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Towards Interactive Dialogic Communication in Online Science Classes Amidst COVID-19 Pandemic: A Case of Indonesian High School

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Abstract

This study explores communication patterns between teachers and students during online science classes in Indonesia. Due to the COVID-19 pandemic, schools worldwide were closed, and physical or face-to-face classrooms were replaced by remote learning and online classes. Nevertheless, how teachers can engage students in online learning through interactive communication was rarely examined. Therefore, we analyzed the video recording of online classes during the pandemic and characterized the communication approaches. For this analysis, we selected three teachers from a high school in Pontianak, each with expertise in one of the specific subjects: biology, chemistry, and physics. The discourse analysis was made for one chapter/unit of each subject, which consisted of four to five lessons. The results show that the three teachers dominantly used authoritative - non interactive approaches during the online classes. In addition, students were generally more hesitant to participate in whole-class discussions due to technical problems and online learning constraints. However, teachers can engage students in interactive dialogic discussion by asking them to propose an explanation of a phenomenon and use their prior knowledge in a new context. The findings suggest that teachers must expand communication approaches and instructional strategies to facilitate students' active participation in meaningful learning.

Key words: COVID-19 Pandemic, Science Learning, Communicative Approach, Online Class

Introduction

Due to the COVID-19 pandemic, schools worldwide were temporarily closed, and physical or face-to-face classrooms were replaced by remote learning and online classes. However, remote and online learning are generally less effective, especially in underdeveloped and developing countries, since teachers were unprepared to transfer to online

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teaching and learning (The World Bank et al., 2021). Wisanti et al. (2021) reported that most science teachers in Indonesia experienced difficulties in conducting online learning.

The new learning environment required teachers to modify their instructional strategies. Students may find that online learning is less engaging (Ionescu et al., 2020) and have difficulties focusing during online learning (Bao, 2020). In addition, teachers need to adjust their teaching content and encourage students' high-quality participation for effective online learning (Bao). Many studies have focused on investigating teacher and student perceptions, challenges, and difficulties in online learning during the pandemic (Azhari & Fajri, 2022; Bao; Ionescu; Kamal et al., 2020; Karnalim & Wijanto, 2021; Mailizar et al., 2020; Mishra et al., 2020; Wisanti et al., 2021; Yildiz, 2021). Moreover, various instructional strategies were explored to engage students in an online learning environment (Arghode et al., 2018; Babinčáková & Bernard, 2020; Joshi, 2021; Sepp et al., 2022). Nevertheless, communication and interaction between teacher and students in online learning during the pandemic have rarely been examined. Identifying communication discourses in online classes is important to understand which aspects teachers need more support and training to conduct effective online learning, especially for teachers with little or no experience in online teaching. Therefore, this study explored online science class discourse during the COVID-19 pandemic in Indonesia. Particularly, the following research questions were addressed:

(1) What were the characteristics of the communication approaches used during online learning, particularly in biology, chemistry, and physics classes?
(2) How did the teachers engage the students interactively and dialogically during online learning?
(3) What were the difficulties or challenges in teaching science online related to the interaction with the students?

Literature Review

Online learning

Technological advancement and the internet provides an alternative learning environment besides the traditional physical classroom. Remote learning, or distance learning, separates the instructor and learner by physical space (Moore et al., 2011). Remote learning can be implemented in various ways, such as via postcards or online learning. Online learning utilizes digital tools such as mobile phones, digital devices, and laptops with internet connection (Clark & Mayer, 2016). With these technologies, learners can easily access unlimited information and engage with various visualizations, simulations, digital games, etc. Digital technologies offer an immediate learning environment, instant response and engagement. Learning can occur at any time and place, beyond the physical classroom.

Despite the potential and affordances of online learning, important principles in designing effective online instruction are similar to physical instruction (Partlow & Gibbs, 2003). In addition, Mayer (2019) suggests that the instructional method has a greater impact on students' learning than the instructional media. Studies indicate that engaging students in cognitive processing activities is more effective to promote meaningful instruction than behavioral activities (Skuballa et al., 2018; Yannier, et al., 2020). Behavioral activities (i.e.,

hands-on activities) require learners' participation in manipulating objects, whereas cognitive activities involve cognitive or mental processing with the materials (Bonwell & Eison, 1991; Haury & Rillero, 1994). In a digital learning environment, dragging and dropping matching information or highlighting important information are considered a behavioral activity, while constructing self-explanation is a cognitive activity (Bodemer, et al., 2004; Ploetzner, et al., 2013; Skuballa et al.). While utilizing the unique features of the digital learning environment, instruction should be used to guide students to active cognitive processing rather than focusing on hands-on activities.

Education during COVID-19 in Indonesia

The advancement in technology and the internet provides an alternative learning environment in addition to the traditional environment, i.e. the physical classroom. Due to the COVID-19 pandemic, remote learning was implemented in many countries to control the spread of the virus, thus limiting in-person contact between teacher and student. In Indonesia, physical classes were suspended following the Circular of the Minister of Education and Culture Number 4 of 2020. As a response, since March 24, 2020, remote learning has been implemented in almost all schools and colleges/universities in Indonesia.

Different approaches to remote learning were implemented according to accessibility to internet access and learning tools. In areas where access to the internet was limited, teachers utilized educational broadcasts on television and radio provided by the government for students' learning (Azhari & Fajri, 2022). In addition, parents or students can collect and submit learning materials at school or appointed locations coordinated with village heads (Azhari & Fajri). Meanwhile, with the availability of the internet and digital devices, online classes were conducted through video conferencing apps.

The sudden change to remote learning has presented challenges for teachers, especially in conducting classes. Most teachers have no experience and training in conducting online learning (Wisanti et al., 2021). Consequently, they are not confident and have difficulty using applications to conduct online classes (Azhari & Fajri, 2022; Rasmitadila et al., 2020; Wisanti et al.). Nevertheless, they have learned to operate information and communication technology for teaching, e.g., application for video conferencing, from their peers (Azhari & Fajri). In addition, science teachers have learned to use virtual laboratories as a substitute for experimental activity (Wisanti et al.). They familiarize themselves with applications to record lecture videos to help students to review unclear lesson materials (Karnalim & Wijanto, 2021).

On the other hand, teachers have complained about students' participation and enthusiasm during online classes (Rasmitadila et al., 2020). Although teachers have used video to engage and motivate their students (Rasmitadila et al.; Wisanti et al., 2021), many students still struggle to understand lessons during online learning (Karnalim & Wijanto, 2021). Their difficulties are associated with limited interaction with teachers and peers (Karnalim & Wijanto). However, little is known about interaction and communication during online learning. Thus, we shall analyze the communication between teachers and students to understand how teachers can effectively engage students in discussions during online learning.

Communicative approach

This paper analyzed teacher-student interaction during whole-class teaching sessions using the Communicative Approach (CA) developed by Mortimer and Scott (2003). The discourse can be identified as combining two dimensions: *dialogic-authoritative* and *interactive-non-interactive*. Different points of view were presented in the dialogic approach, while only one point of view (i.e., school science) was heard in the authoritative approach. Meanwhile, the interactive approach involved other people in the classroom talk; conversely, the non-interactive approach allowed one-person participation only (i.e., teacher). Therefore, combining the two dimensions, the discourse may be composed of four different types of CA: Authoritative-Non-Interactive (A/NI), Dialogic-Non-Interactive (D/NI), Authoritative-Interactive (A/I), and Dialogic-Interactive (D/I). Description and examples for each type of CA are presented in Table 1. The four categories of CA allow us to determine how teachers work with their students in developing ideas (Mortimer & Scott) are:

- Authoritative-Non-Interactive (A/NI): Teacher presents a single point of view, usually scientific, without interacting with the students.
- Dialogic-Non-Interactive (D/NI): Teacher presents and explores two or more viewpoints, but does not involve the students in the processes.
- Authoritative-Interactive (A/I): Teacher guides the students through a series of questions and answers centered around a scientific point of view.
- Dialogic-Interactive (D/I): Teacher and students propose and explore various points of view about a certain phenomenon or problem.

Table 1. Description and examples of communicative approaches

Types of CA	Description	Example
A/NI	Formal lecture type, where the teacher presents a single scientific point of view	Teacher: Theoretically, we know that the reaction rate will increase as temperature increases. Why? Because the particles gain additional energy. Hence, successful collisions will occur more frequently. But, ...
D/NI	Another type of formal lecture, where the teacher addresses different points of view without interaction with the students	Teacher: Every object experiences a gravitational force from the earth. Usually we say that this force is pulling us downward. However, it is actually directed toward the earth's center.
A/I	Question-answer or discussion of different ideas, but focuses only on one correct answer or idea, usually one that the teacher already predetermines	Teacher: ... How about (blood type) AB? Do you think it can receive blood from (blood type) A? Student 1: Yes. Teacher: Why? Student 1: Because it has no anti-B or anti-A. Teacher: Okay. It does not have antibodies. So it will not attack (the antigens). So, it is fine. There is no agglutination. How about the (blood type) O? If blood type B gives blood to (blood type) O, what will happen? Is it okay or not okay? Student 1: Agglutination will happen.
D/I	Discussion of phenomena or problems that allows students to propose different points of view or solutions	Teacher: If we consider the electron's motion, where will the electrons dominantly go? Student: The lower resistance. Teacher: Why? Student: Because... If there are places (streams) with few or many stones, the current will go to the fewer stones since there is less resistance. Teacher: Yes, correct! So... the electron will go to the lower resistance.

Note: CA: Communicative Approach; A/NI: Authoritative-Non-Interactive; D/NI: Dialogic-Non-Interactive; A/I: Authoritative-Interactive; D/I: Dialogic-Interactive.

Although several studies provide examples of dialogic interaction (e.g., Aguiar et al., 2010; Lehesvuori et al., 2013; McMahon, 2012), both dialogic and authoritative approaches are beneficial for students' learning (Lehesvuori et al.; Scott et al., 2006). In other words, teachers should be able to bring out students' everyday perspective of phenomena and connect it with a scientific point of view for meaningful learning of science. Moreover, different CAs may be used in different lesson stages and for different pedagogical purposes (Lehesvuori et al.; McMahon). However, Lehesvouri et al. suggest that dialogic discussion at the beginning of a lesson is necessary so that teachers can consider students' contributions and prior knowledge when going into scientific explanations, i.e., authoritative discourse. On the other hand, non-interactive ways might be used to impart procedural knowledge and meanings of terminology, while students' ideas and observations about phenomena could be explored through interactive discourses (McMahon). Therefore, teachers must shift between and use different CAs for meaningful and effective learning.

Methods

Participants and settings

The data of this study were collected from online learning conducted in a high school in Pontianak, Indonesia. Due to the COVID-19 pandemic, the school was closed and physical classes were suspended from mid of March 2020. The school started using Microsoft Teams (MS Teams) for online classes in April 2020. Different channels in MS Teams were set up for each subject and class. Video meeting was utilized for the synchronous classes, while other features in MS Teams (e.g., post, assignment, chat, etc.) allowed sharing of files, information, and communication between teachers and students. Like physical classes, the online classes were held from Monday to Friday, with 10 daily lesson periods. However, each period was shortened to 30 minutes for online classes from initially 45 minutes.

This descriptive case study research that aims to describe a phenomenon (Yin, 2018). Purposive sampling was adopted to see variability in online classes to understand the discourse better. Three teachers were selected, one for each science subject in senior high school in Indonesia (i.e., biology, chemistry, and physics). To maintain the anonymity of the teachers, we refer to them as Teacher B, Teacher C, and Teacher P. All three teachers are females with bachelor's degrees aligned with the discipline they teach. Their teaching experience ranged from 3 to 12 years. The background information about the three teachers is summarized in Table 2.

Although teacher B and P had less than 5 years of teaching experience, they trained students to participate in local, national, and international competitions. They used various strategies to engage students and develop their conceptual understanding effectively. Meanwhile, teacher C was certified and had long experience teaching chemistry. She has excellent class management and maintains a good relationship with the students. The three teachers have excellent knowledge of the subject, skills in engaging students in their learning, and encouraging active participation during physical classes. Therefore, their practices may provide insight into effective online teaching. For this study, we observed the recordings of their online classes and conducted semi-structured interviews with the three teachers.

Table 2. Background information of the teachers

Information	Teacher B	Teacher C	Teacher P
Subject	Biology	Chemistry	Physics
Gender	Female	Female	Female
Educational background	B.Sc. in Biology for Teachers	B.Ed. in Chemistry	B.Sc. in Physics
Teaching experience	4 years	12 years	3 years

Data collection methods

Online classes observation

This study analyzed the lessons from science subjects, including biology, chemistry, and physics. Table 3 shows the grade and lesson unit taken for the analysis. We observed the online discourse of classes of grade 11 and grade 12. The class had 34 to 36 students, with almost a similar proportion of boys and girls in each class. The lessons analyzed in this study were taken from the second year of online learning implementation. For each subject, video recordings of the lessons for one unit were collected, which took about 10 to 12 periods. The topic was selected since it was near the first semester's end. Therefore, the teacher was already familiar with the characteristics of the students and the class. In addition, natural and comfortable interactions between teachers and students were already established.

Individual semi-structured interview

To further understand teachers' communication approach during the online learning, a semi-structured interview was performed. The semi-structured interview is an in-depth conversation between the researchers and the participant. It allows reciprocity. That is researchers may ask further questions to the participants for clarification, meaning-making, and critical reflection (Galletta, 2013). Due to geographical distances and for time flexibility, the interviews were conducted via text messages. Moreover, text messages allowed the participants to respond in their convenient time and provide a considered reply (Bampton & Cowton, 2002). Open-ended questions were given to explore teachers' experiences in online teaching and the difficulties related to their interaction with the students. Teachers' opinions about online teaching are important since they were not used to this learning environment prior to the pandemic and it might affect their communicative approach. Further, one aspect of communication approach is interactivity. Therefore, teacher-student interaction is highly connected with the approach they used. Below are a few sample questions:

- In your experience, how were teaching online classes different from face-to-face classes?

Table 3. Grades and lessons of case study

Information	Biology	Chemistry	Physics
Grade	11	11	12
Number of students	36	36	34
Gender	15 boys, 21 girls	15 boys, 21 girls	19 boys, 15 girls
Lesson unit	Circulatory System	Rate of Reaction	Electromagnetic Induction
Number of lessons (total periods)	5 (12)	4 (12)	4 (10)

- What difficulties did you experience when teaching online related to interaction with students?

In addition, the researcher asked follow-up questions for unclear responses or further elaborations. Teachers' responses were received within a day after the questions were sent. Main themes and key findings are summarized in section "Difficulties during online learning."

Data analysis

In this study, we observed the video recordings to analyze the talks in the online science classes. Interaction and participation of students during the discourse were determined using the concept of CAs developed by Mortimer and Scott (2003). Meanwhile, we examined teachers' responses to the interview questions to identify the challenges they faced when interacting with the students during online classes. Content analysis of teachers' answers to our questions was performed by identifying prevalent ideas related to their instructional strategies and interaction with students.

A modified framework by Lehesvuori et al. (2013) was utilized for the analytical procedures of video recordings, as presented in Figure 1. The analysis started with defining the episodes as the unit of analysis. The episodes allowed us to break the discourse into smaller 'chunks' for more detailed analysis. Moreover, teachers normally orchestrate different activities to keep student engagement and participation during online classes. Aside from lecturing, teachers might guide students into discussion, problem-solving, or questions and answers, which provide opportunities for students to express their ideas or understanding of the subject matter.

Types of activities during online classes and the CAs as the main focus of analysis were used in defining the episodes. The shift of discussion topics/activities indicated the beginning or end of an episode during teaching sequences. Teachers' approaches to learning content or activity can be captured this way. For example, the episode was regarded as changing when the teacher changed the discussion from Faraday's law to Lenz's law. Similarly, changes in CA were also considered moving to the next episode to show more accurately the presence of each CA. Subsequently, the CA was identified for each episode based on the dominant approach and level of interactivity.

In coding the episode, we used the four categories of CA described in Table 1. Prior to coding the whole data, the first author and one external

Figure 1. Identification process of communicative approach

Source: Modified from "Visualizing communication structures in science classrooms: Tracing cumulativity in teacher-led whole class discussions," by S. Lehesvuori, J. Viiri, H. Rasku-Puttonen, J. Moate, & J. Helaakoski, 2013, *Journal of Research in Science Teaching*, *50*(8), 912-939.

member independently coded 30% of the data. The interrater reliability was calculated using Cohen's Kappa ($K = 0.656$, $p < .001$). This measure of agreement is considered substantial (Landis & Koch, 1977). Then, the coders compared their coding, solved disagreements, and clarified the coding protocols. Finally, the first author continued the coding for the entire dataset.

Next, the occurrences of each CA were analyzed to characterize the communication between teachers and students during the online classes. Moreover, teachers' responses to the interview questions were examined to better understand the difficulties they encountered and the strategies they used during online learning. In addition, examples of interactive and dialogic episodes were presented to exemplify the teachers' strategies for engaging students during online learning. These exemplary episodes illustrate various ways interactive and dialogic approaches can be used productively in online teaching.

Findings

Characteristics of communication approach during online classes

This analysis aims to better understand the discourse during online learning in Indonesia. Figure 2 shows the distribution of communication approaches during biology, chemistry and physics online classes. Generally, authoritative approaches dominated online science classes. The authoritative approaches (i.e., A/NI and A/I) were about 87% - 92% of the overall episodes in the online classes, indicating that the instructions were mainly focused on scientific perspectives. Regarding

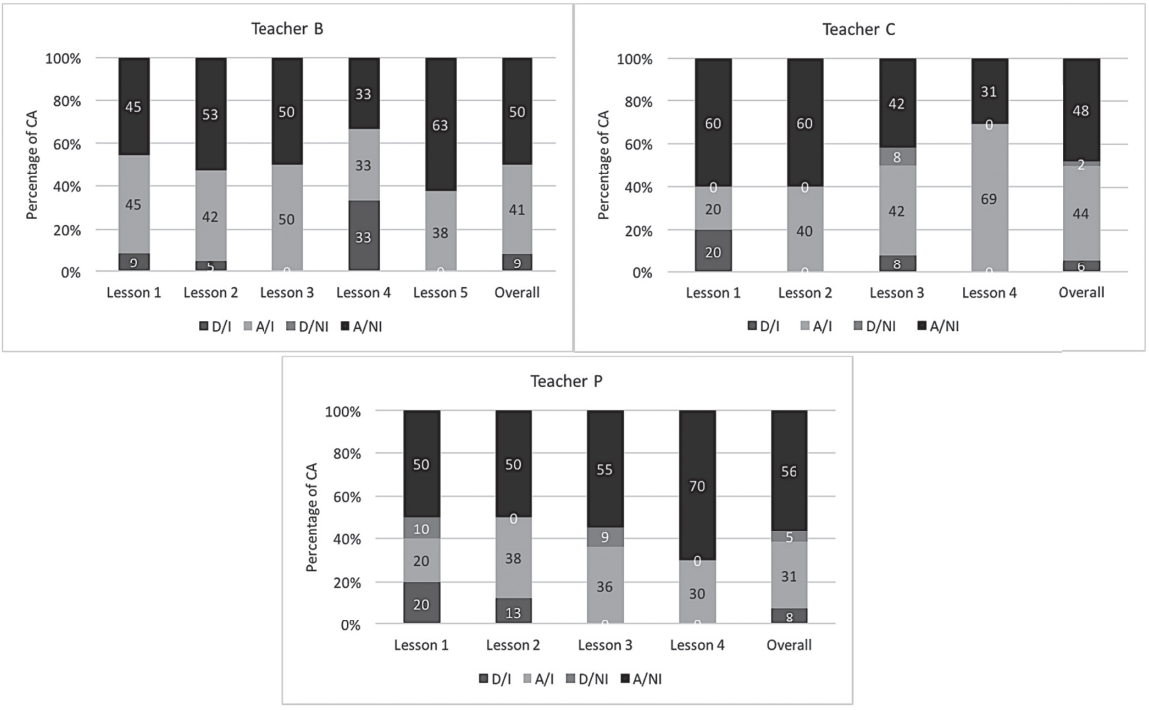

Figure 2. Percentages of CA during online classes

interactivity, equal percentages were recorded for the overall interactive and non-interactive episodes in biology and chemistry classes (i.e., 50% interactive), whereas physics classes were less interactive (overall 61% non-interactive).

All three teachers used A/NI (biology 50%; chemistry 48%; physics 56%) and A/I (biology 41%; chemistry 44%; physics 31%) approaches during their online classes. These approaches become more prominent as no dialogic episode occurred throughout the last lesson in each subject. Further, D/NI (biology 0%; chemistry 2%; physics 5%) and D/I (biology 9%; chemistry 6%; physics 8%) approaches were rarely used during online learning. However, D/I episodes appeared in about one-third of Lesson 4 in biology class. During this period, the teacher discussed blood clotting and typing with the students. The detailed discussion is presented in the following section.

Table 4 shows the activities in each CA during the online classes. The non-interactive (authoritative and dialogic) episodes include the activity of lecturing and problem-solving. On the other hand, Q&A, discussion, and problem-solving activities appeared in the interactive (authoritative and dialogic) episodes. The three teachers mostly did lecturing (biology 50%; chemistry 36%; physics 41%) during their lessons. Teacher B often used Q&A (biology 44%; chemistry 26%) to communicate interactively with her students. Meanwhile, teacher C and P engaged interactively with their students mostly during Q&A and problem-solving (chemistry 42%; physics 30%).

Although the three teachers rarely used the D/I approach, we can find D/I episodes during the online classes. Some of these episodes are presented in the following section to provide examples of dialogic and interactive communication in science learning.

Dialogic/Interactive episodes

The three teachers used a dialogic/interactive approach to teaching science during online classes.

Table 4. Distribution of activities for each CA

	Teacher B		Teacher C		Teacher P	
Activity	Frequency	%	Frequency	%	Frequency	%
A/NI						
Lecturing	23	50	18	36	14	36
Problem-solving	-	-	6	12	8	20
D/NI						
Lecturing	-	-	-	-	2	5
Problem-solving	-	-	1	2	-	-
A/I						
Q&A	17	37	12	24	6	15
Discussion	2	4	1	2	-	-
Problem-solving	-	-	9	18	6	15
D/I						
Q&A	3	7	1	2	1	3
Discussion	1	2	-	-	1	3
Problem-solving	-	-	2	4	1	3

In the blood clotting discussion, teacher B asked about their daily experience. She asked the students to explain why they feel itchy when a mesh is formed on a wound.

Teacher: When the mesh is formed for a while on a wound, but you peel it off because it is itchy, there is still blood. Why?

Student 1: The tissue forming is not completed yet, so there is still blood (underneath).

Teacher: True. So, cell division is not yet completely made. So not perfect yet, but you peel it off. If it is just halfway in the formation, the mesh will exist for a long time. Does anyone have an idea why the mesh is itchy? Have you ever searched (for a reason) or read about it? Any opinions? Any guesses?

Student 2: Because it is something foreign on the skin, the brain signals to remove that foreign thing.

Teacher: So the signal from the brain commands you to rub it? Okay. Others? Thank you, student 2.

Student 3: Maybe because there is external stimulation.

Teacher: What stimulation, for example?

Student 3: Maybe a certain substance is ejected.

Teacher: Okay. So there is stimulation that causes itchiness. Any other opinion?

Student 1: Like the opinion of student 2. So, the pain in our wound signals the brain, so we feel the itch.

Initially, teacher B and the students discussed scientific knowledge on blood clotting. Nevertheless, she extended the dialogue and related it to students' experiences when they have wounds. The students were led to propose their explanations of the phenomena.

Teacher C engaged interactively and dialogically with the students during the problem-solving activity. After a student explained his solution to the given problem, teacher C explained her method to solve the same problem.

Student 1: I used the formula of molarity.

Teacher: Okay. Which formula?

Student 2: Molarity is equal to mole divided by volume in liter. Since it is given (in the problem) that the molarity is 0.15, the mole is unknown, and the volume is 0.5. Therefore, the mole is 0.075. Using the same formula, now the mole is the same, but the molarity is 2.5. So, we got a volume is 0.03 liter.

Teacher: Yes. The answer is correct, 0.03 liter or 30 milliliters. There is a shortcut, so we do not need to work twice (the formula). So, this question is about dilution; we want to reduce the concentration of a solution. If the case is about dilution, we can use the formula of $M_1V_1 = M_2V_2$. ... So, this is used when we want to dilute, which is by changing the initially concentrated (solution) to become diluted.

Moreover, teacher C often encouraged the students to use their prior knowledge and provided alternative solutions to solve a problem rather than memorizing new formulas.

The dialogic/interactive episode during the lesson of teacher P occurred during the question and answer session. After lecturing about the concept of motion emf, teacher P asked to have the students who understood to explain.

Student 1: What if both (ends) were closed? Is it (the current) similar?

Teacher: Both ends were closed… like this?

Student 1: Yes

Teacher: Is there any resistor (here)?

Student 1: Yes

Teacher: Okay. Then it becomes like a parallel circuit, didn't it?

Student 1: Yes

Teacher: Then we can find the current from the emf. The current will flow to this side, … also this side, but the magnitude of the currents will be different.

Student 1: Hmm, okay! So is it like a lightbulb?

Teacher: Yes. Because when current is induced, there is a change in electric potential or emf. The emf at this side is equal to (the emf) at this side (pointing at different loops/sides). Remember our discussion before about serial and parallel circuits?

Student 1: So the current flowed at both (sides)? How about the electrons? Will they dominantly go to the higher or lower resistance?

Teacher: We have discussed this before. Where will they dominantly go? To higher or lower resistance?

Student 2: The lower resistance.

Teacher: Why?

Student 2: Because… If there are places (streams) with few or many stones, the current will go to the fewer stones

since there is less resistance.

Teacher: Yes, correct! So… the electron will go to the lower resistance.

The concept of motion emf was introduced after the students learned about electrical circuits. Thus, seeing a diagram similar to an electrical circuit, a student was curious about how the concepts of electric current could be applied to their recent topic. Teacher P guided the students to recall their prior knowledge regarding the flow of electrons in a circuit. A student came out with the analogy of water flowing down the streams to explain that electrons tend to flow to the lower resistance.

In conclusion, teachers can initiate a dialogic/interactive approach during online science learning. The teachers in this study used students' daily experiences, employed multiple strategies to solve problems, and encouraged students to explain a scientific concept.

Difficulties during online learning

Based on teachers' responses to the interview, interacting with the students during online classes was challenging; this is partly due to technical problems, as indicated by teacher B: "… it is difficult to interact (with the student), maybe because of the internet connection, camera, etc." In addition, teacher P mentioned, "… because of connection disruption, the classes are interrupted, and thus it is difficult to interact with the students." Teacher C commented, "During online classes, it is difficult to bond with students, maybe because the space limits us. In a physical classroom, we can see the students. In online classes, we cannot see their faces when we screen share."

Generally, students were reluctant to participate in whole-class discussions. They took more time to respond to the teacher and were less active. Teacher B commented, "…when I asked a question, no one answered. Then, I appointed a student to answer, but the student responded slowly." Teacher P said, "Students were more hesitant to propose questions than in physical classes. Many students send private messages when they have questions rather than asking directly during online classes." Moreover, teacher C said, "Only some students actively participated during the whole-class discussion, while the others (students) were not enthusiastic, especially those who did not like to study." Although the students adapted to the online learning environment, many still felt uncomfortable participating in whole-class discussions.

Discussion

As described previously, we approached this analysis from the communicative approach, in which the classroom discourse was analyzed in two dimensions: *dialogic-authoritative* and *interactive-non-interactive* (Mortimer & Scott, 2003). This perspective allowed us to see the dominant approach and the level of interactivity in teacher-student interactions. In this study, the three teachers mainly used authoritative approaches in both interactive and non-interactive ways during online classes.

The implemented curriculum in Indonesia, the 2013 Curriculum, lists attitude, procedural skill, and knowledge competencies in the graduate competency standards. However, the nationwide as-

sessments, i.e., National Examination and National Standardized School Exam, cover knowledge competency only. In addition, teachers usually give summative tests at the end of each instructional unit to prepare for the nationwide test and evaluate students' conceptual understanding in that particular unit. Therefore, it is common for teachers to focus their instructions on preparing students for the tests (Faisal & Martin, 2019). Knowledge competency in science education curriculum includes students' understanding of various scientific concepts reflected in the authoritative approaches used by the teachers, which centered around scientific perspectives. These approaches were used extensively during the online classes, and especially throughout the last unit lesson by the teachers as they prepared for the summative tests.

Lecturing about scientific concepts (A/NI) dominated in the online science (biology, chemistry, and physics) classes. Similarly, Rasmitadila et al. (2020) also found that teachers prefer lecturing due to the time constraint of online learning. Although the 2013 Curriculum advocates active learning and student-centered instruction, the science curriculum includes a wide range of content (Faisal & Martin, 2019). Therefore, teachers prefer to use instructional methods that can cover the contents of the curriculum in a short period, such as lecturing. Afterward, Q&A and problem-solving sessions (A/I) were often directed to check students' understanding of the scientific concept presented by the teachers.

On the other hand, the three teachers understand the importance of students' participation during learning. Interactive approaches, especially Q&A and problem-solving, often appeared between non-interactive approaches. Moreover, they used various strategies to engage the students in the interactive discussions. For example, teacher C and P often encouraged the students to present their solutions to the given problem (A/I). Further, they also asked why the students used a particular approach in solving a problem and suggested different strategies (D/I). However, only certain students voluntarily responded to teachers' or asked questions. As indicated in teachers' responses to the interview questions, these students are usually interested in the subject matter or perform satisfactorily. Meanwhile, the engagement of other students in the discussion was primarily prompted by teachers' inquiries, potentially attributed to the unfamiliarity of the digital learning environment (i.e., digital learning). Students are used to physical classrooms, which allow face-to-face social interaction. The digital learning environment creates limitations for teachers and students to build close relationships, thus making them unable to interact comfortably. In addition, technical problems such as unstable or disrupted internet connection can greatly impact the interactions during online classes (Babinčáková & Bernard, 2020).

Moreover, the D/I approach was exemplified by the three teachers in their teaching by asking students to propose their explanation of a phenomenon and use their prior knowledge in a new context. In biology class, teacher B opened up a discussion about itchiness caused by wounds. Students tried to make sense of the phenomenon by relating it with various concepts they have learned in biology, such as stimulation and brain signals. During chemistry class, teacher C presented a problem that can be solved in multiple ways. Often

a phenomenon can be analyzed from different concepts. Thus, students were encouraged to use their prior knowledge to solve problems in new contexts efficiently.

Meanwhile, students' prior knowledge extended the discussion about motion emf through student's questioning in physics discourse. These activities encourage students' participation and implement active learning during the online class. In this case, active learning was achieved through engagement in cognitive processing activities. Mayer (2009) suggests that students are cognitively active when selecting relevant information, relating it with relevant prior knowledge, and using them to construct appropriate self-explanation. Thus, the D/I approach provides an opportunity to engage students in cognitive processing activity necessary for meaningful learning. Meaningful learning improves students' retention and ability to transfer learning to new tasks or contexts.

Online learning was widely implemented due to the COVID-19 pandemic. The physical restriction to contain the virus has forced educators to shift to this mode of instruction immediately. However, they were unfamiliar with online teaching and had limited or no training to conduct online classes. This study showed that teachers can conduct effective online classes through dialogic/interactive communication. Therefore, in addition to technology literacy, teachers' training must focus on different strategies to engage students in cognitive activities during dialogic interaction, such as argumentation and self-explanation (McNeill & Pimentel, 2010; Skuballa et al., 2018). Adoption of appropriate strategies and supporting technologies are necessary for effective online learning (Azid et al., 2022; Muñoz-Najar et al., 2021).

Conclusions

This study found that the three teachers dominantly used authoritative/non-interactive (i.e., lecturing) and authoritative/interactive (i.e., Q&A and problem-solving) approach to focus on scientific knowledge in their online teaching. The teachers also faced difficulties interacting with students since the students were reluctant to participate in online learning. However, teachers can use dialogic interactive communication to engage students in active cognitive processing. This approach can improve students' participation and better outcomes during online learning. Therefore, training is needed to support teachers in using suitable communication approaches and instructional strategies.

This study had some limitations, and further research is thus required. First, the sample size for our study is relatively small. Therefore, the findings should not be generalized to all schools in Indonesia. Future work involving more teachers from different schools is necessary to reflect better the general interaction and challenges in online science classes and more effective strategies for dialogic and interactive online teaching. Moreover, the communication structures presented in this study focuses only on Indonesian schools' context. The curriculum, historical and cultural backgrounds, etc., might differ from other countries. Accordingly, future cross-cultural comparative studies could extend the understanding of differences in communication method and content between teachers and students in different cultural contexts. Lastly, we only analyzed the communication approaches during whole-class discussions since most of the time for online classes was allocated for this activity and discourse data during small-group activity

were unavailable. In further studies, including both whole-class and small-group discussions is recommended to provide comprehensive structures of communication during online learning.

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COVID-19 期間之在線科學課程的交互式對話交流：以印度尼西亞高中為例

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摘要

本研究探討了印度尼西亞在線科學課程中師生之間的交流模式。由於 COVID-19 期間，世界各地的學校實體或面對面的課堂被遠距學習和線上課程所取代。然而，教師如何透過線上學習讓學生參與互動式交流鮮少被研究。因此，我們分析疫情期間線上課程的錄影，並辨別交流方式的特徵。我們選擇坤甸一所高中的生物、化學和物理科的各一位教師。本研究針對每個科目的一章或單元，總計四到五節課進行言談分析。結果指出線上課程中，三位教師主要使用權威—非交互方法。由於技術問題以及線上學習環境限制，學生普遍更不願意參與全班討論。然而，教師可以讓學生提出對現象的解釋，並讓他們將現有知識運用於新的情境中，從而讓學生參與互動對話討論。本研究建議教師需要擴展溝通方法和教學策略，以促進學生積極參與有意義的學習。

關鍵詞：COVID-19 疫情、科學學習、溝通方法、線上課程

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