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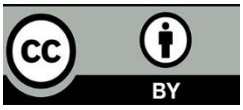

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Rauvolfia Serpentina and *Peperomia Pellucida* as Antiparasitic Spray Against *Rhipicephalus Sanguineus Latreille*

[1]Mahmooda Aziza Bhatti, [2]Mutahir Saeed, [3]Marites Hugo & [4]Jerico Guevarra

Abstract

Rauwolfia serpentina (serpentina) and peperomia pellucida (pansit-pansitan) were used as the raw materials for creating different mixtures to determine which concentration is faster in exterminating Rhipicephalus sanguineus latrille (common ticks). The process used was decoction, the harvested extract was used for the creation of the spray mixtures. The process used three different preparations of mixture concentration with variants concentration ratio of serpentina/pansit-pansitan as: mixture 1 with 50%/50%; mixture 2 with 75%/25%, and mixture 3 with 25%/75%. The study recorded the testing times in exterminating the ticks as: mixture 1 had the results in 1.5 hours (sprayed once), 1.33 hours (sprayed twice), and 1.25 hours (sprayed thrice); mixture 2 had the results in 3.5 hours (sprayed once), 3.42 hours (sprayed twice), and 3.33 hours (sprayed thrice); and mixture 3 had the results in 1.5 hours (sprayed once), 1.42 hours (sprayed twice), and 1.33 hours (sprayed thrice). The experiment showed that mixture 1 and mixture 3 almost had the same results, if not for a few second differences, mixture 1 was always faster than mixture 3, while mixture 2 was left behind for a few hours. Therefore, mixture 1 is the best concentration to exterminate the ticks in a controlled environment.

Keywords: *Serpentina, Pansit-Pansitan, Ticks, Antiparasitic*

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1. Introduction

Rauwolfia serpentina has been used since the pre-vedic period to treat many infections and diseases. It is a large glabrous herb or shrub belonging to the family Apocynaceae and found in Assam, Pegu, the Himalayas, Java, Tenasserim, Deccan, Peninsula, Bihar, and the Malay Peninsula. It is a source of many phytoconstituents including alkaloids, carbohydrates, flavonoids, glycosides, phlorotannins, phenols, resins, saponins sterols, tannins, and terpenes (Chauhan et al., 2017). In a study by members of the Department of Chemistry at HNB Garhwal University, they used the roots of Rauwolfia Serpentina against Salmonella Typhimurium, Escherichia Coli (E-Coli), Citrobacter freundii, Proteus Vulgaris, Enterococcus faecalis, and Staphylococcus Aureus. The researchers have commented that "the research supports folklore" (Negi et al., 2014). On the other hand, pansit-pansitan, scientifically known as peperomia pellucida, is a medicinal plant with anti-gout properties. Its anti-gout properties help lower the uric acid amount in the blood. It was one of the ten medicinal plants which underwent clinical testing as per orders of the Department of Health (DOH).

A study by Akinnibosun et al. (2021) on the antibacterial activity of pansit-pansitan against three-gram negative bacterial isolates showed that the plant indeed has antibacterial properties. The plant undergoes a decoction process, and its extract was added to solvents, namely water, and ethanol. The results varied with the two solvents, wherein peperomia pellucida with ethanol is much more effective than peperomia pellucida with water. While the study focused only on bacteria and viruses using pansit-pansitan and serpentina separately, this study investigated the possibility of mixing the two (2) herbal medicines and finding out if they have powerful and effective effects in exterminating ticks specifically the brown ticks. Brown ticks, scientifically referred to as rhipicephalus sanguineus latrille, is a common tick found almost in any dog. This type of tick is usually reddish-brown in their adulthood, with no specific marks, unlike other species. Brown dog ticks often travel into houses on canines, their preferred hosts, or cats. Because they are found deep within the hair of animals, homeowners may not immediately see them. Adult ticks typically embed themselves to a dog's ears and between its toes, while larvae and nymphs typically attach to the back of the dog. If brown dog ticks do not have a host to feed upon, they will readily seek

out humans for them to survive. The pests attach themselves to an animal's skin to feed on its blood and lay eggs in its fur. After entering homes, they breed and can spread onto residents and other pets (Orkin, 2021).

This study aims to concoct a substance made from serpentina and pansit pansitan that exterminates the brown ticks among the animals. This uses variations of solutions and durations of tick exposure to the mixture. Although these plants have antibacterial properties and ticks are not bacteria, the study used these plants to remove ticks found on domestic cats and dogs, to provide alternative herbal antiparasitic spray without harmful chemicals thus lessening the environmental hazard and health hazard for both animals and human.

2. Literature review

2.1.Serpentina

The existence of enormous therapeutic properties makes Rauvolfia serpentina an essential medicinal plant in the pharmaceutical world (Khurshid et al., 2022). Because of the inclusion of alkaloids, carbohydrates, flavonoids, glycosides, phlobatannins, phenols, resins, saponins, sterols, tannins, and terpenes, the plant is used to treat a variety of ailments (Malviya & Sason, 2016). High blood pressure (Lobay, 2015), emotional agitation, epilepsy, traumas, anxiety, excitement, hysteria, sedative insomnia, and insanity (Ali et al., 2022) have all been treated with plant bits, seeds, and rhizomes for centuries in Ayurvedic medicine (Khurshid et al., 2022).

Rauwolfia Serpentina is noted to have reserpine, a substance that is used to cure hypertension (Lobay, 2015). In a study by the Department of Chemistry at HNB Garhwal University, they used the roots of Rauwolfia Serpentina against Salmonella Typhimurium, Escherichia Coli (E-Coli), Citrobacter freundii, Proteus vulgaris, Enterococcus faecalis, and Staphylococcus Aureus to quantify the reserpine content of the plant and test the antimicrobial effectiveness of its menthol extract. The menthol extract of Serpentina inhibited the growth of several bacterial species and concluded that the study supports the folklore claims of the plant species (Negi et al., 2014). Rauwolfia serpentina has been used since the pre-vedic period for the treatment of a lot of infect more than 50 distinct alkaloids in the plant. Ajmaline, ajmalicine, ajmalimine, deserpidine, indobine, indobinine, reserpine, reserpiline, rescinnamine, serpentine, and yohimbine are the most important alkaloids.

Antimicrobial, antifungal, anti-inflammatory, antiproliferative, antidiuretic, and anticholinergic properties are also known for serpentina. Because of its societal acceptability, greater compliance with the human body, and fewer side effects, herbal medicine is now the source of primary health care for 75–80 percent of the world's population (Ekor, 2014; Welz et al., 2018). As a result, naturally occurring remedies are now alternatives to save millions of patients around the world. The current study attempts to examine the different pharmacological, phytochemical, and medicinal effects of serpentina as a result of both of these properties (Kumari et al., 2013).

In a study, Alshahrani et al. (2021) explored the antibacterial activity of R. serpentina. Ethanolic extract of root was evaluated using the well-diffusion method. Two Gram-positive (Bacillus subtilis and Staphylococcus) and three gram-negative bacteria (Klebsiella pneumoniae, Pseudomonas aeruginosa, and Salmonella typhimurium) were used for the activity of which only three bacteria Klebsiella pneumonia, Staphylococcus, and B. subtilis bacteria are found susceptible. Similarly, Negi et al. (2014) studied the antibacterial activity of methanolic extract of roots (MREt) of R. serpentina. Antibacterial activity was evaluated using the agar well diffusion method against gram-positive and gram-negative bacteria for the determination of minimum inhibitory concentration (MIC) and the diameter of the zone of inhibition (ZOI). The study revealed that Staphylococcus aureus shows the highest ZOI (13 mm) with the lowest MIC (625 µg) and Escherichia coli possess the highest MIC (10 mg), whereas Proteus vulgaris was observed resistant to tested extracts up to 10 mg. Hence, R. serpentina exhibited strong antibacterial activity. Nigussie et al. (2021) used methanolic and chloroform extracts of the leaf and root of R. serpentina for antibacterial activity. The activity was assessed against S. aureus, E. coli, P. aeruginosa, B. subtilis, and K. pneumonia by disk diffusion method. 50 µl/ml concentrations of leaf and root chloroform extracts showed no ZOI against S. aureus and B. subtilis. Maximum zone inhibition was observed at 15.0 mm and 15.5 mm against E. coli for leaf and root extract, respectively. 100 µl/ml concentration showed maximum zone inhibition against all test organisms for both leaf and root extract. All the bacteria were more susceptible to methanolic extract than chloroform ((Chauhan et al., 2017).

Azmi and Qureshi (2012) determined the phytochemistry and effect of Rauwolfia serpentina methanolic root extract (MREt) on diabetic alloxan-induced male mice. Mice were

categorized into diabetic (distilled water at 1 mL/kg), negative (0.05 percent dimethyl sulfoxide at 1 mL/kg), positive (glibenclamide at 5 mg/kg) controls, and three test classes (MREt at 10, 30, and 60 mg/kg). For 14 days, all medications were given orally. MREt included alkaloids, carbohydrates, flavonoids, glycosides, cardiac glycosides, phlobatannins, resins, saponins, hormones, tannins, and triterpenoids qualitatively, while the extract contained complete phenols quantitatively. Root powder was also tested for flavonoids, saponins, and alkaloids. When opposed to diabetic treatment, MREt was shown to be successful in increasing body weights, glucose and insulin levels, insulin/glucose ratio, glycosylated and total hemoglobin in research groups. Total cholesterol, triglycerides, low-density lipoprotein (LDL-c), and relatively low-density lipoprotein (VLDL-c) cholesterol levels were all found to be significantly lower in the test groups. Both research groups' liver tissues showed significant lipolysis and increased glycogenesis. All of the groups had standard ALT levels. In alloxan-induced diabetic mice, MREt increases glycemic, antiatherogenic, coronary risk, and cardioprotective indices.

In another study, Santhosh et al. (2016) analyzed antibacterial activity and preliminary phytochemical screening of Endophytic Fugal Extract of Rauvolfia serpentine. Sarpgandha (Apocynaceae) is a common medicinal plant that is best known for its numerous phytochemicals. The key goal of this research was to see whether Rauvolfia serpentina L. had some antifungal action against Alternaria alternata, Aspergillus flavus, and Mucor rouxii, which are all phytopathogenic fungi. The antifungal function of aqueous extracts of the entire plant, stem, and roots of Rauvolfia serpentina L. was investigated using an agar well diffusion assay. Rauvolfia serpentina L. aqueous root extract had significantly greater antifungal efficacy than the other extracts tested against Alternaria alternata and Aspergillus flavus. Their research explicitly demonstrates Rauvolfia serpentina L.'s antifungal properties, implying that it may be used to combat pest control in a variety of plants and animals. Endophytic fungi isolated from Rauvolfia serpentina, a well-known Indian medicinal herb, are used in Ayurveda for the treatment of many diseases (Santhosh et al., 2016). The antibacterial behavior of isolated endophytes against pathogenic bacteria was tested. Twenty fungal isolates were recovered from various sections of the host plant and characterized for their morphological features using Scanning Electron Microscopy (SEM). They were classified into eight genera based on observations: Fusarium sp., Phomopsis sp.,

Colletotrichum sp., Cladosporium sp., Aspergillus sp., Xylaria sp., Alterneria sp., and Gleomastix sp. The examination of the extract against the target bacteria exposed the secret of the medicinal plant's fungal endophytes. Colletotrichum sp. (Rs-R5), Fusarium sp. (Rs-R1), (Rs-R7), and Cladosporium sp. (Rs-S4) extracts were shown to be selective against human pathogenic bacterial strains E. coli (ATCC 25922), Gram-negative bacteria, and S. aureus (ATCC 25323), Gram-positive bacteria. The most effective sample was an ethyl acetate extract of an active fungal isolate (Colletotrichum sp; Rs-R 5) against E. coli and S. aureus, with maximal inhibition zones of 16 mm and 14 mm and minimum MICs of 25 g/ml and 36.5 g/ml, respectively. They found eight endophytic fungal genera in R. serpentina, according to Santhosh et al., (2016): Fusarium sp., Alternaria sp., Phomopsis sp., Xylaria sp., Gleomastix sp., Aspergillus sp., Cladosporium sp., and Colletotrichum sp. Out of 20 fungal isolates tested, four showed antibacterial activity: Fusarium sp. (Rs-R1, Rs-S7), Cladosporium sp. (Rs-R5), and Colletotrichum sp. (Rs-R5). Using ethyl acetate extract, the inhibition zone and MIC were detected. Against E. coli, the maximal inhibition region (16 mm) and minimum MIC (25 g/ml) were observed. Secondary metabolites such as alkaloids, polyphenols, flavonoids, hormones, and saponins were present in abundance in the ethyl acetate sample.

Plant products are gaining popularity as bactericides and fungicides (Sharanabasappa et al., 2015) due to their systemic efficacy and low phototoxicity. Sharanabasappa et al. (2015) attempted the antibacterial and pharmacological effects of various Rauvolfia serpentina extracts since a significant number of plants are recognized for their antibacterial and antifungal function. They tested the antibacterial efficacy of various Rauvolfia serpentina extracts against E. coli, Klebsiella, Pseudomonas, and S. Aureus. The components used are as follows: Nutrient agar medium, sterile Petri dishes, 0.1–0.2ml pipettes, cultures, nutrient broth, and sterile test tubes containing a proven concentration of the extract of the solutions. The cup plate method was used in the experiments, with a dosage of 1 mg/ml. Water and chloroform extracts were the most effective against bacterial strains E. coli and S. aureus. E. coli and P. aeruginosa Klebsiella and the rest of the Pet ether and ethanol extracts were also effective against P. aeruginosa and S. aureus. Various Rauvolfia serpentina extracts were examined for antifungal activity among various extracts of the Pet. Ether and ethanol extracts were found to be effective against A. flavus and A. niger. The operation of niger and the

remaining extracts was low to moderate. The antifungal efficacy of plant extracts was compared to that of normal antifungal drugs fluconazole by cup plate process, with A. Flavus and A. niger as the fungi chosen for this. Rauvolfia serpentina extracts were tested for antibacterial and antifungal function. Rauvolfia serpentina extracts were tested for antibacterial and antifungal function. The water and chloroform extracts were the most effective against the bacterial strains E.coli and P. klebsiella, as well as the remaining Pet. ether and ethanol extracts were also effective against P. aeruginosa and S. aureus. The Pet. Ether and Ethanol extracts had excellent antifungal activity against A. flavus and A. niger, while the other extracts had low to moderate antifungal activity (Sharanabasappa et al., 2015).

2.2.Pansit-Pansitan

Pansit-pansitan, scientifically known as peperomia pellucida, is a medicinal plant valued for its anti-gout properties which help lower uric acid in the blood. It was one of the ten clinically tested medicinal plants endorsed by the DOH. It was reported that pansit-pansitan contained high amounts of toxic metals like lead (Pb) and cadmium (Cd) surpassing the limits allowed by the World Health Organization (WHO). To regulate the uptake of nutrient elements in pansit-pansitan, the use of hydroponic culture through non-aerated Hoagland's solution was studied (De Guzman, 2000).

Peperomia pellucida (Linn.) is a piperaceae bush with a glossy or silvery appearance. This plant's ethnomedicinal applications include curing stomach pain, abscesses, inflammation, boils, colic, and exhaustion (Gomes et al., 2022). Abdulrazaq (2018) extracted from the air-dried leaves of P. pellucida the essential oils using a Clevenger apparatus and a hydro distillation process. The essential oil obtained was light yellow in color, had an unpleasant odor, and yielded 0.30 v/w. Elemol (9.32 percent), Neointermedeol (8.35 percent), 1H-3a,7-Methanoazulene- (5.60 percent), and Bicyclo [2.2.1] heptanes,2,2,3-trimethyl are the main constituents (5.08 percent). A large amount of the leaf oil was made up of sesquiterpenes and oxygenated sesquiterpenes (52.71 percent). The antimicrobial effects revealed that it has a Minimum Inhibition Concentration (MIC) on Pseudomonas aeruginosa and Bacillus subtilis at 0.01 percent oil concentration, with inhibition zones of 7.0 mm and 9.3 mm, respectively; however, MIC against Bacillus cereus was obtained at 0.1

percent oil concentration. Antifungal tests on Lasiodiplodia theobromae, Fusarium oxysporum, and Aspergillus tamari at percent levels that revealed the plant's essential oils had potent antifungal effects on all three fungi species. These findings suggested that the plant's essential oil could be used as an antimicrobial agent (Abdulrazaq, 2018).

The anticancer, antimicrobial, antioxidant, and chemical compositions of Peperomia pellucida leaf extract were also studied. In the study of Wei et al. (2011), the anticancer activity of P. pellucida leaf extract was determined using a colorimetric MTT (tetrazolium) assay against the human breast adenocarcinoma (MCF-7) cell line, and the plant extract's antimicrobial property was discovered using a two-fold broth microdilution system against 10 bacterial isolates. The plant extract's antioxidant activity was then determined using the DPPH radical scavenging process, and the chemical compositions were screened and classified using gas chromatography-mass spectrometry (GC-MS). The findings of this analysis revealed that P. pellucida leaf extract had anticancer properties, with an IC50 of 10.4±0.06 g/ml. The plant extract was found to inhibit the growth of Edwardsiella tarda, Escherichia coli, Flavobacterium sp., Pseudomonas aeruginosa, and Vibrio cholerae at 31.25 mg/l; Klebsiella sp., Aeromonas hydrophila, and Vibrio alginolyticus at 62.5 mg/l; and Salmonella sp. and Vibrio parahaemolyticus at 125 mg/l. The plant extract was observed to inhibit 30% of DPPH, a free radical, at a concentration of 0.625 ppt. The main compound in the plant extract was phytol (37.88%), followed by 2-Naphthalenol, decahydro- (26.20%), Hexadecanoic acid, methyl ester (18.31%), and 9,12 Octadecadienoic acid (Z, Z)-, methyl ester (9.12%). (17.61 percent). The results of this study showed that a methanol extract of P. pellucida leaf had a lot of potential as a medicinal drug, particularly in the treatment of breast cancer (Wei et al., 2011).

In the study of Bojo et al. (1995), fresh and air-dried Peperomia pellucida plants were subjected to a differential extraction method using three solvents: methanol-water (14:1), ethyl acetate, and hexane. The ethyl acetate extract yielded a strong antibacterial extract. A major fraction of the ethyl acetate extract was shown to have strong antibacterial efficacy against Staphylococcus aureus, Bacillus subtilis, and Pseudomonas aeruginosa that was more active than the penicillin norm, indicating its ability as a wide spectrum antibiotic. Meanwhile, the study of Apatas et al. (2020) aimed to see whether Pansit-pansitan (Peperomia pellucida Linn) aqueous leaf extract has anti-inflammatory properties in vitro.

Fresh leaves were gathered, air dried, and aqueous extracted before being prepared in various doses (200, 400, 600, 800, and 1000ug/mL). In-vitro anti-inflammatory activity was assessed using inhibitors of HRBC lysis and protein denaturation. The existence of secondary metabolites, which are believed to have anti-inflammatory properties, may be due to the aqueous extract's anti-inflammatory effect on the plant. However, these metabolites are not sufficient enough when used in low dosages.

2.3.Ticks

Rhipicephalus sanguineus is usually reddish brown in their adulthood, with no specific marks, unlike other species. Brown dog ticks often travel into houses on canines, their preferred hosts, or cats. Because they are found deep within the hair of animals, homeowners may not immediately see them. Adult ticks typically embed themselves in a dog’s ears and between its toes, while larvae and nymphs typically attach to the dog's back. If brown dog ticks do not have a preferred host to feed upon, they will readily seek out humans for their needed blood meals. The pests attach themselves to an animal's skin to feed on its blood and lay eggs in its fur. After entering homes, they breed and can spread to residents and other pets. Unlike other species, brown dog ticks can survive and complete their entire life cycle indoors. Warm temperatures help these pests develop and reproduce, causing infestations to spread quickly. Brown dog ticks may transmit canine-related diseases, such as canine ehrlichiosis and babesiosis. They are known transmitters of Rocky Mountain spotted fever to humans, but are not known to transmit Lyme disease. However, they are often mistaken for deer ticks, which are known carriers of Lyme disease (Orkin, 2021).

According to John et al. (2017), ticks are tiny crawling bugs in the spider family that feed by sucking blood from animals. They are second only to mosquitoes as vectors of human disease, both infectious and toxic. Infected ticks spread over a hundred diseases, some of which are fatal if undetected. They spread the spirochete (which multiplies in the insect's gut) with a subsequent bite to the next host. Among vector-borne diseases, the most common, Lyme disease, also known as the great mimicker, can present with rheumatoid arthritis, fibromyalgia, depression, attention deficit hyperactivity disorder, multiple sclerosis, chronic fatigue syndrome, cardiac manifestations, encephalitis, mental illness, name some of the many associations.

3. Methodology

This experimental study strictly followed scientific procedure. The series of steps were followed to generate accurate and substantial data collection.

1. Prepare and gather all materials that are required in the whole procedure of making the antibacterial spray.
2. Wash all the leaves with tap water.
3. Crush 20 leaves with a mechanical blender to get their extract.
4. Boil each 20 crushed leaves in separate pots with 400 ml water.
5. Stir the materials evenly for 30 seconds up to 1 minute.
6. Prepare 3 glass containers and label them from mixtures 1 to 3. Use the funnel and measuring cups to follow the percentages needed for different concentrations of the mixtures.

   Mixture 1: 200 ml of Serpentina and 200 ml of Pansit-pansitan Mixture

   Mixture 2: 300 ml of Serpentina and 100 ml of Pansit-pansitan Mixture.

   Mixture 3: 100 ml of Serpentina and 300 ml of Pansit-pansitan.

7. Stir the materials evenly for 30 seconds up to 1 minute.
8. Cool the mixture and transfer it to a spray bottle.
9. Prepare 9 plastic cups and fill them with 3 ticks each with the following label:

   Label 1 - Mixture 1 (spray once)

   Label 2 - Mixture 1 (spray twice)

   Label 3 - Mixture 1 (spray thrice)

   Label 4 - Mixture 2 (spray once)

   Label 5 - Mixture 2 (spray twice)

   Label 6 - Mixture 2 (spray thrice)

   Label 7 - Mixture 3 (spray once)

   Label 8 - Mixture 3 (spray twice)

Label 9 - Mixture 3 (spray thrice)

10. Every solution is sprayed in the labeled plastic cups of different concentration
11. After an hour from the first spray, record how many ticks were found dead.
12. This manner of checking is done until all the ticks are dead.

The duration of the experiment is as follows:

Week 1. The last days of week 1 will be fully devoted to the creation of the mixture. To be safe, the study used two (2) days for the preparation of the mixture.

Week 2. This is the period of experimentation and observation. Every hour, the researcher sprays the ticks in the petri dish with the mixture assigned to them. The experiment and observation are enclosed in a week.

The method of observation is descriptive, wherein the ticks were placed in a controlled environment and then exposed to the mixture of serpentina and pansit-pansitan in different amount of concentrations. It was observed for an hour and the observer took notes of all the changes that took place.

4. Findings and Discussion

This study experiments on Rauvolfia Serpentina (Serpentina) and Peperomia pellucida (Pansit-Pansitan) as an anti-parasitic spray against Rhipicephalus Sanguineus Latreille (Common Ticks). The first scientific query is the time required for the anti-parasitic spray treatment to suppress the ticks as shown in table 1.

Table 1

Testing results of the mixtures

	Mixture 1	**Mixture 2**	**Mixture 3**
Once	1hr 30mins (1.5 hrs)	3hrs 30mins (3.5 hrs)	1hr 30mins (1.5 hrs)
Twice	1hr 20mins (1.33 hrs)	3hrs 25mins (3.42 hrs)	1hr 25mins (1.42 hrs)
Thrice	1hr 15mins (1.25 hrs)	3hrs 20mins (3.33 hrs)	1hr 20mins (1.33 hrs)

The table shows the number of times that the mixture has been sprayed on the ticks in a controlled environment. It also shows the length of time that the ticks exterminate after the mixture has been sprayed with Mixture 1 with the shortest period in the three instances of spraying. The longest period of extermination is Mixture 2 with minimum of 3 hours 20 minutes in three sprays.

Table 2

The number of ticks that exterminate

Mixture	Mixture 1	Mixture 2	Mixture 3
Number of times that the mixture has been sprayed	3	3	3
Several ticks died	3	2	2

Table 2 shows the number of times that the mixture has been sprayed on the ticks. In a span of 1 (one) hour and 30 (thirty) minutes, mixture 1 killed 3 ticks and mixture 2 killed 2 ticks.

The experiment used three solutions or three variants of concentration. The three mixtures used are: mixture 1 has 50%/50% of Serpentina and Pansit-Pansitan diluted with water; mixture 2 has 75%/25% of Serpentina and Pansit-Pansitan diluted with water; and mixture 3 has 25%/75% of Serpentina and Pansit-Pansitan diluted with water. The study experimented on the appropriate mixture for extermination with results shown in table 3.

Table 3

Summary of testing results

Mixture 1			Mixture 2			Mixture 3		
Times sprayed	Number of Hours	Number of ticks died	Times sprayed	Number of Hours	Number of ticks died	Times it sprayed	Number of Hours	Number of ticks died
1	1.5	3	1	3.5	2	1	1.5	2
2	1.33	3	2	3.42	2	2	1.42	2
3	1.25	3	3	3.33	2	3	1.33	2
Average	**1.36**	**3**	**2**	**3.42**	**2**	**2**	**1.42**	**2**

Table 3 shows the summary of the testing of the three (3) mixtures of serpentina and pansit-pansitan in different concentrations spraying against the brown ticks in a controlled environment. For mixture 1, the average time in hours that the brown ticks have been exterminated is 1.36 hours in relation to the number of times the mixture is sprayed. The brown ticks that have been killed are 3 from one (1) to three (3) sprays of the mixture. In mixture 2, the average time in hours that the brown ticks have been exterminated is 3.42 hours and it only kills 2 ticks with the different number of times that the mixture is sprayed. Lastly, mixture 3 has an average of 1.42 hours in relation to the number of times that the mixture was sprayed on the brown ticks. It exterminated 2 ticks in each number of times that the mixture was sprayed.

Table 4

Summary Result of the Three (3) Mixtures

Groups	Count	Sum	Average	Variance
Mix1	3	6.66	2.22	0.04120
Mix2	3	1.75	0.58	0.00023
Mix3	3	4.24	1.41	0.00723

Table 4 shows the number of times that the mixtures are sprayed on the brown ticks and the average time, in an hour, that the mixture exterminated the ticks. It also shows the computed variance of each mixture.

Table 5

Result of One-Way ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	4.018289	2	2.009144	123.8514	**0.0000132**	5.143253
Within Groups	0.097333	6	0.016222			
Total	4.115622	8				

** Significant difference among groups (P-value < 0.05)*

Table 5 shows the result of the one-way analysis of variance (ANOVA). It shows the degree of freedom (df) which are 2 for between groups and 6 for within the groups, then the calculated F value which is 123.8514 along with the P-value of 0.0000132 while the critical F value is 5.143253. For the p-value, it is 0.0000132 in comparison to the level of significant value which is 0.05 implying significant difference in the mixtures.

Table 6

t-test Results between Mixtures

	Between Mixtures 1 & 2		**Between Mixtures 1 & 3**	
	Mix1	**Mix2**	**Mix1**	**Mix3**
Mean	2.22	0.583333	2.22	1.413333
Variance	0.0412	0.000233	0.0412	0.007233
Observations	3	3	3	3
Hypothesized Mean Difference	0		0	
Df	2		3	
t Stat	13.92663		6.348667	
P(T<=t) one-tail	0.002558		0.003953	
t Critical one-tail	2.919986		2.353363	
P(T<=t) two-tail	0.005116		0.007906	
t Critical two-tail	4.302653		3.182446	

Table 6 shows the t-test between mixture 1 and mixture 2. The mean of mixture 1 is 2.22 while mixture 2 is 0.58333 the calculated t-value is 13.92663 against the critical t-value is 2.919986 for one-tail and 4.302653 for two-tail and the degree of freedom (df) value is 2. Meanwhile, the result of t-test between mixture 1 and mixture 3 shows the mean for mixture 1 is 2.22 and for mixture 3 it is 1.413333, the degree of freedom value is 3. The calculated t-value is 6.348667 while the critical t-value for one-tail is 2.353363 and for two-tail is 3.182446.

Table 6

The Average Number of Ticks that Died per Hour

Mix1	**Mix2**	**Mix3**
2.00	0.57	1.33
2.26	0.58	1.41
2.40	0.60	1.50

Table 6 shows the average number of ticks died per hour after the mixture have been sprayed on the brown ticks. Mixture 1 had exterminated an average of two (2) ticks for an hour followed by mixture 2 with less than 1 tick exterminated and mixture 3 with an average 1 tick per hour.

After all the testing and calculations, the most effective variation in concentration out of the 3 mixtures used against Rhipicephalus Sanguineus Latreille is mixture 1, which consists of 50%/50% of Serpentina and Pansit-Pansitan diluted with water. It showed the fastest effect in suppressing Rhipicephalus Sanguineus Latreille with the shortest amount of time needed. As shown in the result in table 6, mixture 1 has exterminated an average of 2 brown ticks compared to the other two mixtures which exterminated less than 1 tick for mixture 1 and 1.5 ticks for mixture 3.

The results have also been confirmed using the one-way ANOVA. In comparison to the level of significance value of 0.05, the calculated p-value is 0.0000132 which is less than 0.05 and means that there is a significant difference among the groups of mixture that have been used. This only signifies that the most effective concentration of the mixture is 50% pansit-pansitan and 50% serpentina.

Further confirmation of the result, the study used the t-test between mixture 1 and 2 which shows that mixture 1 is still the most effective concentration having the t-value of 13.92663 which is way up higher than the critical t-value of 2.919986 for one-tail and 4.302653 for two-tail. Thus, the result shows that there is a significant difference between mixture 1 and mixture 2. In comparing mixture 1 to mixture 3, another t-test have been done to prove that mixture 1 is the most effective concentration. The calculated t-value is 6.348667 which is also higher than the critical t-value having 2.353363 for one-tail and 3.182446 for two-tail. The p-value also confirms the result, having the following value: 0.003953 for one-tail and 0.007906 in comparison to a 0.05 level of significance.

The results further showed that the most effective application out of the 3 durations provided against Rhipicephalus Sanguineus Latreille is thrice per hour. It showed the shortest amount of time in suppressing the tick in all three mixtures used. The result of the experimentation showed that Rauvolfia Serpentina (Serpentina) and Peperomia Pellucida (Pansit-Pansitan) as an antiparasitic spray against Rhipicephalus Sanguineus Latreille (Common Ticks) is effective.

5. Conclusion

This study proved that the mixture of pansit-pansitan and serpentina can really exterminate the brown ticks as a result of physical observation and statistical analysis. Statistically, the mixture that has the most effective concentration in exterminating the brown ticks is mixture 1 for it shows that it can exterminate a minimum of 2 brown ticks in an hour compared to the other concentration can only exterminate less than 1 tick and 1.5 ticks for mixture 2 and 3 respectively in an hour. Even though all mixtures are effective in exterminating ticks, mixture 2, which has a 75/25 ratio of Serpentina and Pansit-pansitan, is the slowest followed by the mixture 3. Therefore, mixture 1 is the fastest option in terms of effectiveness and rapidity in the extermination of ticks.

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Eating Habits, Nutrition Literacy, and Mathematics Performance of Junior High School Students

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Abstract

This study determined the students' level of eating habits, nutrition literacy, and mathematics performance and the relationship among them in a select school in Laguna, Philippines during the Academic Year 2021-2022. It also determined the difference in eating habits and nutrition literacy according to the profile. It used descriptive-correlational research design through a survey of 430 respondents selected using multi-stage random sampling. The adapted and validated instrument showed reliability analysis, internal consistency carried out using Cronbach's Alpha, with eating habits (α=0.70) and nutrition literacy (α=0.83) reached high reliability. Frequency, percentage, mean, standard deviation, independent samples z-test, one-way ANOVA, and chi-square test for association were used. The study found that most respondents have 85 to 89 mathematics performance while the level of eating habits and nutrition literacy was high and the mathematics performance was satisfactory. There was a significant difference in eating habits (F=2.47, p=0.04) and nutrition literacy (F=5.56, p=0.00) as to age, while no difference was found as to sex (p>0.05). There was also a significant difference in nutrition literacy according to grade level, while no significance was found in eating habits according to grade level. Respondents' eating habits were associated with nutrition literacy (x2=48.90, p=0.00), and mathematics performance (x2=18.28, p=0.03). It indicated that eating habits greatly affect the nutrition literacy and mathematics performance of the students. The study formulated recommendations for the teachers, school heads and administrators, parents and guardians, students, and future researchers.

Keywords: *Eating Habits, Nutrition Literacy, Mathematics Performance, Mathematics*

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1. Introduction

Mathematics performance in school is often perceived as a great challenge for students. It is also challenging for teachers to change their students' perspective of this subject. In a worldwide assessment conducted by the Trends in International Mathematics Science Study in 2019, the Philippines is the bottommost and consistently ranked behind in math. Problems related to mathematics are very evident in the Philippines and globally (Blomeke & Delaney, 2014). Although the country provides educational modules containing specific topics and instructional plans, Filipino students still have low understanding and thinking skills when it comes to learning Mathematics (Aksan, 2021). Even college students are still struggling in mastering the math subject itself (Dinglasan & Patena, 2013; Ganal & Guiab, 2014). Because of the various factors associated with the problems in teaching mathematics, efforts had been made by the researchers to find out the cause of the student's low performance in Mathematics. The Department of Education (DepEd) had taken it as a challenge to improve and enhance students' literacy and performance of the country's education. It employs concrete policies and actions in addressing the gaps and problems in teaching the subject (Mendoza, 2020).

Numerous determinants affect the intellectual and academic performance of students in school. These could be the school quality indicators, family characteristics, individual characteristics, and interestingly, dietary patterns (Kristo et al., 2020). According to Tucker (2010), the dietary patterns have a significant effect on the ability of the students, particularly the adolescent. The nutrients and composition of meals have a significant impact on students' behavior and thinking ability in school. An inadequate and unbalanced diet could reduce the attention, perception, struggle in erudition, encourage behavioral ailments and absence, worst, on the overall academic performance of an individual (Demirezen & Cosansus, 2005). It suggests schools to ensure students have access to healthy, nutrient-rich meals in order to maximize their ability to learn and grow (Tucker, 2010).

With the significant findings on the correlation of dietary patterns on academic performance, this study aimed to come up evaluate dietary plan appropriate for the needs of adolescent students. While there are studies of the same nature previously conducted, there were limited studies in the Philippine setting. Hence, the study is novel. Eating habits and nutrition literacy correlated with the students' mathematics performance has not been a

research subject. While a research has been conducted in the same locale (Munda & Tamban, 2019), it was only limited to Mathematics performance correlated with other variables like interpersonal, intrapersonal, and adaptability of students. Therefore, this study aimed to determine the students' level of eating habits, nutrition literacy, and mathematics performance in a select school in Laguna, Philippines during the Academic Year 2021-2022. It also aimed to test the difference in eating habits and nutrition literacy according to demographics and the relationship among eating habits, nutrition literacy, and mathematics performance.

2. Literature review

2.1. Eating Habits

There were several studies conducted on the eating patterns of students during the pandemic. For instance, Chen et al. (2022) found that 51.2% of the 426 students surveyed in Malaysia had increased eating, snacking (55.2%) and online food ordering (71.1%) during the lockdown. A similar eating pattern was established in the study of Arif et al. (2022) among Indonesian students but emphasized female students with significantly lower physical activity than male students. According to Olfert et al. (2022), students showed significant increase in eating and consumption of almost every food group where 32.6% had increased eating patterns since the pandemic due to boredom. Meanwhile, 332 Portuguese university students healthier eating habits were adopted during the pandemic lockdowns due to decrease in meal delivery platforms used and increased consumption of vegetables, fruit and legumes (Monteiro & Ferreira-Pego, 2022). Similar patterns were recorded by Gaa et al. (2022) where 59% students who skipped meals before COVID-19 was down to 47.8% during lockdowns and consumption of homemade meals increased from 64.1% to 82.3%.

Although there was improvement on eating healthy during the pandemic, the concern increased as to obesity. According to Lowry and Shores (2022), there has been an accelerated trend in obesity due to changing patterns of eating habits, access to healthy food and decrease activity. In a study by Di Renzo et al. (2020), 48.6% of the total 3533 respondents have perception of weight gain. While Cantarero et al. (2023) reported a 17.9% improvement in sports habits, a total of 13.6% were dependent on mobile phone. Galali (2021) also reported that more than half of people surveyed had harmed lifestyle during lockdowns, which appeared to have detrimental effect on eating habits leading to strong perception of weight

gain. The study also found that participants appeared to moderately adhere to Mediterranean diet, particularly vegetables, fruits, and legumes. The post lockdown also shown similar pattern of eating habits with 8.63% drop in the consumption of homemade foods and 26.67% of students gained weight (Shaun et al., 2021).

2.2. Effects of Eating Habits on Academic Performance

In a study conducted by Teves and Narciso (2017) on the 348 secondary students of Negros Oriental in the Philippines, the eating behavior showed inclination to eating bread, pastries, junk foods, candies and soft drinks while the academic achievement was average. The study found strong significant positive correlation between students' eating behaviour and nutritional status but there was no significant relationship between nutritional status and academic performance. Similarly, Beredo and Aceron (2019) found a negligible negative correlation between weight and academic performance based on the computed r value of 0.349. However, Reuter et al. (2019) found that healthy eating habits benefit students' academic performance emphasizing that breakfast consumption was associated with an increase in self-reported GPA, whereas fast-food consumption was associated with a decrease. Kristo et al. (2020) also discovered a significant positive correlation between eating habits score, family affluence score, and student success through Scholastic Aptitude Standardized Examination (SASE) scores while Correa-Burrows et al. (2016) assert that higher-quality diet improved respondents' average scores in language, mathematics, and GPA.

Mora et al. (2019) found physical activity and eating recommended number of meals per day associated with improved academic performance. physical activity and proper nutrition are significant predictors of achievement scores (Asigbee et al., 2018). However, Pearce et al. (2018) discovered that academic performance was found to be negatively related to a nutrient-deficient, energy-dense diet, but not to a nutritious diet. Students' lack of basic nutritional knowledge is associated with low scores on assessments (Badrasawi et al., 2020).

2.2. Theoretical framework

This research is linked to the Planned Behavior Theory, which was developed to encompass all behaviors that humans can exert self-control. Behavioral intentions are

influenced by one's attitude toward the likelihood that the behavior will produce the desired result and one's subjective assessment of the associated risks and benefits. This theory has been used to explain and predict a variety of health behaviors and intentions, including smoking, drinking, seeking medical care, breastfeeding, and substance abuse. It claims that motivation and ability are required for behavioral success. It categorizes beliefs as behavioral, normative, or control (LaMorte, 2019a). It is also associated with Social Cognitive Theory of Albert Bandura, which suggests that knowledge takes place in a social context and is characterized by a dynamic and reciprocal relationship between the individual, their environment, and their behavior. It considers the unique ways in which people acquire and maintain behaviors, as well as the social context in which they occur (LaMorte, 2019b). These theories were linked to this study since the aim is to determine the students' level of eating habits, nutrition literacy, and mathematics performance. Improved math performance could be obtained if individuals have good eating habits and high literacy on food nutrition.

3. Methodology

Descriptive-correlational research design was used in this study. Of the 1,049 learners enrolled in the online and blended learning modalities, 430 Grade 7 to 10 students were chosen as respondents through multi-stage sampling. Stratified sampling was utilized in the first stage, while simple random sampling was applied in the second stage.

Table 1
Demographic Characteristics

Profile	Frequency	Percent
Sex		
Male	188	43.7
Female	242	56.3
Age		
12-13 years old	217	50.5
14-15 years old	124	28.8
16-17 years old	81	18.8
18-19 years old	6	1.4
20 years old and above	2	0.5
Grade level		
Seven	146	34.0
Eight	93	21.6
Nine	95	22.1
Ten	96	22.3
Total	**430**	**100.0**

The table shows the demographic characteristics of the student-respondents who are mostly female students (242 or 56.3%), between 12 and 13 years old (217 or 50.5%), and seventh grade (146 or 34.0%).

This study's instrument consists of three parts. The first section focuses on the demographic characteristics, while the second part solicits data on the respondents' self-reported Mathematics performance through their rating in the first quarter. The mathematics performance categories of the respondents were based on the DepEd Order No. 8, series of 2015. The third part is an adapted questionnaire from Naughton et al. (2015), Steptoe et al. (1995), Roininen et al. (1999), and Park (2011) to determine the respondents' level of eating habits and nutrition literacy. The instrument was adjusted to reflect the respondents' present scenario. Each statement is a 5-point Likert scale. The instrument was tested for content validity by four specialists and reliability analysis through internal consistency. Cronbach's alpha demonstrated that eating habits scale ($\propto = 0.70$, 10 items) and nutrition literacy scale ($\propto = 0.83$, 17 items) reached high reliability. The questionnaire was distributed to the respondents via Facebook Messenger group chat as Google Form Link.

In carrying out the data collection, permission was given by the division superintendent and the school heads, parents and respondents of the study. In compliance with research ethics, it was stressed that participation in the survey was voluntary. The data were kept confidential to the full extent of the law.

The study employed frequency and percentage to describe the demographic characteristics, and mean and standard deviation to assess the level of mathematics performance, eating habits, and nutrition literacy. Moreover, independent samples z-test and one-way ANOVA were applied to test the difference in the level of eating habits and nutrition literacy between two and three independent groups, respectively. Lastly, chi-square test for association was performed to examine the link among the categorical data on eating habits, nutrition literacy, and mathematics performance.

4. Findings and Discussion

Table 2 demonstrates the level of the eating habits of the respondents. The statement with the highest mean is "*I keep three regular meals a day*" (x=4.19, SD=1.03), interpreted as "high level." It indicates that most junior high school students strongly agreed that they

should continue eating three meals every day. The statement with the lowest mean is "*I do not eat cake, ice cream, and other sweets/desserts and soda between meals*" (x=2.87, SD=1.19), interpreted as "Average level." It suggests that majority of respondents had a moderate level of agreement that they do not consume sweets, desserts, and soda between meals. It shows that most respondents have healthy eating habits. On the other hand, it also shows that despite having healthy eating habits, most respondents love to eat unhealthy foods for their appetite.

Table 2

Eating Habits of the Students

Statement	Mean	Std Dev	Interpretation	Rank
1. I eat dairy products such as cheese, butter, cream, yogurt, and other milk-based products every day over one serving size.	3.53	1.11	High level	5.5
2. I eat meat, fish, egg, bean, or tofu every day over 1-2 serving sizes.	3.74	0.95	High level	4
3. I eat vegetables every day over 1-2 serving sizes.	3.85	1.05	High level	3
4. I eat one serving size of fruit or drink 2-3 servings of fresh fruit juice every day.	3.47	1.06	Average level	6
5. I do not eat fried or stir-fried food every day more than the recommended amount.	3.53	1.01	High level	5.5
6. I eat fatty meat (pork: *kasim, lomo, liempo, pata, pigue or* chicken: skin, drumstick, thigh, wing, neck) every three days over one serving size.	3.07	1.13	Average level	8
7. I do not add table salt or condiments like soy sauce, vinegar, catsup, patis, bagoong to food generally.	3.12	1.19	Average level	7
8. I do not eat cake, ice cream & other sweets/desserts and soda between meals.	2.87	1.19	Average level	9
9. I keep three regular meals a day.	4.19	1.03	High level	1
10. I eat a variety of foods.	4.03	0.98	High level	2

Legend: 4.50 – 5.00 Very High, 3.50 – 4.59 High, 2.50 – 3.49 Average, 1.50 – 2.49 Fair, 1.00 – 1.49 Poor Level

The results show similarity to Kristo et al. (2021) that 64.4% skip at least one meal every day, while 35.6% do not. Breakfast is the most frequently skipped meal, whilst dinner is the least frequently skipped meal. While skipping a meal is attributed to many factors and medical implications, the result show that the eating habits of the students are on the average

level signifying mostly adherence to good nutrition with some inclination to sweets and oily foods.

Table 3

Nutrition Literacy of the Students

Statement	Mean	Std Dev	Interpretation	Rank
1. I always follow a healthy and balanced diet.	3.83	1.00	Highly literate	13
2. The healthiness of food has an impact on my food choices.	3.99	0.94	Highly literate	9
3. I am very particular about the nutrient content of the food I eat.	3.97	0.88	Highly literate	10
4. It is important for me that my diet is low in fat.	3.66	1.01	Highly literate	14
5. I pay attention that I do not use too much sugar.	3.84	1.04	Highly literate	12
6. It is important for me that my diet contains a lot of vitamins and minerals.	4.09	0.90	Highly literate	7
7. I am prepared to eat a lot as healthy as possible.	3.94	0.99	Highly literate	11
8. I think it is important to know how to eat healthy food.	4.50	0.73	Very highly literate	1
9. It is important that the food I eat helps me control my weight.	4.33	0.82	Highly literate	2
10. I worry about the healthiness of food that I eat.	3.22	1.32	Moderately literate	16
11. I avoid foods if they may raise my cholesterol level.	3.28	1.22	Moderately literate	15
12. I ask myself all the time whether the things I eat are good for me.	3.18	1.26	Moderately literate	17
13. It is important that the food I eat are not only healthy but also keeps me awake and alert.	4.07	0.94	Highly literate	8
14. It is important that the food I eat helps me cope with life.	4.11	0.87	Highly literate	6
15. It is important that the food I eat helps me relax.	4.26	0.80	Highly literate	4
16. It is important that the food I eat cheers me up and makes me feel good.	4.32	0.86	Highly literate	3
17. It is important that the food I eat helps me cope with stress.	4.13	0.97	Highly literate	5

Legend: 4.50 – 5.00 Very Highly Literate, 3.50 – 4.49 Highly Literate, 2.50 – 3.49 Moderately Literate, 1.50 – 2.49 Fairly Literate, 1.00 – 1.49 Not Literate

Table 3 illustrates the level of nutrition literacy of the respondents. The statement with the highest mean is "*I believe it is necessary to know how to consume nutritious food"*

(x=4.50, SD=0.73), interpreted as "extremely literate." It indicates that most respondents strongly think that healthy eating is vital. The statement with the lowest mean is "*I ask myself all the time whether the things I eat are good for me*" (x=3.18, SD=1.26), interpreted as "moderately literate." It indicates that most respondents agreed with the statement that they constantly question whether the food they consume is healthy. It shows that most respondents have a high level of nutrition literacy. On the other hand, despite having knowledge of nutrition literacy, most respondents want to eat foods that are not good for their health.

This shows congruence with Demir (2020) showeing 96.3% of students with sufficient level of nutrition knowledge. Insufficient literacy was found in 50% of the academics whereas 17.2% demonstrated acceptable literacy. In the area where questions about food portion sizes were included, half of the academicians (50.0 %) were found to be illiterate, whereas just 17.2 % were found to be illiterate. Overall, the respondents' nutritional literacy levels were deemed to be high. Unfortunately, they still want to eat unhealthy food even they know it is not good for their health. In addition, with a mean score of 5.34 out of 7, Naughton et al. (2015) determined that the respondents in this study had a favorable attitude toward healthy eating. Meanwhile, Ashoori et al. (2021) found that the level of food and nutrition among senior high school students in Tehran was relatively low. Food and nutrition-related knowledge and skills should be prioritized in schools, according to these findings.

Table 4

Test of Difference in Eating Habits and Nutrition Literacy According to Sex

Variable	Mean	SD	Interpretation	z value	P-value	Interpretation
Eating Habits						
Male	3.56	0.61	High level	0.73	0.47	Not significant
Female	3.52	0.61	High level			
Nutrition Literacy						
Male	3.95	0.56	Highly literate	0.67	0.51	Not significant
Female	3.92	0.53	Highly literate			

Legend: 4.50 – 5.00 Very High/ Very Highly Literate, 3.50 – 4.49 High/ Highly Literate, 2.50 – 3.49 Average/ Moderately Literate, 1.50 – 2.49 Fair/ Fairly Literate, 1.00 – 1.49 Poor Level/ Not Literate

Concerning the respondents' eating habits, male participants (x=3.56, SD=0.61) had higher mean than females (x=3.52, SD=0.61). Male participants' mean score of nutrition literacy (x=3.95, SD=0.56) is also higher than females (x=3.92, SD=0.53). The results indicate that the null hypotheses were retained since the probability values were greater that the level of significance. It signifies that there was no statistically significant difference between the sexes in terms of eating habits (z=0.73, p=0.47) and nutrition literacy (z=0.67, 0.51) of the respondents. In other words, male and female respondents have the same level of eating habits and nutrition literacy.

This study disputed the study of Demir (2020) that women had greater nutritional literacy ratings than males, Valladares et al. (2016) that women scored considerably higher than males in the category of emotional eating and Miller et al. (2021) that there are statistically significant gender differences for eating the appropriate foods to avoid illness and disease, eating the appropriate foods to stay active, and reducing food waste.

Table 5

Test of Difference in Eating Habits and Nutrition Literacy According to Age

Age	Mean	SD	Interpretation	F value	P-value	Interpretation
Eating Habits						
12-13years old	3.60	0.60	High level	2.47	0.04	Significant
14-15 years old	3.56	0.59	High level			
16-17 years old	3.38	0.64	Average level			
18-19 years old	3.22	0.70	Average level			
20 years old and above	3.75	0.21	High level			
Nutrition Literacy						
12-13years old	4.05	0.53	Highly literate	5.56	0.00	Significant
14-15 years old	3.83	0.56	Highly literate			
16-17 years old	3.79	0.48	Highly literate			
18-19 years old	3.69	0.72	Highly literate			
20 years old and above	4.01	0.42	Highly literate			

Legend: (Eating Habits) 4.50 – 5.00 Very High, 3.50 – 4.49 High, 2.50 – 3.49 Average, 1.50 – 2.49 Fair, 1.00 – 1.49 Poor Level;
(Nutrition Literacy) 4.50 – 5.00 Very Highly Literate, 3.50 – 4.49 Highly Literate, 2.50 – 3.49 Moderately Literate, 1.50 – 2.49
Fairly Literate, 1.00 – 1.49 Not Literate; Significant if p-value is < 0.05

When respondents were categorized by age, there were substantial differences in their eating habits and nutrition literacy. Regarding eating habits, students aged 20 and older had

the highest mean (x=3.75, SD=0.21), whereas students aged 18-19 had the lowest mean (x=3.22, SD=0.70). In terms of nutrition literacy, students aged 12 to 13 years had the highest mean (x=4.05, SD=0.53), while those aged 18 to 19 years had the lowest mean (x=3.69, SD=0.55). In addition, the results indicate that there is a statistically significant difference in the eating habits as to age groups (F(4,425)=2.47, p=0.04). Post hoc through Scheffe's test revealed that there was statistically significant difference between 12-13 years old and 16-17 years old (p = 0.04). Respondents who are 12-13 years old (x=3.60, SD=0.60) got higher mean score on eating habits than 16–17-year-old (x=3.38, SD=0.64) respondents. Also, there is a statistically significant age-based difference in the nutrition literacy of the respondents (F (4,425) =5.56, p=0.00). There were statistically significant differences between 12-13 years old and 14-15 years old (p = 0.01) and between 12-13 years old and 16-17 years old (p = 0.01), as determined by Scheffe's post hoc test. Respondents who are 12-13 years old (x=4.05, SD=0.53) obtained higher mean score on nutrition literacy than 16–17-year-old (3.79, SD=0.48) respondents. It indicates that there is difference in eating habits and nutrition literacy of respondents according to age. It shows that mostly younger students have more knowledge about nutrition literacy and aware of their eating habits than older students. They were aware what food is healthy and what is not. This explains the findings of Demir (2020) that nutritional literacy scores decline with age.

Table 6

Test of Difference in Eating Habits and Nutrition Literacy According to Grade Level

Grade Level	Mean	SD	Interpretation	F value	P-value	Interpretation
Eating Habits						
Seven	3.58	0.64	High level			
Eight	3.59	0.58	High level	2.54	0.06	Not significant
Nine	3.58	0.58	High level			
Ten	3.39	0.61	Average level			
Nutrition Literacy						
Seven	4.06	0.53	Highly literate			
Eight	4.04	0.54	Highly literate	8.57	0.00	Significant
Nine	3.81	0.55	Highly literate			
Ten	3.77	0.51	Highly literate			

Legend: (Eating Habits) 4.50 – 5.00 Very High, 3.50 – 4.49 High, 2.50 – 3.49 Average, 1.50 – 2.49 Fair, 1.00 – 1.49 Poor Level;
(Nutrition Literacy) 4.50 – 5.00 Very Highly Literate, 3.50 – 4.49 Highly Literate, 2.50 – 3.49 Moderately Literate, 1.50 – 2.49 Fairly Literate, 1.00 – 1.49 Not Literate; Significant if p-value is < 0.05

Concerning eating habits, Grade 8 students obtained the highest mean (x=3.59, SD=58) compared to other grade levels. In terms of nutrition literacy, Grade 7 students had the highest mean (x=4.06, SD=0.53) compared to other levels. According to the results, there is no significant difference in students' eating habits categorized by grade level (F(3,426)=2.54, p=0.06). Meanwhile, there was a significant difference in the nutrition literacy of respondents by grade level (F(3,426)=8.57, p=0.00). There were significant differences in nutrition literacy between Grades 7 and 9 (p = 0.01), Grades 7 and 10 (p = 0.00), Grades 8 and 9 (p = 0.03), and Grades 8 and 10 (p = 0.01), according to Scheffe's post hoc test. Grade 7 students (x=4.06, SD=0.53) got higher mean scores on nutrition literacy than the Grade 9 (x=3.81, SD=0.55) and Grade 10 (x=3.77, SD=0.51) students. Meanwhile, Grade 8 students (x=4.04, SD=0.54) got higher mean scores on nutrition literacy than the Grade 9 (x=3.81, SD=0.55) and Grade 10 (x=3.77, SD=0.51) students. These indicate that lower grade levels have more knowledge about nutrition literacy than higher grade levels. This is similar to the study of Kristo et al. (2020) that grouping respondents by grade level did not reveal any statistically significant differences in eating habits, or meal skipping.

Table 7

Students' Mathematics Performance

Grade Scale	Frequency	Percent	Mean	Std Dev	Interpretation
75 – 79	102	23.7			
80 – 84	120	27.9			
85 – 89	129	30.0	3.28	1.02	Satisfactory level
90 – 100	79	18.4			
Total	**430**	**100.0**			

Legend: 4.50 – 5.00 Outstanding level; 3.50 – 4.49 Very satisfactory level; 2.50 – 3.49 Satisfactory level, 1.50 – 2.49 Fairly satisfactory level; 1.00 – 1.49 Poor level of Math Performance

According to the results in table 7, majority of respondents earned grades between 85 to 89 (129 or 30.0%), while the least obtained grades between 90 to 100 (79 or 18.4%). Further, students' level of mathematics performance falls to the "satisfactory level" (x=3.28, SD=1.02). This is similar to the study of Munda and Tamban (2019) where they utilized a mathematics assessment to describe their respondents' mathematics performance. Accordingly, the mathematics performance of their respondents reached satisfactory level.

Table 8

Test of Relationship among Nutrition Literacy, Eating Habits, and Mathematics Performance

Variables	x^2	p-value	Decision	Interpretation
Nutrition Literacy and Eating Habits	48.90	0.00	Reject the Null hypothesis	Significant
Eating Habits and Mathematics Performance	18.28	0.03	Reject the Null hypothesis	Significant
Nutrition Literacy and Mathematics Performance	14.47	0.27	Failed to reject the Null hypothesis	Not significant

Legend: Significant if $p<0.05$

According to the results presented in table 8, there is a significant link between nutrition literacy and eating habits ($x^2=48.90$, $p=0.00$). There is also a significant connection between eating habits and mathematics achievement among junior high school pupils ($x^2=18.28$, $p=0.03$). These imply that nutrition literacy and eating habits, as well as eating habits and mathematics performance, are significantly associated. It indicates that nutrition literacy affects eating habits. If students are highly literate, they are likely to have good eating habits. On the other hand, eating habits of the students affects their mathematics performance. However, the result demonstrated no correlation between nutrition literacy and mathematics performance ($p>0.05$).

The findings refute the study of Taleb and Itani (2021) that there was no correlation between nutrition literacy and eating patterns and affirm Kristo et al. (2021) on the correlation between a family's socioeconomic status and a student's performance through SASE scores. With the significant correlation between eating habits and mathematics achievement, this study asserts the findings of Reuter et al. (2020) that healthy eating habits boost students' academic performance, Burrows et al. (2017) that moderate relationships exist between dietary intakes and academic performance results, Mora et al. (2019) that eating the necessary number of meals per day relate to increased academic performance, and Asigbee et al. (2018) that good nutrition was important performance score predictors. The findings were contradicting Pearce et al. (2018) that academic performance was negatively correlated with a nutrient-deficient, energy-dense diet, but not with a nutrient-dense diet.

5. Conclusion

This study discovered significant difference in nutrition literacy of the students in terms of age and grade level signifying decreased nutrition literacy as student progressed by age and grade level. On the other hand, there is an association between nutrition literacy and eating habits, and eating habits and mathematics performance. With the positive association of eating habits and mathematics performance, this study concludes that the eating nutritious foods have significant impact on students' academic performance.

With the vital findings on the value of nutrition, this study suggests teachers to teach adolescent students the significance of eating healthy food by explaining the details of dietary plan and its benefits to increase students' awareness. Similarly, school heads and other superiors in DepEd may consider developing an effective dietary plan to help the learners improve their health, thereby improving academic skills. They may include the dietary plan in the schools' feeding program and in the discussions in Health or Technology and Livelihood Education subjects.

As the study was limited to three variables and grade levels of respondents, further studies can increase the sample to different grade levels and include other variables to further strengthen the findings that nutrition literacy and mathematics performance are correlated.

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Contextualized Question-Embedded Video-Based Teaching and Learning Tool: A Pathway in Improving Students' Interest and Mathematical Critical Thinking Skills

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Abstract

Filipino students exhibit lower levels of performance in mathematics and science competency compared to neighboring countries based on national and international surveys. The root cause of this issue is the decline in students' interest in learning mathematics alongside their insufficient critical thinking skills. This has posed challenges among mathematics teachers to innovate ways on how to enhance students' critical thinking skills and motivate students towards better performance in mathematics. The primary objective of the study was to determine the effectiveness of a contextualized question-embedded video-based teaching and learning tool on the interest and mathematical critical thinking skills of Grade 10 students. The study used a descriptive experimental research design with the REACT and Socratic methods to contextualize and embed questions in the video tool. A survey questionnaire was used to assess students' interest before and after utilization, and a pretest and posttest assessment was conducted to evaluate students' interpretation, analysis, evaluation, and inference skills. Based on the findings, using a contextualized question-embedded video-based teaching and learning tool is effective in increasing students' interest and critical thinking skills. Moreover, there was a significant difference between students' mathematical interest in terms of their attitude, initiatives, mathematics experience, and the utilization of contextualized question-embedded video-based teaching and learning tool. The pretest and posttest results of the experimental and control groups also showed significant differences in critical thinking skills. The study concludes that using contextualized question-embedded video-based as teaching and learning tools effectively improves students' interest and critical thinking skills in Mathematics. Further larger-scale studies with different grade levels can validate the findings of the current study.

Keywords: *Contextualized, Question-embedded, Interest, Critical thinking skills*

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1. Introduction

Wong et al. (2019) highlights that interest significantly influences student motivation and engagement, particularly in the context of education. Increasing student interest in the subject matter enhances learning outcomes, comprehension, and effort. The context of mathematics education poses an even greater challenge due to students' generally lower interest levels in mathematics, which possibly hampers the development of critical thinking skills. To address this issue, educators must adopt effective interventions to promote student motivation towards mathematics to enable the development of higher-order thinking skills. According to Azmidar et al. (2017), systematic intervention such as the use of technology in the presentation of mathematical concepts is effective in nurturing students' interest and engagement.

The World Economic Forum (2021) reports that one of the essential skills that students need to develop for future occupations in 2030 is critical thinking. Mathematics education serves the dual purpose of critical thinking and problem-solving. The low critical thinking achievement rate among Filipino students in national and international surveys (Guinocor et al., 2020; Ganal et al.,2014) emphasize the need for contextualized learning materials (CLMs) and question-embedded video-based learning tools to promote student interest and critical thinking skills in mathematics. These interventions promote deeper understanding, stimulate curiosity, and lead to better performance in problem-solving and mathematical reasoning (Bottge et al., 2013; Vural, 2013).

The declining interest in mathematics and a lack of critical thinking skills among students pose significant challenges for mathematics teachers, as suggested by Otoo et al. (2018). Students' confidence in mathematics affects their interest and motivation levels, emphasizing the importance of promoting higher-order thinking skills such as problem-solving and critical thinking. Educators can use questioning strategies such as Socratic questioning and prototype lessons to encourage critical thinking and reasoning skills (Alcantara et al., 2017; Alsaleh, 2020).

The Philippines Department of Education recognizes the importance of developing higher-order thinking skills among secondary high school students, and teachers play a critical role in this endeavor, as stated by Quimod (2020). According to the TIMSS (2019) results, Filipino students demonstrated proficiency in fundamental mathematical skills such as addition, subtraction, multiplication, and division of one- and two-digit whole numbers, as

well as simple fractions. They also showed competence in recognizing common geometric shapes, solving basic word problems, and interpreting simple bar graphs and tables. However, they faced challenges when it came to solving complex problems and higher-order questions. Therefore, interventions aimed at improving critical thinking skills in mathematics, such as the use of CLMs and question-embedded videos, must be prioritized to equip students with the skills needed to succeed in current and future careers.

This study aims to determine the effectiveness of a contextualized question-embedded video-based learning tool in enhancing Grade 10 students' mathematical interest and critical thinking abilities. The study is conducted in a setting with a declined average mathematics performance score (MPS). The goal of the intervention program, which employs the video-based instructional tool, is to enhance students' cognitive thinking skills, focusing on the higher-order thinking levels based on Bloom's Taxonomy (Fitzpatrick et al., 2011). The results of this study have the potential to inform the development of interventions that can help improve students' critical thinking skills in mathematics. This study further aims to examine the following hypotheses:

Ho1: There is no significant difference in the student's interest before and after the utilization of the contextualized question-embedded video-based teaching and learning tool.

Ho2: There is no significant difference in the pretest and posttest results of the student's critical thinking skills in the control group.

Ho3: There is no significant difference in the pretest and post-test results of the student's critical thinking skills under the experimental group.

Ho4: There is no significant difference between the pretest and posttest results of the student's critical thinking skills under the experimental and control groups.

2. Literature Review

2.1. Contextualization

According to Wang et al. (2017), contextualization and the use of contextualized learning materials have been acknowledged as effective strategies to promote student engagement and enhance learning outcomes, particularly in mathematics. The authors suggested that teachers can make math more accessible and relevant to students by providing real-life examples and experiences that connect with their interests and experiences. Likewise, Orozco and Pasia (2021) underscored the importance of taking a contextualized approach in sociocultural mathematics teaching to develop higher-order thinking skills. By

utilizing various group activities and problem-solving tasks, students can engage in analyzing, evaluating, and explaining their output, which can promote more critical and independent thinking skills.

The use of contextualized learning materials has also been demonstrated to be an effective strategy in enhancing learning outcomes in mathematics (Cubillas, 2018). Contextualized learning materials are instructional materials designed to raise students' knowledge and engagement in the subject matter, particularly in providing remedial support to students who require additional instruction. Smith and Johnson (2018) specifically focused on examining the effects of contextualized learning materials on student achievement in mathematics. The research highlighted the positive influence of incorporating these materials in mathematics instruction, reinforcing their role in improving student learning outcomes in the subject. Cubillas (2020) also found that Contextualized Learning Materials (CLM) were effective in improving students' conceptual understanding of the "sets" competency in mathematics. The study suggests that teachers can develop additional contextualized learning materials for various math topics and other subject areas to address students' areas of weakness. Similarly, Francisco et al. (2019) examined the impact of Contextualized T-Math Video on the performance of Grade 8 Math learners. The results indicated that the intervention method proved effective in motivating learning, changing attitudes, and providing role models to address common math difficulties. The use of video as a medium for mathematics learning was found to significantly enhance Grade 8 learners' mathematical abilities, inspiring and challenging them in the process. Furthermore, Rajab (2019) found that utilizing a contextualized T-Math video as an intervention strategy produced positive effects in motivating learning, increasing mathematical ability, and changing student attitudes towards the subject. Using T-Math video as a learning tool can enhance student engagement and promote deeper learning.

2.2. Question-embedded in Video-Based Teaching and Learning Tool

A significant amount of research has been conducted on the effectiveness of embedded questions in digital lectures and interactive videos in improving student learning outcomes. For instance, Tweissi (2016) conducted a study that compared the effectiveness of question-embedded videos (VEQ) and linear videos (LV) in secondary education. Findings demonstrated that the VEQ version, which allowed students to interact with embedded questions and control the instructional timeline, resulted in higher test scores compared to the

LV version. The incorporation of multiple-choice questions in the VEQ also provided feedback to students on the correctness of their answers, resulting in a more engaging and interactive learning experience. Similarly, Meij et al. (2021) revealed that open-ended embedded questions in digital lectures significantly raised the mean test scores compared to lectures lacking embedded questions. The results suggest that embedded questions can make online recorded lectures effective as learning aids.

Several studies have investigated the impact of question-embedded videos on students' learning experience and mathematics achievement. Orfanou et al. (2020) found that incorporating question-embedded videos positively influenced student engagement and led to improved mathematics achievement. Similarly, Kim and Park (2018) discovered that the use of question-embedded video-based learning significantly enhanced students' mathematical understanding and problem-solving abilities, demonstrating the effectiveness of this instructional approach. Chen and Jilk (2019) focused on the effect of embedded questions in video-based instruction and revealed that including such questions in instructional videos positively influenced students' mathematical learning outcomes, promoting deeper understanding and engagement with the content. These studies collectively highlight the benefits of incorporating question-embedded videos in mathematics education, leading to improved student outcomes and increased engagement with the subject matter.

Moreover, Vural (2013) examined the impact of an interactive video-based learning tool with embedded questions on e-learning and student performance. The study revealed that students who used the question-embedded interactive video environment (QVE) tool expended more time interacting with the learning materials and achieved higher grades compared to students who used the interactive video environment without the question component (IVE) tool. These results suggest that incorporating embedded questions in interactive videos can enhance student engagement and facilitate deeper learning. The literature highlights the potential of embedded questions as an effective tool for improving the efficacy of digital lectures and interactive videos for student learning.

2.3. Student's Interest

Mathematics education is an essential component of any education system, as it lays the groundwork for science and technology-related disciplines. However, students' interest and achievement in mathematics vary significantly depending on teaching methodologies and management styles. According to Illiyas (2017), a positive relationship exists between high

school students' interest in mathematics and their academic performance. To enhance students' interest and engagement in mathematics instruction, researchers and educators have explored various pedagogical approaches. Nyman (2017) concluded that teachers' instructional methods increase students' engagement in algebra. The research showed that working with the target information in the foreground could create a didactical situation that increases student participation, thereby promoting students' interest and engagement in mathematics.

The Interest-driven Creator (IDC) hypothesis proposed by Chan et al. (2018) is a theory that suggests that students can develop as creators through interest-driven learning activities. The IDC theory comprises the following three core concepts: interest, creativity, and habit. These concepts combine to create a continuous learning activity that enhances higher-order thinking skills in students. The theory asserts that providing students with interest-driven activities can significantly increase their engagement and interest in mathematics learning. Hence, incorporating the IDC theory in mathematics instruction can be an effective way to improve students' interest and engagement in mathematics education.

In conclusion, educators must adopt pedagogical approaches that promote active participation, increase students' interest, and provide an environment that nurtures creativity and curiosity to enhance students' interest and engagement in mathematics learning. Illiyas (2017), Nyman (2017), Chan et al. (2018), and Azmidar et al. (2017) have demonstrated that promoting student interest and engagement in mathematics can significantly improve their academic achievement and willingness to participate in the learning process. Therefore, it is essential to explore and integrate pedagogical approaches that foster interest-driven learning activities and increase students' participation in mathematics instruction.

2.4. Student's Interest in Varied Learning Tools and Approaches

Recent studies have shown that the incorporation of video-based teaching resources, such as YouTube videos and short clips from social media applications, can result in improved mathematical achievement and interest among students. For instance, Yeh et al. (2019) found that using Math-Island, a digital math learning tool, led to an increase in students' mathematical achievement, particularly in computation and word problems. Similarly, Korpela (2014) found that short video lectures were effective in enhancing mathematics learning, while Hansch et al. (2015) reported that many students prefer studying from videos as it allows them to learn more freely and independently. Additionally,

Kosterelioglu (2016) found that using video clips during the teaching and learning process supported and motivated students' learning, contributing to long-term memory.

While video-based teaching resources have their benefits, they also present challenges for teachers. For example, internet connectivity can be problematic when using YouTube videos in classes (Wawuda, 2019). Additionally, Macandog and Insorio (2022) highlighted that teachers face a variety of difficulties when using YouTube videos, even though they are helpful in displaying paralinguistic elements like facial expressions, gestures, body movements, and eye contact. Despite these challenges, Robosa et al. (2021) found that teachers are becoming more innovative and resourceful in finding ways to provide instructional materials and learning resources to achieve learning goals, including through the use of video-based teaching resources.

In conclusion, while video-based teaching resources can be an effective tool in enhancing students' mathematical learning and interest, practical considerations and challenges should be taken into account. The literature provides evidence that the use of video-based teaching resources can be valuable in mathematics education, but it should be used alongside other instructional methods to promote a comprehensive understanding of mathematical concepts.

2.5. Mathematical Critical Thinking skills

Critical thinking is a fundamental aspect of education that is crucial for students to acquire. According to Facione (1990), critical thinking abilities are the six cognitive abilities that enable individuals to examine and synthesize information to solve issues in diverse contexts. Alcantara et al. (2017) discovered a positive correlation between a student's level of critical thinking skills, problem-solving skills, and their proficiency in mathematics. Similarly, Syafril et al. (2020) stressed the importance of mathematical critical-thinking skills for students to engage in rational thinking, make decisions, challenge conclusions, and solve complex problems in Mathematics. Therefore, schools must include critical thinking skills in their curricula to improve students' problem-solving abilities and prepare them for real-life challenges.

The concept of critical thinking is rooted in educational philosophy, particularly in the progressive education movement. According to Dewey's progressive education philosophy, education should be an ongoing process of student advancement that focuses on recognizing and adapting to change through problem-solving and critical thinking. This

philosophy emphasizes the value of science-based education, individuality, growth, and change based on students' needs, interests, experiences, and talents. In contrast, Piaget's cognitive psychology approach emphasizes the teacher's role as a facilitator and organizer who creates challenging circumstances and activities to help students develop robust mathematical reasoning abilities. These philosophical perspectives and cognitive abilities should be integrated into school curricula to foster students' critical thinking skills, equipping them for real-life challenges.

3. Methodology

3.1. Research Design

This study employed a descriptive-experimental research method using a randomized controlled trial design to evaluate the effectiveness of a contextualized question-embedded video-based teaching and learning tool on students' mathematical interests and critical thinking skills. This research approach involves manipulating independent variables while observing the effects on dependent variables and describing sample characteristics. According to Creswell (2018), this research approach involves studying either an individual or a group through an internal process that occurs within the individual or group.

3.2. Respondents of the Study

This study was conducted among grade ten students in a national high school in the Philippines. The sample consisted of two sections, each with forty (40) heterogeneous students from diverse communities in Batangas province.

3.3. Sampling Technique

The researcher utilized cluster sampling, which involves dividing a large population into smaller groups or clusters and randomly selecting a sample from each cluster. This sampling method is commonly used to investigate geographically diverse populations and usually employs pre-existing units as clusters, such as cities or schools (Thomas, 2020). In this study, two sections consisting of 40 students were randomly chosen from the Grade 10 students as representatives for control and experimental groups. Grade 10 students were ranked according to their mathematical achievement that served as a basis for selecting students for control and experimental groups.

3.4. Research Instrument

The study used a researcher-made test and survey questionnaire, as well as a video-based teaching and learning tool. Three videos were used in the experimental group during

class discussions. The test had 20 multiple-choice questions covering four critical thinking skills components, while the questionnaire assessed attitudes towards mathematics, initiatives in studying mathematics, and mathematics experience using a 4-point Likert scale. The use of multiple-choice items allowed for quick analysis and improvement of future assessments.

The researcher sought expert validation for the research instruments, including a video-based tool, by collecting feedback from experts in the field. Pilot testing resulted in very good reliability with Cronbach Alpha coefficients for attitudes towards mathematics (0.892), initiative in studying mathematics (0.864), and mathematics experience (0.852). KR coefficients for pretest (0.674) and posttest (0.655) had an acceptable reliability level.

3.5. Research Procedure

The researcher prepared the necessary letters for the conduct the study and explained the purpose of the study to the respondents. Ethical considerations were observed to ensure confidentiality and anonymity of respondents.

Prior to the implementation, the respondents were divided into two sections, one group was designated as the experimental group, while the other was designated as the control group. The experimental group was exposed to a contextualized question-embedded video-based teaching and learning tool, while the control group received lecture method. Afterward, the researcher conducted a pretest of a survey questionnaire on students' interest in learning mathematics, as well as a pre-assessment for the experimental and control groups. The researcher used a contextualized question-embedded video-based as a teaching and learning tool in which the contextualized video-based was structured through the five important engagement techniques named the REACT approach by the Center for Educational Research and Development (CORD) in 1999: Relating, Experiencing, Applying, Cooperating, and Transferring. These strategies include relating what is being taught to the context of the real world, experiencing the new knowledge, applying new concepts to the situations that arise in the real world, solving problems by cooperating with others, and transferring that knowledge to an experience that the students will have in the future. For the delivery of instruction using the video-based teaching and learning tool, each phase of the REACT approach was contextualized video-based learning materials with corresponding questions to capacitate the students' higher-order thinking skills.

The students were exposed for almost a month using the learning materials that covered circles and related terms, angles and intercepted arcs, and distance formulas for

given two points. After the implementation, post assessment and survey questionnaires were administered to assess students' critical thinking skills and interest in mathematics. The collected data were summarized and analyzed using the appropriate statistical tools to address the objectives of the study.

4. Findings and Discussions

Table 1
Perceived Level of Students' Interest

Indicators	Before			After		
	Mean	**SD**	**VI**	**Mean**	**SD**	**VI**
1. Attitude Towards Mathematics	3.21	0.37	MM	3.54	0.26	HM
2. Initiatives in Studying Mathematics	3.31	0.27	MM	3.64	0.23	HM
3. Mathematics Experience	3.09	0.27	MM	3.58	0.25	HM
Over-all	**3.2**	**0.3**	**Moderately Manifested**	**3.59**	**0.25**	**Highly Manifested**

Legend: *1.00-1.49 = Not Manifested (NM), 1.50-2.49 = Manifested (M), 2.50-3.49 = Moderately Manifested (MM), 3.50-4.00 = Highly Manifested (HM)*

This study aimed to determine the effectiveness of a contextualized question-embedded video-based teaching and learning tool on students' perception of mathematics. Table 1 summarizes the data collected regarding students' opinions before and after using the tool. Notably, the results indicated an overall improvement in students' perception of mathematics after using the tool, which highlights the positive impact of the REACT approach on students' attitudes towards mathematics. These findings corroborate previous studies such as Yang and Liu (2018) and Azmidar et al. (2017) that highlighted the importance of using contextualized examples and problem-solving strategies in teaching mathematics.

Furthermore, the study revealed that although students recognize the importance of mathematics and its benefits in securing better job opportunities, they tend to choose a track based on their academic performance rather than their interests. This finding aligns with Malaguial et al. (2023), which showed that socioeconomic status, parental influence, job prospects, and personal interests do not significantly affect students' track choice for senior high school. Instead, academic performance plays a critical role in shaping students' decisions. Consequently, incorporating teaching approaches like the REACT approach could

be instrumental in improving students' perception of mathematics and their interest in pursuing careers that involve mathematics, fostering a deeper understanding of the subject and better academic achievement.

Table 1 also demonstrates the effectiveness of a video-based teaching and learning tool in enhancing students' initiatives to study mathematics. The results indicate an increase in mean values of all indicators, with four statements classified as highly manifested, indicating a positive change in students' mathematical initiatives. These findings align with previous research suggesting that technology-enhanced instructional methods have a beneficial impact on student engagement and motivation in learning mathematics (Chan et al., 2018; Wong et al., 2019). Moreover, the study provides evidence that using contextualized question-embedded videos can be an effective approach to improve students' comprehension of mathematical concepts and tools, organizational skills, and ability to avoid distractions.

The study supports the idea that students' interest in learning mathematics plays a crucial role in their participation and engagement in mathematics class. Azmidar et al. (2017) assert that students' high interest in mathematics can positively influence their attention to learning processes, materials, assignments, and exams. Similarly, this study revealed that students were more motivated and participative in mathematics class when using the video-based tool, which included engaging and interactive activities. These findings emphasize the importance of integrating technology-enhanced instructional methods in teaching mathematics to promote students' interest and engagement.

On the other hand, the results compared students' perceptions of their mathematics experience before and after using a contextualized question-embedded video-based teaching and learning tool. Before the intervention, students had moderate self-reported levels of mathematical proficiency, with specific skills such as exploring problems through practice and keeping an open mind to new procedural contexts being moderately manifested. However, skills such as solving complex problems on their own and expressing opinions freely were lower. The data revealed that students' interest in mathematics had changed after the intervention, with highly manifested skills such as exploring problems through practice, applying new procedural contexts, and expressing opinions freely. The use of engaging and relatable teaching styles, such as incorporating motivational activities and providing opportunities for reflection, was found to be effective in enhancing students' mathematical

proficiency. This finding is consistent with Yeh et. al (2019), which found that the use of Math-Island improved students' mathematical performance and engagement.

After the intervention, students reported an increased appreciation for mathematics when presented in engaging and relatable ways, as well as an increased ability to explain their solutions to problems. Specifically, the study found that six of the nine indicators were highly manifested, while three were moderately manifested. The study's results highlight the importance of utilizing effective instructional materials and teaching styles to enhance students' interest and proficiency in mathematics. Furthermore, the findings suggest that teachers should provide a supportive learning environment, particularly during distance learning, to help students apply procedural context in solving mathematical problem situations. These results are consistent with Wang et al. (2018) that emphasize the role of supportive teacher-student interactions in improving students' academic performance and engagement.

Table 2 displays the pretest scores of students in interpretation, analysis, evaluation and inference skills, with separate columns for the control and experimental groups. The scores are divided into six levels ranging from advanced to did not meet the expectation, with corresponding frequencies and percentages for each level.

In interpretation skills, it suggests that respondents may have limited comprehension and expression abilities when it comes to conveying the importance of data or situations presented in a mathematical problem. The table suggests that the proportion of students did not score well on the pretest, indicating that they may need additional support in interpreting mathematical problems. It is possible that the students' higher-order thinking skills were not maximized, and they may not have mastered basic concepts. This could have resulted in difficulties in interpreting data to solve mathematical problems. Azmidar et al. (2017) also stated that another potential factor is frustration with the complexity of the information or variables presented in the problems.

While in the analysis skills, it indicates that students are poor or fairly satisfactory in recognizing the connection between the data provided and the reasoning put forth, such as determining the validity of statements based on arguments involving circles, intercepted arcs, and the distance formula. Students nowadays are unfamiliar with questions that stimulate their higher-order thinking skills because they are used to answering the learning task at their homes during distance learning. Distance learning has a significant impact on their

performance when face-to-face classes begin because it demonstrates that even Grade 10 students lack basic math skills such as multiplying numbers and performing integer operations. Firdaus et al. (2015) agreed that many issues may hinder students' academic success in mathematics, including a lack of basic concept and skill mastery, and a lack of problem-solving and critical thinking abilities. As a result, students have difficulty solving problems that need reasoning and analyzing which are part of critical thinking.

Table 2

Pretest Score of Students

Score	Control		Experimental		Verbal Interpretation
	F	%	F	%	
Interpretation Skills					
5	-	-	-	-	Advanced
4	-	-	-	-	Proficient
3	3	7.5	10	25	Approaching
2	12	30	11	27.5	Developing
1	20	50	13	32.5	Beginning
0	5	12.5	6	15	Did not meet the expectation
Analysis Skills					
5	-	-	-	-	Advanced
4	2	5	2	5	Proficient
3	7	17.5	3	7.5	Approaching
2	14	35	16	40	Developing
1	10	25	11	27.5	Beginning
0	7	17.5	8	20	Did not meet the expectation
Evaluation Skills					
5	-	-	-	-	Advanced
4	3	7.5	1	2.5	Proficient
3	4	10	13	32.5	Approaching
2	14	35	9	22.5	Developing
1	12	30	10	25	Beginning
0	7	17.5	7	17.5	Did not meet the expectation
Inference Skills					
5	-	-	-	-	Advanced
4	1	2.5	-	-	Proficient
3	3	7.5	10	25	Approaching
2	14	35	12	30	Developing
1	17	42.5	14	35	Beginning
0	5	12.5	4	10	Did not meet the expectation
Total	**40**	**100**	**40**	**100**	

From their pre-assessment result, it was found that most of the students are not familiar with finding errors in solving the distance of given two points using the distance

formula and rewriting the equation of the circle. Students are good at finding or solving unknown quantities but they have limited ability to distinguish and verify errors in a mathematical solution and problem. Similarly, Alcantara et al. (2017) suggested that teachers of mathematics may provide various activities and innovative ways of assessment to improve students' critical thinking and problem-solving abilities.

The result in inference skills that students are not very good at concluding mathematical problems. Most students do not understand the definition of a triangle or how to use the distance formula of two points, so they cannot justify whether the given three points in a plane form an equilateral triangle. The research of Syafril et al. (2020) affirmed that input component is essential in identifying students' critical thinking skills. It implies that mathematical critical-thinking skill is imperative for students in learning Mathematics because it helps rational thinking in making decisions to express an idea, challenging making conclusions with alternative logical thinking, and examining and disregarding various complex problems. This implies that the respondents' prior skills in concluding a mathematical problem are lacking.

The post-test scores of the control and experimental groups in terms of critical thinking skills in interpretation are presented in Table 3. The results indicate that half of the control group received a score of 2, classified as developing level, while 10% scored 0, indicating that students are struggling to interpret figures and data about circles and their angles, equations, and graphs. This finding is consistent with Ganal, et al. (2014) who reported that Filipino students tend to excel in subjects requiring memorization and lower-order thinking skills but encounter difficulties in subjects that require higher-order thinking skills. In contrast, the experimental group showed improvement in their critical thinking skills, with 60% of them receiving a perfect score of 5 with advanced verbal interpretation. This suggests that the use of video tools with embedded questions and Socratic questioning helped enhance the students' critical thinking skills. Alsaleh (2020) supports this claim by using Socratic questioning in lessons encourages students to create insightful questions and strengthens their critical thinking abilities. The video tool utilized in the study also included conceptual clarification questions, which aid students in understanding the fundamental concepts and skills necessary for deeper interpretation. This approach is in line with the REACT approach, in which learners link familiar experiences to new information or

problems to be solved, leading to better interpretation and comprehension skills (Wang et al., 2017).

Table 3

Posttest Score of Students

Score	Control		Experimental		Verbal Interpretation
	F	%	F	%	
Interpretation Skills					
5	-	-	24	60	Advanced
4	-	-	14	35	Proficient
3	2	5	2	5	Approaching
2	23	57.5	-	-	Developing
1	11	27.5	-	-	Beginning
0	4	10	-	-	Did not meet the expectation
Analysis Skills					
5	-	-	23	57.5	Advanced
4	1	2.5	14	35	Proficient
3	24	60	2	5	Approaching
2	12	30	1	2.5	Developing
1	3	7.5	-	-	Beginning
0	-	-	-	-	Did not meet the expectation
Evaluation Skills					
5	-	-	23	57.5	Advanced
4	1	2.5	12	30	Proficient
3	17	42.5	5	12.5	Approaching
2	19	47.5	-	-	Developing
1	3	7.5	-	-	Beginning
0	3	7.5	-	-	Did not meet the expectation
Inference Skills					
5	-	-	27	67.5	Advanced
4	-	-	10	25	Proficient
3	18	45	3	7.5	Approaching
2	21	52.5	-	-	Developing
1	1	2.5	-	-	Beginning
0	-	-	-	-	Did not meet the expectation
Total	**40**	**100**	**40**	**100**	

Based on the comparison between the control and experimental groups' post-test scores for critical thinking skills in terms of analysis, the results show that the majority of the control group improved their skills in the approaching level, with 24 students or 60% receiving a score of 3. This improvement could be attributed to the lecture method, which allowed teachers to personally teach the students, improving their fundamental concepts and skills. However, the experimental group's score greatly increased, with 23 students or 57.5% receiving a score of 5 on the advanced level. This is due to the contextualized video tool

used, which applies new concepts to real-world situations and encourages students to consider the assumptions that support their arguments. The REACT approach used in the video tool was found to improve students' reasoning skills in given problem-solving situations, as supported by Rohayati (2013). The use of embedded questions in instructional interactive films, as investigated by Tweissi (2016), was also found to increase participants' self-efficacy and confidence, supplement their existing knowledge with new information, rehearse memory, and achieve better learning outcomes. Therefore, innovative teaching approaches and tools, such as the REACT approach and embedded questions, could further improve students' critical thinking and analysis skills.

The result of control and experimental groups' post-test scores for critical thinking skills in terms of evaluation indicate that the experimental group outperformed the control group, with a higher percentage of students achieving advanced and proficient levels. Additionally, the REACT approach, which was utilized in the experimental group, played a vital role in improving students' critical thinking skills. The approach allowed students to apply new mathematical ideas and approaches to find and prove errors in a given problem. This finding is supported by the Vural (2013), which suggests that using a Question-Embedded Video-based Learning Tool on E-learning can improve student achievement. The video tool also helped students improve their evaluation skills by including questions with logical consequences that can be calculated to prove and find errors in mathematical solutions and problems. The results also emphasize the importance of utilizing innovative approaches and tools to enhance students' critical thinking skills and improve their academic performance.

Lastly, the post-test scores of the control and experimental groups for critical thinking skills in terms of inference illustrates that the control group showed a low level of performance in drawing conclusions from mathematical problems due to the students' weak basic concepts and skills, as indicated by the absence of students scoring 4 or 5. However, the experimental group's performance hugely improved, with 67.5% of students scoring 5 and 25% scoring 4, demonstrating their ability to solve complex mathematical problems involving circles and geometric figures. This improvement can be attributed to the REACT approach's contextualization and embedded questions based on Socratic methods of questioning, which promote critical thinking and reasoning skills. These findings are aligned with Meij et al. (2021) that open-ended embedded questions in online video-recorded

lectures can enhance their effectiveness as learning aids. Furthermore, the video tool used in this study also includes questions that help students reflect on the underlying motives of lower-level moods and behaviors, which can aid in improving their inference skills. Firdaus et al. (2015) also found that students' ability to draw conclusions and make reasoning improved when they were able to solve complex problems, suggesting the importance of mastering basic concepts and skills.

Table 4

Test of Difference on Students' Interest Before and After the Utilization

Students' Interest	Before		After		T	Sig. (2-tailed)
	Mean	SD	Mean	SD		
Attitudes Toward Mathematics	3.21	0.37	3.54	0.26	-6.176	0.000
Initiatives in Studying Mathematics	3.31	0.27	3.64	0.23	-7.061	0.000
Mathematics Experience	3.09	0.27	3.58	0.25	-10.595	0.000

Table 4 illustrates the difference in the students' interest before and after the utilization of the contextualized question-embedded video-based teaching and learning tool. The results show that there is a significant difference in students' interest in all three measures after the utilization of the intervention with p-values of 0.000. Specifically, the mean score for attitudes toward mathematics increased from 3.21 to 3.54, the mean score for initiatives in studying mathematics increased from 3.31 to 3.64, and the mean score for mathematics experience increased from 3.09 to 3.58.

This indicates that the use of the contextualized question-embedded video-based teaching tool is effective in raising the student's interest in mathematics learning. Also, it has been observed that students find video tools to be more engaging than other study methods and related topics. Students find it particularly helpful when it presents numbers, angles, graphs, and representations of circles since these things make it easier for them to understand the concepts. In addition, using a video tool encourages students to take initiative in engaging in-class activities and completing assigned tasks.

Utilizing video-based tools in mathematics education has been shown to positively affect students' motivation and interest. Kahrmann (2016) and Korpela (2014) have shown that the use of video tutorials and short video lectures in mathematics education can increase

students' self-efficacy, mathematical success, and learning experiences. Hansch et al. (2015) also found that students enjoy studying from videos, which allows them to learn more freely and independently. The contextualized question-embedded video-based tool used in this study has similarly been shown to enhance students' interest and engagement in mathematics as shown in the previous tables. The findings suggest that developing innovative teaching resources and tools that inspire students to participate actively in class activities, complete learning assignments, and understand the value of mathematics can significantly improve students' motivation and performance in the subject.

Table 5

Test of Difference of Scores in the Critical Thinking Skills of the Control Group

Critical Thinking Skills	Pretest		Posttest		t	Df	Sig. (2-tailed)
	Mean	SD	Mean	SD			
Interpretation	1.33	0.8	2.58	0.8	-6.3	39	0
Analysis	1.68	1.1	2.58	0.7	-4.46	39	0
Evaluation	1.6	1.1	2.4	0.7	-4	39	0
Inference	1.45	0.9	2.43	0.6	-5.39	39	0

Table 5 illustrates the difference between the pre-test and post-test scores in the critical thinking skills of the students in the control group. The results demonstrate a significant difference in mean scores between pretest and posttest for all four critical thinking skills with p-value of 0.000. Specifically, the mean scores for the interpretation skill increased from 1.33 to 2.58, while the analysis and the inference skills' mean scores each increased from 1.68 to 2.58 and 1.45 to 2.43, respectively. Moreover, the mean score for the evaluation skill showed an increase from 1.60 to 2.40 post-intervention.

The lecture method can enhance critical thinking skills in mathematics but it may not be sufficient to reach the desired level of interpretation, analysis, evaluation, and inference as shown by post-test mean scores. Students tend to focus on identifying unknown quantities and defining terms, which limits their higher-order thinking skills. Firdaus et al. (2015) emphasized that mathematics education goes beyond imparting mathematical knowledge as it also plays a crucial role in cultivating critical thinking abilities that are crucial for solving problems in both academic and real-world settings.

To improve students' critical thinking skills, teachers should ask questions that challenge and strengthen these skills and contextualize teaching and learning materials (Cubillas, 2018). Furthermore, contextualizing Mathematics in a sociocultural classroom by connecting it to the real world and presenting contextual problems has been found to motivate students, challenge them to apply Mathematical reasoning to different situations, and engage them in higher-order thinking (Orozco & Pasia, 2021). Thus, to help 21st-century learners achieve their learning objectives, educators and schools must provide teaching and learning materials that improve their mathematical critical thinking skills, as they are considered digital learners.

Table 6
Test of Difference of Scores in the Critical Thinking Skills of Experimental Group

Critical Thinking Skills	Pretest		Posttest		t	Df	Sig. (2-tailed)
	Mean	SD	Mean	SD			
Interpretation	1.63	1	4.55	0.6	-15.07	39	0
Analysis	1.5	1.1	4.48	0.7	-16.14	39	0
Evaluation	1.78	1.2	4.45	0.7	-12.56	39	0
Inference	1.7	1	4.6	0.6	-17.76	39	0

Table 6 presents a significant difference between the pretest and posttest mean scores in the critical thinking skills of the students in the experimental group, which were exposed to contextualized question-embedded video-based teaching and learning tools. The findings indicate a notable difference in the mean scores between the pretest and posttest for all four critical thinking abilities, with a p-value of 0.000. Specifically, there was a marked increase in mean scores for the interpretation skill from 1.63 to 4.55, while the mean scores for the analysis and evaluation skills increased from 1.50 to 4.48 and 1.78 to 4.45, respectively. Additionally, the inference skill's mean score showed an increase from 1.70 to 4.60 after the intervention.

This implies that the utilization of this video tool is effective in improving the mathematical critical thinking skills of the experimental group. This finding is consistent with Rajab (2019) that using contextualized T-Math videos for grade 8 learners greatly improved their mathematical ability. Similarly, Vural (2013) reported that students who utilized a question QVE tool interacted more with the learning materials and achieved higher grades. These studies provide evidence of the effectiveness of video-based teaching and learning tools in enhancing the critical thinking skills of students in mathematics.

The study also revealed that the use of the contextualized question-embedded video-based tool improved students' confidence in answering learning tasks and assessments. The tool helped students recognize their prior knowledge, develop their skills in mastering the lesson, and improve their problem-solving skills in complex mathematical problems, requiring critical thinking. Thus, the utilization of this video tool is effective in improving the mathematical critical thinking skills of the experimental group and can serve as an intervention method that helps students overcome typical math difficulties.

In conclusion, the findings of this study support the effectiveness of utilizing contextualized question-embedded video-based tools in enhancing students' critical thinking skills in mathematics. These tools not only provide engagement activities that are in consonance with the needs of the learners but also develop their motivation to learn mathematics, grasp more ideas and skills in mathematics, and improve their higher-order thinking skills.

Table 7
Difference of Pretest Scores of Control Group and Experimental Group

Critical Thinking Skills	Control		Experimental		T	df	Sig. (2-tailed)
	Mean	SD	Mean	SD			
Interpretation	1.33	0.8	1.63	1	-1.5	78	0.15
Analysis	1.68	1.1	1.5	1.1	0.72	78	0.48
Evaluation	1.6	1.1	1.78	1.2	-0.7	78	0.5
Inference	1.45	0.9	1.7	1	-1.2	78	0.24

Table 7 shows the difference in critical thinking skills between the control and experimental groups in the pretest. It is demonstrated that the mean pretest scores of the two groups are nearly identical or do not differ significantly. This means that the respondents in the control and experimental groups are evenly distributed. Sample selection and promotion of heterogenous class in the junior high school are contributing factors for the non-existence of significant difference. Heterogeneous class sectioning over homogeneous class sectioning is implemented to avoid stigmatizing and stereotyping students' academic performance in lower sections in the public schools in the Philippines. To assess the efficacy of an experimental study, respondents should be evenly distributed in terms of academic performance, behavior, likes, intelligence, and other criteria (Mitchell, 2015).

Table 8 presents a comparison of the critical thinking skills post-test scores between the control and experimental groups, revealing a significant difference between the two

groups with a p-value of 0.000. It was observed that the experimental group, which was exposed to contextualized question-embedded video-based teaching and learning tools, demonstrated better engagement and collaboration when solving learning tasks. In contrast, the control group took longer to analyze and solve word problems and had difficulties interpreting graphs and identifying errors in mathematical solutions.

Table 8
Difference of Posttest Scores of Control Group and Experimental Group

Critical Thinking Skills	Control		Experimental		T	df	Sig. (2-tailed)
	Mean	SD	Mean	SD			
Interpretation	2.58	0.8	4.55	0.6	-13.1	78	0
Analysis	2.58	0.7	4.48	0.7	-12.2	78	0
Evaluation	2.4	0.7	4.45	0.7	-13.2	78	0
Inference	2.43	0.6	4.6	0.6	-16.4	78	0

The results underscore the efficacy of using contextualized question-embedded video-based teaching and learning tools in enhancing critical thinking skills in mathematics, specifically in interpretation, analysis, evaluation, and inference. The findings are aligned with Meij et al.'s (2021) that incorporating open-ended embedded questions in online video-recorded lectures led to significantly higher mean test scores. Wang et al. (2017) also highlights the importance of contextualization in creating a more stimulating learning environment, supporting the use of the REACT approach in contextualizing video tools in the present study.

Overall, the study recommends that teachers adopt these innovative teaching strategies to improve their students' learning outcomes in mathematics. By integrating contextualized video tools and embedded questions using Socratic questioning, students can develop their critical thinking skills and enhance their academic performance in the subject.

5. Conclusion

The study shows that incorporating contextualized question-embedded video-based teaching and learning tools can effectively enhance students' interest and critical thinking skills in mathematics. It also highlights the limitations of traditional teaching methods in developing higher-order thinking abilities in students. Therefore, it is suggested that educators may adopt more innovative teaching strategies and materials to adapt to the evolving needs of digital learners.

The study suggests that targeted training and seminars on innovative teaching and learning tools should be provided to math teachers by school administrators, supervisors, principals, and master teachers. By integrating technology into the teaching and learning processes, the education system can undergo a transformative change, equipping students with the essential skills to tackle complex problems in the digital age. Additionally, teachers are encouraged to develop supplementary instructional materials like interactive video lesson that foster student motivation, enhance learning, and promote the development of critical thinking skills.

To confirm the results of the study, future research can be conducted with a larger sample size or a different academic level. Comparative studies can also be done to determine the most effective instructional tools in boosting students' interest and critical thinking skills in mathematics. This can pave the way for the development of more effective teaching and learning tools that cater to the needs of both students and teachers in the education system.

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