



# European Journal of Educational Research

Volume 12, Issue 4, 1601 - 1616.

ISSN: 2165-8714

<http://www.eu-jer.com/>

## Teachers' Articulation in Implementing Biology Laboratory Courses in an Online Distance Learning Mode

Gualberto A. Lantaya Jr. 

Zamboanga State College of Marine Sciences and Technology, PHILIPPINES

Received: January 19, 2023 ▪ Revised: April 1, 2023 ▪ Accepted: May 21, 2023

**Abstract:** Biology laboratory courses (BLC) are designed to enhance and concretize students' understanding of biology concepts. However, due to threats posed by the COVID-19 pandemic, education institutions were compelled to devise methods for teaching outside of laboratory structures and in a distant learning format. This phenomenological research explored the teachers' articulation in the delivery of online distance learning (ODL) in BLC. Specifically, this study identified various methods and alternatives employed by biology teachers in conducting laboratory activities. Purposive sampling was used to select participants in survey, interview, and focus group discussion. The data were analyzed using thematic analysis. The study revealed that teachers articulate the delivery of online biology laboratory courses by employing different instructional practices in the three areas of learning experience: planning, implementing, and assessing stages. The results provide practical implications for the improvement of biology instruction and recommendations to support the delivery of flexible learning modalities during educational disruptions.

**Keywords:** *Biology laboratory courses, online distance learning, teachers' articulation.*

**To cite this article:** Lantaya Jr., G. A. (2023). Teachers' articulation in implementing biology laboratory courses in an online distance learning mode. *European Journal of Educational Research*, 12(4), 1601-1616. <https://doi.org/10.12973/eu-jer.12.4.1601>

### Introduction

Biology laboratory courses (BLC) are designed to enhance and concretize students' understanding of biology concepts, experts believe that exposing students to hands-on biology activities contributes to students' content mastery and skills development (Sepulveda-Escobar & Morrison, 2020). Brockman et al. (2020) made a similar point, claiming that laboratory exercises considerably improve classroom instruction. In biology, laboratory activities are viewed as an essential component of instruction that aids students' understanding of topics and the development of scientific abilities (Lashley & McCleery, 2020).

In a typical set-up, subject instructors and facilitators conduct laboratory activities in specialized laboratory rooms where students get to use actual laboratory tools and conduct experiments under the supervision of an expert laboratory instructor. Students benefit from this setup because they can see the outcomes of their science experiments, receive immediate feedback, and receive help from their teachers, this provides them also with a learning environment in which they can gain and improve scientific skills and knowledge that they would not otherwise be able to obtain through traditional classroom instruction (Udin et al., 2020).

However, the global pandemic caused school closures and suspension of in-person laboratory activities, posing a threat to the delivery of high-quality biology instruction (Hallyburton & Lunsford, 2013). To address this and ensure learning continuity at all levels, the delivery of biology laboratory courses at the undergraduate level in the Philippines adopted an online distance learning approach which compelled higher education institutions (HEIs) to devise methods for teaching science concepts outside of laboratory structures and in a distance learning environment.

In the Philippines, the Commission on Higher Education (CHED, 2020), released a memorandum order CMO No. 4, series of 2020 which provided guidelines for the delivery of flexible instructional modalities, emphasizing the adaption of flexible and alternative techniques in the delivery of instructions in HEIs and to ensure continuity of learning in tertiary level.

---

#### \* Correspondence:

Gualberto A. Lantaya Jr., Zamboanga State College of Marine Sciences and Technology, Zamboanga City, Philippines. ✉ [glantaya@zscmst.edu.ph](mailto:glantaya@zscmst.edu.ph)



Science courses having laboratory components, which include biology, have resorted to the use of online distance learning (ODL) in teaching biology laboratory courses as part of the learning continuity strategy among HEIs, with the goal of targeting the set of knowledge and skills required for the course.

With the ongoing threat of the global health crisis, biology teachers are mandated to apply a paradigm shift and slowly embrace the use of online distance learning in the delivery of biology instruction (Crawford-Ferre & Wiest, 2012). The use of ODL is viewed as an effective teaching and learning approach to fulfill the instructional needs of students and teachers who are separated by distance (Hussain et al., 2020). In the context of biology education, ODL is seen as a feasible alternative to delivering biology laboratory courses.

Although there have been reports and studies about the effectiveness of ODL and some unanticipated drawbacks of substituting online distance modalities for in-person instruction (Lee et al., 2012), the way biology teachers articulate the process of doing ODL in biology laboratory courses remains theoretically vague, particularly in the local context. More importantly, since the outbreak of the global pandemic, the different ways in which schools have implemented online biology laboratory courses is an interesting area of study.

Hence, this study set out to examine the articulation of biology teachers in implementing ODL in undergraduate biology laboratory courses in one of the state-owned colleges in the Philippines. Specifically, the study aimed to answer how teachers articulate the implementation of ODL modality in biology laboratory courses. The term articulation as defined operationally in this study refers to the methods and alternatives employed by teachers in conducting biology laboratory activities in an online and distant format.

## Methodology

### Research Design

This study utilized qualitative research design employing the principles of phenomenology. As phenomenological research, this study was focused on describing the articulation of biology teachers in terms of conducting ODL in undergraduate laboratory courses in biology. The research design used in this study is shown in Figure 1.



Figure 1. Design of the Study

As shown in Figure 1, this study utilized the methodological triangulation technique to enhance the internal validity of the research findings. Specifically, this study utilized an expert-validated Self-Administered Questionnaire (SAQ) and interview methods in gathering information on the experiences of the biology teachers in implementing laboratory courses using the ODL approach and to investigate their articulation in implementing ODL in Biology Laboratory Courses.

The responses of the teachers in the SAQ and interview were cross validated by the data from students' responses in the focus group discussion (FGD) to check areas of complementarities and divergence in the responses.

To further explore and exhaust the meaning of the teachers' responses in self-administered questionnaires and interview findings, an in-person FGD with select teachers was conducted. The qualitative data that were obtained from different methods were subjected to thematic analysis to facilitate interpretation and generation of conclusions.

### Sample and Data Collection

This study employs purposive sampling to select the participants of the study. There were fourteen (14) biology teachers who participated in the survey.

The demographic profile includes the age and gender of the participants. The summary is expressed in percentages and presented in Table 1.

Table 1. Summary of the Demographic Profile of the Participants of the Study

Demographic Profile		Frequencies (%) (N = 14)
Age	20 – 29 years old	8 (57%)
	30 – 39 years old	4 (29%)
	40 – 49 years old	1 (7%)
	50 – 59 years old	1 (7%)
Gender	Male	5 (36%)
	Female	9 (64%)

As shown in Table 1, there are fourteen (14) participants for the study, the participants for this study are instructors and/or professors teaching Biology. Many of the participants come from the age group of 20 to 29 years old, or 57% of the total participants. With regards to gender, many of the participants are female, or 64% of the total participants of the study.

Moreover, a purposive sampling technique was used to select the student participants (N=32) in the FGD. Only the students who were taking biology courses were included in the study with consideration to their availability, willingness to participate, and access to the Internet since the interview was conducted through google meet.

Specifically, the students that were considered in the study are those that are enrolled and have taken biology laboratory courses through the ODL modality. There are six FGD sessions conducted, each session is composed of five (5) to six (6) students representing various programs such as bachelor of secondary education major in sciences, bachelor of science in food technology, bachelor of science in environmental science, bachelor of science in marine biology, and bachelor of science in fisheries.

#### *Research Instruments*

There were four instruments utilized in the study which were made by the researcher, this includes the following: The Questionnaire on Biology Online Distance Learning Challenges and Articulation (QBODIL-CA), Interview Guide on Online Distance Learning Challenges and Articulation (IGODIL-CA), Discussion Guide on Online Distance Learning Challenges and Articulation (DIGODIL-CA) and Discussion Guide on Teachers lived Experiences on ODL (DIGOTELE-ODL).

The QBODIL-CA is a self-administered survey questionnaire that is divided into three (3) sections which are generally focused on gathering information relevant to the teachers' demographic profile. Further, the questions are intended to gather data on teachers' articulation towards implementing ODL in BLC in terms of lesson preparation, lesson implementation, and learning assessment.

The IGODIL-CA is an interview guide composed of nine (9) semi-structured questions which are aligned with teachers' instructional practices while the DIGODIL-CA is a discussion guide composed of five (5) semi-structured questions intended for the students. This tool is intended to validate the responses of teacher participants in the survey and interview.

Lastly, DIGOTELE-ODL with six (6) open-ended questions is a discussion guide used in focus group discussions with biology teachers. This is composed of emerging and clarificatory questions based on the results and responses of teachers in the self-administered questionnaires and interviews.

#### *Validity and Reliability of the Instruments*

The QBODIL-CA was evaluated by five (5) validators to ensure the appropriateness of the instrument. These tools were used to validate the appropriateness of the instruments based on the objectives of the study and improve its content in terms of language, style, and grammar. All experts' suggestions were incorporated in the final copy of the instruments. The final copy of the instruments was pilot tested on a non-participating biology teacher who is implementing ODL in BLC and students who are currently enrolled in any of the biology laboratory courses.

#### *Analyzing of Data*

The qualitative data that were obtained were analyzed using the thematic analysis approach to facilitate discussion and interpretation. In doing this, the researcher followed systematically important steps which can be depicted in Table 2, the data analysis procedure of the study.

Table 2. Data Analysis Procedure of the Study

Steps	Description
Step 1 Transcription	All recorded interviews and FGD raw data were transcribed by the researcher in verbatim.
Step 2 Organizing Transcripts	The accomplished questionnaire and interview transcripts were organized according to the professional attributes of the participants and subsequently. The FGD data were organized according to the program where the participants belong.
Step 3 Coding and Identifying themes	The data from the questionnaire, interview, and FGD were coded to identify convergence in the responses of the participants and subsequently determine emerging themes.
Step 4 Checking of Consistency	The teachers' responses in the interview were cross validated by the data from the self-administered questionnaire and FGD.
Step 5 Interpreting	The researcher compared the obtained data from the findings or information derived from the literature or theories to confirm past information or deviate from it.

To establish reliability in analyzing the qualitative data, the researcher utilized two methods; first is the tabular recording of data in MS Excel to formally organize the transcripts and to establish ease in coding and assessment of results. This enabled the researcher to easily compare common and varied responses from the individual participants.

Secondly, data triangulation was employed, in which the data from the teachers' narratives were cross validated from the claims of student participants during the focus group discussions to check for complementarities and divergence in their responses. This method is done on top of analyzing and comparing the results from literature and related studies to confirm past information or differ from it.

### Findings/Results

From the data obtained from the interview, questionnaire, and FGD involving teachers, including the data obtained from the FGD with students generated five (5) major themes, relevant to how the biology teachers articulate the implementation of ODL in BLC. These themes include the following: (a) Preparing for ODL Learning Opportunities, (b) Preparing for Instructional Materials and Technology, (c) Implementing Distance Learning Laboratory Experiences, (d) Utilization of Technology to Support ODL Delivery, and (e) Implementing Flexible Assessment Methods.

Additionally, the major themes are categorized following the major areas of the learning experience; planning, implementation, and assessment which are color-coded in green, blue, and red respectively for easy identification and clarity. Figure 2 shows the diagram depicting the emerging themes and subthemes relating to Teachers' Articulation.



Figure 2. Major Themes and Corresponding Subthemes on Teachers' Articulation

These themes and subthemes are explicitly presented hereunder with the corresponding interpretations.

*Theme 1: Preparing for ODL Learning Opportunities*

The data revealed that one of the ways for biology teachers to articulate the delivery of ODL in BLC is by preparing the ODL learning opportunities for the students. Under this theme, there are five (5) subthemes that emerged which include clarifying target learning outcomes, developing home-based activities, retrofitting the curriculum to an online scheme, benchmarking potential learning opportunities, and identifying potential risks and hazards. These subthemes are presented in Table 3 and subsequently followed by the discussion and interpretation.

*Table 3. Subtheme and Corresponding Responses on Teachers' Articulation of ODL in BLC in Terms of Preparing for ODL Learning Opportunities*

<b>Subthemes</b>	<b>Responses</b>
Clarifying Target Learning Outcomes	The teachers wrote in the questionnaire that: Teacher 8: These laboratory experiments have SMART objectives and tangible outcomes. Teacher 9: Understand your students/set a clear objective for the prepared lessons/incorporate visuals. Teacher 11: Competencies are maintained but with corresponding tools to help attain them i.e., modified lab activities and use them in the class and evaluate their uses in attaining the competencies. Teacher 14: Intended Learning Outcomes (ILO) of the course.
Developing Home-based Activities	The Teacher said in the interview that: Teacher 4: Then for the laboratory I give tasks that can be done at home or home-based lab individually, I prepare activity sheets for them to do. Teacher 7: Of course, yung availability of materials at home in replacement sa actual na lab, so if wala talagang replacement then next na sir. [Of course, the availability of materials at home in replacement of the actual lab, so if there really is no replacement, then next question sir] Teacher 11: Sa laboratory, not all activities pwedeng gawin sa bahay so yung type of laboratory activities na ina adopt ko paminsan ini improvise namin kasi from that type of activity ma determine naming kung ano yung alternative or substitute materials like wala silang scalpel sa bahay they will use knife or gillet for dissection...[In the laboratory, not all activities can be done at home so the type of laboratory activities that I adopt, is sometimes we improvise because from that type of activity we can determine what are the alternative or substitute materials, say if they don't have a scalpel at home they will use a knife or blade for dissection as alternative]
Retrofitting the Curriculum to Online Scheme	The teachers said in the questionnaire that: Teacher 3: I see to it that key points will be delivered, and I choose materials by properly scrutinizing them. Reliability of the references available online. Teacher 11: In a regular set-up (i.e., non-pandemic situation) it works well especially in blended scheme as long as the curriculum and instructional requirements are well prepared and pre-determined to deliver the instruction satisfactorily if not outstanding at all. BLC following ODL may have its impending challenges since an actual laboratory set-up is necessary, but it can be retrofitted as long as all necessary curriculum preparation are made and met. Teacher 12: I usually use a chunk or bite-sized approach wherein from the course syllabus, I make it a point to prioritize topics and skills which students can take in or digest and needs the most. This approach is utilized both for lecture and lab components.

Table 3. Continued

Subthemes	Responses
Benchmarking Potential Learning Opportunities	<p>The teachers said in the FGD that:</p> <p>Teacher 1: First somewhat new siya at that time, so I have attended various seminars and webinars online; from there I do benchmark some of my learning materials and the practices of other participating schools. I think some of the seminars sina ma'am _____ yung nag conduct. [First, it was somewhat new at that time, so I have attended various seminars and webinars online; from there I benchmark some of my learning materials and the practices of other participating schools. I think some of the seminars were conducted by ma'am _____.]</p> <p>Teacher 2: For me, since I am newly hired during that time is I consult my colleagues particularly on how to deliver the lab component of the course, sa online kasi mahirap gawin ng students so kailangan talaga na may initiative. [For me, since I am newly hired during that time is I consult my colleagues particularly on how to deliver the lab component of the course because it's hard for students to do it online, so it's really necessary to have initiative.]</p> <p>Teacher 4: Siguro yung binigay na seminar na binigay nina maam [Maybe the given seminar conducted by maam_____] the last time synchronous and asynchronous seminars. Other than that, I have videos from YouTube how to start classes in online set-up, there I learn some of my practices now.</p> <p>Teacher 11: Same thing with __, because majority of the benchmarking initiatives was also done online cause whenever we attend online seminars or webinars participants from different schools get to share their best practices, that is where we also get ideas. The beauty about online trainings is that we get to learn from the best schools like UP College of Education they usually conduct trainings, intensive trainings really it would take one month to finish with the outputs so that's a very avenue to benchmark.</p> <p>Teacher 12: Sometimes there are trainings that the scope is nationwide with SUCs all over the country, so they get to share how they write modules, their SPLM or self-paced learning materials we get to learn from other schools like PNU, Ateneo de Manila, La Salle and even University of Baguio so yung ang kagandahan during the online set-up. [So that's the beauty during the online set-up]</p>
Identifying Potential Risks and Hazards	<p>The teachers said in the FGD that:</p> <p>Teacher 12: I think the factor really is the materials or resources because considering the restricted movements siyempre you have to consider if I will ask them to dissect for example and then with the limited movement baka san sila pupunta because if you require them to search for the exact material or resources needed for that experiment they will really find ways to the extent that they might put their safety at risks so we really have to adjust or make some tweaks or modification as to the materials even gale sa internet connection di mo alam san sila pumupunta to connect how much more sa materials, so yung talaga yung first ko na consideration. [Of course you (I) have to consider if I will ask them to dissect for example and then with the limited movement maybe where they will just wander because if you require them to search for the exact material or resources needed for that experiment they will really find ways to the extent that they might put their safety at risks so we really have to adjust or make some tweaks or modification as to the materials even in internet connection you don't know where they go to connect how much more with the materials, so that's really my first consideration]</p> <p>Teacher 2: In my case, I ask my students to visit a nearby ecosystem to identify flora and fauna pero naisip ko din na safe ba sila baka nagliligo na doon or baka sabihin nila sa parents nila na inutusan sila ng teacher so what I did is I require them to look for a pair di pwedeng sila sila lang magpunta tapos they are required to document through video for me to check if they are doing it seriously. [But I also thought of their safety, it might be they are just going there for outing and used it as an excuse to tell their parents that the teacher ordered them so what I did is I require them to look for a pair, they can't go by themselves then they are required to document through video for me to check if they are doing it seriously.]</p> <p>Teacher 1: In my case, I don't think my risks kasi mostly I only ask them to draw wala masyadong lab activity na lalabas sila. [In my case, I don't think there are risks because most of the time I only ask them (students) to draw, there is not much lab activity that will require them to go out.]</p> <p>Teacher 4: As what I mentioned earlier, during the time na teaching ako nasa 3rd year na level na sila so I was already told that they have their own dissection kit so di nahirapan masyado and then mostly sa species nila is from the market binibili. [I mentioned earlier, during the time that I became their teacher during their 3rd year, so I already told them that they should have their own dissection kit so it was not too difficult and then mostly their species are bought from the market.]</p>

As shown in Table 3, four (4) teachers said in the questionnaire that they articulate the delivery of ODL in BLC by clarifying the learning outcomes, these outcomes are communicated to students to set clear lesson expectations and to ensure that students are well guided as they go through their lessons. These learning outcomes ensures alignment of teaching and learning activities and assessment tasks intended for the lesson.

In relation to setting a clear lesson outcome, teachers also prepare and develop home-based activities in the planning stage of ODL, these activities are seen as an alternative to laboratory activities and to address the absence of physical laboratories. The home-based laboratory activities involve the utilization of common tools and materials readily available in the household as substitute to actual laboratory equipment; these practices were conveyed by three (3) teachers during the interview.

The various practices implemented by teachers are done in their efforts to they retrofit the curriculum to online scheme during the preparation stage of ODL, this is shared by three (3) teachers who wrote in the questionnaire. Also, during the FGD, there are five (5) teachers who said that they do benchmarking of potential learning opportunities in variety of ways, this includes but not limited to attending to webinars or seminars conducted by reputable universities where they get to have access on the best practices and learning materials utilized during online classes. The newly hired faculty also do benchmark activities through consultation with other senior faculty members or their colleague with long years of teaching experience.

Further, there are four (4) teachers who stated that they identify potential risks and hazards in view of ensuring the overall safety of their students conducting laboratory activities in their respective spaces, teachers considered careful planning and identifying of risks and hazards associated with the conduct of any laboratory activities in an online and distant format.

These accounts indicate that biology teachers articulate the implementation of ODL in BLC by carefully planning and preparing for the learning opportunities. This means that clarifying the learning outcomes for laboratory courses in biology to be delivered in ODL mode, developing activities that matches the needs of ODL in BLC, retrofitting the curriculum to online scheme, benchmarking of potential learning opportunities that match the need of the students, and identifying potential risk and hazards in the conduct of home-based laboratory activities are the basic requirements in the planning stage to effectively deliver ODL in BLC.

The results implied that in planning for ODL learning opportunities, it is important for teachers to clarify the target learning standards which will serve as a guide in developing learning opportunities and in redesigning the curriculum with consideration on the best ODL practices of other institutions and the overall safety of the students when the ODL curriculum is implemented.

This agrees with the study of (Musingafi et al., 2015) who made a notable conclusion on the importance of clarifying the lesson learning outcomes as it guides the teachers in making important decisions in the planning stage of the lesson. In addition, the learning outcomes or the lesson objectives target measurable aspects of the students' learning to include knowledge, skills, and attitudes.

#### *Theme 2: Preparing for Instructional Materials and Technology*

Biology teachers articulate the delivery of ODL in BLC by preparing instructional material and technology that are needed in the delivery of the modality. Subthemes include preparing audio-visual materials, utilizing printable online resources, preparing for devices and course materials, and ensuring internet access. These subthemes are presented in Table 4 and subsequently followed by the discussion and interpretation.

*Table 4. Subtheme and Corresponding Responses on Teachers' Articulation of ODL in BLC in Terms of Preparing for Instructional Material and Technology*

<b>Subthemes</b>	<b>Responses</b>
Preparing Audio-Visual Materials	The Teachers stated in the Questionnaire that:
	Teacher 1: In consideration of the pandemic, I usually upload or play videos for my students while we are having our discussion so they can relate to what I am trying to express.
	Teacher 4: As for that aspect, we only refer to available materials online such as video presentations which demonstrate the steps or processes in a supposed in-situ laboratory activity.
	Teacher 5: I prepare a video that will serve as my lessons.
	Teacher 7: Manuals and Video Demo via YouTube.
	Teacher 10: I do prepare recorded videos for Laboratory activities, modules, and some other home-based lab activities.
	Teacher 14: By availing online videos and virtual lab tour.

Table 4. Continued

Subthemes	Responses
Utilizing Printable Online Resources	<p>The teachers said in the interview that:</p> <p>Teacher 5: I browse the internet for open sources or ready-made instructional materials that I can use for the lab activities.</p> <p>Teacher 7: So, coupled siya sir with module and then for demonstration kasi nag sesearch lang ako sa YouTube... [So, it is coupled sir with module and then for demonstration, I just searched on YouTube.]</p>
Preparing for Devices and Course Materials	<p>The teachers mentioned in the questionnaire that:</p> <p>Teacher 6: Availability of connectivity of the students and laboratory equipment and other materials needed.</p> <p>Teacher 7: Availability of materials at home.</p> <p>Teacher 8: Simple and easy to understand and the materials locally/readily available.</p> <p>Teacher 11: Availability of materials (allowing students to be more resourceful). A set of series of supplemental activities to reinforce learning and attainment of content standards.</p> <p>Teacher 13: Availability of improvised laboratory tools to perform laboratory activity that requires such.</p>
Ensuring Internet Access	<p>The teachers said in the interview that:</p> <p>Teacher 3: I see to it na malakas yung internet connection, so for teachers like us actually nag prepare ako ng or may dalawang networks talaga meron ng Wi-Fi meron pang mobile data, should in case mawala yung signal sa isa meron pang backup. [I see to it that the internet connection is strong, so for teachers like us, I actually prepared or there are actually two networks, there is Wi-Fi, there is also mobile data, should in case the signal is lost on one source, I have another backup connection]</p> <p>Teacher 4: Considered dapat yung internet connection... [The internet connection should be considered]</p> <p>Teacher 5: And year level tapos connectivity ng students [And also the year level and the connectivity of students to internet]</p> <p>Teacher 6: Yung pinaka first talaga sir is yung connectivity both students and teacher, dapat strong ang internet connection kasi ang hirap kasi talaga especially students residing in far flung areas napaka hirap sa kanila ang internet connection yun talaga kinoconsider ko... [The very first thing, sir, is the connectivity of both students and teachers, the internet connection must be strong because it is really difficult because especially students residing in far flung areas, the internet connection is very difficult for them, that's what I really consider.]</p> <p>Teacher 11: Then another thing not all students can access the internet, so meron akong tinatawag na online group and offline group and meron ding both, they participate in online classes... [Then another thing not all students can access the internet, so I have what is called online group and offline group and there is also both, they participate in online classes.]</p> <p>Teacher 13: One of the factors on my part as teacher is yung internet connectivity ng students... [One of the factors on my part as a teacher is the students' internet connectivity.]</p>

As shown in Table 4, teachers articulate the delivery of ODL in BLC by preparing the needed instructional materials and technology prior to implementation. There are six (6) teachers who wrote in the questionnaire that they prepare the audio-visual materials prior to implementation, the teachers resorted to video materials available online and in YouTube as supplementary to their lectures, this video includes prerecorded laboratory activities and post laboratory lectures where students can watch at the comfort of their home.

The interview data also shows that teachers utilized printable online resources in the preparation stage to give their students readily downloadable materials and references from the web. The data also revealed that five (5) teachers answer in the questionnaire that they prepare for the devices and course materials needed in their laboratory activities.

Also, six (6) of the teachers also mentioned in the interview that they ensure that they have access to the internet prior to implementation of ODL in BLC as the most important requirement in conducting online laboratory activities.

The subthemes indicate that the biology teachers articulate the delivery of ODL in BLC by preparing for the instructional materials and technology during the planning stage. This means that the teachers need to prepare audio-visual materials, utilize printable online resources, prepare for devices, and course material, ensure internet access during the planning stage to ensure that effective delivery of ODL in BLC.

The results implied that planning and preparing the instructional materials and technologies needed in the delivery of ODL in BLC are essential requirements to the successful conduct of ODL in BLC. This concurs with the study of (Picciano,



2015) who claimed effective planning of instructional resources, materials, and technologies to use online teaching is pivotal to ensure the successful and effective delivery of online instruction.

### *Theme 3: Implementing Distance Learning Laboratory Experiences*

The data revealed that the biology teachers articulate the delivery of ODL in BLC by designing and implementing distance learning laboratory experiences. Under this theme, there is only one subtheme which is the delivery of home-based and community-based laboratory activities. The responses of the teachers under this subtheme and the corresponding interpretation are presented Table 5.

*Table 5. Subtheme and Corresponding Responses on Teachers' Articulation of ODL in BLC in Terms of Implementing Distance Learning Laboratory Experiences*

<b>Subthemes</b>	<b>Responses</b>
Home-based and Community-based laboratory activities	<p>The teachers mentioned in the interview that:</p> <p>Teacher 2: I ask them to look for a nearby ecosystem in their residence or community like rivers or oceans, they were asked to identify the aquatic resources available and let them identify the biotic and abiotic factors.</p> <p>Teacher 4: Ano nalang yung alternative ko they have to source out fish supply sa market or any riverine ecosystem nearby, any fish will do as long as they can identify the diseases or abnormalities based on the guide provided or during the lecture. [In my case, the alternative way is I ask my students to source out fish supply in the market or any riverine ecosystem nearby, any fish will do as long as they can identify the diseases or abnormalities based on the guide provided or during the lecture.]</p> <p>Teacher 6: Laboratory or on field so those who are residing near in coastal areas dun ko nalang sila pinagawa ng laboratory activities like for example like organisms or species in coastal then yung medyo malayo pinapapunta ko sila sa wet market or public market, then yung preparation nila is sa bahay if they can afford to buy a dissecting kit pinapabili ko. [Laboratory or on field so those who are residing near in coastal areas I just have them do laboratory activities in nearby coastal community, then the ones who is living far from coastal communities, I ask them to visit a nearby wet market or public market, then their preparation is in house also, if they can afford to buy a dissecting kit I ask them to buy it.]</p> <p>Teacher 5: So I ask the students kung ano yung available resources sa bahay nila then I improvise or let them improvise lab equipment, example in ichthyology, since identification to of fishes I ask them to identify available species in their area that require simple materials lang. [So I ask the students what are the available resources in their house then I improvise or let them improvise lab equipment, example in ichthyology, since it is focus on identification of fishes I ask them to identify available species in their area that only require simple materials.]</p> <p>Teacher 7: Other than the activities mentioned above, they also have activities that requires them to visit a field like coastal areas.</p> <p>Teacher 11: Yun kung ano yung available na material sa bahay yun yung alternative. [I resort to available materials at home as an alternative.]</p> <p>Teacher 13: Same with us, they work from home, in the absence of laboratory equipment and tools so they make use of what is available materials at home, for example sa kitchen man kadalasan, for chemicals and reagents we sort to available substitute at home.... [Same with us, they also work from home, in the absence of laboratory equipment and tools so they make use of what is available materials at home, for example are kitchen utensils, for chemicals and reagents we sort to available substitute at home.]</p>

As shown in Table 5, there are seven (7) teachers who stated in the interview that they articulate the delivery of ODL in BLC by conducting home-based laboratory activities and community-based observations and activities. This indicates that in the delivery of ODL in BLC, teachers allow students to use materials and resources at home and in the community to conduct laboratory activities given restricted and limited access to physical laboratories during the time being.

This implies that the ability of the teachers to identify the locally available materials which the students can access in the conduct of home-based and community-based laboratory activities in biology is important in the delivery of ODL in BLC. This agrees with the study of (Owolabi et al., 2021) who concluded that the teachers' capability to identify locally available materials and alternatives are necessary in the delivery of home-based laboratory activities in the different fields of science including biology.

### *Theme 4: Utilization of Technology to Support ODL Delivery*

In the implementation of ODL in BLC, the biology teachers articulate the process by utilizing technology. Under this theme, there are four subthemes that emerged which include maximizing the use of online learning management

platform, utilizing video-guided laboratory lessons, and applying online guided inquiry, synchronous and asynchronous online sessions. These subthemes are presented in Table 6 and subsequently discussed and interpreted.

*Table 6. Subtheme and Corresponding Responses on Teachers' Articulation of ODL in BLC in Terms of Utilizing Technology to Support ODL Delivery*

Subthemes	Responses
Maximizing the use of online Learning Management Platforms	<p>The teachers answered in the interview that:</p> <p>Teacher 3: So basically, Zoom yun una, and then we also had Google classroom. [So basically, I used Zoom at first and then we also had Google classroom.]</p> <p>Teacher 4: Ano lang...Facebook messenger and google classroom. [We only made use of Facebook messenger and google classroom.]</p> <p>Teacher 6: Synchronous and asynchronous we use Google classroom and google meet...</p> <p>Teacher 7: Ano lang google classroom. [We only made use of google classroom.]</p> <p>Teacher 11: Google classroom for posting of activities...</p> <p>Teacher 13: Posting and uploading of their activities in Google classroom</p>
Utilizing Video-Guided Laboratory Lessons	<p>The teachers answered in the questionnaire that:</p> <p>Teacher 1: By uploading videos or showing to them during our discussion through google meet.</p> <p>Teacher 3: We use videos available online I and the students will get to familiarize the procedures by watching the videos.</p> <p>Teacher 4: The internet has full of academic information and instructional videos. I cite or provide the link of the video to my students.</p> <p>Teacher 5: Send videos/presentations showing different procedures or techniques done in a particular activity.</p> <p>Teacher 8: Use of video clips, demonstrate how the activity is to be done thru video.</p> <p>Teacher 11: VRFDD or video-recorded fish dissection demonstration used in Gensci 2 zoology lab class for environmental science program.</p> <p>Teacher 13: A tutorial video with a PDF format laboratory activity is also given beforehand, so students can prepare in advance.</p>
Online Guided Inquiry	<p>The students mentioned in the FGD that:</p> <p>Student 3: One of the methods that our teacher asks us to do is to read and review published literatures related to our topics. He provided us with guide questions to answer.</p> <p>Student 1: During the pandemic time sir, pinagawa po kami ng synthesis paper based on literatures provided and dissection paper and other than that wala naman pong pinagawa samin. [During the pandemic time sir, we were made to do a synthesis paper based on literatures provided and dissection paper and we have no other activities other than mentioned.]</p> <p>Student 13: Meron po kami sa plant bio po nag research po kami about sa plant then nag collect po kami ng data about sa plant yun po sir. [In our plant bio subject, we did research about the plant, then we collected data about the plant, sir.]</p> <p>Student 14: So, since di po kami makapunta sa school kasi nga may pandemic po, yung binigay ni sir is activities tapos may pinagawa din siyang dissecting sir, dissecting a scientific paper ganun po. (So, since we couldn't go to school because of pandemic, what sir gave was activities and then he also did dissection activity, sir, like dissecting a scientific paper.)</p> <p>Student 29: Same lang po sir, I'd like to share lang about yung virtual laboratory po kasi we are engaged talaga during that time kasi we can see sample specimen in various magnification, yung lang po. [It's the same sir, I'd like to share about the virtual laboratory because we are really engaged during that time because we can see sample specimens in various magnifications, that's all.]</p>

Table 6. Continued

Subthemes	Responses
Synchronous and Asynchronous Online Sessions	<p>The Teacher said in the interview that:            Teacher 2: For lab post discussions, we meet via Google Meet, their post lab reports should be submitted in PDF file in Google classroom. These activities are all embedded in their self-paced modules.            Teacher 4: After their activity I conduct post lab discussions via google meet especially the results of the lab.            Teacher 6: Synchronous and asynchronous we use Google Classroom and google meet, yung style ko sir I will provide the modules to the students and then after answering all those questions discussion kami via online. [Synchronous and asynchronous we use Google classroom and google meet, my style sir is I will provide the modules to the students and then after answering all those questions we will meet for discussion through online meetings.]            Teacher 7: Ano lang google classroom and YouTube, pati yung Adobe flash player yung mga interactive, kaya nga di lahat ng students may device or able yung adobe flash. [In my case I used google classroom and YouTube, and interactive videos through Adobe flash player, that's why not all students have a device or capable of playing the videos through adobe flash.]            Teacher 11: Google classroom for posting of activities, announcements, submission of outputs, then at first Zoom then changed to google meet.            Teacher 13: I use Facebook, messenger for the communication, Gmail, Google Meet and posting and uploading of their activities in Google Classroom.</p>

As shown in Table 6, there are six (6) teachers who said in the interview that they articulate the Delivery of ODL in BLC by using different online platforms. Also, students said in the FGD that their teachers utilize online platform such as Zoom, Google Meet and ClassIn during the implementation of ODL in BLC. In the state college where the study was conducted, google classroom appeared to be commonly used as their learning management platform.

In addition, the data showed that seven (7) teachers mentioned in the questionnaire that they utilize video-guided laboratory activities as they deliver ODL in BLC. This is confirmed by students in the FGD and teachers in the interview that teachers are indeed using video-guided laboratory activities in the delivery of ODL in BLC. In doing this, teachers provided students with web links that will direct students to websites, google drive and YouTube videos, students access these files and are tasked to watch and answer the guided questions prepared for them.

There are five (5) students who said that their teachers utilize online guided inquiry as an approach in the delivery of ODL in BLC. Teachers maximized the use of online web sources where students can access and navigate through its various contents, student queries and concerns are attended through online meetings.

Further, there are six (6) teachers who mentioned in the interview that they conduct synchronous and asynchronous sessions for pre-laboratory and post-laboratory discussions. This is confirmed by students that their teachers meet them online via conferencing app to discuss the instructions and materials needed for the laboratory activities, the same method was done by their teachers for post laboratory and rationalization of lessons and laboratory results.

This account indicates that the biology teachers articulate the delivery of ODL in BLC by utilizing technology in the process. This means that the use of online learning management platform such as google classroom and ClassIn, video-guided laboratory lessons, online guided inquiry, and synchronous and asynchronous online sessions thru Zoom or google meet plays a vital role in the effective delivery of ODL in BLC.

This implied that biology teachers should be equipped with technological and techno-pedagogical knowledge and skills to effectively deliver ODL in BLC. The findings also agree with the study of (Kosterelioglu, 2016) who discovered that the use of video clips and instructional materials during online instruction arouses interest, improves memory in learning, and provides intelligibility of the topic.

The finding also agrees with the study of (Asad et al., 2021) who concluded from their study that the teachers' ICT knowledge and skills are important in ensuring the effective delivery of instruction and transfer of facts and information to the students.

#### *Theme 5: Implementing Flexible Assessment Methods*

The data revealed that in the delivery of ODL in BLC, teachers implement flexible assessment methods that will match with the needs and technological capabilities of the students. There are four subthemes that revolve around this major theme which include recorded return demonstration video, output-based performance tasks, online comprehension check, and performance task rubrics. These subthemes are presented in Table 7 and explicitly discussed hereunder.

Table 7. Subtheme and Corresponding Responses on Teachers' Articulation of ODL in BLC in Terms of Implementing Flexible Assessment Methods

Subthemes	Responses
Recorded Return Demonstration Video	<p>The teachers said in the interview that:</p> <p>Teacher 2: I require them to document their work through recording a video of them doing the lab work. Say in my class, we discuss biogeochemical cycles, I let them choose one of the cycles and prepare guide questions to answer and prepare a video presentation.</p> <p>Teacher 4: So, in my case, big factor talaga yung mag video sila pano nila ginawa yung lab experiment and coupled with written reports lahat ng results they have to record or put that in writing. [So, in my case, a big factor is that they make a video of how they did the lab experiment and coupled with written reports, all the results must be recorded.]</p> <p>Teacher 5: Sometimes, I let them create a video presentation of the activity that they have done, they have to document their self.</p> <p>Teacher 6: But if not, I offer alternative materials in home, tapos ang importante talaga yung recording video recording nila yung documentation then they will present it to class via synchronous sessions yung iba na malalayo I ask them to send their videos. [But if not, I offer alternative materials at home, then what is really important is their recording video for documentation purposes then they will present it to class via synchronous sessions, for students who have difficulty to present due to their signal and location, I ask them to send their videos through email instead.]</p> <p>Teacher 11: Then outputs-based man talaga kami like yung sa fish dissection so to make sure na tama yung ginawa nila that's why I ask them to record a video or video recording. [Then in our fish dissection activity, I based on outputs, and so to make sure if what they did is right, I ask them to record a video or video recording.]</p>
Output-based Performance Tasks	<p>The students mentioned in the FGD that:</p> <p>Student 8: Meron pa sir, gumawa po kami ng 3D model ng cell especially yung difference between ng healthy at unhealthy cell like sa red blood cells yung samin, at lagyan namin yung description doon sabay sa model, tapos yun na yung tinatawag niya na FLC or flexible learning contracts po yun na yung ginagamit niya na biology laboratory. [Additionally, sir, we made a 3D model of the cell, especially the difference between healthy and unhealthy cells, like the red blood cells, and we put the description there together with the model we call it FLC or flexible learning contract, the is one activity our teacher used in our biology laboratory.]</p> <p>Student 13: We also do reportings yun nga po yung PMIGA, yung PMIGA po yun po pinaka laboratory task na nagawa namin like taking photos of different plants and dissect information about the plants. [We also do reporting, the PMIGA is an alternative to laboratory task we've done like taking photos of different plants and dissect information about the plants.]</p> <p>Student 17: Gawan po namin ng observation at meron din po kami po yun nagcoconduct po sinusunod lang po namin yung process po or steps na nasa module. [We were asked to make an observation and we also do the actual conduct of the laboratory; we just follow the process or steps indicated on the module.]</p> <p>Student 18: Meron pa po sir, ginamit po namin yung google classroom po dun po namin sinasubmit yung outputs namin sir. [In addition, sir, we used the google classroom and submitted our outputs there.]</p>
Online Comprehension Check	<p>The teachers said in the interview that:</p> <p>Teacher 3: So, I require them to submit post laboratory reports based on the videos provided.</p> <p>Teacher 5: I do give quizzes and oral recitation after the lecture.</p> <p>Teacher 6: Yung style ko kasi sir, I give the exam through synchronous meeting, they have to focus their camera on their paper while flashing the questions isulat nila yung answers nila sympre minomonitor ko sila if they are cheating or not. [My style sir is I give the exam through synchronous meeting, they have to focus their camera on their paper while I'm flashing the questions, they write their answers on the paper, there I can simply monitor them if they are cheating or not.]</p> <p>Teacher 11: If I may remember, may mga formative tests kung baga yung FLC kasi nagiging package siya, like the entire output tapos may corresponding formative test. [If I remember, there are formative tests like the FLC it's more like a package, like their entire output and then there is a corresponding formative test.]</p> <p>Teacher 13: I give short quizzes for me to assess if meron silang nakuha. [I give short quizzes for me to assess if they learned something.]</p>

Table 7. Continued

Subthemes	Responses
Performance Task Rubrics	<p>The teachers answered in the questionnaire that:</p> <p>Teacher 5: Rubrics for specific activity.</p> <p>Teacher 8: Students will have the demo and graded using rubrics.</p> <p>Teacher 9: Creating and using of rubrics.</p> <p>Teacher 10: Provide students with explicit and detailed rubrics to accurately communicate expectations for students' performance.</p> <p>Teacher 11: Rubrics and other assessment tools are pre-determined and understood by the students to make sure objectives and content standards are attained well.</p>

As shown in Table 7, biology teachers implement flexible assessment approaches in assessing students' learning as they undergo ODL modality in BLC. There are five (5) teachers who mentioned in the interview that they utilize recorded return demonstration as one of the approaches in the delivery of ODL. This is confirmed by students during the FGD and three teachers who answered the questionnaire. In doing this, teachers require their students to record thru video recordings their actual conduct of the laboratory activities, these recordings are then submitted to their teachers for checking and as basis for assessment.

In addition, there are four (4) students mentioned in the FGD that the teachers provide output-based performance tasks which are delivered online. This is also supported by teachers who answered the questionnaire and during the interview claiming that most of their laboratory activities require actual outputs and performance.

Further, the result also revealed that five (5) teachers said they conduct online comprehension check as a formative tool. This is confirmed by teachers who gave a similar statement in the questionnaire, which claimed that online quizzes and recitation is conducted during and after laboratory activities through video conferencing app to check on the extent of student learning the ideas and concepts.

Five (5) teachers wrote in the questionnaire that they utilized scoring rubric in evaluating students' performance and laboratory outputs, this is facilitate transparent and reliable evaluation of submitted outputs by students online, these rubrics were also cascaded to students prior to the conduct of laboratory activities.

These results indicate that the biology teachers employ flexible assessment methods in the delivery of ODL in BLC. This means that teachers employ the use of recorded return demonstration video, output-based performance tasks, online comprehension check, and performance task rubrics as components of online assessment approaches.

The results implied that for effective assessment of students' exposure to ODL in BLC, teachers must have sufficient knowledge on the use of flexible assessment approaches that suits the needs of the learners who are in the ODL modality. This is similar to the study of (Conrad & Openo, 2018) who emphasized that providing students with options and establishing flexibility in the assessment process are important assessment strategies that contribute to the success of online teaching and learning.

Irwin and Hepplestone (2012) supports this finding who concluded in their study that introducing flexibility in the assessment procedure when students are exposed to online education greatly contribute to develop students' learning autonomy.

### Discussion

Results and findings from data gathered through a survey method, in-depth interviews, and focus group discussion involving the biology teachers handling biology laboratory courses provided substantial information to explore the articulation of biology teachers in implementing Online Distance Learning (ODL) in biology laboratory courses (BLC). The data gathered from the self-questionnaire were used to find the answer to the questions that guided the study and the qualitative data from the interview and FGD were used to strengthen the internal validity of the results and findings.

In the account of the articulation of the biology teachers, the analysis revealed that the biology teachers articulate the delivery of ODL in BLC by considering the activities needed in the planning stage, implementation, and assessment. In the planning stage, biology teachers articulate ODL in BLC by preparing the ODL learning opportunities.

In doing this, the biology teachers clarify the learning outcomes, develop activities that matches the requirements of ODL in BLC, retrofit the curriculum to an online scheme, benchmark of potential learning opportunities, and identify potential risk and hazards. In addition, teachers also articulate ODL in BLC by preparing the instructional materials and technology such as audio-visual materials, printable online resources, devices and course material, and internet access during the planning stage.

In the course of implementing ODL in BLC, teachers provide distance laboratory experiences where teachers allow students to use materials and resources at home and the community to conduct laboratory activities. Teachers also use

technology to support ODL delivery in BLC using online learning management platform, video-guided laboratory lessons, online guided inquiry, and synchronous and asynchronous online sessions.

In terms of assessment, teachers articulate ODL assessment through flexible assessment methods such as the use of recorded return demonstration video, output-based performance tasks, online comprehension check, and performance task rubrics. In connection to giving assessment tasks to students online, it is imperative that teachers should consider various alternative assessment practices and outcomes-based tasks to reliably measure the extent of students learning even in distant format.

### **Conclusion**

From the findings of the study, it is concluded that the teachers' articulation of ODL in BLC commences with careful planning of ODL learning opportunities where clarifying the target learning standards serves an important role in developing learning opportunities and redesigning the curriculum with consideration on the best ODL practices of other institutions and the overall safety of the students. The planning stage is considered as an important component of instructional delivery since it sets first the direction of teaching and learning.

It is also concluded that planning and preparing the instructional materials and technologies needed are essential requirements for the successful conduct of ODL in BLC. The ability of the teachers to identify the locally available materials which the students can access in the conduct of home-based and community-based laboratory activities in biology is important in the delivery of ODL in BLC as an alternative to in-person laboratory activities.

In terms of lesson implementation, the use of home and community-based laboratory activities as teaching alternative was considered in view of the limited access to physical laboratory facilities during online and distant formats. In addition, teachers also maximized the use of learning management platforms and computer applications such as Google Classroom, Google Meet, and Zoom among others to deliver lessons and conduct learning activities in synchronous and asynchronous formats.

Along this line, teachers should be equipped with technological and techno-pedagogical knowledge and skills to effectively deliver ODL in BLC through a series of capacitating and retooling workshops focusing on the delivery of learning activities in an online and distant format. This can be achieved through the constant support of the administration and various stakeholders to help teachers and students alike to effectively navigate ODL in BLC.

Further, for effective assessment of students exposed to ODL, teachers must have sufficient knowledge on the use of flexible assessment approaches that suit the needs of the learners and the requirements of online learning modality. This will help teachers to gather and measure reliable data on student progress and performance in class even in distant settings.

In addition, the use of outputs and performance-based assessment practices allows students to be actively engaged in the learning process despite the limitations of the online distance learning modality. It is also concluded that assessment tools such as scoring rubrics ensure a clear and concrete method of assessing student outputs and performance.

### **Recommendations**

From the findings and conclusions of the study, Higher Education Institutions (HEIs) should consider the data on teachers' articulation as these will provide substantial data in crafting academic policies and programs relevant to the demands of the new normal education.

Additionally, it is suggested that HEIs should invest in different technologies and software applications that will benefit both teachers and students during pandemic and beyond. The school administrators are encouraged to design and provide training opportunities for biology teachers that will enhance their digital skills to effectively deliver ODL in BLC.

The biology instructors and professors are encouraged to do benchmarking and maintain a culture of collegiality to allow an effective exchange of ideas and improve practices in the delivery of ODL in BLC. They are also encouraged to retrofit and modify the curriculum and anticipate potential hazards if ODL in BLC is to be implemented.

The delivery of home-based and community-based laboratory activities are also encouraged but teachers need to carefully plan the learning opportunities and communicate this with the learners in advance to allow students to effectively adjust to this type of instruction. Most importantly, it is recommended for teachers to always exercise caution in conducting home and community-based laboratory activities to ensure students' safety and welfare given the limited supervision and monitoring during the conduct.

Future researchers are encouraged to conduct a similar study to extend the scope that goes beyond the one school only. The same study can also be carried out in other field of sciences like chemistry and physics with laboratory components. Future studies involving the experiences of the students in online distance learning in biology laboratory courses are also recommended.

### Limitations

The study is only focused on investigating biology teachers' articulation in terms of implementing ODL in undergraduate biology courses. Specifically, the study is focused on documenting instructional practices and alternatives employed by teachers in conducting biology laboratory courses in an ODL mode during Academic Year 2020-2022.

Additionally, this study involved biology teachers in only one state-owned Higher Education Institution in Zamboanga City, Philippines, the case of other teachers in other institutions might be different given various factors such as but not limited to educational background, facilities, and pieces of trainings. The specific biology laboratory courses that are considered in the study are also limited to what is being offered in the participating state college.

### Ethics Statements

The study protocol was submitted to the Zamboanga City Medical Center Technical Review Board for review and approval with the approval code ERB Protocol No. 2022-23 issued April 18, 2022. The study was implemented after its approval from the Technical as well as Ethics Review Board. All the information derived from this study was treated confidential. Informed consent was secured from the participants prior to the gathering of data.

### Acknowledgments

The researcher would like to acknowledge the technical assistance of Dr. Mario R. Obra and Dr. Genelyn Madjos in improving the paper. Appreciation is also extended to Ms. Joni Czarina P. Amora and Dr. Antonino E. Godinez, for their substantial input to the study.

### Conflict of Interest

The author declared no potential conflict of interest.

### Funding

This research was supported by the Commission on Higher Education (CHED) through its Scholarships for Instructors' Knowledge Advancement Program (SIKAP).

### References

- Asad, M. M., Aftab, K., Sherwani, F., Churi, P., Moreno-Guerrero, A.-J., & Pourshahian, B. (2021). Techno-Pedagogical skills for 21st century digital classrooms: An extensive literature review. *Education Research International*, 2021, Article 8160084. <https://doi.org/10.1155/2021/8160084>
- Brockman, R. M., Taylor, J. M., Segars, L. W., Selke, V., & Taylor, T. A. H. (2020). Student perceptions of online and in-person microbiology laboratory experiences in undergraduate medical education. *Medical Education Online*, 25(1), Article 1710324. <https://doi.org/10.1080/10872981.2019.1710324>
- Commission on Higher Education. (2020). *CMO No. 4, series of 2020- Guidelines on the implemetation of flexible learning*. <https://bit.ly/3Pnua0u>
- Conrad, D., & Openo, J. (2018). *Assessment strategies for online learning: Engagement and authenticity*. AU Press. <https://doi.org/10.15215/aupress/9781771992329.01>
- Crawford-Ferre, H. G., & Wiest, L. R. (2012). Effective online instruction in higher education. *Quarterly Review of Distance Education*, 13(1), 11-14. <https://www.learntechlib.org/p/131979/>
- Hallyburton, C. L., & Lunsford, E. (2013). Challenges and opportunities for learning biology in distance-based settings. *Bioscene: Journal of College Biology Teaching*, 39(1), 27-33. <https://www.learntechlib.org/p/156938/>
- Hussain, I., Saeed, R. M. B., & Syed, A. F. (2020). A study on effectiveness of online learning system during COVID-19 in Sargodha. *International Journal of Language and Literary Studies*, 2(4), 122-137. <https://doi.org/10.36892/ijlls.v2i4.404>
- Irwin, B., & Hepplestone, S. (2012). Examining increased flexibility in assessment formats. *Assessment and Evaluation in Higher Education*, 37(7), 773-785. <https://doi.org/10.1080/02602938.2011.573842>
- Kosterelioglu, I. (2016). Student views on learning environments enriched by video clips. *Universal Journal of Educational Research*, 4(2), 359-369. <https://doi.org/10.13189/ujer.2016.040207>
- Lashley, M., & McCleery, R. (2020). Intensive laboratory experiences to safely retain experiential learning in the transition to online learning. *Ecology and Evolution*, 10(22), 12613-12619. <https://doi.org/10.1002/ece3.6886>
- Lee, S. W.-Y., Lai, Y.-C., Yu, H.-T. A., & Lin, Y.-T. K. (2012). Impact of biology laboratory courses on students' science performance and views about laboratory courses in general: Innovative measurements and analyses. *Journal of Biological Education*, 46(3), 173-179. <https://doi.org/10.1080/00219266.2011.634017>

- Musingafi, M. C. C., Mapuranga, B., Chiwanza, K., & Zebron, S. (2015). Challenges for open and distance learning (ODL) students: Experiences from students of the Zimbabwe Open University. *Journal of Education and Practice*, 6(18) 59-66. <https://bit.ly/3NXhPig>
- Owolabi, O. A., Ladeji-Osias, J., Shokouhian, M., Alamu, O. S., Lee, S. W., Oguntimein, G. B., Ariyibi, A., Lee, H. J., Bista, K., Dugda, M. T., Ikiriko, S., & Chavis, C. (2021). Best practices for the implementation of home-based, hands-on lab activities to effectively engage STEM students during a pandemic. In *Proceedings of Research, Virtual ASEE Annual Conference and Exposition* (pp.1-21). ASEE. <https://doi.org/10.18260/1-2--36744>
- Picciano, A. G. (2015). Planning for online education: A systems model. *Online Learning Journal*, 19(5), 142-158. <https://doi.org/10.24059/olj.v19i5.548>
- Sepulveda-Escobar, P., & Morrison, A. (2020). Online teaching placement during the COVID-19 pandemic in Chile: Challenges and opportunities. *European Journal of Teacher Education*, 43(4), 587-607. <https://doi.org/10.1080/02619768.2020.1820981>
- Udin, W. N., Ramli, M., & Muzzazinah. (2020). Virtual laboratory for enhancing students' understanding on abstract biology concepts and laboratory skills: A systematic review. *Journal of Physics: Conference Series*, 1521, Article 042025. <https://doi.org/10.1088/1742-6596/1521/4/042025>