Chemistry teacher responses to learning in the COVID-19 outbreak: Challenges and opportunities to create innovative lab-work activities

A S Shidiq¹², A Permanasari¹*, Hernani¹, and S Hendayana¹

¹Science Education Program, Universitas Pendidikan Indonesia, Jl. Dr. Setia Budhi No. 229, Bandung 40154, Indonesia
²Faculty of Teacher Training and Education, Universitas Sebelas Maret, Jl Ir.Sutami No. 36A, Surakarta, Indonesia

*arishidiq@upi.edu; anna.permanasari@upi.edu

Abstract. The COVID-19 pandemic has forced schools to make a shift in learning mode, from face to face become online remote learning. This is also faced and done by chemistry teachers. The study was conducted to investigate the response of chemistry teachers to online learning in the COVID-19 pandemic. A purposive survey method was used in this study by giving online questionnaires through Google form containing 10 open questions about chemistry learning and practicum conducted by the chemistry teachers in the COVID-19 pandemic. The data were collected for a week at the beginning of June 2020. A total of 55 chemistry teachers from West Java participated as respondents. The result found that chemistry teachers had tried to utilize various technology platforms in conducting learning. Moreover, most of them faced difficulty to arrange the lab-work activities and did nothing. Some teachers try to find lab-work multimedia instead of real activities. However, the multimedia commonly did not make students pertain the processes skills. Since the pandemic could not be predicted when it will finish, this is a kind of challenges and opportunities to think about implementing online chemistry learning from now and then.

1. Introduction
In recent months, Indonesia and the world have been facing the Corona Virus Disease 2019 (COVID-19). In anticipating the spread of this virus, many countries impose a lockdown status. The enforcement of the lockdown status significantly affects not only the economy but also education sector [1]. UN Education, Scientific and Cultural Organization estimates that 107 countries have implemented school closures due to the COVID-19 virus, which affects 862 million children and adolescents or half of the global student population [2].

Children have milder symptoms of COVID-19, and their role in transmitting the disease remains unclear. However, the government can proactively close schools to slow the transmission (delay phase), reduce the burden of health care, or protect populations at risk [3]. Indonesia through the Minister of Education’s Circular Letter number 4 of 2020 confirms that all schools in Indonesia implement distance learning/learning from home. Distance learning is conducted online using technology owned by teachers and students.

In this 21st century, education must be transformed to be able to integrate technology in learning [4], [5]. Technology has significantly influenced education because flexible technology-based learning design is a key factor in creating an effective online learning environment [6]. The implementation of
online learning requires commitment from the teacher to spend time and put efforts to acquire technology skills, develop technology-based classes, and provide relevant education for the students [7], [8].

In chemistry education, online learning and the use of technological sophistication are a common thing. Many researchers in chemistry education have applied online learning such as online organic chemistry learning to build collaborative learning communities [9], [10], chemistry distance learning using CDs and computer simulations [11], [12], learning chemistry with blended learning to improve student learning achievement [13], [14], and virtual and online chemistry practicums using various technologies such as augmented and virtual reality [7], [15], [16]. Online technology-based learning is not without problems; there many various obstacles of using online distance learning like the difficulty of students understanding chemistry subject matter and the lack of chemistry practicum skills of students [17], [18]. Whereas, Chemistry lab work activities are important for student in order to understand the chemical micro representation and to support collaborative learning [19], [20].

This prompt decision of online learning in the COVID-19 pandemic certainly can be a new problem. In addition to the problems of facilities and infrastructure that are absolutely needed during online learning from home, the readiness and response of chemistry teachers can also influence the success of online chemistry learning. The readiness and response of chemistry teachers to effectively and creatively conducted online learning and lab-work activities is needed to make meaningful learning. Therefore, this study is conducted to investigate the response of chemistry teachers to online learning in the COVID-19 outbreak. This study focuses on investigating online learning carried out, problems encountered, and possible opportunities to improve the quality of online chemistry learning and lab-work activities during COVID-19 outbreak. It is expected that this study contributes to providing an overview of the challenges and opportunities in implementing online chemistry learning and lab-work activities during COVID-19 outbreak.

2. Method
A purposive survey method was used in this study by giving online questionnaires via Google form containing 10 open questions about chemistry learning and practicum conducted by the chemistry teachers in the COVID-19 pandemic. The data were collected for 1 week at the beginning of June 2020. A total of 55 chemistry teachers from West Java participated as respondents. The data of the respondents are shown in Table 1. To guide this study, 3 research problems were formulated: (1) how do chemistry teachers implement online learning and lab-work activities the COVID-19 outbreak?; (2) what challenges are faced ?; and 3) what opportunities do chemistry teachers have to improve the quality of learning?

| Table 1. Respondent Data |
|--------------------------|
| **Respondents Background** | **Percentage** |
| Gender | | |
| Male | 32.7 |
| Female | 67.3 |
| Education Level | | |
| BA | 74.5 |
| PPG (Teacher Professionalism Training Program) | 3.7 |
| MA | 21.8 |
| Teaching Experience | | |
| Less than 5 years | 16.4 |
| 10 - 15 years | 9.0 |
| 15 - 20 years | 18.2 |
| More than 20 years | 56.4 |
3. Result and Discussion

3.1. Chemistry learning and practicum in the COVID-19 outbreak

Technology brings new challenges to teaching, including developing knowledge about technology and the integration of the technology with content, teaching, and learning, in certain contexts [21], [22]. The technology referred to here is the technology that can help teachers to represent concepts, principles, or laws. Therefore, teachers should have competencies that include content knowledge, pedagogical knowledge, and technological knowledge [23].

The enforcement of social distancing in Indonesia, which resulted in the closure of schools, indirectly forced teachers to do online distance learning using the technology they have. Based on a survey of chemistry teachers in West Java, most of them have used a variety of platforms and technologies to conduct online learning. The chart of the percentage of platforms used to conduct online chemistry learning is presented in Figure 1.

![Figure 1. Technological Platforms Used by Chemistry Teachers](image)

Online distance learning is conducted by chemistry teachers with available platforms. Most of them use Google Classroom to conduct online learning. Google Classroom is a web service that allows teachers to organize and manage their classes and materials and communicate easily with their students [24]. Some teachers use the Zoom meeting platform. Both most-frequently chosen platforms can transform traditional learning into real-time and face-to-face online distance learning [25]. Teachers also use WhatsApp, Cisco, YouTube, Quizizz, and other apps for online chemistry learning.

Chemistry learning is inseparable from lab work-activities. Some researchers reported that lab work-activities, including practicums, arouse strong student interest in learning chemistry [26]. Lab practicums can also enhance students’ learning abilities as they help the students understand the subject matter [27]. Another reported that students felt more motivated when doing lab practicum in chemistry learning [28]. However, when local lockdown and social distancing were enforced, schools and teachers cannot conduct chemical lab work-activities in the laboratory. In Table 2 are presented several alternative online lab work-activities for chemistry teachers.
Table 2. Online Lab Work-activities Conducted by Chemistry Teachers

| Respondents | Online lab-work activities |
|-------------|---------------------------|
| Teacher A   | Conducting practicum by providing simulations using learning media such as animation and Macromedia Flash |
| Teacher B   | Conducting practicum using virtual PhET lab |
| Teacher C   | Providing a simple practical guide with familiar tools and materials for students |
| Teacher D   | Guiding the students to watch practicum videos on YouTube |

Doing simulations and the virtual lab has advantages; for example, it allows students to do dangerous experiments without putting themselves or others in danger, they can do experiments many times, and it can also be used for distance learning [28]–[31]. Virtual lab and direct practice have their characteristics. Some researchers suggest that virtual experiments with direct practice in the real world can provide the best experience [28], [29]. However, in the application of online practicum in the COVID-19 pandemic, several obstacles were found, such as the lack of virtual lab facilities owned by schools or teachers and limited practical tools and materials to be used by the students at home independently.

Lab-work activities during distance learning is often considered as a major obstacle to the development of effective chemistry distance learning [32]. More significant security issues and pedagogical constraints lie in the assumption that the “laboratory atmosphere” cannot be replicated outside of laboratory settings [12]. Students who conduct experiments outside of laboratory settings and are not supervised by laboratory instructors cannot obtain the necessary laboratory techniques and skills, nor can they carry out experiments with sufficient precision to gather useful data quantitatively [33]. One approach to solving the problem in laboratory distance learning is by designing a virtual lab such as interactive simulations, videos, and animations to convey laboratory experiences [34].

3.2. Challenges and opportunities in chemistry learning in the COVID-19 outbreak

Online distance learning during the COVID-19 pandemic certainly has advantages and disadvantages. Online learning using network technology that connects the teacher and the students is used to facilitate meaningful interactions. The transition from traditional learning to online learning also has advantages, such as minimizing time and space constraints [35]. The survey conducted filtered the opinions about the advantages and disadvantages of online chemistry learning. In this study, disadvantages are referred to as challenges to be faced by teachers while advantages are referred to as opportunities that can be maximized to improve online learning. A summary of the teachers’ views on challenges and possibilities is presented in Table 3.

Table 3. Challenges and opportunities in chemistry learning in the COVID-19 outbreak

| Challenges | Opportunities |
|------------|---------------|
| Limited device and Internet access in some areas | Students can actively looking for information to build their own knowledge |
| It is difficult to conduct lab –work activities | Students not only depend on the teacher, but they can also learn to do their own research through the Internet |
| It is difficult to assess chemistry learning outcomes | It makes the teacher more creative to use various kinds of technology |
| There is a greater chance of misconceptions because teachers cannot control their students’ understanding | It teaches students to learn independently, increases their technological knowledge, and trains their discipline and honesty |
| The decreased teacher-student interaction reduces the teacher’s role in instilling character education | Learning without time and space limits |
The lack of facilities and infrastructure will certainly lead to challenges for teachers, students, and schools to utilize the existing facilities and infrastructure. In addition, the difficulty to conduct lab-work activities becomes the concern of the teacher. This challenge can be faced by doing virtual lab practicum. Research shows that virtual practicum can improve the performance of hand-on laboratory skills [28].

Assessment is also an important aspect to consider. Teachers must be able to ensure that the students' cognitive assessment is fair and accountable. In online learning, an effective online assessment needs to be developed. Various studies on chemistry education have implemented effective electronic assessments, such as computer-assisted assessment products in formative assessments [36], interaction assessments between the Self-Regulated Learning Profile (SRL) and Actual Learning in chemistry blended learning [8], and computerized assessment instrument that shows individual student reports in real-time [37].

The decreased teacher-student interaction and misconceptions in students are two interrelated challenges. Interaction is a key mechanism to promote learning [38]. Student interaction is very important in the online learning environment because the dynamics of the traditional learning context have shifted to a student-centered approach. There are three different but complementary forms of interaction: learner-instructor interaction, learner-content interaction, and learner-learner interaction. Learner-instructor interaction is defined as the interaction between the students and the teacher. Student-content interaction is defined as the interaction between the students and the subject matter. Learner-learner interaction is defined as the interaction between the students and their peers [35], [39]. These interactions should be fulfilled by the teacher and students to minimize the misconceptions during distance learning.

The opportunity of online distance learning as reported by the teachers is it can increase student independence in learning. This is in line with the results of a study stating that online learning with lower teacher attendance makes students think of searching their own knowledge [40]. At the same time, teachers are also encouraged to provide more creative learning by utilizing various technologies. Other studies have reported other advantages of online distance learning, such as learning that becomes flexible [40], efficient, and increases student learning achievement [13].

4. Conclusion

Technology brings new challenges to chemistry learning in the COVID-19 outbreak. Like two different sides of a coin, online chemistry learning using technology has challenges and opportunities. In general, chemistry teachers have responded to this online learning in the COVID-19 outbreak quite well. They had tried to utilize various technology platforms in conducting learning. Moreover, most of the teacher faced difficulty to arrange the lab-work activities and did nothing. Some teachers try to find lab-work multimedia instead of real activities. However, the multimedia commonly did not make students pertain the processes skills. Since the pandemic could not be predicted when it will finish, this is a kind of challenges and opportunities to think about implementing online chemistry learning from now and then. This study describes what chemistry teachers have done to respond to the implementation of distance learning from home. It is expected that this study becomes a reference for chemistry teachers and policymakers to improve the quality of chemistry learning and lab-work activities in the COVID-19 outbreak.

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