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BLENDED DIGITAL AND SELF-DIRECTED LEARNING IN EXAMINING STUDENTS' BEHAVIORAL ENGAGEMENT AND SCIENTIFIC LEARNING PERCEPTION

BY

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Abstract

This study investigated the relationship between blended digital learning and self-directed learning with students' behavioral engagement and scientific learning perception. The participants included 114 grade 12 students from a single educational institution in Laguna province. The study revealed that students were highly satisfied with blended digital learning. They found this instructional approach effective in enhancing their understanding of scientific concepts. Additionally, students demonstrated a strong inclination towards self-directed learning practices, indicating their ability to take responsibility for their learning and pursue independent study.

Furthermore, the students exhibited high behavioral engagement in their science classes. They actively participated in discussions, completed assignments promptly, and demonstrated a genuine interest in the subject matter. This engagement was seen as a positive indicator of their motivation and investment in learning. Moreover, the findings highlighted the manifestation of scientific learning among the students. They demonstrated the ability to analyze information, evaluate evidence, and make reasoned judgments in the context of scientific inquiry. Importantly, the study established a significant relationship between blended digital learning, behavioral engagement, and scientific learning perception.

Similarly, self-directed learning practices significantly correlated with behavioral engagement and scientific learning perception. These findings suggest that utilizing blended digital learning strategies and encouraging self-directed learning can effectively enhance students' behavioral engagement and foster the development of scientific learning perception in the science classroom. This study underscores integrating blended digital learning and fostering self-directed learning practices to promote students' behavioral engagement and scientific learning perception in senior high school science education.

Keywords: *Blended Digital Learning, Self-Directed Learning, Behavioral Engagement, Scientific Learning Perception*

Introduction

Technology has been known as paramount in societal progression as its application in society's different facets made processes or methodologies efficient, effective, and convenient (Loubier, 2021). Unsurprisingly, technology simplifies the method and increases productivity with less cognitive effort. The assistance of technology in the main areas, especially in education, is therefore widely welcomed. Educational technology of various means (gamification, e-books, virtual reality, virtual lab) can improve students' understanding of science concepts in STEM education, enhance their spatial, critical thinking, and problem-solving skills, and increase their motivation and engagement in science learning (Wang et al., 2021).

Moreover, the educational system is amid many improvements that would have been unimaginable only a decade or two ago in K-12 and higher education today. One of these significant shifts involves millions of people participating in self-directed, informal, and distance learning activities. In contrast, countless studies with global peers have signed up for the same course or learning experience. As per these investigations, information and communication technology in the classroom can be essential in developing fresh, cutting-edge ways to support teachers, students, and the entire learning process, even in the comfort of their homes or in combination with in-person teaching (Bonk & Lee, 2020).

Meanwhile, one of the reasons behind the paradigm shift in education was the emergence of the COVID-19 pandemic. During this phenomenon, trust and faith in science skyrocketed more than ever, especially as the methodologies under this discipline helped the world to understand the virus, develop protocols to minimize transmission, and the development of vaccines (Luna et al., 2021). Specifically, the study by Barry et al. (2022) revealed that during distance learning, students' perceptions of scientists and science improved after their exposure to the scientific field.

Similarly, to enhance students' educational experiences, most Philippine academic institutions have consciously committed to using modular remote learning and e-learning more frequently. Laguna University implemented Blended Digital Learning Program in line with its mission to be a socially responsible educational institution (Fucio et al., 2022).

Blended learning is a method of education that mixes in-person classroom instruction with digital resources. Blended learning can help pupils develop character (Yulianti & Sulistiyawati, 2020). They advise mixing online learning activities with regular classroom instruction to help children develop social and emotional skills like communication, collaboration, empathy, and responsibility. It can include using online materials to supplement classroom education or flipped classrooms where students watch lectures online before arriving at class for discussion and activities (Hrastinski, 2019). He believes designing the learning environment carefully to maximize face-to-face and online learning benefits is the key to effective blended learning. According to Gao et al. (2014), asynchronous online dialogues can be beneficial for fostering student participation and critical thinking in mixed-learning settings. Students' academic outcomes may also be affected by how online courses are designed (Jaggars & Xu, 2016).

On the other hand, there have been rising findings among studies regarding the challenges in the understanding and engagement of students in their science classes, which poses risks in developing their inquiry and process skills (Hadzigeorgiou & Schulz, 2019). Thus, there is a growing inquiry regarding the effectiveness of teaching science during blended learning, as this educational approach involves challenges in attention, engagement, and lesson retention, while science is a relatively hard subject that demands profound listening and learning skills (Saleh & Khader, 2016). Additionally, a recent study by Bernardo et al. (2023) revealed that numerous Filipino students have low proficiency in science subjects, which is consistent with the result of the assessment of PISA 2018, revealing Filipino learner's science literacy scores to rank last among other seventy-eight (78) countries.

Meanwhile, Budiastra et al. (2020) stated that students' use of self-directed learning materials can increase their interest in and success with natural science coursework. Kayacan (2019) discovered that assisting students with self-regulated learning strategies promotes self-directed learning readiness and favorable attitudes toward science projects.

Self-directed instruction and technological preparedness in a hybrid setting were studied by Geng et al. (2019). While technology readiness was not a significant predictor of success, they discovered that students who demonstrated higher levels of self-directed learning were more likely to succeed in blended learning. Online learning readiness was also strongly correlated with self-directed learning, metacognition, and 21st-century abilities (Karatas & Arpaci, 2021).

Thus, the study generated detailed information regarding Blended Digital Learning and Self-Directed Learning, examining students' behavioral engagement and scientific learning perception. The study may potentially fill the literature gap regarding the mentioned phenomena and be a basis for developing programs that enhance behavioral engagement and scientific learning perception in science subjects.

Background of the Study. Even before the unpredictable onset of COVID-19, the development of digital teaching methods was on the horizon. However, this pandemic quickly changed the educational landscape and made us understand the value and necessity of technology in the classroom. Barrot et al. (2021) examined Philippine students' pandemic struggles. Their research found that students had problems adjusting to online education due to issues including getting online, needing more technical skills, and needing adequate personal motivation and support. Students coping tactics include asking trustworthy adults for help, finding new ways to stay motivated, and taking regular pauses to decompress.

Online education will eventually become a fundamental part of the educational system because Covid-19 has demonstrated how convenient and adaptable integrated learning is for students and tutors. The pandemic is now gradually dying down, and things are starting to go back to normal. However, opportunities like blended learning have emerged in the educational field to guarantee a much more valuable and practical learning experience (India Today, 2021). Due to the pandemic, online and blended learning, new pedagogical techniques, and health and safety measures have increased (Ancheta and Ancheta, 2020). This study of private Philippine fundamental schools discusses financial and teacher training difficulties. They also say that post-pandemic Philippine private basic education institutions must adapt to the new educational norm.

Because it enables students to participate in their education and the scientific inquiry process actively, self-directed learning is particularly significant in learning science. Self-directed learning allows students to explore scientific ideas and topics that interest them, improve their critical thinking abilities, and broaden their knowledge of the natural world. Self-directed learning also enables students to take charge of their education and acquire the necessary skills to pursue independent scientific careers or projects. The metacognitive abilities required for scientific inquiry, such as problem-solving, hypothesis generation and testing, and evidence evaluation, can also be developed by learners through self-directed learning. Last but not least, self-directed learning can foster a lifelong love of science and a profound respect for the scientific method. Self-directed learning can help to cultivate a sense of wonder and curiosity in learners that can last a lifetime by allowing them to explore science in a way that is specific to their interests and learning preferences (Lonsdale, 2021).

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The Department of Education hopes to develop not just learners but also to produce learners capable of being critical thinkers. The educational system must be aware of its obligation to instill in learners the ability to think critically, which is essential for helping them make morally sound decisions in a constantly changing society (Ramos, 2018). Also, he added that regardless of the discipline they teach in, this must be the top priority for all educators at all educational levels (elementary, secondary, and tertiary).

With the challenges imposed by changes in society, and even in education, there were heightened demands and responsibility in intensifying the scientific commitments and undertakings in education, especially with its crucial contribution in developing students as future drivers of progression through innovation and championing sustainable development. In line with this, the National Economic and Development Authority developed a program called AmBisyon Natin 2040 that envisions Filipinos in 2040 living a secure and comfortable existence, safe in the knowledge that they have enough money to cover their day-to-day requirements as well as unforeseen costs, and that they can anticipate and plan for their future as well as the future of their children. Thus, considering that science and technology can potentially produce educated, innovative, and functional members of society, conducting a study that explores perception in scientific learning and blended learning as the educational approach can be deemed necessary.

At Laguna University, most students, especially in Senior High School, face societal changes and a fast-changing educational environment such as the Blended Digital Learning Program. As explained in the Learning Continuity Plan of Laguna University Senior High School, this program permits packet learning in modules as the major modality, supported by online resources like discussion forums, blogs, emails, and other social media platforms. Depending on what is most convenient for students, they can complete their tasks and submit them online using any platform, as seen in Figure 1. Similarly, the teacher will administer the Online Summative (Quarterly) Assessments using the Laguna University-developed Learning Management System.

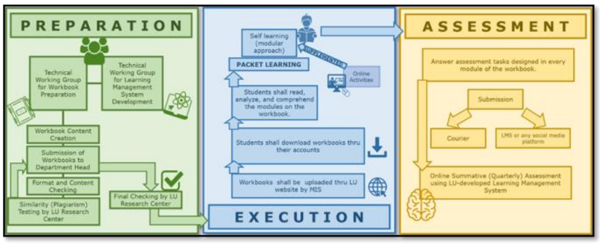

Figure 1. Process of Blended Digital Learning Program at Laguna University Senior High School

As a result, the researcher was engrossed in examining the relationship between Blended Digital Learning and Self-Directed Learning with the students' behavioral engagement and scientific learning perception at Laguna University Senior High School, Santa Cruz, Laguna, School Year 2022 – 2023. In addition, despite the vast literature and studies regarding different school stakeholders' perceptions of blended learning, there is still a lack of studies, especially in the local context, that focuses on the scientific learning perception regardless of the highlighted contribution of science and technology during the pandemic. Moreover, the programs released by government agencies, such as the AmBisyon Natin 2040, envision making Filipinos more knowledgeable and innovative in pursuing a better quality of life, science and technology education is not yet highly given attention. Specifically, exploring the perception of science as a learning discipline in the context of blended and self-directed learning is not highly examined.

Theoretical Framework. Blended Digital Learning is supported by the cognitive load theory, developed by John Sweller, an Australian educational psychologist. Learning can be enhanced by presenting information in a way that lessens cognitive load because the working memory capacity of the human brain is constrained (Sweller, 2017). Various multimedia resources, including videos, interactive simulations, and animations, can be used in blended digital learning to present information that lessens the cognitive load and improves learning.

Moreover, Self-Directed Learning was supported by the Self-determination theory by Edward L. Deci and Richard M. Ryan, two American psychologists. According to this theory, when students feel competent, related, and autonomous, they are more motivated and engaged in learning. Deci and Ryan (2018) further discussed that students have more control over their learning process thanks to blended digital learning, which allows them to work at their own pace, access resources that suit their learning preferences, and get instructor feedback quickly.

Albert Bandura, a Canadian-American psychologist, developed the social-cognitive theory of motivation in the 1980s and 1990s. According to Bandura, people's motivation and behavior are influenced by a complex interplay between social interactions, cognitive processes, and external factors. The theory strongly emphasizes how self-efficacy—individuals' perceptions of their capacity for success—influences motivation, behavior, and learning outcomes (LaMorte, 2022). Informed by the social-cognitive theory of motivation, interventions, and environments that support people's motivation, learning, and well-being have been designed in education and organizational research.

More so, scientific learning perception was supported by the constructivist learning theory of John Dewey, an American psychologist, educational reformer, and philosopher. According to this theory, it is predicated on the notion that learners actively participate in their educational process and that knowledge is built on experiences. Each person considers their experience and combines new ideas with past knowledge as events develop. Students create schemas to arrange their newly acquired knowledge (Kurt, 2021). In connection with scientific learning perception, constructivism proposes that students ought to be effectively engaged with the most common way of building how they might interpret logical ideas. Students should discover and experiment with scientific happenings, make observations, ask questions, and participate in hands-on activities rather than passively acquiring information. Students can better comprehend scientific concepts and principles by actively engaging in learning.

Conceptual Framework

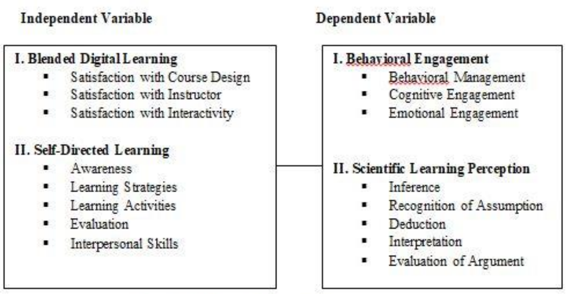

Figure 2. The Research Paradigm

Statement of the Problem

The study aimed to determine the correlation between Blended Digital Learning and Self-Directed Learning on Grade 12 STEM students' behavioral engagement and scientific learning perception at Laguna University Senior High School, Santa Cruz, Laguna, School Year 2022 - 2023. Specifically, this sought to answer the following questions:

1. What is the respondents' level of satisfaction with Blended Digital Learning as to course design, instructor, and interactivity?
2. How may the respondents' Self-Directed Learning practices be described as to awareness, learning strategies, learning activities, and interpersonal skills?
3. How may the respondents' behavioral engagement in Science be described in terms of behavioral, cognitive, and emotional engagement?
4. How may the respondents' scientific learning perception be described in terms of inference, recognition of assumption, deduction, interpretation, and evaluation of argument?
5. Is there a significant correlation between the respondents' level of satisfaction with Blended Digital Learning and their behavioral engagement and scientific learning perception?
6. Is there a significant correlation between the respondents' Self-Directed Learning practices and their behavioral engagement and scientific learning perception?

RESEARCH METHODOLOGY

Research Design. A quantitative research design was used for this study, specifically descriptive and correlation. a survey was administered to the respondents to learn more about the respondents' satisfaction with blended digital learning, self-directed learning practices, behavioral engagement, and scientific learning perception. Moreover, correlational analysis was conducted to determine the relationship among variables.

Quantitative-descriptive correlational research design explores the relationship between two or more variables. This research design entails gathering information on two or more variables and using statistical techniques to examine their relation (Bhandari, 2022).

Respondents of the Study. The study's respondents were the Grade 12 – Science, Technology, Engineering, and Mathematics students at Laguna University Senior High School, Santa Cruz, Laguna, School Year 2022 – 2023. The researcher decided to implement a total enumeration, which includes all 114 students from the academic track.

Grade 12 section in Laguna University	Population
1. STEM 12 A	57
2. STEM 12 B	57
TOTAL	**114**

During the administration of the research instrument, ninety-nine (99) respondents were able to complete the survey, and their responses were retrieved successfully by the researcher. However, fifteen (15) students could not respond to the survey because of unforeseen reasons (e.g., absence or not being conditioned to complete the questionnaire).

Research Instruments. The instrument of this study was a researcher-made survey questionnaire anchored on the works of Wichadee (2018) on students' satisfaction with the blended digital learning environment, Williamson (2007) on students' Self-Directed Learning practices, Appleton et al. (2006) on Behavioral Engagement in Science, and Scientific Learning Perception.

The survey questionnaire was a four-part tool with a four-point Likert-type scale composing of the respondents' satisfaction on participating with Blended Digital Learning (10-item per indicator) as to course design, course instructor, and interactivity; respondents' Self-Directed Learning practices (5-item per indicator) as to awareness, learning strategies, learning activities, evaluation, and interpersonal skills; respondents' behavioral engagement in science (5-item per indicator) as to behavioral management, cognitive engagement, and emotional engagement; lastly, the respondents' scientific learning perception (5-item per indicator) as to inference, recognition of assumption, deduction, interpretation, and evaluation of the argument. The questionnaire was digitized into Google Forms.

Experts in education and assessment and a statistician validated the instrument. It was piloted on 20 students who were not included in the sample. The instrument was tested for reliability using Cronbach alpha using SPSS version 27.

Research Procedure. The researcher asked permission from the University President of Laguna University to conduct the research. Google Forms was used in collecting data from the respondents. The researcher reassured the students that the survey would not affect their grades.

The results and information provided by the respondents were kept confidential by the researcher. Only the researcher and his adviser have access to the data results of the survey questionnaire. The names of the respondents were kept private with full confidentiality.

The information was extracted, summarized, statistically treated, interpreted, and analyzed.

Statistical Treatment of the Data. To determine the respondents' satisfaction with participating in Blended Digital Learning as to course design, course instructor, and interactivity; respondents' Self-Directed Learning practices as to awareness, learning strategies, learning activities, evaluation, and interpersonal skills; respondents' behavioral engagement in science as to behavioral management, cognitive engagement, and emotional engagement; and the respondents' scientific learning perception as to inference, recognition of assumption, deduction, interpretation, and evaluation of an argument, mean and standard deviation were utilized. Furthermore, to determine if a relationship exists among the variables being correlated, Pearson r-moment correlation was employed.

RESULTS AND DISCUSSION

Level of Satisfaction with Blended Digital Learning

Table 1. ***Students' Level of Satisfaction with Blended Digital Learning in Terms of Course Design***

Indicators	Mean	SD	Verbal Interpretation
1. The blended learning course design is well-structured.	3.36	.543	Satisfied
2. The blended learning course design has helped me understand science concepts better.	3.25	.612	Satisfied
3. The course content is interesting, engaging, and relevant to the science subject.	3.38	.601	Satisfied
4. The online materials help us understand science concepts.	3.34	.609	Satisfied
5. The blended learning course design in science has provided a flexible learning experience.	3.31	.565	Satisfied
6. The use of technology in the blended learning course design in science is appropriate.	3.38	.548	Satisfied
7. The use of technology in the blended learning course design in science is easy to use and navigate.	3.31	.600	Satisfied
8. The blended learning course design in science has provided the necessary resources to succeed.	3.34	.556	Satisfied
9. The pace of the blended learning course design in science is appropriate for my learning needs.	3.33	.606	Satisfied
10. The assessment methods used in the blended learning course are fair and appropriate.	3.39	.568	Satisfied
Overall	**3.34**	**.442**	**Satisfied**

Note: 1.0-1.49 (Not satisfied at all); 1.50-2.49 (Less satisfied); 2.50-3.49 (Satisfied); 3.50-4.0 (Highly satisfied)

Table 1 presents the means score and standard deviation of the indicators for the course design of the blended learning approach. The indicators include aspects such as course structure, content, use of technology, flexibility, resources, pace, and assessment.

In the actual implementation of the Blended Digital Learning in the Grade 12 STEM students at Laguna University Senior High School, it can be seen in Appendix I (Sample Module used in Blended Digital Learning Program) that the students were satisfied with positive scientific learning by means of

*Corresponding Author: Rowel B. Gaa

easily conceptualizing data about the concept of electric charge, and answering scientific questions and problems related to the topic. This implies that students are pleased with the blended learning approach's implementation of science courses.

This also shows that students are happy with the course's assessment procedures. Based on the findings, the assessment methods employed in the blended learning course design, as seen in Appendix I, are more varied and complete than those used in traditional classroom-based courses, giving students a more all-encompassing evaluation of their learning. Students feel more comfortable and confident if they see this as fair and suitable.

The findings suggest that the course design, as seen in Appendix I is well-structured, relevant, and engaging and provides the necessary resources to succeed. The use of technology is also seen as appropriate and easy to use. Additionally, the assessment methods used are perceived as fair and appropriate. These positive perceptions are important for student motivation, engagement, and learning outcomes. This is supported by Subramanian and Budhrani (2020). Course design factors, including clear instructions, course material relevant to students' interests and experiences, and the availability of learning resources, are all positively correlated with student motivation and engagement. Course design can influence student participation in online learning settings, as students who reported higher levels of interest and motivation were more likely to participate in online conversations and activities.

However, the statement "The blended learning course design has helped me understand science concepts better" got the lowest mean score ($\bar{x}$ = 3.25). This may indicate that the students struggle to understand scientific concepts, which could be attributed to their grasp of those ideas. This implies that some science concepts may take students longer to understand completely. As Michel and Neumann (2016) stated, students' existing understanding of the nature of science can affect their capacity to grasp new scientific material. To effectively absorb and apply new scientific knowledge, students need a firm grasp of the nature of scientific ideas.

Table 2 shows the overall mean of 3.50 with a standard deviation of .442 and interpreted as highly satisfied on students' level of satisfaction with blended digital learning in terms of instructor.

Students were highly satisfied with the instructor's subject matter expertise and regarded an instructor who is competent and experienced in the subject field, which contributes to their course satisfaction. In the actual implementation of Blended Digital Learning at Laguna University Senior High School, it can be seen that the instructors' knowledge of the subject matter, enthusiasm, organization, and clear communication by using various teaching strategies and methods help students to understand their science course easily.

Table 2. *Students' Level of Satisfaction with Blended Digital Learning in Terms of Instructor*

Indicators	Mean	SD	Verbal Interpretation
1. The blended learning course instructor in science is knowledgeable about the subject matter.	3.60	.533	Highly Satisfied
2. The blended learning course instructor in science is well-organized and well-prepared for the class.	3.51	.578	Highly Satisfied
3. The blended learning course instructor is enthusiastic about teaching science through blended learning.	3.56	.539	Highly Satisfied
4. The blended learning course instructor in science has provided helpful and constructive feedback on my work.	3.46	.559	Satisfied
5. The blended learning course instructor in science has promptly responded to questions and feedback on tasks and assessments.	3.49	.542	Satisfied
6. The blended learning course instructor in science has created a positive and inclusive learning environment.	3.48	.541	Satisfied
7. The blended learning course instructor in science has used various teaching strategies and methods to help me understand the material.	3.45	.520	Satisfied

*Corresponding Author: **Rowel B. Gaa**

8.	The blended learning course instructor in science is fair and equitable during class interactions.	3.52	.541	Highly Satisfied
9.	The blended learning course instructor in science is approachable, available for questions, and willing to assist students outside class hours if needed.	3.45	.540	Satisfied
10.	The blended learning course instructor in science has communicated effectively and clearly.	3.46	.577	Satisfied
	Overall	**3.50**	**.422**	**Highly Satisfied**

Note: 1.0-1.49 (Not satisfied at all); 1.50-2.49 (Less satisfied); 2.50-3.49 (Satisfied); 3.50-4.0 (Highly satisfied)

This implies that students are satisfied with the blended learning approach's implementation in terms of the instructor. This is supported by Latip et al. (2020), students who perceived their instructors as more competent and experienced were more satisfied with the science course.

The indicators with the lowest mean scores are " The science instructor has used a variety of teaching strategies and methods to help me understand the material" and "The blended learning course instructor in science is approachable and available for questions and willing to assist students outside of class hours if needed." These indicators have a mean score above 3.45, although they are slightly lower than others, suggesting space for development.

Providing timely, helpful, and constructive feedback is essential for student learning and growth while using various teaching strategies can help accommodate different learning styles and enhance engagement. Student engagement and satisfaction with their education were higher among those who utilized the personalized learning platform (Deng et al., 2018). Incorporating individualized learning into already established teaching practices yielded the best results. Students' learning outcomes with personalized learning and classroom teaching were the most favorable.

Table 3 shows the results of a survey that measures students' level of satisfaction with blended digital learning in science, specifically in terms of interactivity. The mean score for all indicators is 3.36, with an SD of .413, indicating that students were generally satisfied with the course interactivity in blended digital learning in science.

The highest mean score ($\bar{x}$ = 3.41) is gained by the statement, "The blended digital learning materials in science have allowed me to work at my own pace." This indicates that students value the freedom to set their own pace while studying. Students were generally pleased with the course's engagement, suggesting they appreciated the opportunity to set their own pace while progressing in the blended digital learning science course.

Table 3. *Students' Level of Satisfaction with Blended Digital Learning in Terms of Interactivity*

	Indicators	Mean	SD	Verbal Interpretation
1.	The interactive elements in the blended digital learning science course align with the course objectives and content.	3.39	.568	Satisfied
2.	The interactive elements in the blended digital learning course in science are easy to use and navigate.	3.33	.553	Satisfied
3.	The blended digital learning materials in science have provided clear instructions on interacting with the course material.	3.35	.559	Satisfied
4.	The blended digital learning materials in science have included interactive features that help me engage with the course content.	3.38	.601	Satisfied
5.	The blended digital learning materials in science are engaging, which helps me stay motivated to learn.	3.34	.574	Satisfied
6.	The blended digital learning materials in science have provided a variety of media (e.g., videos, interactive diagrams, animations) to explain difficult concepts.	3.35	.540	Satisfied

*Corresponding Author: **Rowel B. Gaa**

7. The blended digital learning materials in science have allowed me to access additional resources to support my learning easily.	3.38	.566	Satisfied
8. The blended digital learning materials in science have allowed me to interact with other students through discussions, forums, or group projects.	3.30	.504	Satisfied
9. The blended digital learning materials in science have allowed me to practice what I have learned.	3.38	.529	Satisfied
10. The blended digital learning materials in science have allowed me to work independently.	3.41	.535	Satisfied
Overall	**3.36**	**.413**	**Satisfied**

Note: 1.0-1.49 (Not satisfied at all); 1.50-2.49 (Less satisfied); 2.50-3.49 (Satisfied); 3.50-4.0 (Highly satisfied)

Shand and Farrelly (2017) discovered that blended learning in the instructional methods course positively impacted students' learning experiences, particularly in boosting their engagement, motivation, and collaboration. In the actual implementation of Blended Digital Learning at Laguna University Senior High School, it can be seen that the instructor included interactive features and a variety of media during the online discussion via Google Meet that helped the students to engage with the subject matter. This implies that students are satisfied with the blended learning approach's implementation in terms of interactivity.

The statement "The blended digital learning materials in science have allowed me to interact with other students through discussion, forums, or group projects" had the lowest mean score (x = 3.30). Although students expressed general contentment with the course, they seemed less enthusiastic about the possibility of conversing with their classmates. Shea (2017) found that shyness among students was widespread, with students identifying a lack of confidence in their language skills and a fear of social embarrassment as explanations for their hesitation. The survey also discovered that teachers talked more than students in class, leaving little possibility for student participation. This suggests that while students were happy with the interactivity of the course overall, they were less thrilled by the opportunity to engage in interactivity with their fellow students. This could indicate that the course structure needs to be altered to promote greater student cooperation and interpersonal contact.

Students Self-Directed Learning Practices

Table 4. *Students Self-Directed Learning Practices in Terms of Awareness*

Indicators	Mean	SD	Verbal Interpretation
1. I can set realistic goals for myself in this self-directed learning science course.	3.21	.520	Practiced
2. I can manage my time effectively in this self-directed learning science course.	3.17	.623	Practiced
3. I can prioritize my learning tasks effectively in this self-directed learning science course.	3.16	.618	Practiced
4. I can identify and overcome obstacles to my learning in this self-directed learning science course.	3.25	.578	Practiced
5. I can evaluate my learning progress effectively in this self-directed learning science course.	3.25	.560	Practiced
Overall	**3.21**	**.452**	**Practiced**

Note: 1.0-1.49 (Not practiced at all); 1.50-2.49 (Less practiced); 2.50-3.49 (Practiced); 3.50-4.0 (Highly practiced)

Table 4 shows the survey results where students rated their self-directed learning practices in a science course. The indicators measured are related to awareness, specifically, the student's ability to set goals, manage time, prioritize tasks, identify and overcome obstacles, and evaluate their learning progress.

"I can identify and overcome obstacles to my learning in this self-directed learning science course" and "I can evaluate my learning progress effectively in this self-directed learning science course" are the highest-scoring indicators (x = 3.25). This finding shows that students in the self-paced science course are most assured of their abilities to recognize and overcome learning barriers and accurately assess their progress. As a result of learning to recognize and respond to obstacles as they emerge and assess their progress toward goals, students in this course may be more likely to persevere in their studies and complete course objectives. This can

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increase students' interest, motivation, and happiness while learning.

"I can prioritize my learning tasks effectively in this self-directed learning science course" was given the lowest mean score (x = 3.16), the lowest indicator. This indicates that students may not be as confident in their time management skills as in their abilities to engage in the other forms of self-directed learning practices examined in the survey. In a self-paced learning setting, students may need extra aid or access to different tools to manage their time successfully. This could be advice on organizing one's time effectively, helping keep track of and prioritizing one's various responsibilities, or assisting in creating an individual study plan.

Table 5. *Students Self-Directed Learning Practices in Terms of Learning Strategies*

Indicators	Mean	SD	Verbal Interpretation
1. I have better understood my learning strategies after participating in this self-directed learning science course.	3.25	.522	Practiced
2. The self-directed learning approach in this science course has allowed me to choose and apply the learning strategies that work for me.	3.31	.528	Practiced
3. I have learned new learning strategies that I can use in science through a self-directed learning course.	3.37	.527	Practiced
4. I feel more confident in my ability to choose and use effective learning strategies in science after participating in this self-directed course.	3.32	.531	Practiced
5. I feel that the self-directed learning approach in this science course has helped me to develop better metacognitive skills, such as planning and monitoring my learning.	3.38	.509	Practiced
Overall	**3.33**	**.405**	**Practiced**

Note: 1.0-1.49 (Not practiced at all); 1.50-2.49 (Less practiced); 2.50-3.49 (Practiced); 3.50-4.0 (Highly practiced)

This table presents the survey results on self-directed learning practices in a science course. The survey measures the degree of practice of the students with their learning strategies and their ability to choose and apply effective learning strategies. All indicators had mean values above 3.0, suggesting that students are increasingly confident in their ability to learn independently and have a deeper appreciation for the efficacy of their approaches to studying. Overall, a mean of 3.33 indicates that students are pleased with the self-paced nature of the science curriculum.

Students' apparent contentment with self-directed learning implies it has promise as a strategy for boosting interest and enthusiasm in the classroom. Palaigeorgiou and Papadopoulou (2018) discovered that when students used technology, they were more interested in their coursework and more likely to see it through to completion. They were also better able to self-regulate their learning and demonstrate greater independence than the control group. This is especially helpful in science classes because students sometimes have trouble grasping more theoretical or theoretically complicated subjects.

The discovery that the self-directed learning approach fosters metacognitive abilities greatly impacts long-term learning and achievement. Students who can organize and monitor their learning are better positioned for future academic achievement, and metacognitive skills are essential. Metacognitive instruction boosted students' metacognitive awareness and academic performance much more than conventional teaching methods. Langdon et al. (2019) conclude that using metacognitive tactics in the classroom benefits students.

Table 6. *Students Self-Directed Learning Practices in Terms of Learning Activities*

Indicators	Mean	SD	Verbal Interpretation
1. The self-directed learning activities in science have helped me develop a deeper understanding of the course material.	3.29	.539	Practiced
2. The self-directed learning activities have helped me develop new skills and knowledge in science.	3.31	.565	Practiced
3. The self-directed learning activities in science are challenging yet achievable.	3.31	.508	Practiced
4. The self-directed learning materials in	3.30	.524	Practiced

science have allowed me to apply the course material to real-world scenarios and problems.			
5. I feel that the self-directed learning activities have helped me become more independent in science.	3.30	.614	Practiced
Overall	**3.32**	**.448**	**Practiced**

Note: 1.0-1.49 (Not practiced at all); 1.50-2.49 (Less practiced); 2.50-3.49 (Practiced); 3.50-4.0 (Highly practiced)

Table 6 presents the students' responses to self-directed learning practices in science. The mean rating for the students' practice in science self-directed learning was 3.32. The indicator "The self-directed learning activities have helped me develop new skills and knowledge in science" and "The self-directed learning activities in science are challenging yet achievable" received the highest mean score (3.31), suggesting that students practice their ability to acquire new scientific expertise through independent study. The indicator "The self-directed learning activities in science have helped me develop a deeper understanding of the course material" had the lowest mean score, with a mean of 3.29, indicating that students were slightly less practice with their ability to do so.

Students benefit from and acquire new information and abilities through self-directed learning activities in science. Self-directed learning was associated with higher executive attention, even after controlling for working memory and processing speed. As students engage in self-directed learning, which involves goal-setting, activity planning, and progress monitoring, Uus et al. (2020) argued that the capacity to avoid distraction and sustain focus might be especially crucial.

Table 7. *Students Self-Directed Learning Practices in Terms of Evaluation*

Indicators	Mean	SD	Verbal Interpretation
1. The evaluation methods used were fair and objective.	3.35	.521	Practiced
2. The evaluation methods have provided meaningful feedback on my progress and understanding of the course material.	3.40	.513	Practiced
3. The self-directed learning activities have helped me identify areas where I needed to improve my understanding of the course material.	3.40	.533	Practiced
4. I felt that the evaluation methods used have allowed me to demonstrate my knowledge and skills effectively.	3.42	.517	Practiced
5. I believe the evaluation methods accurately reflect my understanding of the course material.	3.36	.579	Practiced
Overall	**3.39**	**.417**	**Practiced**

Note: 1.0-1.49 (Not practiced at all); 1.50-2.49 (Less practiced); 2.50-3.49 (Practiced); 3.50-4.0 (Highly practiced)

Table 7 presents the results of a survey that aimed to explore the students' perception of their self-directed learning practices in terms of evaluation. The survey's indicators include the following: the fairness and objectivity of evaluation techniques; the utility of feedback; the identification of areas for improvement; the efficiency with which knowledge and skills are demonstrated; the accuracy of evaluation methods; and the effectiveness with which knowledge and skills are demonstrated.

With a mean score of 3.42, "I felt that the evaluation methods used have allowed me to demonstrate my knowledge and skills effectively" is the indicator with the highest mean score in the table. This indicates that the students are comfortable with the evaluation employed in their courses, a crucial element of self-directed learning. This is encouraging since it shows that the criteria used by Laguna University Senior High School to assess the student's progress align with their objectives.

"The evaluation methods used were fair and objective" had the lowest mean score (3.35) of all the indicators. The indicator is still within the area, although it has dropped slightly from the other indicators. The students may believe the evaluation processes are opaque or inconsistent or do not accurately reflect their comprehension of the subject matter.

Self-directed learning relies heavily on students' trust in the reliability of their grades and comments, and this finding implies that students have that trust. The students also said they felt they could effectively exhibit their knowledge and

*Corresponding Author: **Rowel B. Gaa**

skills thanks to the evaluation techniques and that they could identify better areas in which they needed to enhance their comprehension of the course material. Lee et al. (2017) discovered that students' comments on instructional films are helpful for independent study. They let students discuss ideas presented in the videos, ask questions, and get clarification. Commenters also shared useful connections to related movies and articles to further learning. The authors argue that the discussion threads around educational films represent a valuable "social learning space" in which students can connect and study together.

Table 8. *Students Self-Directed Learning Practices in Terms of Interpersonal Skills*

Indicators	Mean	SD	Verbal Interpretation
1. The self-learning activities in science have helped me develop better communication skills.	3.30	.543	Practiced
2. The self-learning activities in science have helped me develop better collaboration and leadership skills with my peers.	3.34	.538	Practiced
3. The self-learning activities in science have provided opportunities for me to work effectively in a team.	3.31	.528	Practiced
4. The self-learning activities in science have provided opportunities for me to practice listening and responding to feedback.	3.43	.498	Practiced
5. The self-learning activities in science have helped me develop better conflict-resolution skills and empathy.	3.36	.543	Practiced
Overall	**3.35**	**.412**	**Practiced**

Note: 1.0-1.49 (Not practiced at all); 1.50-2.49 (Less practiced); 2.50-3.49 (Practiced); 3.50-4.0 (Highly practiced)

The table presents the findings of the study about self-directed learning practices related to interpersonal skills in science.

The students' total mean score of 3.35 indicates they are generally happy with their self-directed learning strategies for developing interpersonal skills. When comparing the five indicators, "The self-learning activities in science have provided opportunities for me to practice listening and responding to feedback" (mean score: 3.43) is the one with the highest mean score, while "The self-learning activities in science have helped me develop better communication skills" (mean score: 3.30) is the one with the lowest mean score.

Teachers can help students improve their interpersonal skills by including self-directed learning opportunities in class lessons. Teachers can support and facilitate student-centered learning strategies that empower students to participate more actively in their education. Independent study is beneficial in encouraging pupils to take charge of their education (Oktaviani et al., 2021). They recommend that other Indonesian universities adopt the independent study program to promote autonomous learning and enhance students' academic outcomes.

Students' Behavioral Engagement in Science

Table 9. *Students' Behavioral Engagement in Terms of Behavioral Management*

Indicators	Mean	SD	Verbal Interpretation
1. I stay focused and attentive during science class.	3.34	.657	Engaged
2. I follow the teacher's directions and rules during science class.	3.61	.491	Highly Engaged
3. I complete my science homework on time.	3.48	.578	Engaged
4. I participate in class discussions and activities during science class.	3.56	.557	Highly Engaged
5. I come prepared to class with all my necessary materials and assignments.	3.47	.560	Engaged
Overall	**3.49**	**.432**	**Engaged**

Note: 1.0-1.49 (Not engaged at all); 1.50-2.49 (Less engaged); 2.50-3.49 (Engaged); 3.50-4.0 (Highly engaged)

Table 9 presents the results of a survey conducted on students' behavioral engagement in a science class in terms of behavioral management. The survey assessed five indicators of behavioral engagement: staying focused and attentive during class, following the teacher's directions and rules, completing homework on time, participating in class discussions and activities, and coming prepared to class with all necessary materials and assignments. The overall mean score for all indicators is 3.49, indicating that students' behavioral management in the science class was generally engaged.

The mean scores for all indicators range from 3.34 to 3.61, indicating that students generally reported a high level of engagement in terms of behavioral management in the science class. The highest mean score (3.61) was obtained for the indicator "I follow the teacher's directions and rules during science class," indicating that students were engaged with their ability to comply with the teacher's expectations.

All five indicators suggest that the current behavioral management strategies used in the class effectively promote student engagement and compliance with teacher expectations. Therefore, the teacher can continue using these strategies to maintain students' positive behaviors and promote engagement. Engaging students is a multifaceted and ever-changing process that many external variables affect. Teachers, however, are singled out as significantly impacting students' propensity to participate in class and the quality of their learning as a whole (Pedler et al., 2020).

The lowest mean score (3.34) was obtained for the indicator "I stay focused and attentive during science class," indicating that students were still satisfied but to a lesser degree with their ability to maintain focus and attention during class. This finding suggests that the teacher may need to explore new strategies to enhance students' attention, such as incorporating more interactive and hands-on activities to increase students' interest and motivation. Students who got activity-based education were more motivated and academically successful than those who received standard lecture-based teaching. Activity-based teaching boosts student engagement, active learning, and academic accomplishment (Anwer, 2019).

Table 10. *Students' Behavioral Engagement in Terms of Cognitive Engagement*

Indicators	Mean	SD	Verbal Interpretation
1. I use reasoning and critical thinking to understand scientific concepts.	3.30	.614	Engaged
2. I connect what I learn in science class to my experiences and knowledge.	3.32	.568	Engaged
3. I ask questions and seek out answers to scientific problems.	3.24	.608	Engaged
4. I try to understand scientific concepts in depth, not just memorize them.	3.39	.550	Engaged
5. I use scientific reasoning and evidence to support my ideas and arguments.	3.32	.603	Engaged
Overall	**3.32**	**.445**	**Engaged**

Note: 1.0-1.49 (Not engaged at all); 1.50-2.49 (Less engaged); 2.50-3.49 (Engaged); 3.50-4.0 (Highly engaged)

Table 10 presents the results of students' behavioral engagement in a science class in terms of cognitive engagement. The survey assessed five indicators of cognitive engagement, namely using reasoning and critical thinking to understand scientific concepts, connecting what is learned in science class to personal experiences and knowledge, asking questions and seeking out answers to scientific problems, trying to understand scientific concepts in depth rather than memorizing them, and using scientific reasoning and evidence to support ideas and arguments. The overall mean score for all indicators is 3.32, indicating that students' cognitive engagement in the science class was generally engaged.

The mean scores for all indicators range from 3.24 to 3.39, indicating that students generally engaged with their cognitive engagement in science class. The highest mean score (3.39) was obtained for the indicator "I try to understand scientific concepts in depth, not just memorize them," indicating that students were highly satisfied with their ability to comprehend scientific concepts and ideas in depth. The lowest mean score (3.24) was obtained for the indicator "I ask questions and seek out answers to scientific problems," indicating that students were still satisfied but to a lesser degree with their ability to ask questions and seek answers to scientific problems.

The results suggest that the students surveyed were generally cognitively engaged in the science class, which is a positive indication of their academic motivation and success. The findings also highlight some areas where students may benefit from additional support and encouragement, such as asking questions and seeking answers to scientific problems. Students that used multimedia e-learning also displayed a greater level of self-regulated learning (So et al., 2019). Students who can take charge of their education by developing their learning objectives, evaluating their performance, and adjusting their approach are engaged in self-regulated learning.

Table 11 presents the students' behavioral engagement in terms of emotional engagement in science class. The table includes five indicators: enjoyment, curiosity, subject preference, confidence, and pride.

*Corresponding Author: **Rowel B. Gaa**

Table 11. *Students' Behavioral Engagement in Terms of Emotional Engagement*

	Indicators	Mean	SD	Verbal Interpretation
1.	I enjoy learning about science.	3.41	.589	Engaged
2.	I feel curious and interested in science class.	3.53	.595	Highly Engaged
3.	Science is one of my favorite subjects.	3.26	.790	Engaged
4.	I feel confident in my ability to do well in science.	3.30	.721	Engaged
5.	I feel proud when I understand a difficult scientific concept.	3.54	.540	Highly Engaged
	Overall	**3.42**	**.508**	**Engaged**

Note: 1.0-1.49 (Not engaged at all); 1.50-2.49 (Less engaged); 2.50-3.49 (Engaged); 3.50-4.0 (Highly engaged)

The mean scores for each indicator range from 3.26 to 3.54, with an overall mean score of 3.42, indicating that the students generally engage with their emotional engagement in science class.

Students reported being highly satisfied with their curiosity and interest in science class and feeling proud when they understood a difficult scientific concept. They also reported being satisfied with their enjoyment, confidence, and subject preference for science. These findings suggest that the students in this study have a positive emotional engagement with science, which can contribute to their overall motivation and interest in learning. It also implies that the teachers may create a positive learning environment that fosters emotional engagement among students. Gillen-O'Neel (2019) discovered that on the days that student reported having a larger sense of belonging, they also reported higher levels of behavioral, emotional, and cognitive involvement.

Students' Scientific Learning Perception

Table 12. *Students' Scientific Learning Perception in Terms of Inference*

	Indicators	Mean	SD	Verbal Interpretation
1.	I can use scientific evidence to draw logical conclusions about a phenomenon.	3.14	.623	Manifested
2.	I can identify the underlying assumptions in a scientific argument.	3.19	.601	Manifested
3.	I am skilled at interpreting graphs and charts to draw conclusions.	3.22	.663	Manifested
4.	I can use my scientific knowledge to make predictions about the behavior of a system.	3.27	.636	Manifested
5.	I am good at identifying cause-and-effect relationships in a scientific experiment.	3.29	.627	Manifested
	Overall	**3.22**	**.528**	**Manifested**

Note: 1.0-1.49 (Not manifested at all); 1.50-2.49 (Moderately manifested); 2.50-3.49 (Manifested); 3.50-4.0 (Highly manifested)

Table 12 presents the results of a survey measuring students' scientific learning perception in terms of inference. The survey includes five indicators of scientific learning perception related to inference.

The mean scores for the five indicators range from 3.14 to 3.29, indicating that students often perform these skills. The overall mean score for all five indicators combined is 3.22, interpreted as "Manifested."

The indicator with the highest mean score is "I am good at identifying cause-and-effect relationships in a scientific experiment" (3.29). Students generally manifested that they have a good understanding of cause-and-effect relationships in scientific experiments. This is a fundamental skill in scientific inquiry, and students' proficiency in this area is essential to design experiments, analyze data, and draw conclusions.

While the indicator with the lowest mean score is "I can use scientific evidence to draw logical conclusions about a phenomenon" (3.14). Students may need further support or training in this area to improve their ability to draw logical conclusions based on scientific evidence. This skill is particularly important in scientific inquiry and problem-solving, and a lack of proficiency in this area may affect their ability to evaluate scientific claims and make informed decisions.

Indeed (2022) supported the idea that a technique for reaching a conclusion involves drawing inferences based on data and logic. To link unknown facts with known information, it

*Corresponding Author: Rowel B. Gaa

draws on existing knowledge and experience. Students can comprehend situations and fully understand them by looking at inferences.

Table 13. *Students' Scientific Learning Perception in Terms of Recognition of Assumption*

Indicators	Mean	SD	Verbal Interpretation
1. I recognize when an assumption has been made in a discussion or argument.	3.22	.615	Manifested
2. I can distinguish between statements supported by evidence and those based on assumptions.	3.28	.607	Manifested
3. I am skilled at identifying unstated assumptions in a piece of writing.	3.21	.689	Manifested
4. I can recognize the assumptions underlying an argument.	3.27	.636	Manifested
5. I am good at identifying the implications of assumptions in an argument.	3.26	.616	Manifested
Overall	**3.25**	**.525**	**Manifested**

Note: 1.0-1.49 (Not manifested at all); 1.50-2.49 (Moderately manifested); 2.50-3.49 (Manifested); 3.50-4.0 (Highly manifested)

Table 13 shows that, on average, the students often recognize assumptions in a discussion or argument. The overall mean of 3.25 suggests that students perceived their scientific learning as related to recognizing assumptions.

Among the five indicators, the highest mean is for Indicator 2: "I can distinguish between statements that are supported by evidence and those that are based on assumptions," with a mean of 3.28. This suggests that students perceive themselves as relatively skilled at identifying statements supported by evidence and those based on assumptions.

The lowest mean is for Indicator 3: "I am skilled at identifying unstated assumptions in a piece of writing," with a mean of 3.21. This suggests that students perceive themselves as slightly less skilled at identifying unstated assumptions in writing than the other indicators.

In this regard, assumptions enable rather than constrain; they make it possible for action, choices, and other things to happen. According to this viewpoint, developing theories or engaging in the field is hard without using assumptions as a guide. Assumptions are inescapable and mold students' activities at every stage (Gabbitas, 2009).

Table 14. *Students' Scientific Learning Perception in Terms of Deduction*

Indicators	Me an	SD	Verbal Interpretati on
1. I can draw logical conclusions based on scientific evidence.	3.1 7	.64 0	Manifested
2. I am skilled at making deductions based on scientific observations.	3.1 9	.68 0	Manifested
3. I can reason logically about cause-and-effect relationships in scientific phenomena.	3.1 8	.57 8	Manifested
4. I am good at identifying the necessary steps to reach a scientific conclusion.	3.1 7	.67 1	Manifested
5. I can use evidence to make sound inferences about scientific phenomena.	3.2 3	.62 0	Manifested
Overall	**3.1 9**	**.54 8**	**Manifested**

Note: 1.0-1.49 (Not manifested at all); 1.50-2.49 (Moderately manifested); 2.50-3.49 (Manifested); 3.50-4.0 (Highly manifested)

Table 14 presents the scientific learning perception of students in terms of deductions based on five indicators. The indicators include drawing logical conclusions based on scientific evidence, making deductions based on scientific observations, reasoning logically about cause-and-effect relationships in scientific phenomena, identifying the necessary steps to reach a scientific conclusion, and using evidence to make sound inferences about scientific phenomena.

The mean scores for all the indicators range from 3.17 to 3.23, which indicates that the students often use their scientific learning in terms of deductions. The overall mean score is 3.19, which further supports this interpretation.

The indicator with the highest mean is Indicator 5, "I can use evidence to make sound inferences about scientific phenomena," with a mean of 3.23. This suggests that students perceive confidence in their ability to apply evidence to make logical deductions. The indicators with the lowest mean are Indicators 1 and 4, "I can draw logical conclusions based on scientific evidence" and "I am good at identifying the necessary steps to reach a scientific conclusion," with a mean of 3.17. This suggests that students may perceive these areas as slightly weaker in their scientific learning abilities.

*Corresponding Author: **Rowel B. Gaa**

Teachers can provide them with explicit instruction on how to recognize and apply deductive reasoning in scientific problem-solving. They can also use inquiry-based and problem-based learning strategies to promote deductive reasoning skills (Aiyub et al., 2021).

Table 15 presents the scientific learning perception of students in terms of interpretation based on five indicators. The indicators include interpreting scientific data to make meaningful conclusions, distinguishing between important and irrelevant information in scientific texts, identifying the main arguments and ideas presented in scientific literature, analyzing data to make informed judgments about scientific phenomena, and using scientific evidence to evaluate the validity of a scientific claim.

Table 15. *Students' Scientific Learning Perception in Terms of Interpretation*

Indicators	Mean	SD	Verbal Interpretation
1. I am skilled at interpreting scientific data to make meaningful conclusions.	3.17	.640	Manifested
2. I can distinguish between important and irrelevant information in scientific texts.	3.24	.624	Manifested
3. I am good at identifying the main arguments and ideas in scientific literature.	3.25	.660	Manifested
4. I can analyze data to make informed judgments about scientific phenomena.	3.25	.612	Manifested
5. I can use scientific evidence to evaluate the validity of a scientific claim.	3.27	.636	Manifested
Overall	**3.24**	**.542**	**Manifested**

Note: 1.0-1.49 (Not manifested at all); 1.50-2.49 (Moderately manifested); 2.50-3.49 (Manifested); 3.50-4.0 (Highly manifested)

Students' perceptions of their scientific learning in terms of interpretation are typically positive, with mean scores across all variables falling between 3.17 and 3.27. This interpretation is further supported by the average mean score of 3.24.

The indicator with the highest mean is Indicator 5, "I can use scientific evidence to evaluate the validity of a scientific claim," which has a mean of 3.27. This indicates that students believe they can evaluate scientific statements scientifically using evidence. The mean score for Indicator 1 (3.17), "I am skilled at interpreting scientific data to make meaningful conclusions," is the lowest. This suggests that students may need more support in developing their interpretation skills. Teachers may help students develop their interpretation skills by providing them with opportunities to analyze and interpret data, graphs, and charts. They can also encourage students to ask questions and make connections between different concepts (Aiyub et al., 2021).

Table 16. *Students' Scientific Learning Perception in Terms of Evaluation of Argument*

Indicators	Mean	SD	Verbal Interpretation
1. I can evaluate the strengths and weaknesses of scientific arguments.	3.19	.583	Manifested
2. I can recognize when scientific arguments are based on sound evidence versus speculation or opinion.	3.23	.586	Manifested
3. I am skilled at identifying flaws in scientific arguments.	3.15	.676	Manifested
4. I am able to weigh the relative importance of scientific evidence in supporting an argument.	3.24	.608	Manifested
5. I can evaluate the validity of scientific conclusions based on the evidence presented.	3.30	.646	Manifested
Overall	**3.22**	**.501**	**Manifested**

Note: 1.0-1.49 (Not manifested at all); 1.50-2.49 (Moderately manifested); 2.50-3.49 (Manifested); 3.50-4.0 (Highly manifested)

Table 16 displays the students' scientific learning perception in terms of the evaluation of arguments using five different criteria. These indicators include evaluating the strengths and weaknesses of scientific arguments, recognizing sound evidence versus speculation or opinion, identifying flaws in scientific arguments, weighing the relative importance of evidence, and evaluating the validity of scientific conclusions.

Students are generally optimistic about their scientific learning perception in terms of evaluation of an argument, as the mean scores for all five indicators were interpreted as

*Corresponding Author: **Rowel B. Gaa**

"Manifested." This interpretation is further supported by the average mean score of 3.22 overall.

With a mean of 3.30, "I can evaluate the validity of scientific conclusions based on the evidence presented" indicates the highest mean score. Students appear confident in their capacity to assess the validity of scientific claims. On the other hand, "I am skilled at identifying flaws in scientific arguments" has the lowest mean score of the indicators, coming in at 3.15 on average. Therefore, it seems likely that students view their scientific learning perception in this area as being slightly subpar.

Münchow et al. (2019) supported that all scientific disciplines use arguments and argumentation. However, the details and formats of these arguments might vary between disciplines. Moreover, familiarity with discipline-specific materials and conceptual understanding are likely to play a role in the capacity to evaluate arguments.

Correlation between Satisfaction on Blended Digital Learning and Behavioral Engagement and Scientific Learning Perception

Table 17. ***Correlation between Satisfaction on Blended Digital Learning and Behavioral Engagement and Scientific Learning Perception***

Blended Digital Learning	Behavioral Engagement			Scientific Learning Perception				
	BM	CE	EE	Infe	RoA	D	Inter	EoA
Course Design	.545**	.701**	.589**	.619**	.646**	.607**	.698**	.656**
Instructor	.486**	.490**	.426**	.374**	.361**	.331**	.389**	.428**
Interactivity	.483**	.687**	.469**	.581**	.584**	.559**	.609**	.615**

***Correlation is significant at the 0.01 level (2-tailed).* **Correlation is significant at the 0.05 level (2-tailed).*

Table 17 shows the correlation coefficients between the satisfaction of students in Blended Digital Learning and Behavioral Engagement and Scientific Learning Perception.

The results show that course design has a moderate to strong positive correlation with all three aspects of behavioral engagement (p = .545, .701, .589). The instructor also has a moderate positive correlation with all three aspects of behavioral engagement (p = .486, .490, .426). Finally, interactivity has a moderate positive correlation with behavioral management and emotional engagement (p = .483, .469) and a strong positive correlation with cognitive engagement (p = .687).

Behavioral engagement is an important factor for student success, as it involves students actively participating in the learning process and exhibiting behaviors that demonstrate their investment in their learning. The positive correlation between satisfaction with course design, instructors, and interactivity in blended digital learning and behavioral engagement suggests that students are more likely to engage in the learning process when they are satisfied with the course structure, teaching methods, and interactive elements. This finding is consistent with previous research showing that active learning engagement is positively associated with improved academic achievement.

Kim et al. (2019) found that students' academic engagement and technological preparedness significantly correlated with their academic performance. It was also discovered that digital readiness mediates the connection between academic engagement and student achievement, suggesting that students who were already more interested in their studies were also more prepared to succeed in the digital world. The results imply that online courses can be more successful when students are actively involved in learning and have the essential digital abilities to thrive online.

The results show that course design has a strong positive correlation with all five aspects of scientific learning perception which implies that the Grade 12 STEM students at Laguna University Senior High School perceived subjects under study in terms of inference, recognition of assumption, deduction, interpretation, and evaluation of argument helpful in their learning.

More so, instructor and interactivity, which comprises elements of Blended Digital Learning, directly affect Grade 12 STEM students' scientific learning perception regarding inference, recognition of assumption, deduction, interpretation, and evaluation of an argument, showcased through a weak to a strong positive correlation.

Scientific learning is also essential for student success, enabling students to analyze, evaluate, and apply information to solve complex problems. The positive correlation between satisfaction with course design, instructors, and interactivity in blended digital learning and scientific learning perception suggests that these aspects of the Blended Digital Learning Program of Laguna University Senior High School correlate to the students' ability to think scientifically in the learning process. This allows students to engage in group discussions, online quizzes, and problem-solving exercises.

These results imply that in the actual study, teachers encourage and motivate students to learn, participate in class discussions, and receive constructive criticism. Moreover, integrating well-structured courses, enthusiastic teachers, and stimulating learning activities into mixed digital learning environments boost students' behavior and ability to think scientifically. In addition, it provides more evidence that participating in blended digital learning experiences can affect both behavioral engagement and scientific learning perception. This emphasizes the value of an active learning strategy, including participation in class discussions,

*Corresponding Author: Rowel B. Gaa

completion of tasks, and feedback seeking, in fostering positive behavioral and cognitive changes. The study also demonstrated that the connection between online techniques and learning outcomes was mediated by students' sense of mastery, motivation, and control over their learning.

Correlation between Self-Directed Learning Practices and Behavioral Engagement and Scientific Learning Perception

Table 18. *Correlation between Self-Directed Learning Practices and Behavioral Engagement and Scientific Learning Perception*

Self-Directed Learning	Behavioral Engagement			Scientific Learning Perception				
	BM	CE	EE	Infe	RoA	D	Inter	EoA
Awareness	.531**	.691**	.608**	.746**	.679**	.749**	.720**	.765**
Learning Strategies	.521**	.720**	.586**	.744**	.690**	.727**	.702**	.726**
Learning Activities	.399**	.654**	.600**	.637**	.592**	.654**	.648**	.664**
Evaluation	.384**	.564**	.505**	.514**	.485**	.519**	.522**	.556**
Interpersonal Skills	.390**	.658**	.486**	.623**	.646**	.614**	.672**	.690**

***Correlation is significant at the 0.01 level (2-tailed).* **Correlation is significant at the 0.05 level (2-tailed).*

Table 18 shows the correlation coefficients between the factors of self-directed learning practices and behavioral engagement and scientific learning perception.

Self-directed learning activities are positively correlated with behavioral engagement. The research found that all self-directed learning methods have weak (p =.384). to moderately (p =.531, .521, .399, .390) positive correlations with behavioral management. This shows that those who engage in self-directed learning techniques are more likely to acquire the behavioral competence required for self-management and effective social interaction. Self-directed learning and behavioral management are essential in professional and social settings, where people must interact with others and manage complex tasks and obligations (Gharti, 2019).

The correlation study shows that students who actively participate in their education have higher cognitive engagement levels. For instance, there were highly significant correlations (p = .691, .720, .654, .658) between levels of self-awareness, learning strategies, learning activities, and evaluation. The evaluation was moderately positively correlated with cognitive engagement (p = .564). This shows that self-directed learners may develop the cognitive abilities to manage their behavior and emotions (van Woezik et al., 2021). Students' ability to manage difficult tasks, solve issues, and adapt to changing situations is typically emphasized in academic and professional settings, making the favorable association between self-directed learning methods and cognitive behavioral management particularly significant in these settings.

Emotional engagement is positively correlated with self-directed learning. Awareness and learning activities had especially strong correlations (p =.608 and .600). Moderate positive correlations were found between learning strategies, evaluation, interpersonal abilities, and emotional and behavioral control (p = .586, .505, .486).

The correlation analysis findings suggest a positive correlation between self-directed learning practices and behavioral engagement. The specific correlations between each self-directed learning practice and each type of behavioral engagement suggest that it effectively uses different types of self-directed learning practices for developing specific types of behavioral engagement. These findings suggest that in behavioral engagement, students seek to develop and engage in self-directed learning practices tailored to their specific needs and goals, with potential implications for personal, academic, and professional success.

In the correlation between students' self-directed learning practices and scientific learning perception, it can be observed that factors such as awareness (p = .746, .679, .749, .720, .765), learning strategies (p = .744, .690, .727, .702 .726), learning activities (p = .637, .654, .648, .664 – excluding Recognition of Assumption, p = .592), and interpersonal skills (p = .623, .646, .614, .672, .690) have strong positive correlations to all aspects of scientific learning perception.

The correlation between students' self-directed learning practices and scientific learning perception suggests that students take an active role in the learning process that contributes to the field of science. The finding shows that the students who are more aware of their self-directed learning practices tend to have higher scientific learning levels, suggesting that self-directed students are more likely to be reflective, evaluative, and metacognitive in their approach to learning. Additionally, engaging in various learning activities and using effective learning strategies have also been important for developing scientific students.

Meanwhile, moderate correlations (p = .514, .485, .519, .522, .556) were found in the correlation values produced when evaluation and all aspects of scientific learning perception were tested. The results suggest that evaluation is an important aspect of scientific learning perception but may not be the only factor contributing to scientific learning development. It is also important to note that evaluation is a higher-order thinking skill that involves making judgments and assessing the quality of information. As such, learners skilled in evaluation will likely be better equipped to engage in scientific learning activities (Maknun, 2020).

Based on the aforementioned findings, the implications of the research imply a beneficial association between self-directed learning practices, behavioral engagement, and scientific learning perception. The results indicate that students who actively participate in self-directed learning practices are more likely to be able to regulate their behavior and grow in their capacity for scientific learning. Skills like goal-setting, self-monitoring, and self-evaluation are crucial for behavioral control, and they may be fostered by promoting self-directed learning practices. Possibilities for better self-awareness, self-control, and motivation to act are raised.

CONCLUSION

The research underscores a substantial and noteworthy association between a student's contentment with blended digital learning and two pivotal dimensions of their educational experience: their behavioral engagement and their perception of scientific learning. This revelation accentuates that the degree of satisfaction derived from the blended digital learning environment directly influences how actively students engage with the learning materials and their overall perspective on scientific education.

Students who express higher satisfaction levels with blended digital learning are more likely to exhibit greater behavioral engagement. This means they are not passive recipients of information; instead, they actively participate in learning, leading to more profound comprehension and retention of the material. Such active engagement encompasses many activities, including asking questions, participating in discussions, completing assignments enthusiastically, and proactively seeking additional resources to deepen their understanding. In essence, satisfaction catalyzes heightened involvement and interaction with the subject matter.

Furthermore, the study's outcomes unveil an equally significant correlation related to students' self-directed learning practices. It is evident from the research that students who demonstrate a penchant for self-directed learning exhibit higher levels of behavioral engagement and harbor more favorable perceptions of scientific learning. This correlation underscores the intrinsic motivation and autonomy inherent in self-directed learners. They tend to take the initiative in their learning journey, establishing their goals, seeking out relevant resources, and continually expanding their knowledge independently. Consequently, they are more actively engaged with the learning process and cultivate a deeper and more positive perspective on scientific education.

In essence, these findings accentuate the intricate interplay between satisfaction, self-directed learning, behavioral engagement, and the perception of scientific learning. They underscore the symbiotic relationship between these elements and emphasize the importance of fostering a conducive learning environment that encourages satisfaction and nurtures self-directed learning practices. This approach enhances students' engagement with scientific content and contributes to a more holistic and enriching educational experience. These insights empower educators and institutions to refine their pedagogical strategies and tailor their teaching methods to better align with the needs and expectations of today's learners in the digital age.

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