics questions. The steps taken by the Mojokerto Physics STD administrators in overcoming these obstacles are to empower teachers who have more ability to prepare questions to teach their peers. Another step is to invite expert resource persons to assist the physics teachers in compiling HOTS questions. Thus, a workshop conducted to train and assist physics teachers in the Mojokerto area to collect HOTS-based physics questions. The purpose of providing training and mentoring is to improve the insights and skills of high school physics teachers in the Mojokerto area in compiling HOTS-based physics questions.

2. Method

The research determined the extent to which physics teachers in Mojokerto have compiled HOTS-based physics questions by using a one-shot case study of pre-experimental design. There are 24 participants as physics teachers in Mojokerto who are members of the HOTS-based physics question preparation workshop. The workshop held in the hall of the public senior high school 1 Puri Mojokerto. The lecturers understood HOTS characteristics and trained on how to make HOTS questions to the physics teachers, starting from fundamental competency analysis in the curriculum into creating HOTS questions for physics.

The steps of the activities undertaken to obtain documents on the preparation of HOTS-based questions through stages are shown in Figure 1. These stages carried out systematically so that physics teachers can produce HOTS-based physics questions.

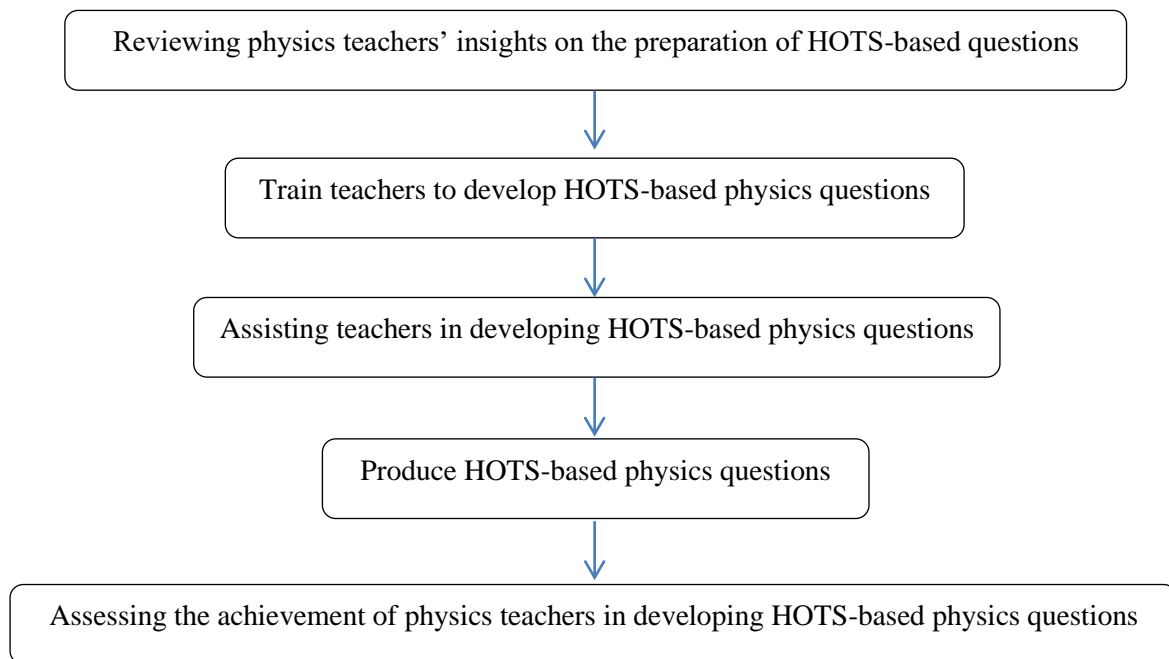


Figure 1. The steps of training HOTS-based physics questions

In the first stage, the lecturers reviewed the training participants' knowledge of HOTS-based test instruments, either in the form of direct question-answer or in a questionnaire. Furthermore, an appropriate approach carried out to provide insight into physics teachers regarding the preparation of HOTS-based test instruments and the importance of HOTS-based assessments in 21-st century learning.

After being given insights on 21st-century learning, HOTS-based assessments, and criteria for good test item preparation, the lecturers provided training to prepare HOTS-based test instruments. Lecturers provide examples of HOTS-based question stem and explain why the test item is called HOTS-based test item. Lecturers also offer directions on how to arrange useful HOTS-based test items and can measure students' HOTS.

After providing training on the preparation of HOTS-based physics questions, the lecturers assisted the training participants in compiling HOTS-based physics questions. Service carried out during the training and after the training so that a product produced in HOTS-based physics questions. Post-training assistance carried out through the WhatsApp Group. The mentoring activity is an assignment for making HOTS questions with the final result in the form of HOTS questions that have been developed by the training participants.

Produce HOTS-physics questions done for months. The product is the HOTS-based physics questions as the result of work in the group for two months. It is also evidence of HOTS question preparation skills improvement because it has produced products in the form of HOTS-based physics questions.

The final stage is assessing the achievement of physics teachers in developing HOTS-based physics questions. In this stage, the lecturers check the physics teachers' results in compiling HOTS-based physics questions based on the products submitted to the Mojokerto Physics STD management.

3. Result and Discussion

In the workshop's implementation, the lecturer provides material following the stages described in the method section. The first steps to train the skills of making HOTS-based physics questions to physics teacher in Mojokerto are reviewing physics teachers' insights on the preparation of HOTS-based physics questions. Based on the workshop's interview, most of the physics teacher participating in the seminar could not distinguish between HOTS questions and challenging questions. More than 50% of the participants thought that HOTS was a difficult question and requires many physics formula applications. Whereas, HOTS-based physics questions are very different from difficult questions. The cognitive processes reflect high-level thinking when they are independent, have social origins, and are

accessible to their self-awareness [10]. HOTS are closely related to the thinking process. HOTS's several aspects are conceptual understanding, systematic thinking, problem-solving, and critical thinking [11]. This understanding is a significant concern that must give to teachers. The HOTS question is not only challenging but has the characteristics of a high-level thinking process. Leaders and teachers must also learn how to view the goals of thinking to be essential and tangible as content goals [12].

To learn the physics curriculum's content goals and train teachers develop HOTS-based physics questions, the researchers defined the characteristics of the HOTS-based physics questions. That is divergent, using knowledge and various skills used in problem-solving, using multi-representations to present data and information, and using real-life context stimuli. Understanding HOTS-based physics questions' characteristics were applied by analyzing sample questions, such as the 2015 PISA question in Figure 2. The real-life context stimuli used in Question 1 (Figure 2) is about the wind farm. Figure 2 shows that the item used visual representation in the form of picture and graphs in the next questions in this topic used verbal presentation and mathematical expression. The question is divergent. To solve this problem (in Figure 2), we need knowledge and various thinking skills. Such as graphic reading skills, skills in understanding the context of the situation in question, skills in analyzing each graphical representation, and skills to evaluate which graph is most suitable as a reference for determining the appropriate location as the wind farm for generating electricity.

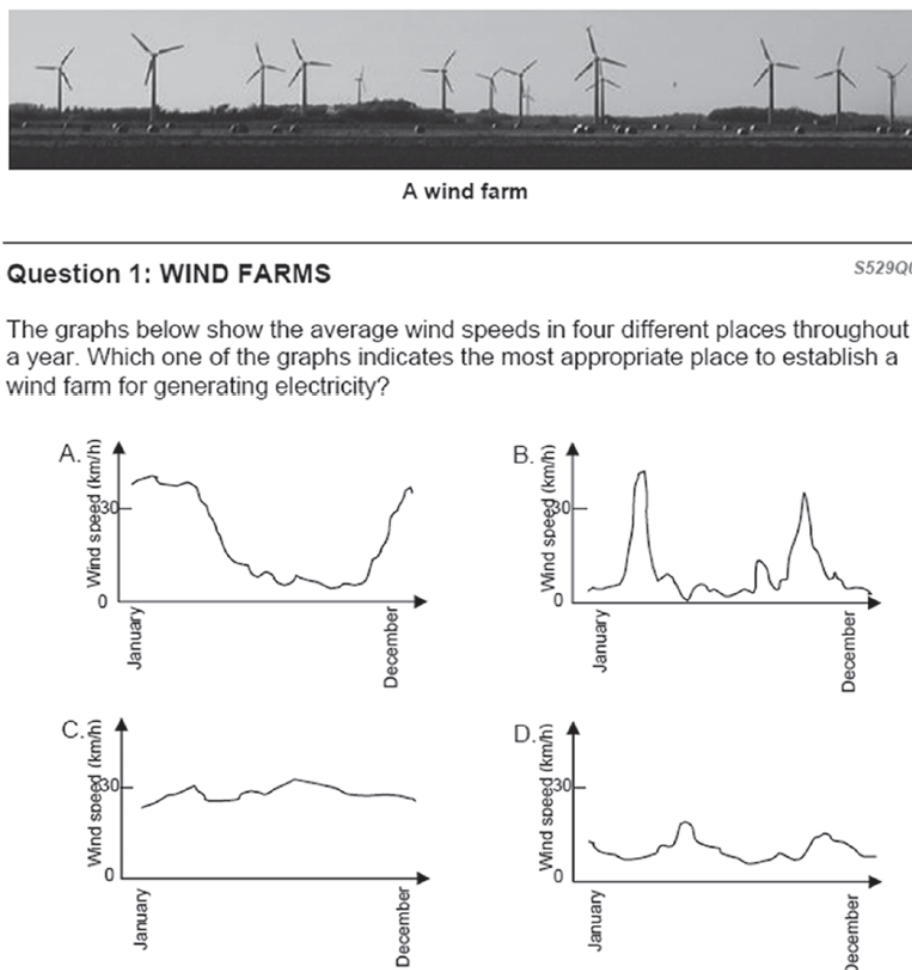


Figure 2. One of the 2015 PISA question [13]

After understanding the characteristics of HOTS, the lecturers gave directions regarding the steps for making HOTS-based physics question instruments. The stages in the preparation of HOTS-based physics questions are: identifying essential competencies in standard curriculum content, formulating

HOTS indicators, looking for real-life phenomena related to measured competencies, using multiple representations, and paying attention to signs of developing right assessment instruments.

Basic competence is a minimum measure in measuring student ability. If essential competencies require HOTS, then the assessment of learning outcomes must base on HOTS. Therefore, the first step in developing HOTS-based physics questions is to identify crucial competencies. Pay attention to the active verbs in the essential competencies listed in the curriculum document. Choose a verb that denotes a verb that requires an advanced thought process. For example, we analyze the basic competencies 3.5 until 3.10, which is written in Regulation of Minister of Education and Culture No. 37 of 2018 for physics subject matter as shown in Figure 3. From six (6) essential competencies shown in Figure 3, five of them have minimum HOTS assessment demand. Only the last basic competence (3.10) that has no minimum requirement for HOTS assessment. Why? Because the active verb on basic competence 3.5 until 3.9 is "analyze". "Analyze" is the cognitive level of C4 which included in the HOTS category [3-8].

3.5 Menganalisis gerak parabola dengan menggunakan vektor, berikut makna fisisnya dan penerapannya dalam kehidupan sehari-hari	3.5 Analyzing the parabolic motion using vectors, along with its physical meaning and its application in everyday life.
3.6 Menganalisis besaran fisis pada gerak melingkar dengan laju konstan (tetap) dan penerapannya dalam kehidupan sehari-hari	3.6 Analyze physical quantities in circular motion at a constant rate and their application in everyday life.
3.7 Menganalisis interaksi pada gaya serta hubungan antara gaya, massa dan gerak lurus benda serta penerapannya dalam kehidupan sehari-hari	3.7 Analyze the interaction of force and the relationship between force, mass and straight motion of objects and their application in everyday life.
3.8 Menganalisis keteraturan gerak planet dan satelit dalam tata surya berdasarkan hukum-hukum Newton	3.8 Analyze the order of motion of the planets and satellites in the solar system based on Newton's laws.
3.9 Menganalisis konsep energi, usaha (kerja), hubungan usaha (kerja) dan perubahan energi, hukum kekekalan energi, serta penerapannya dalam peristiwa sehari-hari	3.9 Analyze the concepts of energy, work, the relationship between work and energy changes, the law of energy conservation, and their application in daily events.
3.10 Menerapkan konsep momentum dan impuls, serta hukum kekekalan momentum dalam kehidupan sehari-hari	3.10 Applying the concepts of momentum and impulse, as well as the law of conservation of momentum in everyday life.

(Indonesian Language)

(English)

Figure 3. The fundamental competencies in Regulation of Minister of Education and Culture No. 37 of 2018 for physics subject matter [14]

They are formulating HOTS indicators by selecting active verbs that are at the level of analyzing (C4), evaluating (C5), and creating (C6) in the Bloom's-revised-taxonomy realm. The development of question indicators is an essential component in the preparation of an assessment instrument. Competency achievement indicators (CAI) are characteristics, traits, signs, actions, or responses that students must perform or displayed by students who indicate that they have mastered specific necessary competencies. The teacher can develop CAI into question indicators used for the preparation of assessment instruments. Question indicators used as signs in the practice of items. For example: from the basic competence 3.2, "Analyze the properties of the elasticity of the materials in everyday life" [14]. The CAI formulation can write as "Presented a characteristic graph (F-x) of five springs that will install on the car as shock absorbers, students can conclude that the right spring installed on the car."

In compiling HOTS questions, it recommended using multiple representations. There are several forms of expression in physics, namely verbal terms, image/diagram representations, graphical representations, and mathematical representations [15]. The model has three functions: complementary functions, interpretation, constraint functions, and understanding building functions [16]. Jauhariyah and Wasis found that students can explain their reasoning very well when interpreting the visual representation given in the test item [17]. It shows that students' high-order

thinking processes in solving problems can be stimulated using multiple names, in addition to the real-life phenomena presented.

The real-life phenomena to measured competencies are used as a stimulus in the stem of physics questions developed by the physics teachers. Several things that needed to consider in preparing the HOTS question stimulus are:

1. choose some information in the form of pictures, graphs, tables, discourses, etc. that have a relationship in a case;
2. the motivation should require the ability to interpret, looking for a relationship, analyze, conclude, or create;
3. choose circumstances/problems that are contextual and interesting (current issue) that motivate students to read;
4. directly related to the question and work as stimulation to solve the problems.

To develop excellent HOTS-based physics questions, we must pay attention to signs of developing good assessment instruments. After arranging the grid, the items made into a blank called Question Card (QC). In addition to containing the QCs, the QC also includes basic competence, CAI, content material, question number, answer key, and cognitive level. QC also made to facilitate qualitative analysis. The item statistic filled in; after being tested, a quantitative study carried out. From the data resulting from this quantitative analysis, the grouping of eligible questions to enter the question bank and those that refused everyone can sort entry to the question bank.

Based on the description, the lecturers form the five (5) groups of all participants. Lecturers provide a copy of Regulation of Minister of Education and Culture No. 37 of 2018 document as a guideline for fundamental competency analysis. Attachments also give the study of real competence to the preparation of a HOTS question grid for physics subjects and the examples. Each group discussed material topics based on basic competence to follow up in preparing question grid and making HOTS-based physics test items. Follow-up activities carried out through the WhatsApp Group, physics teachers as participants and lecturers as interviewees communicated for follow-up activities and assignments. The management of Mojokerto Physics STD also assists the coordination activities. Assistance in the preparation of HOTS-based physics questions lasted for two months.

The results of completing the task are sent to the lead researcher e-mail to evaluate whether the questions include the HOTS category or not. After two months, the participants were the physics teachers who sent three groups of e-mails. It means that only 60% of participants completed and submitted their assignment. Other groups have been in progress. The compilation of questions sent by the participants is then analyzed to determine the percentage of achievement of the physics teacher in the preparation of HOTS questions for high school physics subjects.

Based on all the physics questions received, 80% composed of HOTS questions while the rest were not HOTS questions. It shows an increase in the understanding of physics teachers from those who were not understanding HOTS questions to experience and producing HOTS questions for physics material, even though not all physics teachers submitted assignments according to the agreement. Based on the physics teachers' interview that has not completed the task, they find it challenging to determine appropriate contextual phenomena in the preparation of HOTS questions. Besides, they not accustomed to using multiple representations in presenting one question item.

Table 1 shows the product sample of HOTS-based physics question due to the physics teachers training in making HOTS-based physics questions. Group 3 presented an ambulance moving by turning on the sound of siren phenomena. The items' phenomena are represented in pictures, while the first question shown in tabular form with true/false column. It problem also uses contextual phenomena. This group has tried to construct HOTS-based physics questions in the right way. However, the second question still included in the realm of "applying" (C3). It would be better if there is a comparison of the situation so that it can improve students' thinking processes toward "analyzing" (C4) or "evaluating" (C5).

Table 1. The product sample of HOTS-based physics questions from group 3

Indonesian Language
Fenomena Sirine



Ambulance di kota Garut bergerak di tengah padatnya lalu lintas dengan kecepatan 60 m/s melewati pemotor yang berhenti di lampu merah. Sirine berbunyi dengan frekuensi 800 Hz yang makin lama terdengar makin lemah oleh pemotor.

Efek ini menggambarkan perbedaan panjang gelombang dan frekuensi saat sumber bunyi menjauhi pendengar, sebagai hasil dari gerak relatif dari pendengar atau sumber bunyi. Dengan demikian ketika sumber bunyi menjauhi pendengar panjang gelombangnya membesar.

Pertanyaan 1 : Fenomena Sirine dalam Gelombang Bunyi

Berdasarkan wacana di atas, lingkari 'Benar' atau 'Salah' untuk setiap pernyataan berikut!

Apakah kondisi berikut berkaitan dengan efek doppler ?	Pilihan
Bila pemotor bergerak berlawanan arah dengan ambulan, maka frekuensi yang didengar orang tersebut bertambah.	Benar/Salah
Ketika mobil ambulan meninggalkan pemotor, suara yang didengar oleh pemotor mengecil karena panjang gelombangnya mengecil.	Benar/Salah
Saat masih berada dilampu merah, tiba-tiba angin bergerak searah dengan arah ambulance dengan kelajuan tertentu. Maka frekuensi sirine yang didengar pemotor tersebut berkurang.	Benar/Salah

Pertanyaan 2 : Fenomena Efek Doppler dalam Gelombang Bunyi

Setelah lampu berubah hijau, pemotor segera mengejar ambulance dengan kecepatan 10 m/s dan cepat rambat gelombang bunyi di udara pada saat itu adalah 340 m/s.

- Apakah frekuensi yang didengar orang tersebut berkurang? Buktikan jawaban kamu melalui persamaan matematis.
- Berapakah besar frekuensi bunyi yang didengar oleh orang tersebut?

English

The Sirens Phenomena



Ambulance in Garut moves in the middle of heavy traffic at a speed of 60 m/s past motorists who stop at a red light. The siren sounds with a frequency of 800 Hz which the more prolonged is heard weaker by the motorbike gets. When the sound source is away from the listener, there is a difference in wavelength and frequency. Thus when the sound source moves away from the listener, its wavelength increases.

Question 1: The phenomenon of sirens in sound waves

Based on the above discourse, circle 'T' for True or 'F' for False in each of the following statements!

Are the following conditions related to the Doppler effect?	Chosen
The frequency that the motorist hears increases when he moves in the opposite	T / F

direction to the ambulance.	
The sound heard by motorists decreases because the wavelength decreases when the ambulance leaves the motorbike.	T / F
The frequency of the motorist's sirens decreased while they were still at the red light, and suddenly the wind moved in the direction of the ambulance at a certain speed.	T / F

Question 2: The phenomenon of sirens in sound waves

Motorists immediately chased the ambulance at a speed of 10 m/s when the traffic light turned green. The velocity of sound waves in the air at that time was 340 m/s.

- What frequency did the person hear (decrease or increase)? Prove your answer through a mathematical equation.
- What is the frequency of the sound heard by the person?

As for the workshop participants' response, after participating in the presentation of material about skills in making HOTS-based physics questions, most of them gave positive responses. Figure 4 shows that 46 % of participants felt this training provided many benefits, 50% agreed with the same statement, while 4% strongly disagreed with this statement. After checking in the open questions section, 4% of these participants wanted laboratory equipment training. It happened because there was a lack of coordination between the STD management and the physics teachers who were members of the STD. The administration did not determine the division of the workshop groups. It would be better if each physics teacher could choose his workshop topic according to his/her passion. Of course, the training topic should convey to physics teachers before the activity takes place from the start. Besides, Figure 4 shows that 54% of the participants strongly agree and 46% of the participant agree that they get a clear understanding of the preparation of HOTS-based physics questions. Figure 5 shows that 54% of the participants strongly agree and 46% agree that the training materials help them develop the skills in composing HOTS-based physics questions.

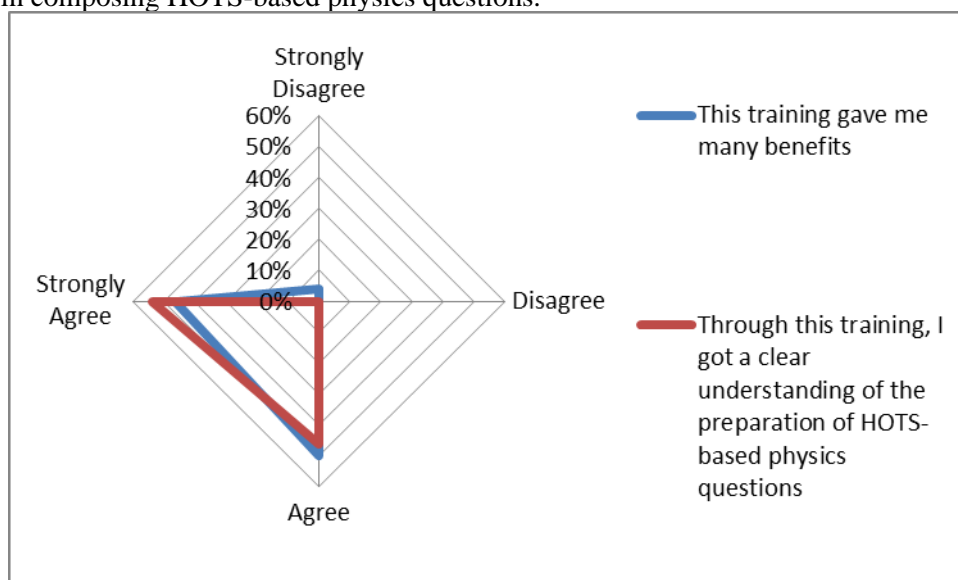


Figure 4. The physics teachers responses on the benefit and the clear understanding of the training of the preparation of HOTS-based physics questions.

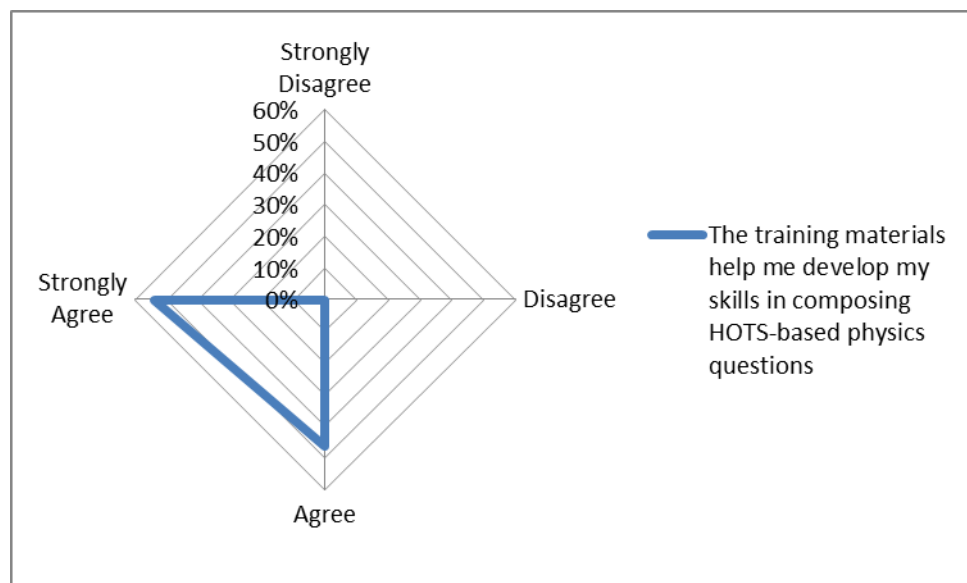


Figure 5. The physics teachers responses on the develop their skills in composing HOTS-based physics questions.

During the training activities, lecturers provide modules containing HOTS material, preparation of HOTS questions, question grid instruments, and several examples of HOTS questions. Based on the workshop participants' questionnaire, 35% strongly agreed, and 65% agreed that the training module was well structured (Figure 6). The hope is that, through this training module, participants can learn independently during the mentoring activities and assist participants in completing assignments as a follow-up to providing material on preparing HOTS questions to workshop participants. Figure 6 also shows the workshop participants' strongly agree that the presenters master the training materials well (62%) and the remaining 38% agree with the same statement.

Although some participants felt that they lacked the time and thought that the training was ineffective because it was too short, more than 50% of participants strongly agreed that the material's delivery was communicative, the rest agreed with the same statement (Figure 6). Figure 6 shows that all the participants also felt that the material's delivery was impressive, 50% of the participants strongly agreed, and the rest of 50% agreed with this statement.

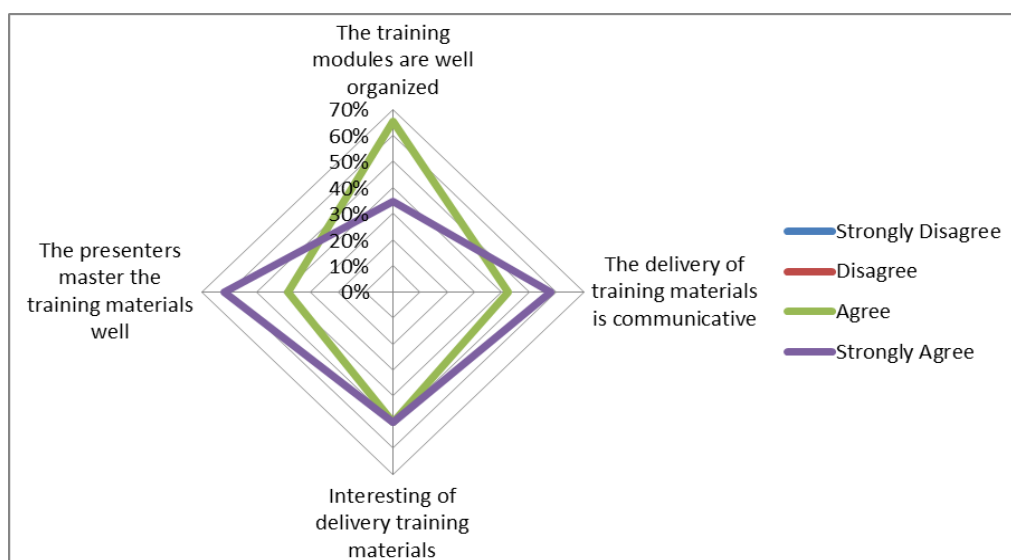


Figure 6. The physics teachers responses on the delivery training materials on making HOTS-based physics questions.

Based on the discussion above, it can conclude that they need more effort to improve a physics teacher's skills in compiling HOTS-based physics questions. Some of the difficulties experienced by physics teachers in Mojokerto include not accustomed to using multiple representations in composing problems and challenges in finding phenomena in everyday life that match the material tested topic. Because habits start from being trained, the end being oriented comes from getting used. It takes an effort to familiarize themselves with high school physics teachers in Mojokerto to compile HOTS-based physics questions. HOTS included 21st-century thinking skills like critical-thinking skills, creative thinking, problem-solving skills, collaborative thinking skills, and communication skills [5]. Of course, it not only applies to question making; the physics learning process must also be accustomed to using strategies to hone students' HOTS. Such as using Problem-Based Learning model [18-19], Project-Based Learning model [19], Creative Responsibility Based Teaching model [20], Collaborative Problem Based Physics Learning model [21], Group Science Learning model [22], Local Wisdom Integrated Learning Model [23], Collaborative Creativity Learning model [24], ORNE Learning model [25]. Other models/methods can also improve the students' thinking skills that hone the students' HOTS. All of the learning models or strategies used in physics learning can improve the student HOTS if there is synchronization on learning objectives, procedures, and evaluation and assessment. Some teachers used the flipped classroom strategy [26]; others used Understanding by Design strategy to teach physics [27].

4. Conclusion

Efforts have made to train skills in making HOTS-based physics questions for physics teachers in Mojokerto. It found that 60% of physics teachers as training participants had completed and submitted assignments, while the rest were in the process of compiling HOTS-based physics questions. About 40% of the physics teachers have difficulty collecting HOTS-based physics questions because not accustomed to using multiple representations simultaneously in items and problems in determining real-life phenomena that are following the topic to test. It is because not all physics teachers have implemented physics lessons that train students' HOTS. It is an essential concern that more effort is needed to familiarize high school physics teachers in Mojokerto to implement learning strategies that teach HOTS and get used to composing HOTS-based physics questions. Physics teachers as training participants gave a positive response to the HOTS-based physics questions preparation training in Mojokerto. They also benefited from this training.

Acknowledgement

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