

Article

Investigating Preceding Determinants Affecting Primary School Students Online Learning Experience Utilizing Deep Learning Neural Network

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Abstract: The pandemic has caused all of the programs that are offered in primary schools to be interrupted. Evaluating the student's learning at this level is essential because education development throughout the epidemic is critical, as there was no other educational alternative available during the pandemic. This study examines the use of deep learning neural network (DLNN) to evaluate the parameters influencing primary school students' online learning experiences during the COVID-19 pandemic. The researchers considered this issue since primary students' online learning experiences needed more attention. To carefully analyze the relationships between the parameters of primary students' learning experience, an online questionnaire was utilized, subject to parents' participation. A total of 385 Filipino elementary school students were selected and surveyed using a purposive sampling method. Participants in this research ranged in age from seven to thirteen and were supervised by their parents or legal guardians. The result of the study showed that open communication, social presence, design and organization, and facilitation had the most impact on predicting students' experiences with online education, having a high accuracy from DLNN of 96.12%. This demonstrates the significance of open communication, draws attention to the importance of helping students feel welcomed and appreciated, and demonstrates the influence that instructors have on the overall positive learning experiences of their students. Finally, the findings of this study gave a strong framework and clear conclusions that both schools and the government's education department could use to improve the way primary education is taught online across the country. Finally, the results and findings of this study could be applied and extended to other related education studies worldwide.

Keywords: primary students; community of inquiry framework; online learning; deep learning neural network



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1. Introduction

The COVID-19 pandemic has harmed the economies of several nations. It altered global operational circumstances within months [1]. The effects of the pandemic are inexorable and unmanageable for several global enterprises, especially the education sector. Around 120 countries ceased face-to-face instruction, affecting the education of nearly one billion children globally [2]. As an emergency action to combat the COVID-19 pandemic, the governments issued orders to close schools and educational institutions worldwide [3]. The impact of COVID-19 on educational institutions was monitored by the United Nations Educational, Scientific, and Cultural Organization (UNESCO). As of 30 March 2020, 87% of the world's children (1.5 billion) were affected by school closures. In accordance, millions

of children involved at the primary and secondary levels were greatly affected, that is those that were enrolled in elementary and secondary institutions [4]. More than 180 nations have enacted countrywide school closures, while others have imposed regional school closures in response to the COVID-19 outbreak [5]. Presently, however, the Philippines have reduced the number of fully online classes, providing a percentage of classes for a semester to be face-to-face. Moreover, other schools are still aligning the classes to be fully online, while others are blended, which offers students the choice of the learning modality they would like to use.

In response to the global outbreak, the Commission on Higher Education (CHED) of the Philippines released guidelines on COVID-19 advisories to prevent COVID-19 virus spread in state and private colleges and universities by means of remote learning for Filipino students [1,3]. COVID-19's Second Advisory Directive on Higher Education utilized distance learning, e-learning, and other teaching methods instead of traditional face-to-face teaching [6]. Different educational administrations in the Philippines have proposed a transition from face-to-face to distance education, highlighting the uncertainty and doubts regarding how this transition is being implemented and its impact on the teaching and learning process for various student sectors, including primary education [7]. The highlight in the education sector of the Philippines showed that macroergonomic appraisals, such as teaching delivery and technology usage for both teachers and students, affected academic performance, including learning styles, and modalities of learning [8].

The importance of uncovering the factors that affect the online learning of primary students is important since primary education is the foundation for all later degrees of education. In relation, the need to assess the student's online learning capabilities at this stage is critical since there was no other option for education during the pandemic. Primary education is an institution for children aged 6 to 11 [9]. This level prepares students for the secondary education level, which is vital to instill fundamental knowledge and abilities among students [10]. Primary school education was one of the most affected educational institutions in the Philippines during the COVID-19 pandemic [5]. It was explained that the ability to focus and maintain attention during online lecture was the most challenging aspect, especially for primary school students whose ability to control themselves in this regard is still developing. In addition, the challenge in navigating online platforms, independence for learning, and overall performance were greatly affected by the online learning modality.

The pandemic has disrupted all primary school programs, including teaching and learning, examinations, extracurricular activities, and academic service programs. As a result of the suspension of classes, the number of children who are not in school has increased. In Ghana, Owusu-Fordjour et al. [11] conducted a study to find out how COVID-19 affects the way schools work. The study identified some of the obstacle students faced during the school shutdown caused by the COVID-19 pandemic; such as students' inability to study efficiently from home, which thus revealed the inefficiency of the online learning method. It also highlighted how the inability of parents to assist their children in accessing online learning platforms and supervise their children's learning at home brought challenges. Related studies, such as those by Ong et al. [1] and Prasetyo et al. [3], discovered how online learning hurt students' ability to learn due to difficulties in adjusting to the new mode of learning, lack of technical expertise with technology gadgets, lack of technological platforms for other subjects, and negative implications brought by the sudden implementation of online learning [11]. Current conditions also limit students who live in rural areas as well as less able parents [12]. Most countries have now reopened their schools to facilitate full face-to-face learning, however, in the Philippines, which is a developing country, is still stuck with blended and online learning—even in the early months of 2023.

In the Philippines, schools are still in lockdown and are still using online learning during the latter half of 2021, and even today in February 2023, limited face-to-face classes are being implemented. Several studies were conducted on the online learning of students. Ong et al. [13] examined college and graduate school students' preferences for online

learning. The study was limited because it only used conjoint analysis and research at a time when the only way to learn was online. Their research article suggested that the study be repeated when both traditional and online learning is available, and that other analysis methods, such as the structural equation model (SEM) and machine learning algorithms, be used. Peltier et al. [14] analyzed the factors of online learning that worked together to influence the quality of online learning. A survey was conducted on college and graduate students using online learning. SEM correlated how the different factors in the study affected the quality of online learning. Factors include the course content, quality of lectures, and interactions between students and teachers. It was also mentioned that online and traditional learning environments should not be treated identically because different variables affect online learning [14]. According to Wu [15], presence and perception are new concepts that affect the learning experience in online learning. The study conducted surveys on college and graduate students and professionals using SEM. It shows that attitude plays an essential role in a person's behavior when studying and that a person's intention to study is weighed by satisfaction and behavior. The mentioned studies expose the lack of research about primary students by focusing on students in college and post-college education.

In education, the relatively new learning medium (online learning) leaves areas that need further research. Thongsri et al. [16] focused on higher education students' adaptation to online learning. The study used SEM and artificial neural network (ANN) to analyze and correlate the relationships of self-directed learning (SDL), motivation for learning (ML), online communication self-efficacy (OCE), and learner control (LC). These factors were the most influential factors for learner readiness in online learning. Bhaumik and Priyadarshini [17] conducted a similar study on senior high school students. In developing countries, such as India, not all students have the devices necessary for online learning. Results showed that some students do not have the proper devices to fully utilize the necessary learning materials, while others do not have good internet connections. Students also experience fatigue and isolation from online learning, which is why suitable learning environments are essential. Their study is limited by using descriptive statistic techniques and focusing only on senior high students.

In New Zealand, Mawson [18] investigated the factors influencing technology learning in elementary school. Several personal and systemic elements were discovered to influence the development of technical literacy. In the US, Glass [19] also studied the factors affecting learning, utilizing attributes, such as changes in physical and sensory capacities, speed and timing, attitudes, learning capacity and performance, changes in memory, and changes in adjustment ability and morale. However, older people are the focus of this study. In India, George et al. [20] found that five things affect a nursing student's ability to learn: the learning environment, services that help the student, qualities of the teacher, problems that the learner faces, and personal factors. It was discovered that the students' perspectives influences learning-related parameters. During COVID-19 in the Philippines, Ong et al. [21] discovered the characteristics of online learning chosen by senior high school students. However, only the delivery type, assigned tasks, evaluation, virtual laboratory, interface layout, and delivery platform were considered. Despite the available studies, no literature covers the behavioral experiences of primary students with online learning.

Prior research has addressed the factors that influence student learning; however, none of these studies have used the community of inquiry (CoI) framework with factors, such as teaching presence, social presence, and cognitive presence, in analyzing the primary school learning experience. Therefore, the CoI framework used by Garrison et al. [22] could be used to assess the general learning experience of primary pupils by measuring the various preferences. Saadatmand et al. [23] used the CoI Framework to examine how the students talked to each other in an open online course for professional development at three Swedish universities. The study looked at how students interacted with each other and how they thought the teacher, other students, and themselves were present in the open online course.

A study by Stodel et al. [24] also identified learners' perceptions of what needs improvement in online learning. It suggested how to continually create new ideas and

improve online learning using a CoI framework. Smadmi et al. [25] considered the CoI framework and how it could be used in assessing nursing learning online. The study found that the CoI framework could help online education by addressing teaching methods, technology, and students' needs. However, there has not been much research on how CoI can be used in online education. Shea [26] stated that the advancement of the CoI framework for online learning has been widely applicable. It helped people in online learning, educational technology, and educational psychology communities in an attempt to learn more about each other's core knowledge.

Standard practices when analyzing the behavioral factors affecting the intentions or experiences of an individual utilize SEM. However, several studies have extensively criticized this multivariate analysis tool. Fan et al. [27] interpreted the results from SEM, critically implicating the lower significant output of relationships due to the presence of mediating effects. Woody [28] also assessed SEM and presented little to no significance of factors having several mediators. Thus, the present study aimed to assess factors affecting the learning experience of primary students' online learning during the COVID-19 pandemic utilizing DLNN. DLNN was widely used to determine the feature importance of behaviorism, cognitivism, and social constructivism.

According to Mahanta [29], neural networks can handle non-linear and complex relationships in various applications, such as pattern recognition, simulation, classification, and optimization. Ong et al. [21] suggested that this algorithm, neural network, may be used to its maximum capability for analyzing variables influencing human behavior. It was determined how this technique significantly improved the study's accuracy and findings regarding human behavior compared to SEM. With this in mind, the present study is considered as the first study to analyze the online discussion experiences of primary pupils in the Philippines during the COVID-19 pandemic. This study's significant and substantial findings would help schools, government organizations, and all facilitators who are experiencing the existing delivery of online learning in primary education. Hence, the results and findings of the study can be utilized as a guide to further improve and optimize the experience that the primary students encountered in an online setting. Lastly, the findings of this study can be applied and extended in other countries since the basic foundation of learning was assessed.

2. Theoretical Research Framework

As outlined by the community of inquiry (CoI) framework (Figure 1) utilized in this study, there are specifications that must be present for an online discussion experience to be measured as successful. The three identified variables from the main framework are the cognitive presence, instructional presence, and social presence, which correlate to the online discussion experience evaluation [30]. This research broadens the scope of the framework to isolate the crucial elements of elementary school children's online classroom discussions.

The theoretical framework, shown in Figure 2, is based on the learning theories (behaviorism, cognitivism, and social constructivism) and the CoI framework. The CoI framework was implemented because it is a validated framework that can be used to evaluate educational experiences in online learning [31]. They were used together to create a more specialized framework for the study's use case, to evaluate the factors that influence the perceived online learning experience of Filipino primary students.

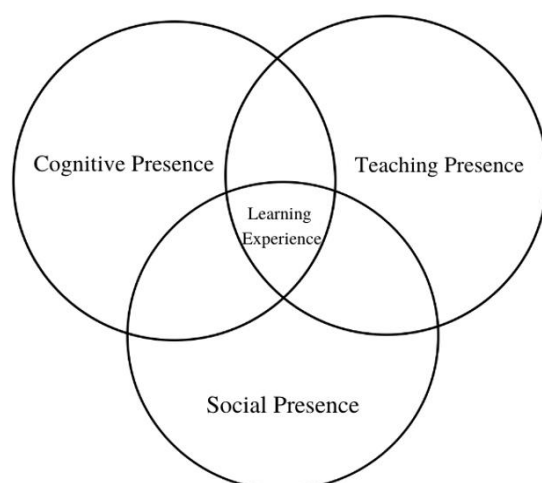


Figure 1. The community of inquiry framework.

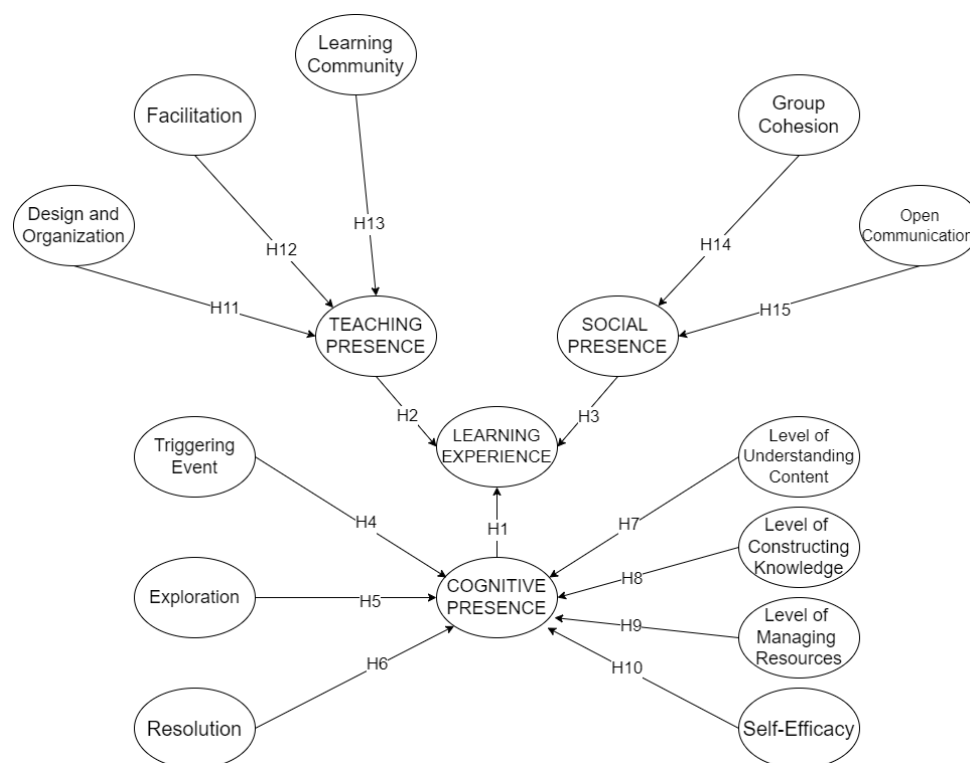


Figure 2. Theoretical research framework.

Behaviorism, cognitivism, and social constructivism are modified by the theoretical model to create interactions. According to previous studies, the three factors, teaching presence (behaviorism), cognitive presence (cognitivism), and social presence (social constructivism), are said to greatly influence online discussion experiences. Madrell et al. [32] explained that these components support the development of higher-order thinking abilities in both students and instructors. Therefore, it was hypothesized that:

H1. Cognitive presence greatly influences the online learning experience.

Cognitive presence is the learners' proficiency in constructing and validating meaning through reflection and conversation [26,33]. Garrison and Vaughn [30] stated that the primary goal of cognitive presence is to assist students in advancing the skills necessary to go through the first stages of learning. Students' involvement in developing and using ideas in learning, such as asking questions and providing disputes, is essential to a high-quality

online discussion experience [34]. According to Anderson et al. [35], successful online discussion participation depends on the growth and integration of both the cognitive and social processes. Additionally, teaching presence is essential to determine the instructors' roles and responsibilities in the online environment, which includes constructing helpful learning content [36]. Yalcin and Erden [37] stated that having access to something like this helps students improve their ability to think creatively and solve problems. As a result, it was hypothesized as:

H2. *Teaching presence greatly influences the online learning experience.*

According to Kreijns et al. [38], social presence emphasized how the involvement and engagement of students affected the online learning environment. Ong et al. [21] pointed out that it is essential for these students to build connections with other students, particularly in an online setting. This would help them acquire the self-assurance necessary to engage in the exchange of ideas and perspectives. Regarding the socio-emotional environment of online classes, Cifuentes [39] considered technology and media as a suggestion to motivate students in distance and online learning. Moreover, Ong et al. [21] stated that other students' participation significantly impacts the student's learning experience. From this, it was hypothesized that:

H3. *Social presence greatly influences primary students' learning experience.*

Through the practical inquiry model (PIM) developed by Garrison et al. [22], exploration, integration, triggering events, and resolution are identified as the higher-order learning stages. These variables are necessary to understand and interpret cognitive presence. Meanwhile, Schrire [40] mentioned that PIM is a framework for illustrating the knowledge-creation process. Sadaf and Olesova [41] then expanded it to use it as an approach for computer-mediated communication in online classes. Thus, the succeeding hypotheses can be proposed:

H4. *Triggering events greatly influences cognitive presence and the process of knowledge and comprehension.*

H5. *The process of knowledge and comprehension by cognitive presence is affected by the exploration.*

H6. *The process of knowledge and comprehension by cognitive presence is affected by the resolution.*

In accordance with the analysis of Bangert-Drowns and Pyke [42] and Kang et al. [43], comprehension of the content significantly impacts cognitive presence. Further, it has been demonstrated that committed students who comprehend the material are more totally and intellectually engaged in their learning activities. In light of this, Wang and Kang [44] provided an explanation of how knowledge construction encourages the processing, diffusion, and creation of information, demonstrating how learners rely on the information at hand to formulate concepts and meaning. According to Oztok [45], creating knowledge is a collaborative process rather than a final product. Based on Ültanir [46], what people can learn through awareness and cognition depends on their perceptions and knowledge. Consequently, it was proposed that:

H7. *Understanding the topics taught by the cognitive presence is determined by the level of understanding.*

H8. *Learning through perception and understanding alongside cognitive process is determined by the level of constructing knowledge.*

A high degree of management of learning resources is required to generate clearly defined learning goals and arrange course content, resulting in a successful learning outcome [43]. A study by Woolfolk [47] also stated that a classroom function is multifunctional, time-sensitive, and laden with various students and responsibilities. An effective and efficient technique is essential for managing and distributing the learning materials equitably among the learners in such a situation. In support, Ong et al. [21] discovered that

the administration of labs and courses during online classes is seen as difficult and is not readily accepted by students. Moreover, Prasetyo et al. [3] have shown that simplicity of use is one of the most essential factors in achieving student satisfaction with online learning systems. Thus, it was hypothesized that:

H9. *Utilizing available learning materials effectively and efficiently has a major impact on mental availability.*

The effects of confidence in one's ability to study online were studied by Lin et al. [48]. It has been discovered in their study that this assertion would significantly impact the motivation of the learners to exert effort. Subsequent research by Wang and Shan [49] corroborated these findings by arguing that students' self-efficacy levels correlate with their level of effort and perseverance in school, and hence, their level of knowledge. Ong et al. [21] demonstrated that it is an element influencing future intentions to get further information by pursuing chemistry-related courses. As a result, this study proposed that:

H10. *Self-efficacy has a substantial impact on cognitive presence by instilling trust and belief in the learner's talents and expertise.*

In the online learning environment, design and structure are believed to be crucial considerations. A teacher's job is to create a learning environment that is engaging and conducive to student participation. According to Khuana et al. [50], instructors may get a birds-eye perspective of all that a course has to cover by using well-prepared and arranged learning material. Furthermore, Ong et al. [13] showed that the way content and learning materials are designed and organized is one of the most important reasons students like online learning. Thus, it was hypothesized that:

H11. *Design and organization have a substantial influence on a teaching presence's ability to build a practical blueprint of knowledge material.*

Students in learning environments can better focus on and discern their classes with teachers who can facilitate them sufficiently [35]. According to Shea et al. [51], teachers who implement course content themselves with clear communication help students feel more connected, which helps students learn more in discussions and tasks. Additionally, Shea et al. [26] mentioned that students in learning environments can utilize the importance of working in groups. Similarly, forming a good learning community between students and teachers is essential to give students academic support to promote persistence and social practices in studying [52]. Successful online learning is tied to the growth of students with the help of an online learning community [53]. Thus, the following were hypothesized:

H12. *Facilitation is an essential factor of teaching presence that engages learning in students.*

H13. *Learning communities are an essential factor for teaching presence to form an environment of learning.*

Yoo and Alavi [54] stated that cohesive groups have positive and close bonds between the members, which strengthen social presence through communication. A peer's contentment and satisfaction with other peers affects the social integrity of the group's cohesion with one another [55]. As a result, Kreijns et al. [38] discovered that learning gets easier as learners collaborate, interchange ideas and perspectives, and interact with each other. Increased participation and learning are closely related to the amount of interactions between students [56,57]. Similarly, Kreijns et al. [38] and Routman [56] both acknowledged the great impact of open communication on student's social interactions and online learning experiences.

H14. *Group cohesion is an essential factor of social presence that affects the relationship and social integration of the members.*

H15. *Open communication is an essential factor of social presence that affects the interaction and collaboration of ideas in communication.*

3. Methodology

3.1. Participants

During the COVID-19 outbreak, 385 primary school pupils from the Philippines (Table 1) were gathered and surveyed using purposive sampling. The research participants varied in age from 7 to 13 years old and were supervised by their parents and guardians. The information was gathered through various social media platforms from November 2021 to February 2022. The respondents that were taken into consideration are currently enrolled as elementary students at various schools in the National Capital Region of the Philippines. More specifically, the students who took part in the research are from the cities of Valenzuela (158), Marikina City (105), Quezon City (62), San Juan City (38), and Mandaluyong City (22).

Table 1. Descriptive statistics of the respondents ($n = 385$).

Characteristics	Category	<i>n</i>	%
Gender	Male	183	47.50%
	Female	202	52.50%
Age	7	37	9.80%
	8	40	10.30%
	9	41	10.60%
	10	67	17.40%
	11	94	24.40%
	12	86	22.30%
	13	20	5.20%
Residence	Mandaluyong City	22	5.70%
	Marikina City	105	27.30%
	Quezon City	62	16.10%
	San Juan City	38	9.90%
	Valenzuela City	158	41.00%

According to Hair [58], the typical number of respondents needed for social science research to achieve generalizability is between 250 and 300 people. Therefore, one could argue that the dataset that was collected for this study is representative of the general population of primary school students during online class set-up.

3.2. Questionnaire

The theoretical framework was to devise a self-administered questionnaire to assess the factors influencing students' perceived online learning experience at the primary level (Table 2). The adapted questionnaire comprised four main sections: (1) Cognitive Presence, (2) Teaching Presence, (3) Social Presence, and (4) Learning Experience, which was evaluated using a 5-point Likert scale.

The cognitive presence comprises seven latent variables: (1) triggering events, (2) exploration, (3) resolution, (4) level of understanding content, (5) level of constructing knowledge, (6) level of managing resources, and (7) self-efficacy. Three latent variables make up the teaching presence: (1) design and organization, (2) facilitation, and (3) learning community. Social presence contains two latent variables: (1) open communication and (2) group cohesion, while affective expression is an indicator.

There were 64 indicators in total, 15 latent variables, and were all adapted from the references. Prior to the distribution, a pilot test was done to validate the adapted questionnaire. The result garnered a Cronbach's alpha value of 0.835, which is considered acceptable [58].

Table 2. Table of constructs.

Construct	Items	Measures	Supporting References
Cognitive Presence	CP1	I raised questions in the class that integrating new information.	[59]
	CP2	I constructed explanations for solutions through learning activities.	[59]
	CP3	I understood the basic and important lessons in the class by reflecting on its contents and discussions.	[59]
Triggering Events	TE1	My interest increased because of the problems presented in the course.	[59]
	TE2	My curiosity increased because of the class activities.	[59]
	TE3	My motivation to explore content-related questions increased.	[59]
Exploration	E1	I explored the problems in this course with different information sources.	[59]
	E2	I resolved content-related questions with the help of related information and brainstorming.	[59]
	E3	I appreciated different perspectives because of online discussions.	[59]
Resolution	R1	I am able to discuss ways to test and apply knowledge gained in the class.	[59]
	R2	I am able to develop solutions to the class problems by practice	[59]
	R3	I can apply the knowledge created in the class.	[59]
Level of Understanding Content	LUC1	Class content is something I want to learn.	[60]
	LUC2	Class content is what I expected.	[60]
	LUC3	I am able to understand the content of the class well enough to apply it.	[60]
	LUC4	I am able to organize what I learned in my class.	[60]
	LUC5	I am able to outline what I learned and understood in my class.	[60]
Level of Constructing Knowledge	LCK1	I search for other course-related materials.	[60]
	LCK2	I think that I can select course-related materials if needed to gain more information.	[60]
	LCK3	I think that I can use my class learnings to do assignments.	[60]
	LCK4	I think that I am learning in this class.	[60]
	LCK5	I am gaining a new perspective through this class.	[60]
	LCK6	I think that I am able to apply my knowledge in reality.	[60]

Table 2. Cont.

Construct	Items	Measures	Supporting References
Level of Managing Resources	LMLR1	I think that I can finish my assignments before the due date.	[60]
	LMLR2	I reorganize the material for the assignment, the course activity, and the discussion.	[60]
	LMLR3	I look for a comfortable environment so that I can focus on my study.	[60]
	LMLR4	I feel that I can control the obstacles that disturb my study.	[60]
Self-efficacy	SE1	I am able to perform well in a self-regulated online class.	[61]
	SE2	I am able to learn class materials presented in the class even with technical difficulties.	[61]
	SE3	I am confident to learn without the assistance of the teacher.	[61]
	SE4	I think it is difficult to understand class content in the online class.	[61]
	SE5	I am confident I can do a good job in the self-regulated online class.	[61]
	SE6	I am confident that I can comprehend difficult class-related materials.	[61]
	SE7	I am confident that I can learn the class-material discussed even with distractions.	[61]
Teaching Presence	TP1	The teacher helped the class to focus on the relevant discussion on issues that helped me learn.	[59]
	TP2	The teacher provided feedback, which made me know my strengths and weaknesses related to the class' goals and objectives.	[59]
	TP3	The teacher gave feedback on time.	[59]
Design and Organization	DO1	The teacher discussed relevant class topics.	[59]
	DO2	The teacher delivered the relevant class goals.	[59]
	DO3	The teacher clearly presented on how to participate in the class activities.	[59]
	DO4	The teacher presented important deadlines for the class activities.	[59]
Facilitation	F1	The teacher helped find agreement and disagreement parts in the class, which helped me to learn.	[62]
	F2	The teacher guided the class in understanding the topics that helped me clear my thinking.	[62]
	F3	The teacher helped the class to engage and participate in a productive dialogue.	[62]
	F4	The teacher helped to keep the class on the task, which helped me to learn.	[62]
	F5	The teacher encouraged the class to explore new concepts to learn.	[62]
	F6	The teacher's actions strengthened the growth of a sense of community in the class.	[62]

Table 2. Cont.

Construct	Items	Measures	Supporting References
Learning Community	LC1	I think that my classmates care about each other.	[50]
	LC2	I think that I am given a chance to ask questions.	[50]
	LC3	I think that I am connected with my classmates.	[50]
	LC4	I think that it is difficult to get help whenever I have questions.	[50]
Social Presence	SP1	Knowing my classmates made me feel that I belong in the class.	[63]
	SP2	I was able to make different impressions of some classmates.	[63]
	SP3	Online communication is a good way of interaction with my classmates.	[63]
Open Communication	OC1	I felt comfortable communicating online.	[63]
	OC2	I felt comfortable contributing in the class discussions.	[63]
	OC3	I felt comfortable socializing with my classmates.	[63]
Group Cohesion	GC1	I felt comfortable disagreeing with my classmates while keeping my trust in them.	[63]
	GC2	I felt that my outlook was recognized by my classmates.	[63]
	GC3	I developed a sense of teamwork through online discussions.	[63]
Online Learning Experience	LE1	I integrated important points to my own understanding when looking at online posts	[64]
	LE2	Online posts gave me time to evaluate what I was to post as a new discussion or reply.	[64]
	LE3	My main concern when looking at online discussions was avoiding posting topics that suggest that I do not know much.	[64]
	LE4	I posted online materials late.	[64]

3.3. Data Pre-Processing

The machine learning algorithm (MLA) was used once proper data preparation had been completed. Initially, Jupyter Notebook 6.4.8 was used to look at the missing data, however, there was no missing data to be found. Furthermore, the correlation analysis was used to clean the data by removing nonsignificant indicators with a p -value higher than 0.05 and correlation coefficient of 0.2 and above. This was done so that the study could be used effectively with significant indicators.

The average of the various indicators was used to aggregate the data to represent the input for the MLA. The indicators that were included in the questionnaire stand in for the latent variables that were taken into consideration for this study. The 15 variables (COG, TP, SP, TE, EX, RES, U, CK, MR, SE, DO, F, LC, OC, and GC) were examined by Jupyter Notebook 6.4.8 for the MLA. After data normalization, deep learning neural network was used to predict the factors that influence the perceived online learning experience among primary students.

3.4. Deep Learning Neural Network

A DLNN is a pattern-recognition machine learning patterned on the human body that imitates how neurons work and communicate together [65]. It is an algorithm that can recreate the functions of the human brain into mathematical functions [66]. DLNNs are used in studies that need human behavior, such as predicting decisions [67,68]. A study by Roark et al. [69] utilized a neural network to examine and simulate human behavior on the perceptions of category learning. A DLNN is comprised of 3 layers: input, hidden, and output layers. Each layer is made of multiple nodes, which can be configured depending on the use case. This study used 15 nodes in its input layer (the latent variables), two hidden layers with optimized nodes from 10 to 100, and one output node (online learning experience). The 15 nodes used were the normalized aggregated data of COG, TP, SP, TE, EX, RES, U, CK, MR, SE, DO, F, LC, OC, and GC. This study considered a feed-forward neural network process. The number of nodes in the hidden layers varies to find the most accurate results.

Furthermore, DLNNs have parameters (activation functions (AF) and optimizers), as seen in Table 3, that alter how the neural network interprets the data. The AF in a DLNN is the set of mathematical equations that processes the pattern recognition. Optimizers, on the other hand, are how the neural network reduces losses when ‘learning’. Multiple works of literature were used to find an AF and optimizer for the study. Sample runs with different configurations were done to find the optimal AF and optimizers. The hidden layers considered ReLu [67,70], Tanh [67,71], Softmax [67,72], and Sigmoid [67,68,70,71,73–75]. The output layer considered only Sigmoid [68,74,76], while the optimizers used were RMSProp [72], Adam [77], and SGD [78,79].

Table 3. Deep learning neural network parameters.

Hidden Layer Activation Function	References
Sigmoid, Tanh, ReLu	[70,72]
ReLu, SeLu, Sigmoid, Tanh	[67,76]
Tanh, Sigmoid	[71]
Sigmoid	[68,73–75]
Softmax, ReLu, Sigmoid	[80]
Output Layer Activation Function	References
SiLu, ReLu, Sigmoid	[76]
Softmax, ReLu, Sigmoid	[80]
ReLu, Softmax, Tanh	[72]
Sigmoid	[68,73–75]
Optimizer	References
RMSProp	[72]
Adam	[77]
SGD	[78,79]

The methodology of Pradhan and Lee [81] guided the study’s neural network by having 10 to 100 iterations with 150 epochs. An epoch is a hyperparameter that represents one cycle of the dataset training. After ten runs with 150 epochs, the number of nodes was changed by an interval of 10 (max. 100). A total of 7200 iterations were necessary for the initial optimization of data.

4. Results

A 96.12% accuracy rate of the deep learning neural network was attained after the final optimization process. The hidden layer activation function that was utilized in this study was Sigmoid, and Softmax was used for the output layer activation function. With Adam as the optimizer at 90:10 training and testing ratio with 200 epochs, Figure 3 represents the final DLNN classification model.

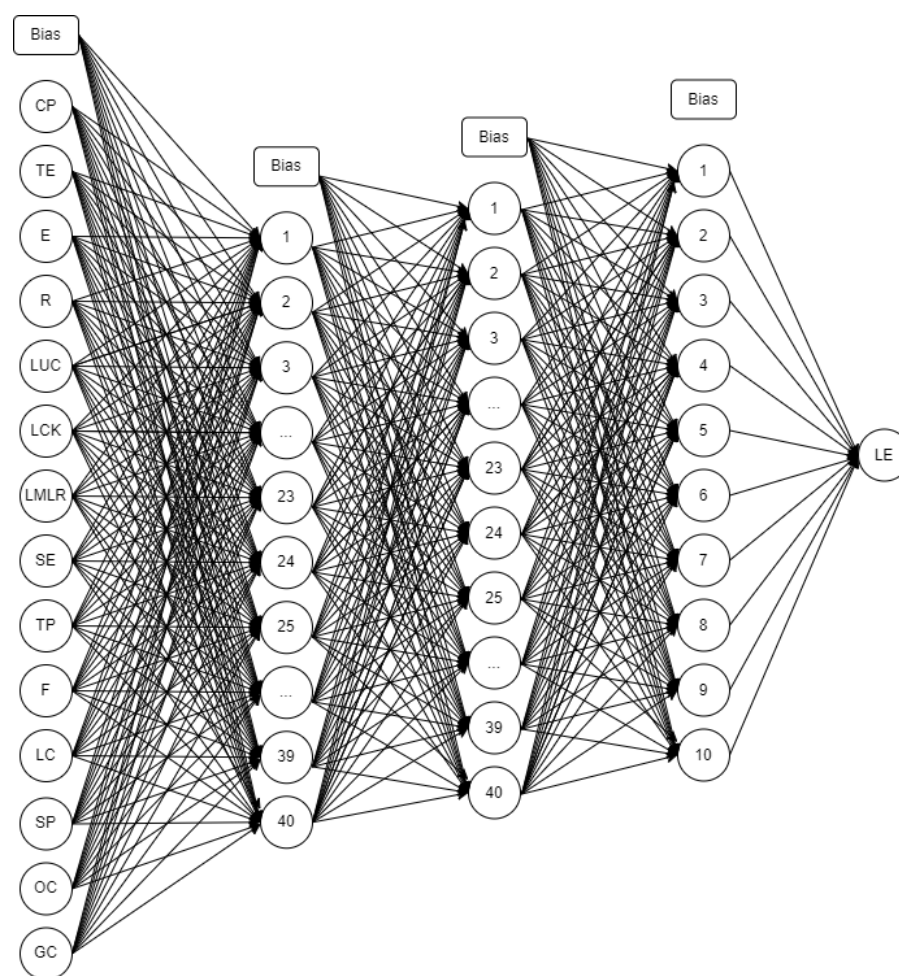


Figure 3. Optimum deep learning neural network model.

With 3 hidden layers, the optimum nodes were 40, 40, and 10, respectively. The resulting training and testing average output are presented in Table 4. From which, it can be seen that open communication, social presence, design and organization, and facilitation were the key factors affecting the online learning experience of primary students. The teaching presence and cognitive presence were also significant factors with facilitation, level managing resources, self-efficacy, level of constructing knowledge, and exploration.

Table 4. Summary of DLNN results.

Latent Variable	Average Training	Standard Deviation	Average Testing	Standard Deviation
Open Communication	93.63	0.103	94.17	0.084
Social Presence	93.04	0.160	93.09	0.068
Design and Organization	90.81	0.184	91.10	0.069
Facilitation	88.33	0.105	90.78	0.087
Teaching Presence	86.27	0.063	86.51	0.150
Cognitive Presence	86.12	0.157	84.04	0.098
Level of Understanding Content	85.56	0.161	81.02	0.074
Level Managing Resources	80.43	0.128	79.43	0.151
Level of Constructing Knowledge	71.98	0.049	75.59	0.124
Self-Efficacy	63.48	0.150	72.34	0.079
Exploration	62.78	0.129	70.18	0.149
Resolution	58.26	0.051	68.39	0.061
Triggering Events	58.48	0.118	65.20	0.015
Group Cohesion	56.02	0.014	61.84	0.058

To verify the findings of this study, the score of importance described in the study by German et al. [82] was implemented. Presented in Table 5 are the normalized score of importance showing the same results. In addition, the Taylor diagram to test the accuracy rate were also considered and calculated for this study.

Table 5. Normalized Score of Importance.

Factor	Normalized Percent Importance
Open Communication	100.0%
Social Presence	98.3%
Design and Organization	96.5%
Facilitation	96.0%
Teaching Presence	87.8%
Cognitive Presence	87.2%
Level of Understanding Content	86.5%
Level Managing Resources	84.2%
Level of Constructing Knowledge	82.8%
Self-Efficacy	81.3%
Exploration	67.4%
Resolution	63.8%
Triggering Events	63.7%
Group Cohesion	61.1%

With a 90% threshold for the correlation of the accuracy with the standard deviation, a 20% error through the root mean square error was set. It could be seen that the highly relevant factors were within range showing that the results were accurate. In accordance, the different factors were also within the threshold set [82], which represents an acceptable machine learning accuracy result. Presented in Figures 4 and 5 are the Taylor diagram and training and validation loss rate, respectively, which shows no under(over)fitting.

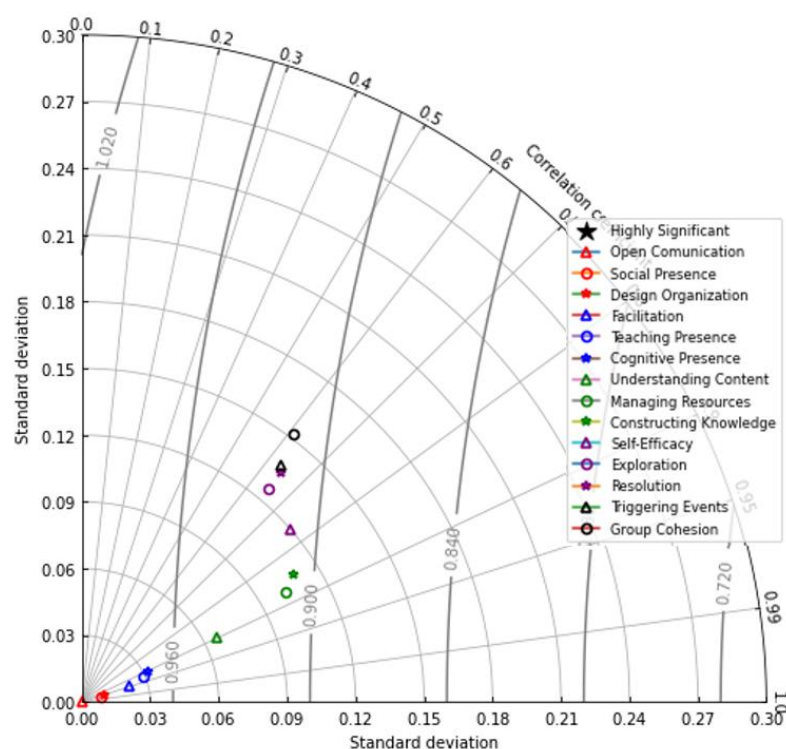


Figure 4. Taylor Diagram.

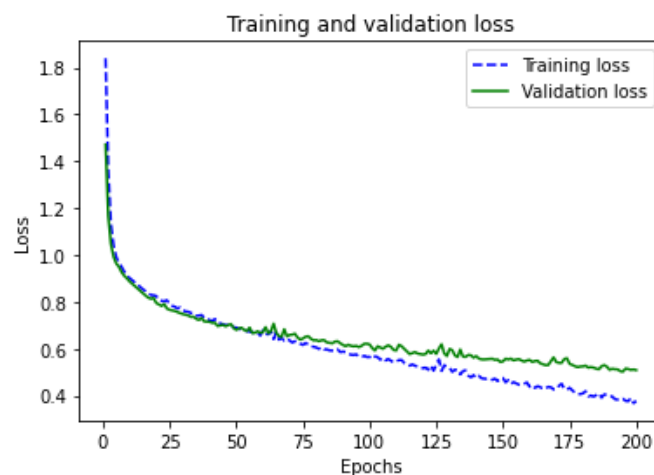


Figure 5. Training and validation loss rate.

5. Discussion

Education is the foundation of society, and for that reason, studying the perceived online learning experience of students is crucial. This study aimed to predict the factors affecting primary students' perceived online learning experience utilizing the community of inquiry (CoI) framework. A deep learning neural network (DLNN) was used to simultaneously assess several latent variables that affect the online learning experience. With an overall accuracy rate of 96.12%, the sequential results are discussed. In addition, obtaining the root mean square error of 0.158, and precision and recall scores of 0.9553 and 0.9601, respectively, showed high acceptability of the neural network model considered in this study [82,83].

The results show that open communication (OC), a latent variable of social presence, has the highest significance effect on the online learning experience among primary students. The students in an online setting indicated that they were comfortable contributing to class discussions, communicating, and socializing with classmates. This shows that primary students can have a positive learning experience when they are able to communicate openly in an online class. A study by Poht [84] also agrees that students have a better educational learning experience when there is healthy and meaningful transactional communication. Additionally, Kear [85] states that open communication is also essential in learning as it is a social process. From present literatures, Sedláček and Šedová [57] discussed how open communication builds not only social abilities among students, but also builds trust, which delivers comfort among students. Thus, learners should be able to communicate comfortably to have a practical learning experience in online learning.

Social presence (SP) is another highly significant variable. Indicators presented that students find online communication helps to make impressions of one another without feeling out of place, which is in line with Cleveland-Innes and Campbell [86]. It was discussed that social presence is a way for learners to express oneself with others positively. In addition, Aragon [87] claims that social presence creates a sense of community. Kear [85] also mentions that the lack of social presence can lead to misunderstandings and a lack of interest resulting in ineffective education. This is one attribute that is challenging during online learning since students do not have time for interaction aside from during the classes allotted for lectures [88]. It is suggested for schools offering online learning to have students feel welcome and validated, provide time for communication, and promote socializing among classmates. This is because students feeling welcome and validated when they are able to be themselves, for being oneself creates a sense of community and promotes a positive learning environment [89].

Design and organization (DO) and facilitation (F) are the third and fourth most significant factors, respectively. Both DO and F are latent variables of teaching presence. Students found that teachers being able to clearly provide the lessons, task instructions,

and deadlines under DO is essential for a positive learning experience. While teachers that engage their students in lessons and tasks, promote higher-order thinking, and provide support and guidance were the important indicators found under F. These findings agree with the study of Shea et al. [51]; teachers should make their students feel accepted and encouraged to participate in class. Moreover, Murphy [36] explained that teaching presence determines the responsibilities of the facilitator, which includes designing learning materials that are helpful to students. Therefore, the quality of directions, materials, and courses that a teacher provides creates a better learning experience, similar with the discussion of Balta-Salvador et al. [89].

The next most significant factor is teaching presence (TP) itself. Indicators show that students have a better experience when teachers can guide students and provide feedback to keep students on track. The study of Akyol and Garrison [90] discovered that teaching presence not only greatly affects the student's learning but also the student's satisfaction in class. Moreover, Anderson et al. [35] states that teaching presence is dependent on the cognitive and social presences as well, indicating a need for balance in the education sector to improve the satisfaction of students in an online learning setup. Thus, teaching presence is needed to guide students and provide feedback to motivate and improve students' work. In the study of Ong et al. [13], it was seen that despite students' preference for self-learning, there would come a time that students would feel the need for facilitators, teachers, or administrators to guide them in their academic works.

Cognitive presence (CP) and level of understanding of content (LUC) were also proved to have a significant relationship with the online experience of elementary pupils. Cognitive presence relates to the ability of students to understand the lessons and discussions. It shows that with the help of the material presented and participation in class discussions, the student has shown an understanding of the fundamental and fundamentally significant concepts covered in the class. According to a study made by Akcaoglu and Lee [91], having higher levels of student cognitive presence, brought about by centering the lesson on a case-based discussion, led to enhanced learning results. A similar study made by Jo et al. [92], also indicates that students' total cognitive presence has a significant bearing on how well they do academically. However, the challenge that current online learning set-ups face is the ability of students to focus during lectures [93]. Provided with a lot of easy distractions at home, students tend to have lower concentrations, which should be considered by teachers.

Correspondingly, the level of understanding content (LUC) relates to the capability of understanding the material covered in the class to the point that the students can effectively apply it. Several studies showed that it is important for the instructors to have an idea of how satisfied the learners are with the quality of the e-learning content and the current content that is being delivered within the context of the online learning setting [3,21,94]. According to a study made by Ehlers [95], it was determined that learning material was one of the most essential aspects to consider when evaluating the overall quality of online learning. This suggests that the content of the learning itself as well as the content of the website have a favorable impact on the quality of online learning and the satisfaction of the students [94]. Thus, it shows that the students should have more experience and a higher cognitive presence to learn effectively. In addition, instructors have to pay careful attention to the process of developing course material as well as the designing of the overall course structure.

The level of managing resources (LMR) and the level of constructing knowledge (LCK), which are the variable of cognitive presence, also have a significant relationship to the perceived online learning experience. This explains that having an effective and efficient use of available learning resources has a significant influence on mental availability among students. Similarly, this suggests that learning through perception and understanding alongside cognitive processes is determined by the level of constructing knowledge; where students can pick course-related resources if they want further information and utilize this new knowledge into reality. These findings are similar to the study made

by Okongo et al. [96], where the utilization of resources in education produces successful learning results when the resources promote and motivate student learning. This is supported by a study made by Momoh [97], who argued that material resources had a substantial impact on student accomplishment because they enhance the acquisition of abstract concepts and ideas while discouraging rote memorization. Furthermore, Wang and Kang [44] gave an explanation of how knowledge building promotes the processing, dissemination, and generation of information, illustrating how learners depend on readily available information to develop ideas and meanings.

Moreover, self-efficacy (SE) and exploration (E) significantly affect the online learning experience. The indicators of SE showed the student's ability to perform well in self-regulated online courses, comprehend course materials despite technical issues, study independently, accomplish well in class, and continue studying even with distractions. This demonstrated that if students feel confident in their capacity to study and learn independently, they are more inclined to achieve a high level of thinking. According to Ong et al. [13], children who seem to be confident in their capacity to learn indicate a drive to study, which encourages them to think critically. However, Wang and Shan [49] argued that learners with varying levels of SE demonstrate consistency with efforts and persistence, which raises the likelihood that it will have an influence on their level of cognition. In addition, the indicators of E showed that learners utilize different sources, explore, and resolve content-related questions and find a better perspective. This indicates that students' effective use of knowledge in identifying issues and resolving them strengthens their cognitive capacities and encourages them to develop a new approach in understanding them. According to Schire [40], exploration is important in education, particularly for young learners since it helps them become aware of various course components. These findings are similar to the study of Sadaf and Olesova [41], which states that learners who are pushed and encouraged to explore higher education are more likely to apply critical thought and to approach problems from a variety of disciplinary perspectives.

Finally, resolution (R), triggering events (TE), and group cohesion (GC) were proved to have the least significant relationship to the student's online learning experience. Resolution and triggering events are latent variables of cognitive presence. The indicators showed that resolution influences the process of cognitive presence-based knowledge and understanding. Along with this, cognitive presence's ability to process information and understanding was profoundly impacted by the occurrence of triggering events. This suggests that students were able to discuss ways of assessing and applying lesson gained in class and the motivation of students to investigate content-related issues were enhanced. A study made by Siklander et al. [98] states that the intensity of a person's attention may be drastically altered and directed by triggers in either a favorable or bad manner. In the beginning, an interest that is sparked by a good trigger may be a transitory emotion; thus, instructors need to be aware of triggers so that they can detach their students' interest from the subject. A cognitive and emotional motivational component, the interest that is generated by triggers is a factor beside which increasing interest, self-efficacy, goal orientation, and self-regulation may emerge. This shows that the processing of information and understanding was significantly impacted by the circumstances that triggered cognitive presence. The resolution also has an effect on the method of knowing and comprehending that is carried out by cognitive presence.

Group cohesion has the least significant relationship with the students' online learning experience. The indicator shows that cohesion within a group has an impact on the members' ability to form relationships and integrate socially. The level of happiness and pleasure one student has with the company of other peers may have an effect on the social integrity and cohesiveness of the group's relationships with one another. It was found that when students work together, share their thoughts and experiences, and engage in conversation with one another, learning is facilitated and made simpler [38]. Similar findings made by Yoon and Leem [99], who also stated that having a feeling of social presence has a good influence on group effectiveness, and the adjustment effect of having a

sense of social presence also has substantial beneficial effects on group cohesiveness and group efficacy.

Overall, it could be deduced that students were able to integrate important points in online learning to their own understanding, being able to apply them in actual practice. Online lectures give primary students time to reflect on what needs to be accomplished and how to do it, and that they do not post and submit requirements later than the indicated dates. Students are still compliant during online learning, but distractions at home, wavering attention spans, and lack of socialization are challenges that faced during online learning, regardless of the level of learning that they are at [13,100]. This should therefore be considered by teachers and schools along the online learning implementation to promote a positive learning experience among primary students.

5.1. Theoretical Contributions

The CoI framework has been utilized widely in the education sector. However, due to the recent COVID-19 pandemic, a new standard of education was implemented to teach students online. While multiple studies have already utilized the CoI framework, little to none, have tackled primary education as their focus in an online setting. The researchers of this study expanded the framework to find the essential latent variables preceding the three main domains of the CoI framework (social, teaching, and cognitive presences). A DLNN was used in this study to assess and predict the factors that affected the student learning experience. Roark et al. [69] showed the feasibility of using DLNNs in the educational sector because DLNNs can simulate how a human brain thinks and learns. Based on the extended framework, the study's findings may be used by educational institutions to improve learners' satisfaction with distance learning. Future researchers may use this study as a theoretical framework to further assess the student's satisfaction, academic output, and experience with education. Government institutions and educational sectors may also use this study to promote a new standard of education focusing on the improvement of student satisfaction and experience.

5.2. Practical and Managerial Implications

The pandemic has affected all primary school programs, including instruction, assessment, extracurricular activities, and academic service initiatives. Due to difficulties in adjusting to the new mode of learning, lack of technical expertise with technology devices, lack of technological platforms for other subjects, and negative implications brought on by the sudden implementation of online learning, online education hinders students' ability to holistically learn. The findings of this study demonstrated the importance of having open communication when it comes to learning whether online or physical modality. This suggests that elementary school pupils may have a good educational experience in an online setting when they are allowed to speak freely with their peers. The findings also showed the significance of social presence to the students, explaining why students find online communication useful for forming impressions without feeling out of place. Suggesting that having students feel accepted and valued for being themselves fosters a sense of community and a healthy learning atmosphere. Moreover, this study also implies that teachers have a substantial impact on students' overall good learning experiences. The presence of a teacher is required to instruct pupils and offer comments to stimulate and enhance their work. The results of this research will be useful for institutions, school administrators, teachers, parents, and students, as they try to figure out how to effectively incorporate online education into their everyday activities. This study shows how the students in grade schools in the Philippines would have better opportunities for online learning, which suggests that children are still acquiring knowledge in an online environment. This study will also assist educators and government education sectors to enhance their online educational infrastructure.

5.3. Limitations

Even with the positive contributions of the study, several limitations and recommendations were considered. Firstly, the study's results were limited by adapting the online questionnaire's constructs. Future researchers are encouraged to repeat a similar study via a qualitative approach. It is recommended that future researchers interview parents regarding their children's behavior and interaction in online classes. This will provide new information and even elements that were not examined in the current research. In addition, researchers may even observe the primary student's interactions between instructors and classmates concerning the indicators present in the theoretical framework. Secondly, the study was also limited by the usage of only one MLA: DLNN. We recommend using different MLAs to target different parts of the findings. MLAs, such as K-means clustering, support vector machine (SVM), or the naïve Bayes classifier, can be used to identify the factors by similarity and probability, in contrast to the individual findings found with the DLNN. The clustering technique would help segregate individual factors with demographic characteristics for assessment of determinants preceding online learning experience. Lastly, the study did not have a large sample size due to the limitations of the COVID-19 pandemic. Future researchers should gather a larger sample size and separate the private and public-school sectors. In the Philippines, public and private schools have different approaches to online learning, so it is vital to reassess primary students' behavior, perspective, and experiences in online learning. This finding is supported by the study of Bernardo et al. [101], wherein public school students have less motivation to study because of worse facilities, parental support, teaching presence, and unhealthy peer relationships. Thus, the need to consider their environment and learning experience would promote suggestions for implementation of a sustainable learning experience.

6. Conclusions

Recent studies on online learning experiences during the COVID-19 pandemic in the Philippines have primarily targeted high school and college or students in general. The need for more consideration for primary students' online learning experiences entailed the researchers' ought to investigate this problem. The community of inquiry (CoI) framework, which integrates learning theories (behaviorism, cognitivism, and social constructivism), was utilized as a tool as it is a validated framework to assess online learning experiences. The study had 385 valid responses from primary school students under the supervision of their parents or guardians to ascertain their experiences with online learning. Fifteen latent variables were simultaneously analyzed using a machine learning algorithm, namely: (1) cognitive presence, (2) teaching presence, (3) social presence, (4) triggering events, (5) exploration, (6) resolution, (7) level of understanding content, (8) level of constructing knowledge, (9) level of managing resources, (10) self-efficacy, (11) design and organization, (12) facilitation, (13) learning community, (14) open communication, and (15) group cohesion.

The study's final findings indicated accurate results from the DLNN. DLNN showed an overall accuracy rate of 96.12% in predicting significant factors affecting primary school students' online learning experiences. Utilizing DLNN can produce highly accurate predictions. Hence, the utilization of MLA in predicting human behavior is extremely advantageous. Thus, DLNN can assess and predict the factors influencing online learning experiences and be applied to other educational studies. Resultantly, DLNN was able to rank the most significant factors down to the least significant, emphasizing how each of the fifteen significant variables influenced primary students' online learning experiences.

The results of this study show that open communication (OC), social presence (SP), design and organization (DO), and facilitation (F) have the most influence in predicting online learning experiences. This indicates the value of open communication, highlighting the importance of making students feel accepted and valued, and shows the teachers impact on students' overall good learning experiences. This study provided a solid framework and conclusive findings that educational institutions, and the government's education

sector can utilize to improve the country's online primary education delivery. The MLA method used in this study can be expanded upon to predict online learning experiences globally. Therefore, MLA can be utilized in conjunction with other research that is relevant to human behavior.

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