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Teaching Experiences of University Science Teachers in Flexible Learning: A Transcendental Reduction

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Abstract

Flexible learning (FL) gained prominence in Philippine higher education institutions during the pandemic and continues to be relevant today owing to the impact of the global oil crises. This study aimed to highlight the challenges, strategies, opportunities and mechanisms for enhancing the continuous adaptation in science courses at a state university in the Philippines. Qualitative data were generated from a semi-structured interview with eight science teachers and documents and analysed within the framework of transcendental phenomenology. Learner-related challenges dominate, followed by institution-related, syllabus-related and a few teacher-related challenges. These challenges mandated teachers to implement strategies that are categorized as flexibility in time, theme, technique and transfer, which are essential for addressing the diverse needs of learners and improving educational outcomes. Additionally, teachers gained opportunities to improve or learn new social, technological, efficiency and pedagogical skills, which helped them become more effective at adapting to new teaching environments. These changes, in turn, led to better student engagement and learning outcomes. Finally, based on the experiences of science teachers, there are still areas that need improvement, particularly in developing a framework or policy that includes all aspects of flexibility and the necessary support systems for flexible learning, such as training programs for teachers and resources for students to adapt to various learning environments.

Keywords: Flexible Learning, Science Education, Science Teachers, Transcendental Phenomenology.

Introduction

Flexible learning (FL) was popularized in the Philippine education setting at the height of the pandemic in 2020, when educational institutions were required by the government to suspend traditional face-to-face instruction. Currently, with the ongoing oil crisis worldwide, higher education institutions are again mandated by oversight agencies to implement this broader approach as universities transition to distance learning. While it was not really a new context in the field of education, colleges and universities were given the academic freedom to adapt it as an alternative delivery mode of instruction, as it was considered the safest and most appropriate strategy during the pandemic (1). The term "flexible learning" has been introduced and used by educators, academicians and scholars since the 1990s (2). It has emerged from the demand for a more student-centered higher education with an emphasis on diversified and personalized instruction that caters to students' needs. Moreover, it is anchored on the tenets of constructivism as an educational philosophy that emphasizes learners' ability to construct new knowledge based on prior experiences. Thus, the students are more involved in the learning process and are given more personal responsibility for their learning. In a broader sense, flexible learning is subject to different formalizations and interpretations (3). However, the convergence of interpretations considers flexible learning as both a philosophy and a pedagogical approach that offers flexibility in a wide range of dimensions of teaching and learning. It is primarily attributable to student-centered and technology-based instruction, although the scope is not confined to the use of technology in the teaching-learning process. As a pedagogical approach, it consists of a set of learning philosophies, administrative support and an instructional support system with student participation in decision-making to meet their individual learning requirements (4). In comparison with other specific modes, such as hybrid learning, online learning and distance

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learning, flexible learning is a broad, multi-dimensional learning design that encompasses some aspects of these other modes (5, 6). It is also considered a framework where learners and institutions have control of time, place, content and processes of learning. In contrast, online and distance learning are modes that generally enable flexibility to a certain extent depending on the design. Moreover, hybrid, blended and hyflex are specific modes that can implement certain degrees of flexibility around location and time. Hence, in general, the emphasis on flexible learning revolves around the dimensions of time, place, pace, learning style, content, assessment, or learning path (7). On the other hand, it is important to distinguish true flexible learning from flexible delivery, as the belief that using technology or economically driven strategies for delivering learning instruction constitutes flexible learning is misleading. To avoid this confusion, there are eight identified principles that are vital to the implementation of flexible learning (8). These are flexible access, recognition of prior learning, flexible content, flexible participation, flexible teaching and learning methods, flexible resources, flexible assessment and ongoing evaluation.

In the Philippines, the Commission on Higher Education (CHED) mandated the different higher education institutions to explore different flexible learning options in delivering instructions during the suspension of traditional face-to-face classroom instruction due to the pandemic (9). Just recently, all government institutions, including higher education institutions, adopted the 4-day work week due to the global oil crisis. This initiative highlighted the need to implement flexible learning. The commission emphasized the use of digital and non-digital technologies and options for different learning modes that may include blended learning, modular distance learning and online distance learning. Hence, higher education institutions formulated their own proactive plans and strategies on how to implement flexible learning in the delivery of instructions. However, the abrupt shift from the traditional to flexible modality presented enormous challenges in planning, implementation and assessment, which greatly affected the quality of instruction that students received (10).

Three years after its execution, several studies have looked into problems, challenges and difficulties in the implementation of flexible learning in higher learning institutions in the country. Generally, the most common problems are centered on resources, particularly access to the internet. The absence or limited connectivity due to the geographic location and financial capability of students has been reported to be the most pressing problem surrounding the implementation of flexible learning (1, 11–17). In addition, teachers also reported that they have poor or intermittent internet connections in their homes and in their institutions (12, 15, 16). Also, students do not have devices or limited access to computers and smartphones; hence, they cannot access learning materials or participate in synchronous classes (1, 11, 13, 15). Some universities and colleges also do not have enough infrastructure or are still beginning to acquire it to support flexible learning (1, 15, 16).

In science instruction, previous studies elicited problems and challenges in relation to the implementation of flexible learning (18–22). However, most of these studies are focused on the experiences of science teachers in basic education in the context of purely modular distance learning. Furthermore, the majority of the studies are focused on the problems and challenges encountered by teachers and students, with only a few considerations given to the strategies employed by teachers to overcome these challenges brought about by the implementation of flexible learning (22). With these gaps in the literature, it can be stressed that there is currently a lack of specific studies looking into the implementation of flexible learning in science instruction at the university level. Hence, this study focuses on the specific challenges encountered by teachers and the corresponding strategies implemented to address them in the university setting. In addition, it further delved into the opportunities that teachers have acquired during and after the implementation of the learning modality based on the essence of their experience as described. Finally, based on the narratives of teachers, implications and suggestions were identified in order for the institution to have a holistic and comprehensive flexible learning plan that can be used as a basis for the continued implementation of the learning approach.

The study assessed the implementation of flexible learning in science courses through the lived teaching experiences of science teachers at the university level. Specifically, it answered the following objectives:

a) To determine the challenges encountered by teachers in the implementation of flexible learning in science courses.
b) To identify the strategies used by teachers to facilitate flexible learning in science courses.
c) To determine the opportunities acquired by teachers in the implementation of flexible learning in science courses.
d) To identify the areas of improvement in the implementation of flexible learning in science courses.

Methodology

The study is qualitative in the scope of transcendental phenomenology since its aim is to describe the intentionality and essence of the lived teaching experiences of science teachers at a state university as they experienced them in a flexible learning environment (23). It was conducted at Benguet State University, Philippines (16°27'07"N and 120°35'27"E) from January 2021 to August 2024. The participants were eight science teachers handling basic and major science courses (physics and biology) during the implementation of flexible learning.

The study utilized three stages of data gathering: the preliminary stage, the conduct of an in-depth interview and the validation stage. In the preliminary stage, prospective participants were informed about the nature of their participation in the study. Upon the selection of participants, they were asked about their preference for the mode of interview, whether face-to-face, focus group, or virtual. Ethical considerations were emphasized prior to conducting the interview. The interview was then conducted according to the preferences of the participants. After the initial data analysis, triangulation was conducted as the last stage through the analysis of syllabi and instructional materials, followed by casual or unstructured interviews. The last stage is validating and verifying the researchers' understanding of the result.

Data analysis included triangulation, casual or unstructured interviews and validation to verify the researchers' understanding of the results. It followed a principle that includes suspension of judgement, phenomenological reduction, imaginative variation and uncovering the essence of experience (23). During the suspension of judgement stage, the researchers set aside their personal assumptions, prior knowledge and preconceived judgements about flexible learning before reading the transcripts, which enabled them to avoid biased opinions and fully understand the participants' experiences instead of relying on their assumptions and judgements. After the suspension of judgement stage, the researchers employed phenomenological reduction by closely examining each transcript, identifying and equally weighting every statement relevant to teachers' experiences of flexible learning implementation. Overlapping, repeated and irrelevant statements were removed, then the remaining horizons of data were clustered into themes. Thematic analyses were done through the combined use of the software QDA Miner Lite and manual clustering through a repertory grid. After the analysis by one of the researchers, the clustered themes were examined by other researchers, followed by identifying the textural and structural descriptions of these experiences and then integrated into composite descriptions across the full set of transcripts.

Results and Discussion

The analysis of participants' individual and collective experiences is organized in a gear, as illustrated in Figure 1. Science teachers' total essence of experience in the implementation of flexible learning in higher education is subdivided into the themes of challenges, strategies and opportunities. These are fixed in the inner part of the pitch diameter. Conversely, the recommendations for improvement provided by the participants represent the outer pitch diameter, while the teeth symbolize the specific sub-themes associated with each main theme. The flexibility gear depicts the dynamics of flexible learning by which science teachers may consider setting the gear in motion should there be a sustained implementation of flexible learning. As a gear transmits motion and force from one component to another in order to set a device in motion, so must science teachers and teachers in general be able to sustain the extensive adoption of flexible learning.

The LIST Challenges

Based on the findings, the challenges are classified into four main themes based on the LIST acronym. These are learner-related, institutional-related, syllabus-related and teacher-related challenges.

There are 10 sub-themes that were developed within the learner-related category based on the clusters of codes that were generated. These sub-themes are lack of communication, poor time management, low comprehension skills, low level of digital literacy, access to resources, lack of engagement, lack of interest or motivation, lack of or prerequisite knowledge, negative attitude towards learning and learning preference.

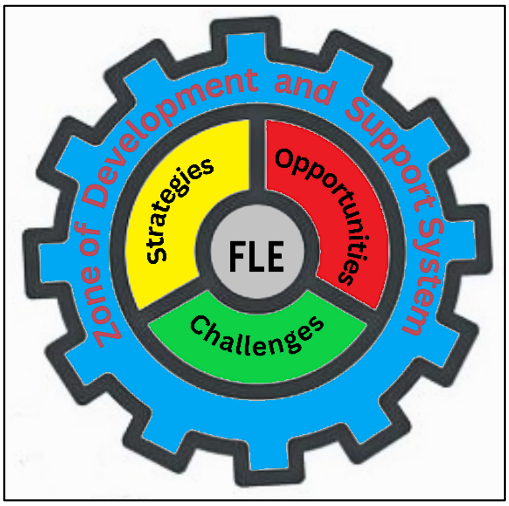

Figure 1: Flexibility Gear in Science Flexible Learning Environment

For all participants, the most crucial challenge was students' access to resources. Accordingly, it was prevalent at the onset of implementation and was the main reason for students not to access learning materials and participate in synchronous and asynchronous classes through the learning platforms. It includes limited to no internet connectivity, a lack of appropriate devices such as smart phones and laptops, the unavailability of resources due to geographic locations and the financial capability of students to have these resources.

This finding substantiates previous studies that while technology is not a requirement for flexible learning, it still appears that in the implementation of flexible learning by science teachers, technology is still a prerequisite, in essence, in the delivery of instruction in online and modular modality (1, 11, 13–16, 24). On the other hand, poor time management due to the number of activities or tasks given by teachers in most of the courses is also a challenge. Students with work or home responsibilities often struggle with time management, leading to conflicts in their schedules, missing synchronous classes and submitting outputs late or not at all. Contrary to the reviewed literature, poor time management by students due to varied reasons did not come up as a challenge. Additionally, some students are employed or have significant responsibilities at home, which often makes it challenging for them to manage their time effectively and complete assigned tasks. These additional responsibilities primarily cause students to miss synchronous classes because of scheduling conflicts, as explained by two science teachers. In essence, these additional responsibilities also contribute to the late submission or non-submission of assignments.

Another sub-theme that can be associated with access to resources is a lack of communication on the part of the students. While there were no mentioned reasons why students rarely respond or do not respond at all to their teachers, it could be associated with a lack of resources of students since they have limited access to network connectivity due to their geographic location or they do not have the means to communicate with their teachers. As expressed,

"Students aren't responsive to messages." (Science Teacher 1)

"Difficult to communicate with students." (Science Teacher 2)

"Some students do not reply to questions." (Science Teacher 7)

"Limitations in the platforms used in communicating." (Science Teacher 6)

This implication corroborates previous findings that the unavailability of networks and the digital divide are the main challenges that students encountered during the implementation of flexible learning (11). Teachers are often challenged by learners' lack of motivation or interest in their studies, which is another sub-theme. Accordingly, based on the interaction between professors and students, some students lack motivation or interest in studying in general or in the science course in particular. This is shown in their participation in and performance in online classes (25). Previous studies also show that loss of motivation and interest in learning is a main concern for students in online learning (11, 13, 26).

Subsequently, the learning preferences of students pose a challenge for teachers, as indicated by two participants who noted that some students are not accustomed to independent learning and therefore request face-to-face classes. Other students also asked for printed copies of the instructional material, while most students preferred a recorded video of the discussions. This result reflects previous studies that show some students have preferences with regards to how they learn (10, 20). In addition, another sub-theme that emerged was the lack of engagement students had with their classmates and teachers. This is true for first- and second-year students who have never met their teachers or classmates. As such, teachers often encounter difficulty having a lively discussion and the active participation of students during synchronous classes. One participant posits that "it's hard to give group activities or collaborative activities since most students aren't familiar with or friends with their classmates." This finding further supports previous studies which found that in flexible online learning, peer review and direct interaction are removed, which also reduces participation and engagement among students (13, 27).

Teachers also encountered students with low comprehension skills, as reflected by their failure to follow instructions during discussions and assessments. As expressed by one participant, "Some students fail to follow instructions in their activities". This form of difficulty is so evident that even with the presence of detailed instructional materials, students still struggle to process, retain, or act correctly on how to respond to simple questions or how to complete a task according to stated processes. This result indicates that comprehension difficulties are a primary barrier in learning contexts in a flexible learning environment that could affect students' academic performance. The interview with one of the participants reflects another sub-theme: the apparent lack of prerequisite knowledge among some students. The teacher claimed that based on students' participation during discussions and as reflected in the assessment, some students do not have the prior knowledge needed for the course. Accordingly, "some students did not acquire pre-requisite topics and/or skills". Prior study emphasized this theme that it is most difficult to cater to students with a lack of prerequisite knowledge for independent learning (28). In flexible learning, it is assumed that students possess the foundational content knowledge and self-regulation skills needed to progress learning without direct and real-time guidance from the instructors. Furthermore, the sub-themes of low level of digital literacy and negative attitude of students were elicited from participants. Accordingly, one of the reasons why there is little participation and engagement among students is that they do not know how to manipulate the learning platforms and other programs used. In the interview, the teacher claimed that students are not very knowledgeable about how to use Google Classroom, other Google applications, or computer simulations. This is also true in some local and international universities and colleges, as reflected in some earlier studies (6, 13, 27). Finally, the negative attitudes of students, which include attitudes towards learning and a lack of netiquette, are also considered challenges for teachers. Some students do not observe proper netiquette, causing disruption in the flow of discussion and the focus of teachers.

Challenges that are thematized as institution-related are divided into two sub-themes: inadequate resources and a lack of planning. Based on the data, three statements are grouped under the theme of inadequate resources. Transcripts reveal that there is a slow or intermittent connection within the university, a lack of a learning management system managed by the university and ICT equipment to support online learning. It was further emphasized by the participants that while the university has multiple internet connections, they become intermittent or slow due to the simultaneous connections of teachers, students and other employees. This issue was apparent during the first year of implementing flexible learning. Furthermore, ICT equipment and infrastructure, such as a web camera, microphone, laptops or desktops, subscriptions to virtual laboratories and rooms dedicated for video or audio recording, were not provided. These were validated during the follow-up interview. Although it is plausible that the institution was taken off guard by the abrupt move from traditional onsite instruction to flexible learning, the same problem continued even after one year of implementation. Other teachers in higher education institutions also experienced inaccessibility, poor internet connections and an insufficiency of ICT resources (1, 13, 15, 16).

Moreover, lack of planning and organization is another sub-theme for institution-related challenges. Accordingly, two statements confirm that there was a general guideline issued by the university regarding the implementation of flexible learning. However, it did not cover specific areas like the scheduling of synchronous classes, the scheduling of laboratory classes, the provision for the printing of learning modules, specific delivery modes and many more. On a positive note, it gives the teachers the freedom to choose the flexibility dimensions they want to attain in their classes. It is, however, emphasized that a lack of preparation and planning for the full implementation of flexible learning affects the quality of instructions provided to learners (11). Prior studies also emphasized that implementing online or blended learning as a teaching modality requires a well-designed technical and logistical implementation plan (27, 29).

On the other hand, syllabus-related challenges include recalibrating the syllabus and making provisions for laboratory classes. One of the key requirements for transforming from traditional to flexible learning is a complete shift in the delivery of instruction, the organization of learning and even the philosophy that teachers embrace in relation to learning. This has been the case for a few of the participants in this study, who mentioned that there is a need to recalibrate the syllabus in order to fit the requirements of a flexible learning environment. One participant stated that he has difficulty transforming traditional courses into flexible learning modes because he himself has a partial understanding of the scope and nature of flexible learning. This was also a very relevant issue in an earlier study, when it stated that faculty themselves have a limited understanding of the scope and practices of flexible learning (16). Based on the participants' coded statements, it appears that, in terms of content, they strictly follow the learning outcomes stated. However, problems arose as they implemented the instructional strategies and activities in a traditional classroom setting. As a result, they were not able to achieve all the learning competencies listed in the syllabus. Further, teachers have trouble choosing appropriate assessment types considering they will be administered remotely. Assessing students' performance using the same types of assessment may compromise the integrity of assessment and the quality of the work of students (16, 17, 19, 20). It was further stressed that transforming courses into flexible learning requires the modification of course content, requirements, course outcomes and learning activities. Several studies also magnified the fact that recalibrating the syllabus is a key component in integrating flexibility into the key dimensions of learning (29, 30).

Laboratory courses are an additional syllabus-related challenge that may be specific to science courses only. How to allow students to conduct experiments remotely and virtually is a major obstacle for instructors of laboratory courses. Earlier study identified this as an obstacle for language teachers at a state university (17). Teachers must then seek alternative learning activities that still develop the necessary competencies for laboratory courses. One of the participants stated that it is difficult to let students perform laboratory experiments without the supervision of the teacher and the necessary laboratory equipment. Hence, teachers handling laboratory courses created simple experiments and activities that could be performed remotely using materials. Moreover, the use of virtual laboratories and computer simulations has become the norm, provided students have access and resources. Laboratory activities were then modified depending on the availability of resources and the capacity of the students. These were evident in the syllabi and laboratory activities prepared by teachers. Previous research indicates that traditional laboratory activities may be eliminated or modified so that students can perform them remotely. However, implementing remote experiments in distance learning can still be a problem when technology is not fully integrated into the instructional practices of teachers or there is a lack of resources (21).

Teachers also encountered challenges that were directly related to them or within their control. Based on the clustered codes, three sub-themes were generated. These are a lack of pedagogical skills, a lack of technological skills and additional preparation. Lack of pedagogical skills is the most common challenge, based on the coding of only two participants. Based on the statements, one of the teachers stated that with the sudden shift to online discussion, she encountered a slight difficulty in finding the right strategies for virtual classroom discussion and classroom management in distance learning. Moreover, she stated at the very beginning that she has limited knowledge of designing the right assessment for purely distance learning. As such, most of the assessments given to students are formative assessments in the form of essays.

In a similar study, it appeared that instructors' limited flexible learning pedagogies were a predictive factor in how well teachers delivered high-quality instruction during the pandemic (1). It was also stated that teachers' lack of organizational skills in managing online learning is one of the difficulties encountered by teachers. Moreover, another study also pointed out that it is a challenge to integrate pedagogy and knowledge of different assessment methods in online learning (19). However, it can be noted that this is only a minimal problem as it was only coming from two participants, which directly supports the findings that faculty perceived it as slightly difficult to implement (28).

Another minor challenge reflected by one of the participants is the inadequate technological skills of teachers. Based on the statement, it can be inferred that most teachers are technologically proficient on the basis that they have the necessary technical skills in the context of computer literacy. However, technological proficiency focuses more on integrating technologies into the learning process (10). As stated, teachers have "limited training on the use of digital tools," which also reflects that while they have undergone training on the use of technology provided by the university, there is still a need to select and effectively utilize appropriate ICT tools in the teaching-learning process (31). Previous study also noted that older teachers experienced technological literacy as a difficulty in implementing blended learning in teacher educational institutions (12).

The last sub-theme is the additional preparation of teachers, which is reflected in one of the participants' transcripts. The demand to create learning materials for distance learning, record and edit videos, schedule synchronous classes, attend to students' concerns beyond office hours, check and record students' outputs and perform other tasks that are outside of the regular workload entails additional preparation on their part. As stated in the interview, "recording or editing videos and preparing learning modules for distance learning consume a great deal of time", which can interfere with their regular activities. This finding is also reflected a particular study when they explained that additional time is needed in preparing instructional materials, resulting in time constraints (30). Based on another study, one of the major challenges is instructional material preparation, like printing, sorting and simplifying the materials to fit distance learning (22).

The 4T Flexibility Framework in a Flexible Learning Environment

Based on the coded statements, four main themes were generated, which can be organized into the T's of flexibility domains. These are flexibilities in theme, time, technique and transfer, similar to existing flexibility dimensions from a previous study (32). Findings indicate that the participants only employed one component of flexibility in theme or content, which is the range of assessment methods and strategies utilized in a flexible learning environment. These themes were validated during the informal interview and review of syllabi. Science teacher one stated that she limits the number of assessments but makes sure that they really measure the performance of students. She also mentioned that she provides individual and collaborative learning activities or requirements. On the other hand, science teacher six usually lets students do practice exercises before undergoing summative assessments. Additionally, he also utilizes varied types of assessments that require students to analyze and think critically. In the same manner, another participant also integrates other forms and types of assessment that can be used, whether remote or traditional face-to-face instruction. This strategy of science teachers conforms to earlier findings that one of the most effective strategies in science teaching is the use of interactive performance-based tasks, inquiry-based activities and self-directed learning activities (22). Preceding works, however, stressed that there will always be an issue with respect to the integrity and quality of students' assessments and requirements in a flexible learning environment (17, 19). This issue may have been properly addressed in this study by the participants through employing various assessment strategies to ensure the academic integrity of students' performance, which was one of the suggested strategies (19, 20, 22).

Based on the coded statements, it can be argued that the participants only employed one component of content flexibility, which is a range of assessment methods and strategies. However, there are other components that were addressed based on the syllabi reviewed and unstructured interviews with the participants. In relation to the topics or course contents, it appears that some science teachers reduced the number of topics covered by selecting the learning competencies that are considered most relevant and are prerequisites for higher major courses. Moreover, topics that were deemed basic and self-explanatory were allotted less time. Furthermore, the sequencing of the topics covered was also modified by some of the teachers to fit the scheduling of face-to-face and synchronous classes. In relation to the types of learning materials, science teachers also had some flexibility in selecting appropriate instructional materials for their students. Students were also given the choice to select from a variety of sources and materials based on the recommendations of the teacher. All of these strategies were utilized by the participants, as evident in the syllabus and instructional materials, but were not reflected in their statements. These acts of intentionality are actively created by science teachers' consciousness as the object of their experiences (33). This intentionality reflects the relationship between real flexible learning and ideal flexibility in the science teachers' consciousness, which means that the act exists in the mind in an intentional way (23).

In order to address problems with late or non-submission of outputs, science teachers usually given ample time for students to do one particular task at a time. In addition, deadlines are consciously extended for a certain period of time, ensuring that students will be able to comply with the requirements. Four participants have expressed that they extend deadlines multiple times, even before the final exam, just to be able to have students accomplish all the tasks given to them. In addition, the time given for summative assessments (objective type), which is normally constrained in a traditional classroom setting, is dilated only to a certain extent. Students are also allowed to negotiate when assessments are to be given, but only to a limited extent. The scheduling of synchronous classes and options to participate are also considered by the teachers. Moreover, the time allotted for certain topics as required in the syllabus is also adjusted depending on the pace of the students and teachers, given the nature of the learning environment. Since learning materials are provided (printed and digital copies), the students can learn at their own pace during asynchronous classes and purely modular instruction. Previous studies further stressed that instead of giving time-bound learning activities to students, performance-based tasks would be more appropriate (6, 22, 25, 27). Generally, based on themes generated through reduction, there are four components of time flexibility that were addressed by the strategies: flexibility in time to submit requirements, interaction with the course, moments of assessment and pace in interaction with the course, which comprise the essence of the experiences of science teachers.

The analysis of the statements revealed that the techniques utilized by science teachers covered instructional approaches and strategies. These are language, learning resources and instructional organization. In terms of the languages used, one participant clearly stated that instructions in assessments, requirements, or any part of the learning process are written in short sentences and in chronological order. Moreover, discussions of course contents in the learning materials and even in synchronous classes are also simplified, using basic and simple terms. Science teachers also utilize code-switching in the traditional or virtual classroom to discuss difficult concepts in remote science teaching (20). These strategies are used to address the issues of students who have difficulty comprehending or to further explain concepts.

Learning materials and resources provided by teachers to students include digital and printed copies. As described by participants, digital copies of modules or learning packets are provided through the learning management system. However, in cases where students asked for copies, some teachers printed copies for students to photocopy. To supplement the printed learning materials, audio and video transcripts are also provided, apart from the in-person and synchronous classroom discussions. One participant stated that he recorded instructional videos specifically on how students perform a remote experiment. Furthermore, experiments that are usually done in a traditional classroom setting were modified for remote experiments using commonly available materials, free and open-source computer simulations and virtual laboratories. While most of the learning materials are provided by the teachers, instructional materials from the web are also utilized by students, as per the recommendations of the science teachers. Common to these are computer simulations, virtual labs, digital copies of books, videos, digital games and other multimedia tools that are interactive. In a similar study, instructional material preparation is one of the most effective strategies for teaching science during the pandemic (22).

Instructional organization strategies were also employed by science teachers. Excerpts from the statements of two science teachers reveal that they utilized strategies in giving feedback to students. As per a statement from one science teacher, he or she checked the outputs of students right away and then provided feedback immediately. Communicating assessment results and monitoring the progress of learners were some of the compromises in flexible learning modalities (20). On the other hand, the other science teacher also claimed that in the course content provided, he made sure that there would always be a review of prior concepts. Other teaching strategies and methods that were not elucidated from the statements but were reflected in the course syllabi can be classified generally into learner-centered and teacher-centered approaches. However, further classifications of these strategies include inquiry-based, reflective, collaborative and integrative approaches. These strategies are considered effective in science teaching during the implementation of flexible learning (22).

Another emerging sub-theme in strategies is personal and professional flexibility, as reflected by the statements of two participants. In order to manage the lack of pedagogical and technological skills, they attended webinars, workshops and trainings related to instruction and technology integration. Most of these are personally financed, while some are sponsored by the university. They even managed to explore and learn how to use different ICT tools on their own. Moreover, teachers also acquired some electronic devices, which include laptops, video recording devices, audio recording devices, tablets, graphic pen tablets and many more. Subscriptions to paid software and programs were also considered. These strategies employed by science teachers show that they are resourceful and innovative for as long as they can provide the best learning experiences for their students.

Finally, based on the transcripts of interviews, there were 20 categorical statements that formed the theme “transfer”. These statements from the participants covered five distinct aspects, including time and locations for support, methods for obtaining support, the type of support available, the location and technology required for course participation and delivery channels. As a strategy to support time and place, one of the science teachers stated that he schedules a specific time for students to communicate, ask questions, or inquire during asynchronous classes. Regularly initiating and maintaining contact with students who did not comply with requirements was also reported by two participants. Based on the teachers' syllabi and the interview transcript, consultations with them may be conducted online or in person for a predetermined time period. However, when students are not available at the indicated time, teachers have always arranged their schedules to accommodate them. This strategy falls under "methods for obtaining assistance." These strategies were not reflected or generated in the literature reviewed.

Furthermore, strategies under the types of support available were manifested in the three categorized statements of the three participants. One of the science teachers specified that for announcements that are general to the class, he utilizes social media group chats and the learning management system. He also requires students that if there are questions directly related to the course contents, they should be done through the group chats so that all students will be able to see and read them. However, for inquiries related to their individual performance and other issues that are specific to a certain student, two of the science teachers stated that they contacted students individually through the learning management system, SMS, personal social messenger and electronic mail. This was also reflected in a similar study, which considered the use of these methods to communicate with students (10). In terms of the location and technology required for participation in the course, two science teachers claimed that during the first semester of implementation, when in-person classes were suspended, students had no choice but to participate in class discussions remotely through the learning management system. However, when face-to-face classes were an option, students were allowed to either participate remotely or in person. On the other hand, two of the science

teachers also observed flexibility in terms of how students submit requirements and participate in assessments. Accordingly, for quizzes, chapter tests and term examinations, which are mostly objective in nature, they use Google Forms and other software or programs for assessment that can be embedded in the learning management system. Assessment and feedback were also done by annotating the digital outputs of students and sending them back to them.

Lastly, strategies and methods used to deliver content courses or information are generally done in person, purely online, or blended. Basic science courses are generally delivered through online distance learning, purely modular distance, or blended learning. Laboratory courses, however, were mostly delivered in person, except during the early stages, when face-to-face classes were suspended. Hence, the use of virtual and computer simulated experiments was realized. On the other hand, major courses, whether practical or theoretical in nature, were mostly delivered in a blended learning modality. These strategies were considered by teachers in previous studies (1, 10, 16, 19, 22, 34).

The STEP Opportunities for Teachers in Flexible Learning Environments

The implementation of flexible learning also presented some opportunities for teachers. These opportunities are the result of the demand for flexible learning environments and the desire of teachers to effectively and efficiently implement flexible learning. Based on the coded statements, there are 28 categorized statements that were clustered into four themes: social, technological, efficiency and pedagogical competences as presented in Figure 2.

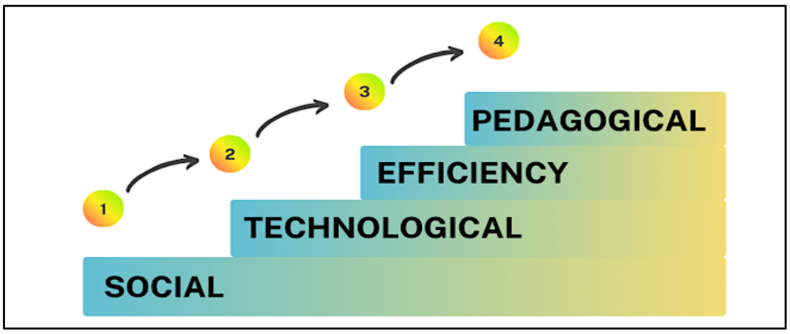

Figure 2: The STEP of Opportunities for Teachers in Flexible Learning Environment

One of the opportunities captured by one of the statements is fostering collaboration and partnerships, which are in essence themed as social competence. As stated by one of the participants, she was given the opportunity to collaborate with other teachers in making instructional materials and delivering content courses through peer teaching and peer mentoring. Such an opportunity can be considered as establishing harmonious collaboration with co-teachers which is the essence of the experience (22). Moreover, it is also stated that such an opportunity to collaborate for a wider social communications network locally and internationally could also result in benchmarking of teaching methodologies and strategies. The desire to overcome or cope with the challenges and difficulties of implementing a flexible learning environment inspires teachers to utilize different strategies, which in turn provide opportunities for them to acquire and enhance professional and social skills.

Another opportunity presented to science teachers is the enhancement of their technological competence. Accordingly, the teachers were able to learn about new and innovative technologies that can be integrated into flexible learning. These competencies were acquired through trainings and seminars that were either provided by the university or through personal initiatives. This was captured through the statements of five science teachers.

"I was able to discover easy to use learning platform." (Science Teacher 5)

"I was able to explore other features of commonly used applications/ software/ platform." (Science Teacher 6)

"I was able to make a 15-minute lecture which is equal to 3 days lecture before. (Science Teacher 1)

"I had more understanding how to balance video lectures to visual learners and non-visual learners." (Science Teacher 2)

"Need to be versatile in using digital tools for flexible learning is a must." (Science Teacher 7)

In a related study, it was also emphasized that science teachers explored and used ICT in teaching and in the preparation of instructional materials (22). Teachers were able to develop localized instructional materials through the learning modules. These findings were also emphasized in another study, which found that teachers were able to utilize ICT tools in delivering instruction based on the needs, interests and context of the students (16).

On the other hand, efficiency was the most stated opportunity or benefit acquired by science teachers during the implementation of flexible learning, as manifested by the 14 categorized statements that were clustered. Most of the statements are focused on the opportunity to do other tasks that are related to making more instructional materials that can be used multiple times. Moreover, the work-from-home scheme initiated by the university had given teachers more time to efficiently prepare for their lessons and other tasks related to instruction. The use of digital learning platforms and programs has also increased the efficiency of teachers in delivering content, providing assessment and feedback and monitoring the progress of students. Previous studies made no mention of efficiency as one of the opportunities presented to science teachers during the implementation of flexible learning, whether the delivery is online, in-person, or purely modular (16, 17, 20–22). These science teachers' essence of experience as they immersed themselves in a flexible learning environment can be transcended as the noesis of experience (33). In this case, the flexible learning environment is the object of experience, which is interrelated with the noesis of experience.

In the same manner, teachers were able to learn and utilize different instructional strategies appropriate for flexible learning. This is clustered into the main theme of pedagogical competence. As stated, the science teacher claimed that because of the implementation of flexible learning, he or she was able to learn what flexible learning really means in both pedagogy and philosophy. Moreover, the need to utilize different strategies in a flexible learning environment permitted some science teachers to learn and implement active and independent learning. These opportunities generated through the reduction of textural and structural descriptions were also captured in prior studies which found that innovation in teaching strategies and the development of new pedagogies, respectively, were opportunities that emerged (16, 22). New instructional designs, learning strategies and assessment tools are considered aspects of pedagogical enhancement. In addition, teachers were able to be engaged in the different trends in science education and other related professional development. Local study also pointed out that the shift to flexible learning provided transformation in the total educational system with the aim of making teaching and learning more learner-centered and empowered (16). As such, the focus is on the needs and contexts of the learners. Furthermore, constructivist theory and other learner-centered theories and philosophies have been strengthened with the adoption and implementation of learning activities that support this.

Zone of Development and Support System: Provision for Improvement

The implementation of flexible learning presented challenges that must be addressed if the university wants to continue implementing flexible learning even with the resumption of traditional classroom instruction. These recommendations are considered zones of development and support systems. Based on the categorized statements, there is really a need to improve the facilities and resources of the university. Most of the statements of participants are focused on having a personalized learning management system at the university and a student portal. One of the suggested features is an interactive LMS that is integrated with the student portal. Moreover, infrastructure and resources to support distance and online learning may also be provided or established. In an earlier study, it was emphasized that many HEIs are still in the process of building the necessary infrastructure ideal for flexible learning (16). Moreover, it was also highlighted that the availability of ICT resources are significant predictors of how well students perform and actively engage in the classroom environment (1).

Another area of improvement that clearly needs attention is the development of a framework for policy at the university. As reduced from the statements of the participants, the policy or framework should be more comprehensive and should address all dimensions of flexibility. It should also contain specific guidelines on how to implement flexible learning with the provision of support systems in all areas. Based on the findings, it can be inferred that the formulation of a policy or a framework will encompass all forms of support mechanisms that may include faculty training, IM development, curricular enhancements or revisions, options for a variety of delivery and learning modes and, in general, flexibility in all aspects of instruction (1, 12, 16, 19, 28, 29, 35–37). Moreover, the framework or policy may also encompass the different dimensions of flexibility that should be addressed and at the same time, an instrument or a tool that can be used to assess the flexibility of all teachers and the institution as a whole (35). The tool may be in the form of a flexibility grid or a questionnaire (38).

Achieving a flexible learning environment requires more than simply integrating some of the characteristics of flexible learning. It is emphasized that the key components of a truly flexible education are the adaptability of learning to learners' needs and circumstances and the instructor's role as someone who monitors, directs and regulates actions toward the goals of information acquisition, expanding expertise and self-improvement (39). Therefore, the transition from traditional face-to-face instruction to flexible learning requires a significant shift in how teachers or instructors manage time, content, instructional strategy and delivery. It should also be noted that instructors can establish flexible learning opportunities in any of the following areas (35). With these, the implementation of a flexible learning environment depends heavily on the teacher. True flexibility goes beyond simply substituting one learning format for another; it entails giving students a genuine choice in how course content is presented or how they are assessed (39).

Conclusion

The study reveals that university science teachers face significant challenges in implementing flexible learning, primarily learner-related. These challenges predict the effectiveness of their teaching and students' engagement and performance. Despite these challenges, teachers have implemented strategies to address them, demonstrating their conscious achievement of flexibility in most dimensions, such as adapting lesson plans, utilizing technology effectively and fostering a supportive classroom environment. While flexible learning presents challenges for science teachers, it also offers opportunities to enhance professional and technological skills and social and personal development. Improvements include improved infrastructure, resources, teacher training and curriculum recalibration, which can lead to more effective teaching methods and better student engagement in science education, ultimately fostering a more adaptable and innovative learning environment for both teachers and students. The administration may revisit policies and consider implementing flexible learning even without such pandemics and global crises.

Based on the specific findings, the institution may strengthen a support system that addresses the connectivity and access barriers that limit students' participation in a flexible learning environment, such as establishing a dedicated support unit that could provide device and data subsidies for students from underserved areas. Likewise, this support unit could be responsible for consolidating innovations into a shared resource for all disciplines so that teachers could access the best practices in implementing flexible learning. Additionally, the university may formalize and institutionalize modality pathways at the course level across all disciplines, not just in the sciences, to create an institutionally supported framework instead of relying on teachers' improvisation. Further, foundational and advanced faculty development programs may also be instituted, particularly for science teachers who need to redesign laboratory and hands-on components for asynchronous classes. It may include a mentoring system of experienced flexible teachers with teachers still adjusting their practice since much of the innovation is from trial-and-error practices rather than established, structured support mechanisms. These recommendations, if taken together, may result in a more specific response from the university grounded on the lived experiences of teachers, rather than an externally adopted framework.

While the study provides valuable insights into the experiences of science teachers, there are certain limitations that may restrict the generalizability of its findings to other disciplines, other institutions of higher learning and educational levels. Findings may not reflect the experiences of teachers in non-science or basic education settings. Also, the study is conducted within a particular period, largely influenced by the pandemic. Hence, these findings may reflect crisis-induced situations rather than long-term and natural adoption of flexible learning that may limit its transferability to other contexts.

Abbreviations

CHED: Commission on Higher Education, FL: Flexible Learning.

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Author Contributions

The work and article are solely done by the author.

Conflict of Interest

The authors report that there are no competing interests to declare.

Data availability

Data can be accessed, subject to the provisions of the Data Privacy Act 2012 of the Republic of the Philippines, upon request from the corresponding author.

Declaration of Artificial Intelligence (AI) Assistance

Artificial Intelligence tools (Claude and Quillbot) were used solely in language refining and formatting the references. The conceptualization and creation of the images included in this study are solely the ideas of the authors. The Canva editor was used to create, edit and improve the overall appearance of the images. The authors take full responsibility for the content's originality, interpretation and accuracy.

Ethics Approval

The authors state that the protocol was presented and approved by the university's agency in-house review (HERRC-2021-SO20) and was carried out in accordance with ethical principles. The authors confirm that informed consent was obtained from all the participants involved in this study.

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