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A Reflexive Thematic Analysis of the Lived Experiences of STEM Students on the Use of Online Inverted Learning Approach in Biology

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ABSTRACT

To improve the quality of Biology teaching and learning, especially in this new normal, it is crucial to embrace innovations, update programs and curriculum, and develop responsive and appropriate materials, designs, and approaches for instruction. The Inverted Learning Approach (ILA) suggests a timely and applicable approach to the new normal teaching-learning process. In this approach, the roles of teachers and students are reversed, causing students to become more actively involved and at the core of the learning process. Having enough time to self-study instructional videos or learning materials outside of class schedule, students may be able to cultivate their inquisitiveness, confidence, and higher-order thinking skills. A reflexive thematic analysis was used in this study to investigate the experiences of STEM students who were exposed to an online Inverted Learning Approach (ILA) in a biology course. Four themes emerged from the researcher's engagement with the participants exposed to ILA, which include: 1) Developing into active and reflective learners; 2) Enabling students to engage and collaborate more freely; 3) Establishing a flexible, seamless, and non-pressuring space for learning; and 4) Becoming disciplined and responsible for one's learning. ILA contributes to furthering the development of evidence-based educational practice. It enables teachers to deliver content more effectively by focusing on appropriate, engaging, and contextualized activities, as well as real-life applications of concepts in the class.

Keywords: *Inverted learning approach, thematic analysis, lived experiences, STEM, biology*

INTRODUCTION

This new normal set-up has become a challenge for teachers to deliver instruction outside of the norm, such as shifting from face-to-face to face-to-screen interaction (Lal, 2020; Jeong et al., 2021; Nair, 2020). Inevitably, online learning has now become a more embraced learning modality, which is an integration of technology into education (Tang et al., 2020). Technological advancement is an

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ongoing and increasing trend, however, the pressure on teachers to adapt to the virtual model of teaching has been extensive. While Lal (2020) believes that traditional teaching is much more convenient because doing online lectures requires time, effort, and preparation affecting the roles of teachers and students, Sharma (2020) deems online classes as better learning platform during these unprecedented times by allowing them to stay at home and study without fear of contracting the virus.

Traditionally, teachers during class provide learning opportunities and deliver instructions. After that, students do tasks or exercises outside of class to reinforce the teacher's explanations and improve retention of learning in the subject (Romero-García et al., 2018). The conventional role of teachers as experts who impart wisdom to their students is no longer seen as appropriate or effective in twenty-first-century education (Nair, 2020). With an influx of easily accessible data and an array of technological skills that can be acquired with a few clicks on mobile devices, tablets, and computers, there has been a significant change in how people look for and exchange information. This shift has resulted in a growing trend in which everyone is increasingly turning to various learning platforms to seek understanding and disseminate information. While teachers will continue to play a critical part in guiding and facilitating learning experiences, the rise of several educational platforms reflects the evolving nature of knowledge acquisition and transfer in the digital age. It shows the importance of institutions and educators to devise learning activities (Aninag et al., 2021), adapting their approaches, and recognizing the value of leveraging educational technology as a powerful tool for improving student mastery of the subject, flexibility, independent and collaborative learning, and 21st-century skills.

To improve the quality of Biology teaching and learning experience, it is necessary to embrace innovations, upgrade programs and curriculum, and create responsive and appropriate instructional materials and pedagogy especially in this new normal. According to Bond (2020), the inverted or flipped learning approach is gaining popularity in both higher education and K-12, owing to its potential to increase active learning and student engagement. It is a relatively new pedagogical method at the secondary level (Offerman-Celentano, 2017). It is gaining traction among researchers and educators (Evseeva & Solozhenko, 2015) because it provides more appealing, convenient, and flexible learning options for learners and makes effective use of different educational tools that reduce boundaries and promote inclusivity and democratization of information.

The Inverted Learning Approach (ILA) intends to increase in-class time for activities that improve student learning while moving some content delivery outside the classroom using short instructional videos, including doing practical tasks

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through learning and teaching discussion/peer collaborative work (Barral et al., 2018; Jeong et al., 2021; Chang & Hwang, 2018). Even though this has been implemented in a variety of educational settings (Kim et al., 2014; Christiansen et al., 2017; Rossi, 2015; Lee & Park, 2018; Burkhart et al., 2020), many variables related to inverted learning remain unknown (Strohmyer, 2016). Similarly, there is a paucity of evidence supporting the efficacy of this approach among high school biology students in an online or virtual environment.

The lived experiences of students with online Inverted Learning Approach (ILA) could provide unique viewpoints and insights into the effectiveness, barriers, and successes of the approach, as well as shed light on areas that need more study. It likewise could reveal differences in how ILA is perceived, accepted, or appreciated because it considers various experiences of students from diverse backgrounds, prior knowledge, and behavior towards learning. Finally, it could explore other factors influencing learning, identify gaps in current practices, and offer improvement strategies, resulting in the development of evidence-based recommendations, the betterment of its implementation, and its contribution to the growing body of knowledge in the field of online or new normal pedagogy.

Objectives of the Study

The study aimed to look into (1) STEM students' firsthand experiences when exposed to online Inverted Learning Approach (ILA), as well as to figure out the (2) detailed explanations for using ILA in teaching Biology based on STEM students' experiences.

METHODOLOGY

This portion includes the research design, population, instrument, procedure and data analysis of the study.

Research Design

This qualitative research study employed Reflexive Thematic Analysis (RTA). This is an experiential analysis that is inductively oriented and is based primarily on data rather than existing theories and concepts (Clarke et al., 2015). It stays as close to the meaning of the data as possible. The design also aimed to verify, evaluate, and analyze non-numerical information and feedback from the respondents. This process was also performed to elucidate the experiences of students who received the ILA.

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Participants of the Study

The participants of the study were purposively selected based on their test performance. They were divided into three (3) groups, denoted by the letters A, B, and C, for separate focus group sessions. Group A got high scores (31 and up), Group B gained average scores (21-30), and Group C obtained low scores (20 and below) on the 50-point validated teacher-made Biology Achievement Test. In total, 26 student participants were assigned numbers 1 through 13, with M representing a male participant and F representing a female participant. Five (5) students were interviewed from these groups to further delve into their experiences with the Inverted Learning Approach. Table 1 shows the profile of the participants.

Table 1

Profile of the participants (N=26)

	Code	A	B	C	Total
Female	1F-13F	5	3	5	13
Male	1M-13M	4	5	4	13
Total		9	8	9	26

Note: Focus Groups (A- high scorers; B- average scorers; C- low scorers)

Data Collection and Instruments

A certificate of approval for ethical considerations was secured last July 2022 from the Cotabato Regional and Medical Center (CRMC) Review Ethics Committee. For the approval to conduct study, a communication letter of permission was given to the school principal. The importance of data privacy and child protection policies was highlighted. Curriculum materials such as curriculum maps and learning plans were submitted to the chairperson of the science department for use in an online (virtual) class observation. This has ensured uniformity and parity in teacher behavior except for the application of treatment.

In the second quarter of the school year 2022-2023 that fell from October to December 2022, the online inverted learning was fully implemented, covering 40 class meetings/ sessions after the orientation week. To lessen the novelty effect of the method, some selected topics in the first quarter (August to October) were occasionally flipped to practice and gradually introduced the intervention. Figure 1 shows the flowchart of events for the ILA based on Gagne's nine (9) events of instruction.

Before the scheduled examination week in December 2022, the researcher-validated Biology Achievement Test was administered as a summative test. The results of the test served as the basis for the selection of the participants for the Focus Group Discussions (FGDs) and interviews. The FGDs were held to process the

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students' experiences as they were exposed to instructional intervention. This information provided recommendations to further improve the adoption of an inverted learning approach.

Figure 1

Flowchart of the Events for ILA based on Gagne's nine events of Instruction

Pre-class (Asynchronous) Discussion videos as *Assignment*	Through Microsoft (MS) Teams, as the school's official Learning Management System (LMS)
Stage 1: Hooking (3 mins) Motivational activities	The teacher employs an activity to create a psychological state in each student who hopes to learn what the teacher intends to teach.
Stage 2: Informing the Learning Targets 5 (mins) Entry ticket via Google forms where learning targets are found per section/part	This shows the student's level of preparedness and establishes the initial information needed to accomplish the task/activity for the meeting.
Stage 3: Activating Prior Knowledge (2 mins) Overview of the summary of the insights from the entry ticket as self-assessment.	The teacher communicates the learning competency and learning objectives for the meeting through an entry ticket. This assesses what students already know after viewing the pre-deployed discussion videos.
Stage 4: Presenting (8 mins) Processing of information based on insights	The teacher implements appropriate instructional methods to process the results of the self-assessment and to deepen the discussion of the concepts.
Stage 5: Scaffolding (17 mins) Mind mapping in preparation for transfer; Process-based, guided activity via breakout rooms.	The teacher provides specific support to students, through various online activities/apps as they develop understanding of the new concept or skill. This may be done in breakout or large group discussions with process-based questions.
Stage 6: Applying (10 mins) Games/ Modeling/ Group output	The teacher conducts drills and practices. This provokes critical thinking and improves their understanding and skills in sharing their ideas, clarifying some concepts, and proposing solutions to real-life problems.
Stage 7: Feedbacking (5 mins) Teacher's assessment/ checking of concepts	The teacher provides students with genuine feedback or a concept and practical check considering their performance with the learning targets.
Stage 8: Assessing (5 mins) Oral questioning	The teacher monitors and measures student's learning and success by carrying out various forms of assessments such as Q and A.
Stage 9: Generalizing (5 mins) Learning logs/ discussion forum	The teacher wraps up the topic for the meeting and directs students to accomplish their learning logs, and for some rewatching the discussion videos and viewing in advance the following learning materials already deployed in the LMS.

Analysis of Data

Thematic analysis was used to code, interpret, and make sense of the qualitative data (Atwa et al., 2022). To generate themes from textual and audio-to-text data obtained through focus group discussions and interviews, manual/hand coding was used. By the analytic process of the reflexive thematic analysis, the researcher used the lens of instructional experience and pedagogical practice to temper subjectivity issues. To critically obtain the codes from the etic transcript, which is the scholarly version of the emic transcript taken from the participants' original and raw responses, hand or manual coding was used, which applied both semantic and latent (inferential) analysis. To provide context for the analytic report, data extracts were also included to enrich in the discussion. The inductive bottom-up approach was used to analyze the themes. When information power was attained, the researcher intentionally rested the data collection because responses were recurring, thus avoiding data saturation. Nonetheless, the responses are sufficient to support or address the qualitative part of the study.

To validate the coded and labeled transcripts, the categories formed, and the themes identified, the researcher tapped the service of three (3) language and qualitative research teachers to audit trail the qualitative report. This was intended to ensure that themes are derived from the categories or patterns aligned from the codes clustered. This likewise established the trustworthiness and rigor of the qualitative part of the study. Additionally, a simulacrum was created to display the visual framework and interrelationship of themes and categories critically identified.

Ethical Considerations

Before participating in the research, the participants, and their parents and guardians were asked to read and understand the assent form (signed by the students) and the informed consent form (signed by their parents/guardian). The purpose of the study, the type of research intervention, and the criteria of selection were stated in the forms. In view of their being part of the study, their participation was entirely voluntary. They could withdraw at any time by participating in focus group discussions and interviews. There would be no grade implications or consequences if they choose not to participate in or withdraw from the study at any time. They would also be asked to provide feedback on how the instructional approach has worked and how to improve the learning experience when the intervention is used in class.

There were 8-10 students scheduled for their FGD, led by the teacher-researcher himself. In this way, they could not feel awkward or threatened sharing their experiences and open-ended responses with anyone they do not know. This was also audio-recorded upon their permission, and only the teacher-researcher

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had the copy of the file for the sole purpose of research. The records would be temporarily stored for the duration of the study, and for analysis purposes only. There had been no questions, issues, or discussions which might be sensitive for them or potentially cause them embarrassment. Since their participation was entirely voluntary, they were not compensated for taking part in the study. Likewise, they did not pay or reimburse any costs associated with their participation in the study. They have the right to access their own responses and decide whether they should be included in the data, withdraw at any time, refuse to partake in the research, be informed about how my feedback and relevant data are being processed, and lobby a complaint with the National Privacy Commission.

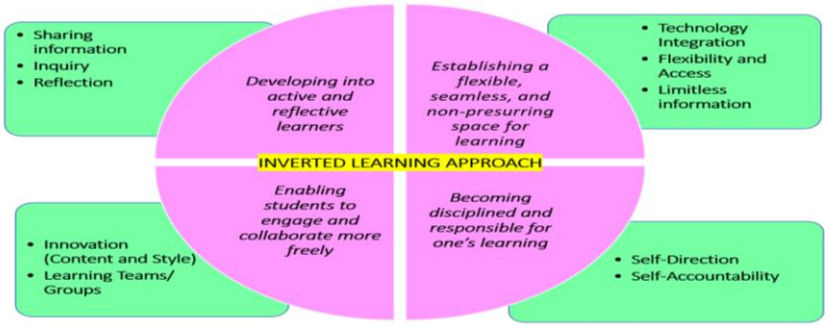
RESULTS AND DISCUSSIONS

Experiences of students with online Inverted Learning Approach in Biology

Generated themes are grounded from the collected data (Clarke et al., 2015). By exploring the essence of experiences of using the Inverted Learning Approach articulated by the STEM students through a semi-structured online focus group discussion, and live informal interviews. Four themes have emerged from the researcher's engagement with the participants, which include a) developing into active and reflective learners, which supports inquiry, reflection, and sharing of information; b) enabling students to engage and collaborate more freely, which involves learning teams or groups and that encompasses innovation in terms of content and style; c) establishing a flexible, seamless, and non-pressuring space for learning, which is flexible and technology-based that renders seamless information; and d) becoming disciplined and responsible for one's learning, which can be the result of student's self-direction and self-accountability of their learning. They are presented in a simulacrum in Figure 2.

Figure 2

Simulacrum of the qualitative report on the use of ILA



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Developing into active and reflective learners

Through the inverted learning approach, students are involved in both the active and passive parts of the learning process. Students are pulled into more active inquiry-based learning rather than being pushed through traditional textbooks, lecture notes and teacher-provided assignments in a one-sided format. This allowed them to come to class prepared as mentioned by one of the responses:

The inverted learning approach helped me to prepare for the incoming written works. My classmates' reactions and participation also got better, and we were able to ask each other about the topic which helps a lot. Tasks are also easier to understand. [The inverted learning approach has made me more prepared in class. My classmates and I got a better understanding of the topic and became more participative.] - *1F, Interview*

Inverted Learning Approach helped students become more comfortable with the material being taught by allowing them to spend time on tasks related to the main concept before going through practice exercises at a slower pace. They too have time to discuss and share knowledge with their classmates as form of interaction. The experience of one of the participants in the focus group was able to narrate, "…easier to learn by listening… I tend to learn when discuss with classmates." [I tend to learn by listening and when discussing with classmates.]- 1M, Focus Group; *"nagtatanong lang po ako sa classmates kung hindi ko ma-gets."* [I ask my classmates when I have questions.] - *2M, Interview*

Inverted learning increased individual confidence and interest, which resulted in good learning performance (Namaziandost & Çakmak, 2020). This approach gave them an opportunity to discover and understand more important ideas, from a variety of perspectives. It helped them become reflective on learning the materials and develop into active learners *(*"When I do get or understand the lesson, it's kinda enjoyable." [When I got the concept, I enjoy it.] - *1M, Interview).* This approach further involves students focusing early on areas in which they know less or think they do ("It helps me to focus and improve my learning skills especially the ability to understand things more thoroughly and concentrate more on the topics." [My focus/ concentration and ability to learn and understand things are improved.]- *2F, Focus Group).*

Enabling students to engage and collaborate more freely

Through social presence (Doo, & Bonk, 2020) and collaborative learning assistance, Inverted Learning Approach has improved learner engagement, particularly in the out-of-class learning phase (Zheng et al., 2020) or asynchronous class meetings. There are opportunities for students to engage in meaningful and deep learning activities which lie at the heart of an Inverted Learning Approach. It

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encompasses both time for one to learn self-pace in watching the discussion videos and to interact with others during activities. This new style of learning is not spoon feeding the students, instead the teacher works with students in small groups for activities that are more authentic and engaging than traditional lecture-based instruction. Evident from their narratives:

> *"…blended kasi may time na makausap mo personal yung iba; and online para may time ka po sa sarili mo, balance lang po."* [I want blended to have time to be with other students; and to have time for oneself as well (online).] - *3F, Interview*
>
> *"Parang mas magustuhan ko yung teacher to make discussion videos; nag e-effort yung teacher para matulungan yung students na ma-learn yung subject."* [I enjoy the discussion videos and see the effort of teachers making them for students to learn from their subject.] - *4M, Focus Group*

Thus, students have more freedom in their ability to explore concepts and become more ready *("…kapag online recitation, nag reready ako ng script."* [Online recitation allows me to make a script before answering.]- *3F, Interview*), make connections between different disciplines, and work better in groups *(*"My classmates are together helping each other so that the learning experience is good at us." [Learning experience is good because my classmates and I are helping one another.]- *3M, Focus Group).* ILA provides students with opportunities to work together to solve problems and gain understanding. It creates an active learning atmosphere in which students could increase their sense of self-efficacy (Latorre-Cosculluela et al., 2021) and improve knowledge retention (Bouwmeester et al., 2019). Teamwork creates opportunities for learning and mastery that would not otherwise be possible. In working collaboratively, students become critical thinkers during and after viewing the learning resources.

Establishing a flexible, seamless, and non-pressuring space for learning

To ensure a continuous success in delivering learning content (Yuan, 2021) in this new normal, while engaging students in online learning to improve their performance and outcomes (Khlaif et al., 2021) and experiences (Nguyen et al., 2021), Inverted Learning Approach uses technology as a learning environment. To help students learn, an environment should be stimulating as recommended by Besavilla & Sapin (2022). The learning environment provided by ILA is flexible and seamless and provides students with high quality, interactive materials, and adaptive support in the classroom. It further allows them to customize their learning experience, which makes it adaptive and non-pressuring ("It is more free for students to study/ watch it anytime they want to. It is a more accessible and more convenient way for students to have active learning in their own space." [It gives

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more freedom to students to study at any time; access and convenience to learn in their own space.] - *10F, Focus Group*). They access content from anywhere and at any point in time and engage in 'flipped' classes where teachers prepare learning activities and then the whole class collaborates on them.

On the positive side, learning materials are available and accessible on their mobile, tablet devices, and computers. The ease and flexibility of asynchronous learning allows students to learn independently and when they are ready ("Information is easily accessible; Encourages us to develop an adaptive learning style; Gives us a bit of breathing space unlike before." [Information is easily accessible; the learning approach encourages adaptive learning style and gives breathing space unlike the learning modality before (pandemic S.Y.)] – *5M, Focus Group*). Through automated technology, such as mobile apps or online quizzes and assessments, students can demonstrate mastery of skills before moving on to new topics.

This approach includes the implementation of new technologies, pedagogies, and learning models (Chattaraj & Vijayaraghavan, 2021) that include synchronous and asynchronous instructions (Shamir-Inbal & Blau, 2021), which means that learning happens both online and offline. This caters for different learning styles of students. Because learners aren't confined to a single venue for instruction, opportunities for synchronous interaction are increased. This approach allows students to work at their pace with clear guidance from instructors or peers who can quickly respond when needed. As recounted: "It made me more alert than usual. My learning style had been changed drastically. It was a familiar experience…" [This familiar experience made me become more alert as my learning style changed.] – *4F, Focus Group*

Becoming disciplined and responsible for one's learning

The approach relies on the learner's ability to learn at their pace within a self-paced learning environment. It encourages self-paced, self-study, and now even accountability. It separates independent work from assessments, making it easier than ever for them to learn how to learn *("I think it's much better na may discussion videos para ma-ready na kami for upcoming lessons."* [The discussion videos make us more ready for the upcoming lessons.]- *6M, Focus Group).* Students can also work asynchronously with their teacher via email, text messages or video conferencing. Using the Learning Management System (LMS), students can also participate in asynchronous discussion forums, meeting chats, and schedule teacher-student consultations with politeness (Urbis et al, 2022), which maintains productive engagement among learners, improves online experience, and fosters a sense of community by encouraging knowledge sharing, reasoning, and creative thinking.

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Students are in control and responsible for their learning. They can decide what to do for the day, when and how often, based on their schedule and preferences. The inverted learning approach makes it easy for students to keep up with the class by ensuring they self-paced, self-study and take ownership of their education. They can try, cope with missed class sessions, make mistakes and try again. Thus, ILA helps students to become self-directed, and accountable as they manage their time, seek out more information when needed, and do further research to prune their understanding beyond what is already given in the pre-recorded discussion videos by the teacher.

Implications on the use of online Inverted Learning Approach in Biology

For students, this Inverted Learning Approach (ILA) provides a more flexible and independent learning experience because they can access their lessons on their own schedule and at their pace ("You can rewatch the video anytime, you have time to take notes, and you have the freedom." [It allows access to the video anytime; one has freedom and can take down notes.]- *13F, Focus Group*). This can be especially beneficial for students who may find it hard to keep up with the pace of a conventional design or who may have other commitments or extracurricular activities outside of school. Students appreciate the teacher-made discussion videos, however, it is crucial for instructors to consider the diversity of their learners' needs and adapt accordingly by providing several options for accessing the types content materials, such as offering both captioned and non-captioned videos ("I suggest is that maybe add subtitles because sometimes the microphone is bad."), or allowing students to choose whether or not they prefer background music ("it is good to use music for us to enjoy the topic especially when the teacher uses popular songs..."). Besides that, teachers should also ensure that the use of background music does not hamper student's concentration or detract them from the lesson content.

ILA gives students ownership of their learning and helps them cultivate essential skills such as creative thinking, cooperation, and communication. It considers one domain or dimension that allows these students to be more motivated and comfortable while learning because they are already accustomed to this type of environment and may have been innate with this technological advantage ("I can catch up easily since i can rewind it when i don't understand. But if you have poor internet connection it can be very frustrating…" [I can catch up easily through the discussion videos which I can rewatch if I don't understand; however, it is challenging with no internet.]- *7F, Focus Group*). Regarding student performance, intentional remediation programs or periods can be an effective way

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to support students who are having difficulty adjusting to the online learning environment ("...individual consultation to the students...").

ILA raises student performance to the level of the content and performance standards set by the Department of Education (DepEd). It can bring students to that level and even beyond. ILA likewise helps to democratize the learning process *("Sana po lahat ng subject sa G12 ganyan yung approach, kase po hindi lahat fast learning isang turo ng teacher gets na agad.").* In an era of ICT advancements that promote online learning as the future of education, learners must become independent and active learners while also being able to collaborate with others. It makes use of technology tools and resources to foster active learning experiences. This helps students become more aware and independent thinkers and problem solvers. It encourages self-directed learning by providing students the chance to explore topics, ask, and engage in independent learning activities at home ("I develop independent learning skills, whenever I'm absent during online classes [I develop independent learning skills; I can cope with the missed topics whenever I am absent.]- *7F, Focus Group*). They may probe deeper into topics of interest, analyze complex ideas, and seek further help to enrich their understanding of the subject. As ILA facilitates learning with classmates and teachers virtually, students can develop necessary digital skills, which are particularly relevant in this new normal, where digital technologies play an important role in doing various scientific research processes and knowledge and skills transfer in the field of Biology.

CONCLUSIONS

The successful implementation of the online Inverted Learning Approach (ILA) in teaching Biology to students has been explained through qualitative data analysis. This pedagogical approach shows how well it works by allowing students to actively participate in the learning process while cultivating their reflective thinking abilities. One significant advantage of ILA is that it encourages interaction and peer engagement. Students are encouraged to communicate freely, share thoughts, and solve problems collectively by forming learning teams or groups. This kind of environment also allows them to learn from the different perspectives and experiences of their classmates. Moreover, ILA creates an atmosphere of learning that is flexible and devoid of excessive academic pressure. By leveraging technology, such as online platforms and educational resources, the approach presents students with access to an array of information and opportunities for learning. Further, ILA is critical in instilling discipline and self-accountability in students. It promotes a sense of taking responsibility for one's learning. This technology-based approach provides flexibility, which allows students to tailor their learning experiences to their

specific needs and interests, concurs with independent and collaborative learning, and is contributing to improving the quality of 21st-century education by leveraging technology and empowering students by placing them at the core of the learning process. Therefore, ILA emerges as an effective pedagogical approach in the field of Biology by promoting active and reflective learning, facilitating peer collaboration, providing a flexible, technology-based, and non-pressuring learning environment, and fostering discipline and responsibility.

RECOMMENDATIONS

The following recommendations are deemed imperative: a) Teachers should innovate their pedagogy and consider ILA in challenging/complex topics that require more time for students to learn/understand, particularly conceptual and computational processes; b) Tenured and future educators could begin developing and producing quality discussion videos for instruction; c) ILA may be applied to social media platforms or applications that are most popular among Gen Z (21st century) learners and are easily accessible for them, such as Instagram, Twitter, FB Reels, Telegram, and Whatsapp. This particular use of various platforms for the implementation of ILA may affect the motivation of students to advance study; and, e) ILA can help students improve in their academic performance so it can be used in another learning areas, grade level in the JHS, or SHS strands such as HUMSS and ABM.

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REFERENCES

Aninag, R. S., Cajindos, R. P., & Torres, J. B. (2021). Predictors of science performance of senior high school students. *Asian Journal of Education and Human Development, 2*(1), 108-117.

Atwa, H., Shehata, M. H., Al-Ansari, A., Kumar, A., Jaradat, A., Ahmed, J., & Deifalla, A. (2022). Online, face-to-face, or blended learning? Faculty and medical students' perceptions during the COVID-19 pandemic: a mixed-method study. *Frontiers in Medicine*, *9*.

Barral, A.M., Ardi-Pastores, V.C., & Simmons, R.E. (2018). Student learning in an accelerated introductory biology course is significantly enhanced by a flipped-learning environment. *CBE Life Sciences Education, 17*(3).

Besavilla, J. B., & Sapin, S. B. (2022). Effectiveness of blended learning techniques in teaching laws of exponents. *The Asian Journal of Education and Human Development (AJEHD), 3*(1), 92-101.

Bond, M. (2020). Facilitating student engagement through the flipped learning approach in K-12: A systematic review. *Computers & Education*, *151*, 1-36.

Bouwmeester, R. A., de Kleijn, R. A., van den Berg, I. E., ten Cate, O. T. J., van Rijen, H. V., & Westerveld, H. E. (2019). Flipping the medical classroom: Effect on workload, interactivity, motivation and retention of knowledge. *Computers & Education, 139*, 118-128.

Burkhart, S. J., Taylor, J. A., Kynn, M., Craven, D. L., & Swanepoel, L. C. (2020). Undergraduate students' experience of nutrition education using the flipped classroom approach: A descriptive cohort study. *Journal of Nutrition Education and Behavior, 52*(4), 394-400.

Chang, S. C., & Hwang, G. J. (2018). Impacts of an augmented reality-based flipped learning guiding approach on students' scientific project performance and perceptions. *Computers & Education, 125*, 226-239.

Chattaraj, D., & Vijayaraghavan, A. P. (2021). Why learning space matters: a script approach to the phenomena of learning in the emergency remote learning scenario. *Journal of Computers in Education, 8*, 343-364. https://doi.org/10.1007/s40692-021-00182-z

Christiansen, M. A., Nadelson, L., Etchberger, L., Cuch, M., Kingsford, T. A., & Woodward, L. O. (2017). Flipped learning in synchronously-delivered, geographically-dispersed general chemistry classrooms. *Journal of Chemical Education*, *94*(5), 662-667. https://pubs.acs.org/doi/abs/10.1021/acs.jchemed.6b00763

Clarke, V., Braun, V., & Hayfield, N. (2015). Thematic analysis. In J. Smith (Ed.), *Qualitative psychology: A practical guide to research methods*. Sage.

Doo, M. Y., & Bonk, C. J. (2020). The effects of self-efficacy, self-regulation and social presence on learning engagement in a large university class using flipped Learning. *Journal of Computer Assisted Learning, 36*(6), 997-1010.

Evseeva, A., & Solozhenko, A. (2015). Use of flipped classroom technology in language learning. *Procedia-Social and Behavioral Sciences, 206*, 205-209.

Jeong, J.S., & González-Gómez, D. (2021). A STEM course analysis during COVID-19: a comparison study in performance and affective domain of PSTs between F2F and F2S flipped classroom. *Frontiers in Psychology, 12*.

Jeong, J.S., González-Gómez, D., & Cañada-Cañada, F. (2021). How does a flipped classroom course affect the affective domain toward science course? *Interactive Learning Environments*, *29*(5), 707-719.

Khlaif, Z.N., Salha, S.H., & Kouraichi, B. (2021). Emergency remote learning during COVID-19 crisis: Students' engagement. *Education and Information Technologies, 26*, 7033–7055.

Kim, M. K., Kim, S. M., Khera, O., & Getman, J. (2014). The experience of three flipped classrooms in an urban university: an exploration of design principles. *The Internet and Higher Education*, *22*, 37-50.

Lal, A. (2020, Sep 06). From noisy classrooms to virtual teaching, teachers brave 'new normal' [patna]. *The Times of India.* https://www.proquest.com/newspapers/noisy-classrooms-virtual-teaching-teachers-brave/docview/2440306609/se-2?accountid=207160

Latorre-Cosculluela, C., Suárez, C., Quiroga, S., Anzano-Oto, S., Lira-Rodríguez, E., & Salamanca-Villate, A. (2021). Facilitating self-efficacy in university students: an interactive approach with Flipped Classroom. *Higher Education Research & Development, 41*(5), 1603-1617.

Lee, M. K., & Park, B. K. (2018). Effects of flipped learning using online materials in a surgical nursing practicum: A pilot stratified group-randomized trial. *Healthcare Informatics Research*, *24*(1), 69-78. https://synapse.koreamed.org/articles/1075893

Nair, P. (2020, Jul 08). Unlocking opportunities [times nation]: as technology-enabled education gains ground and blended learning becomes the new normal, the education sector in the country is on a paradigm shift, redefining the role of educators and opening up new career opportunities. *The Times of India (Online).* https://www.proquest.com/newspapers/unlocking-opportunities-times-nation/docview/2420906542/se-2?accountid=207160

Namaziandost, E., & Çakmak, F. (2020). An account of EFL learners' self-efficacy and gender in the Flipped Classroom Model. *Education and Information Technologies, 25*(5), 4041-4055.

Nguyen, T.T., Netto, C.L., Wilkins, J.F., Bröker, P., Vargas, E.E., Sealfon, C.D., Puthipiroj, P., Li, K.S., Bowler, J.E., Hinson, H.R., Pujar, M., & Stein, G.M. (2021). Insights into students' experiences and perceptions of remote learning methods: from the COVID-19 pandemic to best practice for the future. *Frontiers in Education, 6*, 1-9.

Offerman-Celentano, A. (2017). *Flipped classrooms: How secondary instructors and administrators define and implement flipped instruction*. EdD dissertation, St. John's University (New York).

Romero-García, C., Buzón-García, O., & Touron, J. (2018). The flipped learning model in online education for secondary teachers. *Journal of Technology and Science Education, 9*(2), 109-121. https://doi.org/10.3926/jotse.435

Rossi, R. D. (2015). ConfChem conference on flipped classroom: improving student engagement in organic chemistry using the inverted classroom model. *Journal of Chemical Education*, *92*(9), 1577-1579.

Shamir-Inbal, T., & Blau, I. (2021). Facilitating emergency remote k-12 teaching in computing-enhanced virtual learning environments during COVID-19 pandemic - blessing or curse? *Journal of Educational Computing Research, 59*, 1243-1271.

Sharma, N. (2020, Jul 18). Educating... though online! [Unlock positivity]: Education has begun in its earnest, online. Students and teachers are all learning the nuances of online teaching and learning to adhere to the new normal. *The Times of India (Online).* https://www.proquest.com/newspapers/educating-though-online-unlock-positoivity/docview/2424568894/se-2?accountid=207160

Strohmyer, D. (2016). Student perceptions of flipped learning in a high school math classroom. PhD dissertation, Walden University.

Tang, T., Abuhmaid, A. M., Olaimat, M., Oudat, D. M., Aldhaeebi, M., & Bamanger, E. (2020). Efficiency of flipped classroom with online-based teaching under COVID-19. *Interactive Learning Environments, 31*(2), 1077-1088.

Urbis, N. A. B., Almachar, J. L. T., & Mariñas, E. M. V. (2022). Politeness strategies in online classroom chats: its implication in the teaching-learning process. *The Asian Journal of Education and Human Development (AJEHD)*, *3*(1), 66-79.

Yuan, L.M. (2021). Student's attitude and satisfaction towards transformative learning: a research study on emergency remote learning in tertiary education. *Creative Education, 12*, 494-528.

Zheng, X., Johnson, T. E., & Zhou, C. (2020). A pilot study examining the impact of collaborative mind mapping strategy in a flipped classroom: learning achievement, self-efficacy, motivation, and students' acceptance. *Educational Technology Research and Development, 68*(6), 3527-3545.