# Exploring Senior High School Students' Experiences in Chemistry Laboratory Classes in a Blended Learning Environment

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## Abstract

*Chemistry laboratory activities cultivate scientific inquiry that enable students to experience and discover scientific processes and occurrences. Likewise, research examining the synergy of online and face-to-face modalities in the context of post-pandemic education is still in its formative years. Drawing from these premises, this study aimed to analyse the insights and experiences of senior high school students in chemistry laboratory classes in a blended learning environment. This research utilized a case study approach that involved fifteen (15) Grade 12 STEM students. Primarily, semi-structured interviews elicited students' insights and experiences on chemistry classes in a blended learning setting. Thematic analysis revealed that the experiences of the students could be viewed in terms of social interaction, learning engagement, lesson understanding, and course design and resources. Similarly, these experiences encapsulated the benefits, challenges, and suggestions for improvement of a blended learning environment. Particularly, designing chemistry laboratory classes in a blended learning set-up should capitalize on the learners' context by considering their insights and experiences. These findings shed light on designing learner-centred chemistry laboratory classes in a blended learning environment that optimizes science learning amid the transition in the educational landscape.*

**Keywords:** chemistry education, science laboratory activities, blended classes, secondary education, learner-centred

## Introduction

Chemistry is the central science which is the cornerstone of other branches of science (Brown et al., 2014). Improving chemistry education is crucial in empowering and equipping students with the necessary competencies to contribute to scientific knowledge and capacity building. Chemistry laboratory activities allow students to experience "science in action" and interpret observations based on their existing contexts and prior conceptions (Buntine et al., 2020). It also allows students to actively observe the phenomena, establish meanings through the development of cognitive structures, and facilitate collaborative inquiry through social interactions.

Due to the pandemic, a paradigm shift calls for innovative strategies to ensure learning continuity to make the educational system resilient. Rather than taking this only as a challenge, this situation can be viewed as an opportunity to improve existing educational practices and provide a relevant learning experience to all learners. With this, blended learning is seen as a versatile learning modality that can easily adapt to different learning conditions.

Blended learning is the combination of face-to-face instruction and the online classroom that promotes flexibility and adaptability of the course (Longo, 2016; Scholten et al., 2021). Blended learning is considered an effective instructional approach by Horizon Reports 2019 and 2020 wherein it has gained widespread adoption to enhance learning experiences (Alexander et al., 2019; Brown et al., 2020).

Despite its pre-pandemic implementation, the evolving educational landscape necessitates a closer examination of blended learning especially now that the pandemic has made students accustomed to online learning. This sudden shift also poses challenges to teachers in preparing for the transition (Adriyanto et al., 2023; Sia et al., 2023). Cobo-Rendon et al. (2022) underscored that blended learning is appropriate for the post-pandemic transition since this approach incorporates what has been learned during the pandemic. Nevertheless, recent literature emphasized that implementing and integrating blended learning into curricula has formidable challenges, particularly in developing nations where resources and infrastructure may be limited (Adriyanto et al., 2023; Sia et al., 2023). Therefore, the current research could contribute to the growing body of literature on the design and implementation of blended learning in the post-pandemic world, particularly within developing countries.

Utami (2018) highlighted that blended learning is increasingly used in tertiary education but its implementation in high school merits investigation. This underscores the significance of examining a blended learning environment in senior high school. The development of competencies at this stage is a prerequisite for tertiary education courses, particularly given the inherent changes in the post-pandemic era.

In the Philippines, the Department of Education has proposed that blended learning could become a permanent method of educational delivery in the post-pandemic period. This approach could ensure learning continuity despite classroom suspensions caused by natural disasters and other unprecedented events as well as to address shortages of classrooms and teachers (Barcelonia, 2023). Hence, this study could provide insights into this proposal. Likewise, in this study, student-generated suggestions were used as a springboard in determining the factors in designing a blended learning environment.

In this light, this study aimed to determine the Filipino senior high school students' experiences in chemistry laboratory classes in blended learning. Findings could guide into how a chemistry blended learning environment can be designed to foster engagement in learning science.

## Literature Review

### Chemistry Learning

Chemistry is considered the central science since many other fields of study use basic chemistry concepts and principles as their foundations (Brown et al., 2014). This establishes the significance of teaching chemistry with utmost clarity and an active level of engagement to minimize misconceptions and promote learning motivation. Studying chemistry entails three levels of understanding: symbolic, microscopic, and macroscopic (Dori, Avargil, Kohen, & Saar, 2018). This necessitates adequate scaffolds to manage the cognitive load needed to understand chemistry in a comprehensive and integrative manner.

Laboratory activities provide opportunities to visualize macroscopically the occurrences happening at the microscopic level which could then be translated into symbolic representations. The laboratory activities cultivate inquiry learning that allow students to recognize the concepts' applications and have first-hand experience with scientific processes. For this reason, well-structured experiential laboratory activities are essential to effectively learning chemistry since these allow students to engage in cognitive, affective, and psychomotor activities (Bretz, 2019; Enneking et al., 2019; Novak, 2010).

Likewise, a thoughtfully designed blended learning environment fosters opportunities for students to actively construct the meaning of science in real-life situations. For instance, Kuroki and Mori (2021) designed a physical chemistry blended learning class that included video materials for flipped learning, a cloud computing environment, and a video conferencing tool wherein students recognized the benefits of the setup as it increased their educational efficiency. Moreover, the necessity of blended learning in high school chemistry has been emphasized in the needs analysis study conducted by Nababan, Hastuti, and Indriyanti (2019).

**Blended Learning Environment**

Blended learning is increasingly recognized as an emerging learning delivery, especially in science and health-related courses, due to its nature as an evidence-based practice (McCown, 2014). Blended learning synergistically amalgamates the self-directed learning component of online classes and inquiry learning possessed by hands-on activity in face-to-face classes (Longo, 2016; Rivera, 2016). This learning modality elicits flexibility and adaptability of the course that fosters student engagement (Longo, 2016; Scholten et al., 2021). In blended learning, students have to plan and monitor their learning progress during the online learning and evaluate the extent of their lesson understanding as they are prompted to engage in class discussion and apply the concepts learned from online resources and classes during the face-to-face classes.

Existing studies provide empirical evidence of the effectiveness of blended learning. The meta-analysis of Ottogalli, Rosquete, Amundarain, and Borro (2019) highlighted that blended learning could effectively improve the students' conceptual knowledge and satisfaction with learning. Miguez-Alvarez, Crespo, Arce, Cuevas, and Regueiro (2020) reported increased student motivation in engineering education in blended learning. Similarly, this corroborates with the findings of Singh, Rocke, Pooransingh, and Ramlal (2019) that blended learning facilitated the enhancement of learning engagement of the students, which was further associated with improved learning performance. Likewise, Mutya and Mahusay (2023) found that students' academic achievement in science has a significant relationship with the extent of implementation of blended learning in terms of content and assessment.

In the current study, the research participants were exposed to blended learning for their chemistry classes. Blended learning situates students in varied learning opportunities that maximize independent learning of resources through online modality and then deepen their lesson understanding through face-to-face class discussion and class activities like laboratory experiments that concretize learning science.

Although blended learning was practiced before the pandemic but given the dynamic shifts in the educational landscape, it is imperative to re-examine blended learning practices considering the widespread adoption of online learning by students during the pandemic and changes in the way students engage with educational content (Adriyanto et al., 2023). This could provide essential insights into identifying strategies to effectively integrate both face-to-face and online learning modalities to ensure a seamless learning experience for students while supporting teachers in preparing for the complexities of the blended learning environment.

### Theoretical framework

The Community of Inquiry (CoI) Framework and the Complex Adaptive Blended Learning System (CABLS) Framework are the theoretical underpinnings of this research.

The Community of Inquiry Framework is proposed by Garrison, Anderson, and Archer (2000) which underscores that learning happens through the co-creation of shared meanings and interaction of the three core elements namely: cognitive presence, social presence, and teaching presence. Cognitive presence involves the process of engaging students with the content through four phases (triggering event, exploration phase, integration of meanings, and resolution through the application of ideas) (Garrison et al., 2000; Zhang, 2020). Social presence involves providing a setting or climate that *"supports and encourages probing questions, skepticism, and the contribution of explanatory ideas"* (Garrison, 2017, p.37). Teaching presence encompasses designing, facilitating, and directing cognitive and social presences aimed at achieving personally meaningful and educationally worthwhile learning outcomes (Zhang, 2020). CoI has been used by several researchers who investigated blended learning (Garrison, 2017; Zhang, 2020).

Wang, Han and Yang (2015) developed the Complex Adaptive Blended Learning System which provides a systematic and holistic view of blended learning by having a deeper understanding of the dynamic and adaptive nature of blended learning through the interactions of the six subsystems: learner, the teacher, the technology, the content, the learning support, and the institution. Mutya and Mahusay (2023) utilized CABLS as they investigated the implementation of blended learning in senior high school science education which was participated by both students and teachers. In CABLS, the role of learners evolves as they engage with system components for the first time or in new ways wherein it is pivotal to have a well-documented transition from passive to active learning. Meanwhile, the role of teachers transforms parallel to the students as they interact and adapt with one another and to the four remaining subsystems (Mutya & Mahusay, 2023).

## Research Questions

This research primarily sought to investigate the following questions:

1. What are the students' experiences in chemistry laboratory classes in a blended learning environment?
2. What could be the considerations in designing a learner-centred chemistry laboratory class in a blended learning setting?

# Methodology

## Research Design

This was qualitative research that employed a case study approach. Using this approach, this study examined the experience of a person or group of people that could provide information to understand a particular event, process, or interaction (Cohen, Manion, L., & Morrison, 2018).

## Research Sample

The participants were Grade 12 STEM students from a science-oriented high school taking Intermediate Chemistry II. All students already passed Intermediate Chemistry I in the previous grade level. Based on the overall student population of 84 STEM students, an equal proportion of students were selected wherein there were eight female students and seven male students ranging from 17 to 18 years old. All students were categorized based on their academic performance (high, average, low) wherein students were selected from different groups. Therefore, to some extent, the research sample could be considered representative of the population.

## Research Context

At the start of the semester, students had alternating face-to-face classes and online learning wherein they visited the school every two weeks. After two months the students had one online class session and two face-to-face class sessions every week.

For the learning materials, the students were given modules containing the content of the lesson, YouTube videos, and other relevant resources. The topics covered were solutions, thermochemistry, chemical equilibrium, chemical kinetics, acids and bases, and redox reactions. Before their chemistry classes, students were tasked to study the module. During online classes, the teacher facilitated the deepening of the details of the lesson by extending the insights discussed in the module and addressing the students' clarification in the module. Meanwhile, students engaged in hands-on activities such as laboratory activities and other activities during face-to-face classes.

## Research Instruments

Two instruments were utilized in this study. The preliminary information about the students was obtained using a survey questionnaire but the main instrument used to determine students' experiences was the semi-structured interview.

The survey questionnaire aimed to determine the student's basic demographics and existing insights regarding their chemistry laboratory experience. The survey was composed of a Likert scale and three open-ended questions about the experiences of conducting chemistry laboratory activities which was adopted from Barrie et al. (2015). This survey provided initial ideas about the student's experiences in the chemistry laboratory.

The semi-structured interview focused more on deepening of students' insights and experiences. The interview questions were framed based on the Rose-Thorn-Bud activity, a reflective and evaluative activity that determined the positive experiences of chemistry laboratory in a blended learning setting (rose), challenges encountered in chemistry blended learning (thorn), and new insights for improvement (bud) (Gonzales, 2022). The follow-up questions focused on the course design, learning experience, and personal factors based on Bhagat, Cheng, Koneru, Fook, and Chang (2021).

### Data Gathering Procedure

The researcher secured a permit to conduct a study through the approval of the school principal. A Plain Language Statement was given to the participants that indicated the details of the study (e.g., purpose, benefits, possible risks, confidentiality agreement). Similarly, informed consent to parents was given if the students were minors and informed assent was given to seek permission from the students to participate in the study. These letters ensured data privacy and ethical standards. Similarly, the letters indicated that the participants could freely decline and withdraw their participation at any point in the study.

Also, the researcher had meetings with the chemistry teachers regarding the calendar of activities, class discussion flow, class characteristics, student class list, and other relevant information. In coordination with the teachers, a survey questionnaire was administered to gain preliminary information on the students' experiences in the chemistry laboratory activities that would provide important information for the researcher during the interview. Consequently, the researcher conducted a semi-structured interview with the selected participants wherein each session ranged from 12 to 30 minutes.

### Data Analysis Procedure

The results of this study were analysed in three cycles based on the study of Stammes, Henze, Barendsen, & de Vries (2020) that adhered to the spiral approach in qualitative data analysis discussed by (Creswell, 2013). Inductive coding was used in this study. This involved detailed reading and analysis of the statements to extract the multiple meanings inherent to the statements. Consequently, keywords were used to identify a certain statement then eventually these were analysed into themes (Thomas, 2006). In addition, the responses were manually coded and analysed. The 15 students were able to provide a plethora of insights that enabled the researcher to reach data saturation.

The first cycle involved transcribing and coding the responses. The second cycle involved condensing the data by identifying patterns. For the third cycle, the identified themes were enriched by examining patterns across themes and interview questions. Upon careful analysis, the recurring codes aligned with the CoI and CABLS. Furthermore, the researcher discussed with the students the findings as part of the participants' validation phase of the study which helped to establish the credibility of the results.

## Results and Discussion

### Students' Experiences on Chemistry Laboratory Classes in a Blended Learning Environment

The initial survey indicated that students had relatively good learning experiences in their chemistry laboratory ($M$ = 4.06). In addition, some insights on which part they found enjoying (e.g., hands-on experience, chemical reactions) and encountered challenges (e.g., time allotment, equipment, learning adjustments) were obtained from the survey. These insights were considered essential context for the researcher to have a deeper probing of experiences during interview.

Findings revealed students’ experiences in chemistry laboratory blended learning could be viewed in terms of social interaction, learning engagement, lesson understanding, and course design and resources (Table 1). To the best of the researcher's knowledge, these themes represent the lens on how students’ learning experiences can be perceived that have several characteristics in terms of having benefits, challenges, and suggestions for improvement of the blended learning environment. The findings corroborate with previous studies that accentuate the pivotal role of laboratory classes as authentic scientific inquiry processes that increase student engagement and enhance students’ understanding of how science works (Buntine et al., 2020).

One notable aspect of this research is its comprehensive approach. Rather than solely examining students' experiences through their perceived benefits and challenges, this research probe further the students’ suggestions that can enhance the facilitation of blended learning by considering contextual factors during the learning transitions.

Table 1. Students’ experiences in chemistry laboratory classes in a blended learning setting.

| Aspects | | | Snippets |
|---|---|---|---|
| Social Interaction | Benefits | Better student-student and teacher-student interactions | *"I think the strongest points of lab activities are collaboration skills and how lab activity helps you to communicate more with people to provide your input and also listen to them."* |
| | Challenges | Necessity for sustained engagement in learning | |
| | Suggestions | • small group activities<br>• assignment of roles during the activity | *“Before class hours, I hope there could be mini group activity that could social interaction and engagement in learning”* |
| Affective Domain | Benefits | • motivation<br>• self-efficacy | *"I am excited about performing laboratory activities in this learning set-up since it motivates me to think about what I should and can do."* |
| | Challenges | experiencing learner's fatigue | |
| | Suggestions | • scheduling of activities<br>• incorporation of reflection on learning progress | *“Sometimes I felt the lack of motivation due to learner’s fatigue.”* |
| Lesson Understanding | Benefits | • Better visualization of concepts<br>• More avenues to discover learning opportunities | *“I am a visual learner, so I can better understand the lesson when I can observe the process [simulation and hands-on]. During face-to-face activities, I am* |

| | | | |
|---|---|---|---|
| | Challenges | • cognitive preparedness<br>• learning continuity | *more observant and critical since I am the one responsible for knowing the answers during the experiment"* |
| | Suggestions | • redesign activities<br>• supplementary materials | *"We are all adjusting since we forgot the lab practices. Perhaps, there is a need to review the processes so that we can clarify things that could address our difficulty and unsure information."* |
| Course Design and Resources | Benefits | • cultivating self-directed learning through flexible learning delivery<br>• provision of varied resources | *"Blended learning helps me process chemistry concepts better since I am given the opportunity to learn the lesson beforehand so that I am more prepared during class discussion. It [simulations and videos] helps me to explore experiments with less fear since I can control the setup. This then gives me more confidence as I will perform the experiment during face-to-face session."* |
| | Challenges | • time management<br>• classroom management<br>• limited resources | |
| | Suggestions | • mutually complementary design of online and face-to-face activities<br>• provision of sufficient materials and good facilities<br>• deliberate integrative approach in lecture and laboratory components | *"It would be better to lessen the disconnect between theoretical and lab classes. If possible, there should be an integrated approach in lecture and laboratory so that computation [chemistry problem-solving calculations] makes sense to us. Use data from the lab in the lecture."* |

*Social Interaction.* Students underscored better student-student and teacher-student interactions in chemistry classes in a blended learning environment. The results support Vygotsky's Social Constructivism Theory that emphasizes more knowledgeable others, such as chemistry teachers, and peers could facilitate the learning process. As the students work as a group, there are opportunities for the intellectual exchange of ideas, hence facilitating learning through shared understanding of the lesson and construction of knowledge (Othman, Hussain, & Nikman, 2010). This mirrors the research of Zhang (2020) regarding the strong correlation between cognitive and social presence as reflected by having supportive discourse in learning. Engaging in dialogue with both the teacher and peers can enhance students' lesson understanding through clarifying information, revisiting prior concepts, and extending ideas.

On the other hand, students expressed that one of their challenges is having a sustained engagement in learning due to the proximity of individuals, learning space, and internet connectivity, while for face-to-face classes, there is a need to further re-establish interpersonal skills since they have been used to independent learning. This substantiates the claim of Zhang (2020) that blended learning is not merely the integration of online learning and face-to-face instruction but intertwines individual learning with collaborative inquiry.

These findings build and extend the view of Garrison et al. (2000) that accentuates the necessity for collaborative constructivist activities through the synergy of cognitive, social, and teaching presences as depicted in CoI. In line with this, the students suggested that there could be small group activities before classes so that they could establish rapport within the group. This could be related to the development of collective efficacy through exchanging knowledge, sharing experiences, and collectively searching for solutions to problems (Moolenaar, Sleegers, & Daly, 2012). Students also recommended the assignments of roles to structure interaction and facilitate task accomplishment. This allows to have a sense of accountability and responsibility within and for the group. This fosters positive social interdependence that aligns with the elements of fruitful collaboration discussed by Johnson, Johnson, and Smith (2007) which include shared understanding, accountability, diversity and support, and evaluation.

*Learning engagement.* Dohn, Fago, Overgaard, Madsen, and Malte (2016) emphasized that students with high interest and enjoyment have heightened task alertness and attention, problem-solving abilities. They are also persistent and exert more effort in performing activities and learning the lessons. Due to the nature of the laboratory activities, students are active contributors to the co-creation of learning. This has implications on their motivation, efficacy, and satisfaction in the learning process.

On the other hand, students mentioned that due to the learning modality transitions, they experienced fatigue since a specific learning modality required a unique set of preparation for learning. This finding accords with Sia et al. (2023) that mental well-being is considered an important concern during the post-pandemic period wherein institutional support is needed to address this concern.

Hence, students suggested revisiting the schedule of activities, not just for science but for all classes, so that there would be a mapping of requirements to help manage student workload. They also mentioned that it would be helpful to have deliberate time for reflection on their learning progress to guide them on what they need still improve or the aspects that they need additional guidance. These recommendations are concrete examples of learning support of the CABLS. As discussed by Wang, Han, and Yang (2015 p. 384), *"the development of learning support mechanisms should be informed by the needs of the learner, effectuated by the expertise of the teacher, necessitated by the constant advances in technology, and ensured by institutional support".*

*Lesson Understanding.* Students shared that blended learning facilitated better visualization of concepts and better participation in the learning process. Laboratory activities foster meaningful learning by encouraging students to integrate theoretical concepts with its application that eventually concretize learning and recognize its relevance.

Blended learning enables students to have co-ownership in learning since it allows them to prepare more for class activities (Kuroki & Mori, 2021). Abstract concepts in chemistry need more time to further process the information. Hence, students have increased participation in learning since they can research more or understand the topics beforehand whereas face-to-face classes are focused on deeper processing of the content. This insight aligns with the academic learning support in the CABLS which involves helping students to have learning strategies for time management (Wang et al., 2015).

As for the challenges, students encountered difficulty in adjusting to the new normal education wherein they needed more cognitive preparation as they have been used to having remote or online learning. Also, there was a concern about learning continuity since there were instances that due to time constraints, students were not able to accomplish the activities in one session that would be continued in the next session. These valuable insights shed light on the challenges encountered by the students, thus warranting consideration in the design of blended learning.

Building on these insights, students suggested revisiting which procedure could be further simplified or merged, allowing the accomplishment of the activities within the class time. Although during the pre-pandemic, the activities could be accomplished within class time, but being in a post-pandemic period is another story since students are in learning transitions.

In line with this, the design of the class session is suggested to foster a state of flow among students. In Educational Psychology, the state of flow as reflected in the Flow Theory considers contextual task features, learners' characteristics and psychological state, and performance which could guide in designing class activities (Egbert, 2003). If the activity is within their skills and context, students might be fully immersed in performing the activity and consider the task intrinsically motivating.

Moreover, students recommended supplementary materials like a prelab walkthrough wherein there would be a customized overview of the laboratory activity, not just those found on YouTube. This is to augment the competency preparedness in the learning transition. This corroborates and extends the suggestion of Cobo-Rendon et al. (2022) that amidst the transition to post-pandemic education, the implementation of blended learning should prioritize providing learning resources tailored to students' needs. This targeted support is crucial for managing the academic workload while considering the challenges of transitioning back to face-to-face instruction. Although it is common to provide scaffolds for learning activities, students also emphasized having enough scaffolds to guide them in the execution of the activities, both for online and face-to-face classes. In addition, one of the students suggested that aside from conducting laboratory experiments during class sessions, there might be chances where they could perform home-based experiments as a supplementary activity.

*Course design and resources*. Blended learning enables students to cultivate self-directed learning as they can study at their own pace and have greater accessibility to varied resources (Wang et al., 2015). The online and face-to-face learning environments synergistically contribute to the dynamic classroom ecosystem that optimizes science learning. Both modalities offer affordances that complement one another rather than as competing learning components of blended learning. Using online resources allows the students to understand the topic and experience laboratory activities with fewer worries about committing errors. Consequently, face-to-face classes would focus on deepening the lesson, conducting experiments, applying science concepts, and developing science process skills.

Students shared their sentiments regarding time constraints in performing the laboratory activity, classroom management, and limited resources. Even before the pandemic, the issues of laboratory resources such as equipment, reagents, and facilities were evident. Studies have consistently emphasized the pressing concern about the availability of facilities for science laboratories (Antonio, 2018). To some extent, simulations help address concerns about resources by allowing students to explore experiments virtually.

Similarly, students highlighted the importance of having instructional support to deliberately facilitate an integrative approach to the lecture and laboratory components. This aligns with the recommendations of Wang et al. (2015) regarding the provision of learning support to effectively adapt to blended learning. Although connections between the lecture and laboratory activity do exist, it is suggested that deliberate scaffolds and approaches be made explicit to further reinforce interconnectedness. As mentioned by the students, the data obtained from laboratory experiments might be used in problem-solving activities in the lecture. With this, insights are more realistic, and learning is more authentic and meaningful.

**Considerations in Designing a Learner-Centred Chemistry Laboratory Classes in a Blended Learning**

Figure 1 illustrates the factors to be considered when designing chemistry laboratory classes in a blended learning environment based on the research findings.

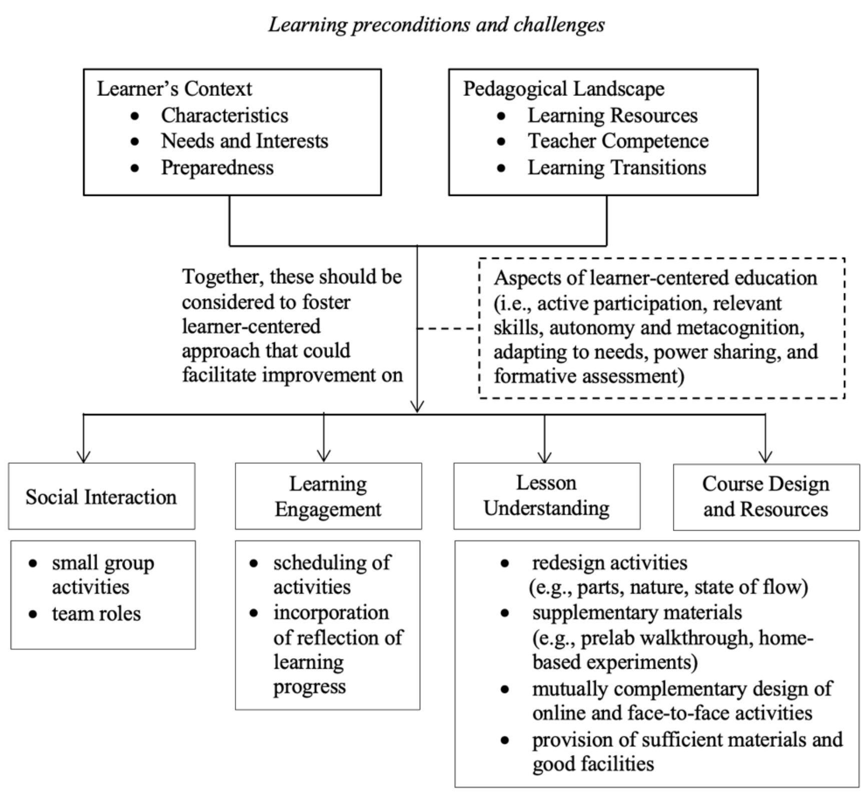

Figure 1. Considerations in designing chemistry laboratory classes in a blended setting.

Designing chemistry laboratory classes in a blended setting should capitalize on the learners' context by considering their characteristics, learning needs, interests, and preparedness as Gen Z learners. Empathy is a primary principle in design thinking since it guides to development of materials that would reflect the needs and interests of the intended users. This agrees with the claim of Ni Shé et al. (2022) that it is always essential to meet the needs of the students to develop connected and effective methods in instructional design. It is also equally significant to consider the pedagogical landscape that includes, but not limited to, learning resources, teacher competence, and learning transitions. Additionally, the aspects of learner-centred education such as active participation, relevant skills, autonomy, metacognition, adapting to needs, power sharing, and formative assessment, can be deeply incorporated into chemistry laboratory classes (Bremmer, 2021). In this manner, there could be improved learning outcomes and could have essential implications on social interaction, learning engagement, lesson understanding, and course design. Collectively, optimizing these facets of learning could guide in designing a relevant and responsive chemistry laboratory class in a blended learning environment.

## Conclusion and Implications

This research investigated senior high school students' experiences in chemistry laboratory classes in a blended learning setting. This research substantiated and extended existing studies focused on blended learning and chemistry laboratory classes wherein the learning transition is an interesting case noteworthy to be examined.

The findings of this study have several important implications for future practice. Analysis revealed that the experiences of the students could be viewed in terms of social interaction, lesson understanding, learning engagement, and course design and resources. These insights could guide the considerations to facilitate learner-centred chemistry laboratory activities in a blended learning setting. Particularly, the results of the study were communicated to the chemistry teachers of the school where the study was conducted and served as their guide in redesigning their respective chemistry classes.

From a broader perspective, this research contributes to enhancing the understanding and designing of blended learning in laboratory classes in post-pandemic education. While blended learning was utilized before the pandemic, the shifts in educational dynamics and students' learning orientations necessitate a comprehensive approach to crafting adaptable instructional designs that promote inclusivity in education.

Learning should not exclusively prioritize cognitive outcomes but equally consider the development of socio-emotional dimensions such as social interaction and learning engagement, while simultaneously considering course design and resources. Initiatives to integrate the suggestions and address the challenges could help strengthen the benefits of chemistry laboratory classes, which have not only effects on students' cognition but also the other skills that can prepare them for future STEM-related careers and equip them to apply science concepts in real-life scenarios. Utilizing blended learning in chemistry enables reskilling students with science process skills and at the same upskilling them to be prepared for the college degree program.

Further studies are needed to extensively cover the student's insights and experiences in chemistry laboratory classes in a blended learning setting. It is recommended to have further analysis, such as a focus group discussion on the identified themes, aside from having online consultations with the respondents. It is also suggested to have a prolonged engagement to gather additional information about the case. Detailed investigation of the different aspects of CoI and subsystems of CABLS could be explored. Nevertheless, this research could be considered an essential basis for future studies on blended learning and in designing chemistry classes that can create a responsive and meaningful learning experience.

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