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Bouncing Back, Blogging Knack: A General Overview of Resilience and Blogging as a Psychological Intervention

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Resilience

During adverse life circumstances, it can be hard to stay positive and find our balance; this is a situation that requires resilience. Given that mental health problems are associated with large direct costs for individuals and society, it is pragmatic to explore what constitutes resilience and find resources on how it can be enhanced. When these resources are cultivated, they can improve a person's overall ability to effectively cope with stress and hardship.

Emmy Werner (1971) was one of the first researchers to spearhead the use of the term *resilience*, while the first research on psychological resilience was published by Norman Garmerzy (1973). In the succeeding years, many researchers have contributed to a collective understanding of resilience, which has made its definition rich and varied.

One of the most widely cited – more than 6,200 citations, as of September 2020 – definitions of resilience is by Walker et al., (2004, p.4) who described it as 'the capacity of a system to absorb disturbance and reorganise while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks'. While other researchers propose that resilience encompasses positive adaptation to stressful situations (e.g., Kidd & Davidson, 2007; Martin & Njoroge, 2005; Masten & Reed, 2002). Meanwhile, the American Psychological Association (APA, n.d.) defines resilience as 'the process and outcome of successfully adapting to difficult or challenging life experiences, especially through mental, emotional, and behavioural flexibility and adjustment to external and internal demands.' APA's definition also identifies a 'number of factors contribute to how well people adapt to adversities, predominant among them (1) the ways in which individuals view and engage with the world, (2) the availability and quality of social resources, and (3) specific coping strategies.'

However, to date, it has remained elusive as to what constitutes resilience and what is the most appropriate measure to capture its conceptualisation. Since resilience is a multifaceted construct, it has inevitably led to training programmes that focus on reducing mental health symptoms, while others focus on improving psychological resilience.

The history of blogs

A blog is an online journal where an individual, group, or corporation presents a record of activities, thoughts, or beliefs. Some blogs operate mainly as news filters, collecting various online sources and adding short comments and website links. Other blogs concentrate on presenting original material. In addition, many blogs provide a forum to allow visitors to leave comments and interact with the publisher. Blogging is the act of composing material for a blog. Materials are largely written, but pictures, audio, and videos are important elements of many blogs. The 'blogosphere' is the online universe of blogs (Dennis, n.d.).

It is generally recognised that the first blog was Links.net, created by Justin Hall in 1994, while he was a student at Swarthmore College. Of course, at that time they were not called *blogs*; Hall simply referred to the platform as his 'personal homepage' (Gunn, 2020).

Blogs as digital mental health intervention

There have been a number of studies which explored the dimensions of blogging as a means to marshal mental health support (e.g., Rains & Keating, 2011), and blogs have been known to confer psychological benefits associated with supportive communication (Park & Cameron, 2014).

Due to the ability of blogs in providing supportive communication, and their popularity among adolescents (Mazur, 2005), they have been widely used as an intervention for adolescents – mainly to improve literacy (McGrail & Davis, 2011) and critical thinking (Chamberlain, 2015). More importantly, blogs have also been used to address social-emotional difficulties among adolescents (Boniel-Nissim & Barak, 2013).

As blogs continue to proliferate, over the years, a small number of blog-based interventions have been developed – such as those that are intended to address social-emotional difficulties among adolescents (Boniel-Nissim & Barak, 2013); to promote mental health among adolescents (Clarke et al., 2015); or to foster empowerment among women (Stavrositu & Sundar, 2012).

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Received 16th Nov. 2020; Accepted 16th Nov. 2020

Owing to blogging being a relatively recent phenomenon, there are varied ways on how it is implemented as a psychological intervention.

Future directions

My research aims to design a psychological intervention that will be trialled on a different cohort of university students. It will explore how effective it is in promoting resilience to address anxiety and depressive symptoms among Filipino adolescents, with the ultimate goal of addressing suicidal behaviour.

With suicidal behaviour being a global public health dilemma, the implications of my research project are threefold: First, this will be the first empirical study which will investigate the efficacy of a blog-based psychoeducation intervention for suicide prevention among adolescents. Second, it will build upon previous works on ways to promote resilience among adolescents. Finally, it will form a comparative framework for future research on blog-based intervention.

With the ever-increasing popularity of blogs, it makes sense that they should be adapted in order to improve the way people think and act about mental health. The good news is that across the world, people use blogs as a platform to share experiences, to increase awareness and understanding, and to offer comfort and support.

It might sound surprising to most people but there is a psychology behind blogging. An emerging subfield in psychology that focuses on the application of psychological principles and research in order to optimise the benefits that readers can derive from consuming blogs is known as 'blog psychology' (Relajo, 2017).

Conversations about mental health, psychology, and well-being play a crucial role in helping people feel better about themselves. Blogging gives people a chance to create these conversations.

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Exploring Relations between Muslim Women Traders and Non-Muslim Clients in Bukidnon: *Discerning Strategies for Peace*

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ABSTRACT

While deliberately formulated initiatives on achieving peace in Mindanao are recognized, there may also be latent, unintentional mechanisms derived from mundane, casual social relations. Thus, this study explored the experiences of Mëranao women traders in relating with their non-Muslim clients in two selected non-Muslim cities in Bukidnon. As an exploratory study, it employed In-depth Interviews among selected Mëranao women traders. Their diaspora in these communities is brought about by economic, socio-political, and climatic factors. They both have negative and positive experiences relating to their non-Muslim clients. They may have negative responses to the unpleasant treatment by some non-Muslims. However, generally, their responses demonstrate both a potential for a multicultural ethnic relation and a sense of agency despite their subordinated position as women, small-scale traders, and ethnic minorities. There is also a need for their host communities to raise their cultural sensitivity to eliminate prejudices towards Muslims. The study recommends for the LGUs concerned to conduct socio-cultural activities bringing Muslims and non-Muslims together, asking the big companies to consider advertisements that promote cultural understandings and sponsoring IECs fostering multi-culturalism. Likewise, curricular program planners are encouraged to embed cultural sensitivity in the curriculum. The study recommends that the LGUs concerned with conducting socio-cultural activities bringing muslims and non-muslims together, asking big companies to consider advertisements that promote cultural understanding and sponsor IECs to foster multi-culturalism.

Keywords: inter-ethnic relations, Muslim-Christian relations, trading, women

INTRODUCTION

Achieving peace has been a long-time concern in Mindanao. While there are various efforts to attain it, armed conflict still persists, at least in some localities of this second-largest island of the country. Some sectors are hopeful that the Bangsa Moro Law (BBL), which has just been enacted, could be a mechanism for addressing this Mindanao conflict. Others, however, have a critical view of it.

There is a contention that poverty is one of the major causes of such conflict. This could be supported by the fact that many provinces in this island are at the bottom poor cluster based on the 2012 Official Provincial Poverty Statistics Report by the National Statistics Coordination Board (2013). Ironically, vast natural resources, e.g., agricultural lands, minerals, aquatic, are found in this part of the country. Buendia (2015:2) may be right when he contended that the conflict is caused by a "combination of the state's centralism that effectively restricts Muslim self-governance, the long-drawn socio-economic deprivation of Mindanao, especially the Muslim areas, and the historical biases and prejudices between Muslims and Christians that have not been completely expunged."

While deliberately formulated initiatives on promoting peace are to be recognized, there may also be latent, unintentional mechanisms derived from mundane, casual social relations. Such argument, however, needs to be further explored. Thus, this research examines the possible connection between the trading activity of Muslim women and promoting relatively peaceful inter-ethnic relations.

It focuses on women because many Muslim entrepreneurs/traders in many cities in the Philippines are observed to be women. This may contrast to the experiences in other Muslim countries where women are less visible in the economic space (Zakaria, 2001; Roomi and Parrott, 2008). There are, however, few countries where women play significant economic roles, just like India. In a study conducted considering 50 samples, Laxmidevi et al. (2018) tried to understand the social status of Muslim women who are street vendors. The study revealed that though Indian Muslim women do not enjoy equal status with men because of religion and socio-cultural practices, they are good in finances and economy. Though most of them are illiterates, they know how to run a business like vending, and they know how to calculate and gain profit. Likewise, Azmi (2017) emphasized that Islam does not restrict Muslim women from engaging in business. In fact, women's participation in an economic enterprise can be traced back to Prophet's (PBUH) time when his wife SayiditinaKhadijah was a successful businesswoman.

Thus, it could explore the changing and potential role of women in a country's economic development. More so, many studies presented the critical role of women in promoting peace. It may be stereotypical to argue that women are often less involved in armed conflict, though this could also be due to assigning 'military' roles mostly to men. However, empirical data support this contention that women are actively involved in peace negotiations

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Received 10th July 2019; Accepted 23rd October 2020

(Rehn & Sirleaf, 2002; Hunt & Posa, 2001; Karam, 2000). Hence, when such potential of women be maximized, they could be assets for both an economically progressive and peaceful community. Thus this research aimed at assessing the possible relation between Muslim women's activity and relatively peaceful ethnic relations. Generally, it tried to explore the relations of Muslim women entrepreneurs and their non-Muslim clients. Specifically, the research wanted to identify "PUSH"- "PULL" factors relating to Muslim women's migration to non-Muslim communities; describe their positive and negative experiences in relating with non-Muslim clients; and explore their corresponding responses to such experiences with their non-Muslim clients.

METHODOLOGY

This is a descriptive and exploratory study. It was conducted in two cities in Bukidnon namely, Malaybalay and Valencia. These cities in the region were purposely selected because of a relatively higher number of Mëranao

women traders. It employed a qualitative method of data collection, particularly, In-depth interviews, to ensure more depth of information being generated. Thus, 26 Muslim women entrepreneurs were purposely selected. The generated data were then transcribed and analyzed through thematic analysis. Based on the respondents' narratives, themes and patterns were established.

Table 1 presents the socio-demographic profile of the respondents.

RESULTS AND DISCUSSION

Before exploring the relations of the Mëranao women traders with their non-Muslim clients, it is important first to identify the factors or reasons for their migration in the selected non-Muslim communities. The "PUSH-PULL" theory is known for explaining migration. These "push" and "pull" factors are common to migrants in their decision to migrate, as mentioned by an early theorist in Demography, Donald J. Bogue (1969 cited in Poston

Table 1

Demographic and Socio-Economic Profile of the Respondents (n=26)

VARIABLE	FREQUENCY	PERCENTAGE
Level of Education		
College level-graduate	4	15.4
High school level-graduate	17	65.4
Elementary level- graduate	5	19.2
Marital Status		
Married	22	84.5
Single	2	7.7
Widow	2	7.7
Age		
15-19	3	11.5
20-29	7	26.9
30-39	6	23.1
40-49	8	30.8
50-59	2	7.7
Number of Children		
0-2	9	34.6
3-5	7	26.9
6-9+	10	38.5
Number of years in the community		
Below 10	5	19.2
10-20	8	30.8
Above 20	13	50.0
Number of years as vendor/ss trader		
Below 10	13	50.0
10-20	7	26.9
Above 20	6	23.1
Net daily income		
100 & below	11	42.3
101-300	8	30.8
400 & above	7	26.9

& Bouvier, 2010). "Push" factors refer to unfavorable conditions in the place of origin, while "Pull" factors are the favorable conditions that encourage migrants to come to their place of destination. A combination of these factors prompts migrants to transfer their place of residence.

"PUSH"- "PULL" Factors of migration

Table 2 shows why the Měranao women respondents and their relatives have migrated from Marawi, their place of origin, and decided to reside presently in non-Muslim communities. While economic factors like unemployment, poverty, etc., are the primary consideration in most migration decisions (Poston and Bouvier, 2010), the above data demonstrate some socio-political and environmental/climatic conditions. Aside from economic factors, the data show the problem of peace and order in Marawi. It could be noted that the data were generated before the siege in the area. However, the respondents revealed that conflict is present in their place of origin brought about by rebellion and the cultural practice of "rido." Some of the respondents' narratives relate to this situation, such as the following:

"...naa lagi nagahitabo nga mga gulo2...basta mga Muslim grabe na..." (there is conflict happening there...if the Muslims, it is terrible..)

"...kay gubot kaayu didto...kanang mga rebelde bitaw..." (...because there is really trouble/conflict there... due to the rebels...)

"...kana bitaw dili magkasinabtanay mag family..." (...when families do not understand each other...)

"o magpinatyanay...parti sa mga yuta...mga anak... pareha kanang imung anak awayon niya ang imung silingan nga anak unya molaban bitaw iyang ginikanan ana...usahay mga mananap... naay mawala nga mananap ikuan sa imuha unya walay ebidensya nga ikaw nagkuha ana..." (yes they kill each other...due to land...the children... just like if your child and that of your neighbor will quarrel, the parents will interfere...sometimes about animals, when they are lost/stolen...they will accuse you even if there is no evidence...)

Aside from "rido", the armed struggle between the government and the secession rebel groups had

been existing in Marawi (and other places like Lanao del Norte). The problem of peace and order in Mindanao is not something new. It has been there for scores, and has led to an increasing trend of Internally Displaced Persons (IDPs). Unfortunately, peace negotiations and peace- talks stumble, and violence has remained uncured (IDMC 2008). The factors mentioned compelled the Muslim women to seek refuge in neighboring provinces, which they perceive to be relatively peaceful like Bukidnon. In fact, there is also a growing number of Muslim communities in Luzon. Watanabe (2018) stressed that migration peaked in the 1970s and has continued to increase as years go by. Most of them are in Quiapo, Manila. The presence of mosques is a sign of the existence of Muslim communities.

Likewise, the above data demonstrate Měranao's 'clannish' practice. Some of them came to their communities of destination because of the presence of their relatives (who came first), although ironically, they also left some of their relatives in Marawi. However, they revealed that they regularly visit the latter if their resources permit. The relatively cool climate in Bukidnon likewise enticed them to stay in the province.

Měranao women traders' experiences with non-Muslim clients

After identifying the factors that affect the respondents' decisions to migrate to non-Muslim communities, their experiences (as women traders) in their present residence, which is predominantly non-Muslims are worth noting. Their narratives revealing their experiences may be analyzed from the perspective of ethnic pluralism or multiculturalism.

Based on the respondents' narratives, two major themes emerged: their positive or pleasant experiences, and their negative or unpleasant experiences, with their non-Muslim clients.

Positive or pleasant experiences

The Měranao women respondents shared their positive experiences with their non-Muslim clients. They considered some of their non-Muslim clients as loyal, friendly, and understanding based on their narratives. One of the respondents shared that *"kung wala among stock ila jud nang hulatan...mangutana sila, ngano diay Gang layo? Doul ra man...sige maghulat na lang ko kay pang buena*

Table 2. Table Summary of factors relating to migration

"PUSH" Factors
Limited economic opportunities
Presence of conflict
"PULL" Factors
Available means of livelihood
Relatively peaceful
Presence of relatives
Good climate

mano man kaha..." (If we don't have stock, they would really wait...they would ask, why is it far Dear? It is just near...ok I will just wait because as you said, it is for Buena Mano (first buy)...").

A worth noting relation established by the Mëranao women vendors with their non-Muslim clients is "suki." A "suki" may originate from the Chinese word and directly translated as a "special customer." It may be "applied to any person or role relationship in the trade network..." (Davis,1973). While a *suki* is simply a common term associated with the clients by the Mëranao traders and vice versa, when it is treated as a social relation, it has a deeper meaning. This could be illustrated by the following narratives of the respondents.

A respondent shared her experience with her "suki" and related that, *"...ang tinuod nako nga suki kay bisan wala ko sakong baligya hulatan ko nila..."* (My real "suki" would wait for me when I am not yet at my stall...). Another respondent also revealed that *"...Ang among suki kay magbalikbalik kay tungod na amigo/amiga na namo sila..."* (Our suki keeps on coming back because we have become friends already.)

These narratives demonstrate friendly relations between the Mëranao women vendors and their non-Muslim clients. These relations may show that ethnic pluralism could be evident in Mindanao. Thus, behind the 'sensationalized' conflicting relations between the Muslims and non-Muslims, there are relations that show accommodation, acceptance, and respect by both groups. The following section, however, also indicates negative or unpleasant experiences of the respondents.

Negative or unpleasant experiences

While the Mëranao women vendors have positive experiences with their non-Muslim clients, they also have negative encounters. Many of their responses demonstrate a relatively negative impression for non-Muslim clients.

First, the respondents described some of their non-Muslim clients as overly meticulous and difficult to understand. According to one of the respondents, *"...Dili masabtan...pangutan on nimo, dili mutubag biyaan ra kag kalit..."* (Cannot be understood...if you ask them, they won't answer, or they would just leave you...). Another respondent said, *"...naa pajuy customer ba nga sigeg pa testing unya dili diay mupalit..."* (there are customers who just keep on "testing" your product, but they do not buy...). Other respondents also said *"...usahay kanang mag bungkag lang silag baligya unya pag ihatag nimu sa iyaha muingon nga ay! Kanang lahi nga color, unya muingon lahi napud pagkuhuman pagkuan sa iyang ginapangita muingon dayun siya nga, ahh balik lang ko..."* (sometimes, they only disarrange your products then if you offer one, they would say another color, then another color again, and then eventually, they would say, I will just come back...).

Second, the respondents revealed that their clients seem insensitive in disorganizing/dismantling the arrangement of their products without thinking of their effort in arranging them. They related that:

"...naa poy uban nga igo ra mangukay...unya ilang daot daoton...dili mupalit..." (There are some who are just fond of disorganizing/ dismantling (their products)...and yet they do not buy...)

"...Mamungkag ug baligya unya dili gihapon mupalit..." (...they disorganize/dismantle our product, and yet they do not buy...)

"...kanang mangukay ba unya dili diay magpalit ingon rag balikan na lang namu unya dili diay mubalik..." (...those that disarrange your products, but they do not buy, they will say they will come back, but they do not actually come back...)

Third, the respondents considered some of their clients as fond of haggling. One respondent related that *"...Ai kanang kusog kaayo muhangyo...kanang capital hangyoun pa...pila ra among ginansya..."* (...one who is so fond of haggling...even the capital they haggle...we only have meager profit...). Another respondent also commented, *"...kanang customer bitaw nga lain kay mga barat kayo grabe makahangyo halos kuan wala nay maginansya..."* (...a customer who haggles too much even to the point that we do not have anymore profit...). Still, another respondent shared that, *"...Kasagara sa manghangyo sila usahay nga kanang wala jud sa capital..."* (...those who usually haggle lower than our capital...).

Fourth, the respondents mentioned that some of the non-Muslim clients are strict and naughty. Two respondents have these narratives, *"...naay uban kanang imong tawagon dili motubag murag dili makadungog sa imuha, naa poy uban nga estrikta... naay mag mug ot..."* (...there are those that do not answer you, it seems that they do not hear you...others are strict...there are those that frown...).

One respondent also related her experience of quarrelling with her non-Muslim client. She said that the client came back to her to return the radio she bought because it is accordingly damaged. The client arrived at her stall very angry and dropped the radio in front of her and said, *"...isumbong ta ka sa taas..."* (...I will report you to the "top," which means to the authorities...).

Fifth, some customers throw malicious jokes at the respondents, especially to the younger ones, as revealed by them. According to one of the respondents, *"...Gajoke kay naay customer nga bastos...magbinuang usually mga lalaki..."* (...They throw jokes, some customers throw malicious jokes, usually the males...).

Last, some respondents revealed that they are prejudiced by some of their clients. One respondent shared that, *"...dili daw sila mamalit sa amoa kay mga isog daw mi..."* (They don't buy from us because they thought we are threatening). Another respondent mentioned what their clients said, *"...kani mang naa sa sidewalk kay dali raman mangadaot (...that these sidewalk vendors sell low quality (easily broken) products...)*. There is also a respondent who revealed that *"...usahay mahadlok sila mupalit sa amoa... mahadlok sila kay mga Muslim daw mi..."* (...sometimes

they are afraid to buy from us...they are afraid because we are Muslims...). They are also perceived to be selling products with 100% mark up/profit. Thus, their clients haggle a lot. One of the respondents said, *"...makaingon man sila mga Muslim daw kasagara daw magginansya sila ug tinunga..."* (...they say/perceive that Muslims are gaining 100% profit...").

The above narratives reveal many realities in the context of inter-ethnic relations. The first three experiences may be viewed as rational actions of a customer, such as being haggler, choosy, and meticulous. Any customer may do the same just to have the 'best' buy.

However, the last three experiences manifest the subordinated position of the respondents, simultaneously as M̃ranaos, as poor, and as women. Thus, there seems to be evidence of an intersection of subordination experienced by the respondents. The theory of Intersectionality argues that while women experience oppression based on gender, they are "differentially oppressed by varied intersections of other arrangements of social inequality" (Ritzer, 2011).

In the above narratives, it can be inferred that as M̃ranaos, they suffered from negative perception or prejudice. As small-scale traders, they are labeled to be selling products of low quality and subordinated and victimized by global capitalism. Women are shaped by gender stereotypes and experienced harassment (though subtle) in the marketplace.

These experiences are threats to ethnic pluralism. There can be no parity when any of the groups in a society or community are prejudiced and discriminated against. The prior experience, in particular, signals an offshoot of the historically rooted prejudices of non-Muslims to the Muslims. This is supported by the studies on Muslim-Christian relations presented by Manacsa (2002), which showed that Christians have a more negative perception of Muslims than the other way around. In fact, Manacsa (2002) challenged such an attitude of the Christians, for they could be a hindrance to solving the Mindanao problem.

In the case of this study, the M̃ranao women have varied responses to such experiences, as presented in the next section.

4.5 M̃ranao women's responses to their experiences with non-Muslim clients

The narratives on how M̃ranao women traders respond to the pleasant and unpleasant experiences with their non-Muslim clients suggest some interpersonal dynamics that could also be analyzed within the frameworks of Ethnic Pluralism and Agency. Based on their narratives, four patterns of responses are established: assert, negotiate and explain, compromise, and establish a "suki" relation, as shown in Figure 2. It is presented in a manner of progression from less positive to more positive responses, in ethnic pluralism. However, each response demonstrates a unique potential of the respondents as an agent both in promoting peaceful relations and contributing to the economy.

4.5.1 Assert

Few Maranao women traders assert and talkback argumentatively when they have an unfavorable encounter with their non-Muslim clients. The following lines by some respondents demonstrate such assertiveness:

"...unsa man ka kuya kung dili ka ganahan ana akong mga benta hindi naman kita pinipilit na bumili eh ..." (...what is wrong with you brother, if you do not like my product, I am not forcing you to buy it...)

"...grabe sad ka makahangyo ana..." (...you haggle too much on that...)

"...usahay masuko jud ko kay muingon sa akong baligya nga, pangit mani, motubag jud ko nga ayaw sad anaa akong baligya kung dili ka mupalit, ayaw, kay ikaw naa diyay kay baligya nga ingon ani? Kung lainan ka nganong mo gunit man ka?" (...sometimes I get mad because they say that my product is ugly or of low quality, so I would answer, do not say like that to my product; if you do not want to buy, then don't! Do you have a product to sell like this? If you do not like it, then why are you holding it?)

"...nagtuo pod mo nga nagtinunga mig ginanasya diri? ...makalagot man gud usahay ..." (...you

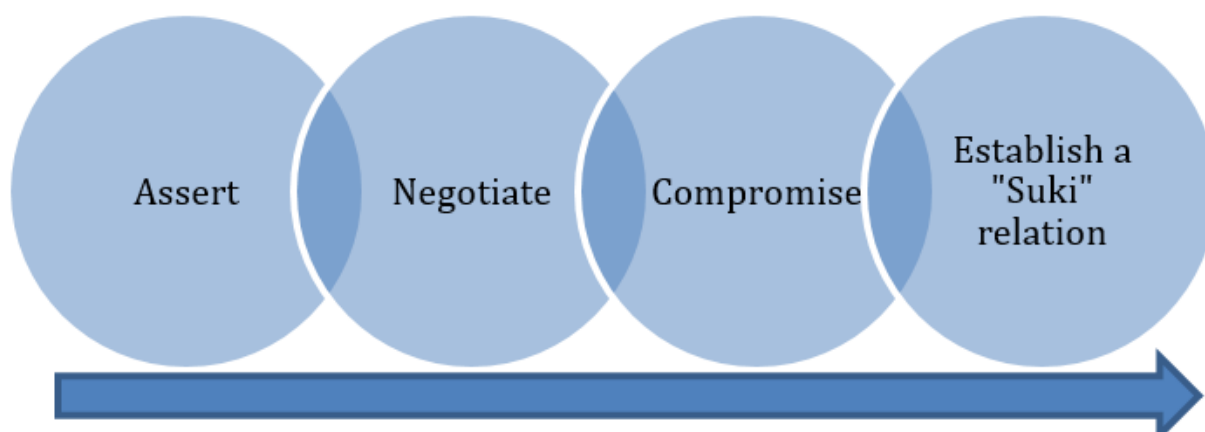


Figure 2. Maranao Women's Response

thought that we have 100% profit?...it is really annoying sometimes...)

Among the four established patterns of responses, it has the most negative implication, particularly in peace and a pluralist interethnic relation. It may manifest a "natural" response of one who receives an unpleasant stimulus, as argued by the Behaviorists (Watson, 2013; Pierce & Cheney, 2013). This response may also demonstrate the "*maratabat*" or the sense of pride of the Mëranao.

While such responses may have negative implications on promoting peaceful relations, these may also show the empowering potential of the Mëranao women. In other words, these women are less likely to be oppressed and dominated. Thus, such response indicates a particular manner through which the Mëranao women, as agents, manage their social context.

As the above response denotes propensity towards conflicting relations, the following responses may have the potentials to achieving and sustaining ethnic pluralism.

4.5.2 Negotiate and explain

Many of the respondents negotiate with their non-Muslim clients when they are not treated well or when the latter haggle too much. They would explain the reason why such is the price of their products. One respondent said, "...*estoryahon lang ug tarong... ayo-ayohon para walay samok...*" (...we will just explain to them nicely...be nice to them so that there is no conflict...). Another respondent also said that "...*estoryahon nga ayaw pag abusado kay dili man mi abusado ...*" (...tell them not to be abusive because we are not abusive...).

The following are other narratives that demonstrate their negotiating skills and of promoting peaceful relations by explaining to their clients.

"...dili lang me magminaldita, pero among gina hinay hinayan og storya aron mupalit lang..." (...we do not have to be tough, but we talk to them explain to them clearly/slowly so that they will buy...)

"...pagsabihan na kung may problema ka sa bahay, wag dalhin dito, iba ang problema sa bahay, iba din dito..." (...we will tell them that if you have a problem in your house, do not bring it here, the situation in your house is different from here...)

"...e-explain namin na kung mura masyado, wala na sa capital...utang pa naman namin ang capital..." (...we will just explain that if it is so cheap, it is lower than the capital...and we just borrowed our capital)

Evidently, the above narratives demonstrate the Mëranao women's potential as agents in promoting peaceful relations in a community. They can navigate from a relatively subordinated position (as poor, ethnic minority, women) to becoming agents of promoting peace. They spend time explaining to their clients just to avoid conflict

and, at the same, convince the latter to buy from their products. This response likewise supports ethnic pluralism with peaceful relation through respect as a priority.

4.5.3 Compromise

The respondents also make compromises with the demands of some of their clients. They compromise so that conflict between them and their clients may be avoided. Also, they would give in to the haggled price, despite low (or even no) profit, so that they would have a sale for the day. The following are some of their narratives that demonstrate their tendency to compromise:

"...usahay ilisan na lang namo bisag walay daut...kay kung maglalis dili man mahuman..." (sometimes we would just replace (the product) even if it is not defective...because if we argue, it will not stop...)

"...mulaylo na lang mi kay unsaon ta man customer is always right man jud..." (...we would just mellow down because we cannot do anything, the customer is always right...)

"...magpahangyo man ta kay wala baya tay halin diri kung dili ta magpahangyo..." (...we would just give in to their haggled price. Otherwise, we have no sale here...)

"...Sir kung asa ka makakita ug barato, didto na lang ka palit..." (...Sir just go to where you can buy a cheaper one...)

"...sige lang suki, adto na lang sa uban naa moy ganahan, dili ta mag away para walay gubot..." (it is fine "suki," you just go to others that have your preferred products, we do not have to argue so that there is no conflict...)

This third response exceeds the second for it involves a sort of 'sacrifice' on the part of the respondents. Why do they compromise? First, they compromise to avoid conflict, as clearly shown in their narratives. Second, they give in to the demands of their clients so that at least they could have a sale for the day. Such responses manifest again the potential of the Mëranao women for a peaceful relation, even to the point of compromising their own benefit. Ethnic pluralism is more likely to occur if various groups are willing to compromise at the expense of their benefit.

4.5.4 Establish a "suki" relation

Among all the patterns of responses of the Meranao vendors, establishing "suki" relations demonstrates the most peaceful and friendly relations with their non-Muslim clients. A "suki" is one who regularly buys and goes back to the vendor or a "special customer" according to Davis (1973).

The respondents shared the reasons for establishing a "suki." First, they offer a special, lower price to their suki, even to the extent of having no profit. Second, they give presents (e.g., shoes, shirts, slippers) to

their suki, especially during holiday seasons. Third, they believed that they are good at entertaining their "sukis." One respondent shared, "...*nakaayon sila sa akoo kay dili daw ko isog mag-entertain bisan maabog-abogan akong gbaligya....dili daw ko pareha sa uban nga masuko...*" (...they like me because I do not get mad when I entertain, even if my products get dirty (caused by the customer)... unlike others who get mad...). Last, they have established friendly relations with their customers. According to one of the respondents, "...*among suki kay magbalikbalik kay tungod na amigo/amiga na namo sila...*" (...our suki keep on coming back to us because we have made them our friends already...). Another respondent revealed that "...*maluoy ko sa ila...dayun kanang among gamit nga dili na namu gamiton akong ihatag sa ilaha, mga gamit sa akong mga anak, akong ihatag sa ila...*" (...I feel pity for them... I give them hand-me-downs....those of my children, I give to them...).

Based on the above narratives, it is apparent that the respondents were able to bridge the gaps of interethnic relations brought about by deep-rooted prejudice and discrimination. As shown in a "suki" relation, the Mëranao women could be agents of peaceful inter-ethnic relations and pluralistic society. Their day-to-day encounter with their non-Muslim clients and their desire to have more sales have developed in them a strategy for winning them. They negotiate, compromise, and eventually establish a "suki" relation. "Suki" implies a good relationship, and it connotes trust. This means stereotyping, prejudice, and discrimination attached to the two different cultures slowly melted down because of day-to-day casual interaction.

The study of Lois Ann Hall on "Gensan is halu-halo: A study of Muslim/Christian social relations in a regional city of the Southern Philippines" (2010) described and examined how the two distinct groups interact and relate with one another. The author considered in her interview various classes of individuals who are regarded as ordinary citizens. By ordinary, she meant neither elite nor held religious or political functions and positions. She interviewed government employees, teachers, farmers, and vendors. She concluded in her study that Gensan is halu-halo, which means that though the label of Christians and Muslims have remained very distinct, the relationship of the two has blurring boundaries. The two groups are able to live their day-to-day life in harmony and peace. They celebrate some holidays together, and the neighbors can build friendships regardless of their religion. The author claims there is no apparent conflict between the two groups. Hence, she considered the Christian-Muslim conflict in Mindanao a skewed reality, pursued only by some groups who have extreme ideological leanings. But the majority of Christians and Muslims are forging a harmonious relationship. Muslims perceive their Christian neighbors positively, and they said they get along well with them. As proof of this, many intermarriages are happening in the city. Be it noted that Gensan was inhabited by Muslims before. When the National Land Settlement Authority (NLSA) was undertaken in the 1970s, many Christians were brought by the Philippine government to Gensan, and they lived with the Muslims. Both camps consider their relationship to have grown better with time when they knew each other well and developed a

sense of trust. Prejudice, slowly eradicated when they become friends and able to develop family ties through intermarriages. Likewise, both camps learned to respect the doctrines and practice of the other's religion.

The situation of Bukidnon and Gensan is in a similar context. It talks about two distinct groups- the Muslims and the Christians. They may have different historical backgrounds, however. Gensan was predominantly a Muslim area that accommodated the entrance of Christians seeking a greener pasture, while Bukidnon is predominantly a Christian province accommodating Muslims who were seeking refuge from a war-torn Marawi.

CONCLUSION

The Mëranao women's diaspora in non-Muslim communities reflects certain social realities not only in the areas of migration but also of inter-ethnic relations. Their movement is attributed to economic and socio-political conditions in their places of origin and destination, attesting the "push-pull" theory of migration. What may be distinct and novice in the case of the Mëranos' movement are their experiences of conflict in their place of origin and their economic marginalization brought about by global capitalism in both their places of origin and destination.

Most importantly, their diaspora in non-Muslim communities resulted in interesting inter-ethnic relations. Their involvement in the economic sphere as traders could be translated into spaces for promoting a pluralist inter-ethnic relation. While there are instances of negative responses due to negative stimuli/treatment (from their non-Muslim clients), they have shown positive actions and reactions that are potential for multiculturalism or ethnic pluralism. The casual vendor-client relationship between the Muslim and non-Muslims has developed into a "suki" relationship, hence developing a sense of trust and a good relationship between the two distinct groups. Likewise, they are far from known Muslim extremists and radicalists. Despite their subordinated position as an ethnic minority, poor (small-scale traders), and women, they are able to navigate and survive both for establishing relatively peaceful relations and for meeting their family needs.

Nevertheless, their demonstrated potential to assert when negative treatment is accorded to them implies that their non-Muslim clients also have to raise their level of cultural sensitivity. Respect is highly demanded to the point of erasing historically-rooted prejudices against each other.

It takes both groups to intentionally pursue a more pluralist community or society.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations may be forged:

1. For the LGUs of Valencia and Malaybalay City to conduct activities bringing Muslims and non-Muslims together;
2. For the LGUs of Valencia and Malaybalay City to ask

the big companies to consider advertisements that promote cultural understanding and to sponsor IECs fostering multi-culturalism;

3. Curriculum designers/planners and educators are encouraged to emphasize the integration of cultural sensitivity in curricular programs;
4. The non-Muslim customers are encouraged to visit and buy at Muslim's stalls as a constant interaction between the two groups may contribute to a better understanding between non-Muslims/Christians and Muslims; and
5. Researchers may conduct related studies on Muslim women traders to validate and enhance the findings of this study for further utilization of research results.

ACKNOWLEDGMENT

The researchers wish to thank the CMU administration for the support to fund this study. They also express their gratitude to the Muslim/Meranao women traders for sharing their time as respondents of this study.

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ABSTRACT

Lake Apo, an 18-hectare lake situated in Guinoyoran, Valencia City, Philippines is a tourist destination. It was once an ordinary pond, but with the initiatives of the community and some visionary private individuals, it has become a promising tourism site. Hence, the study was conducted to assess the initiatives of conservation undertaken by the stakeholders of Lake Apo, analyze the issues confronting the lake, and describe the tourists' assessment on the lake. The study is descriptive employing quantitative and qualitative approaches. Survey, Focus Group Discussion, and Key Informant Interview were the tools used in data gathering. The residents claimed to be highly dependent on the lake. It gives them livelihood since it was opened to tourism, a source of leisure, and a source of protein. As a tourist spot, the lake receives positive assessment from tourists. Its beauty and serenity appear captivating. Tourism is the lake's most viable utility. The stakeholders are desirous to transform the lake into a vibrant and sustainable ecotourism site. However, young as it is now, tourism in Lake Apo is hounded with controversy on conflicting claim of ownership, and issues on poor resource management, unregulated anthropogenic activities, and poor waste management.

Keywords: ecotourism, assessment, perceptions, conflict

INTRODUCTION

Tourism is the most rapid growing industry and economic generator to many destinations, towns and regions globally (Yusof et al., 2010). According to Smith (1995) tourism can make important contribution to poverty alleviation, employment, and development of rural areas. Hence, many sites like mountains, beach-fronts, rivers, and lakes have been developed into tourist destinations. These natural settings are aesthetically enhanced to cater public recreation. The conversion is designed mainly for socio-economic development (Tikkanen, 2003). However, tourism may give grave pressures on the environment as more and more visitors come (Bushell, 2006). Much more so that some tourists rarely understand how their gay activities give physical impacts on the environment (Rizvi, 2008). Hence, for many years, experts on environmental protection and water supply like the International Lake Environment Committee (ILEC) try to solve the problems behind the conversion of some sites to tourism, and aimed for sustainable tourism and protection of lake ecosystems (Kurleto, 2013).

Despite the promise of tourism, several reputable lakes have lost its prominence due to apathy, neglect, irresponsible use, and over-exploitation among local residents. Such behaviour may spring from insufficient knowledge and lack of awareness on protection and conservation of lakes (Thomas et al, 1996). This is unfortunate because the natural resource could have been a potent source of income among the locals. Likewise, Drake (1991) stressed that participation of the stakeholders is very important and fundamental in the planning, management, and effectiveness of tourism. More so, according to

Diedrich & Garcia-Buades (2009) understanding and assessing the impacts of tourism development on local communities are important to ensure the sustainability and long-term success of the industry. It is on this regard that Jenkins & Henry (1982) argue that the government has a major role to play, for its responsibility in the protection and conservation of tourism sites is higher than the private sectors' involvement for tourism development. Therefore, the government should get involved in dealing the impacts of tourism on host sites and communities. The study of Guerrero (1999) on 36 major lakes in the Philippines found that only 41.7% are in good condition, while 55.5% are threatened, and 2.7% are in critical condition.

Hence, the study on Lake Apo, an 18 hectare beautiful lake situated at Barangay Guinoyoran, Valencia City was conducted. Some 30 years ago, the lake was just considered a pond where carabaos used to wallow, a place for washing clothes, and a dumping area for household garbage. Some visionary residents, however, saw its potential to become a tourist spot, cleaned and developed it into a tourist area. Now, it is one of the tourist destinations in Bukidnon.

The study is anchored on the principles of ecotourism. Ecotourism is a sub-category of tourism that is seen to be desirable because it gives income to the locals while holding intact the ecosystem. It conserves the status of the natural resources used while affording livelihood. Primarily, it is aimed at improving the lives of

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Received 20th March 2020; Accepted 23rd October 2020

the locals. Likewise, it is also seen as an effective tool for environmental conservation (Garrod, 2003). Unlike other forms of tourism, ecotourism banks on natural resources and landmarks to attract tourists (Stem, 2003) like forest, lakes, mountains, rivers, etc. More so, ecotourism is seen to be a good example of sustainable development. It supports the locals economically, and it conserves the natural resources used. The Brundtland Commission defined sustainable development as "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs" (Report of the World Commission on Environment: Our Common Future. N.D.). Henceforth, ecotourism demands conservation, which according to Mondino (2019) is a tough job to do. It demands high quality maintenance of natural resources, training people with local knowledge as guides and interpreters, educating and making people aware on conservation practices, among others. Nevertheless, the author finds ecotourism a promising alternative path to development, especially on areas where extraction livelihood does not warrant. Developing an effective ecotourism business maybe challenging, however Bonilla (2003) has suggested a method which has been proven effective, at least in few tourist destinations where the method was applied. This method is popularized by the Conservation International (CI). Basically it suggests the crafting of a tourism plan that is participatory, where the community, non-government Organizations, local government units, ecotourism specialist, the private sectors, together would craft the vision and mission of the tourism project and strategize its implementation. Being participative, its implementation is feasible, better than consultant-driven plans.

Anchored on ecotourism, the study tried to answer the following questions: How do residents of Lake Apo perceive and describe their relationship with the lake? What privileges, opportunities, and benefits has the lake

afforded to them? How do tourists describe and assess the lake? What are some of the tourists' suggestions to better improve the services of the lake? What are the initiatives of conservation undertaken by the LGUs and residents of Lake Apo? And, what are the issues confronting Lake Apo? In general, the study assessed the communities' relationship with the lake and its initiatives of conservation, analyzed the issues confronting the lake, and described the tourists' assessment on Lake Apo.

METHODOLOGY

Study Site

Lake Apo is situated in Sitio Lake Apo, Guinoyoran, Valencia City, Philippines (Fig. 1). The lake has been developed into a tourist area, which efforts started in 1990s as initiated by Dr. Almer Alfonso, a member of the Sangguniang Bayan of Valencia City. The lake has an area of 18 hectares with 108 households.

Aside from occasional employment afforded by tourism, most locals engage in farming, while some engage in fishing using gill nets, and banatans (Quimpang, 1991).

The study was conducted on March to July 2019. It assessed the communities' management on Lake Apo as a tourist area. The study is descriptive using a combination of survey among residents and tourists, Focus-Group Discussion (FGD) among local officials, and Key Informant Interview (KII) among lake managers. There are 108 households in Sitio Lake Apo and 60 (55%) were randomly chosen as respondents. They were asked to answer a self-formulated and peer-reviewed questionnaire. The questionnaire had five parts: A. Biographical Information; B. Utilization, Dependence, and inhabitant's Relationship with Lake Apo; C. Initiatives of Conservation; D. Development of

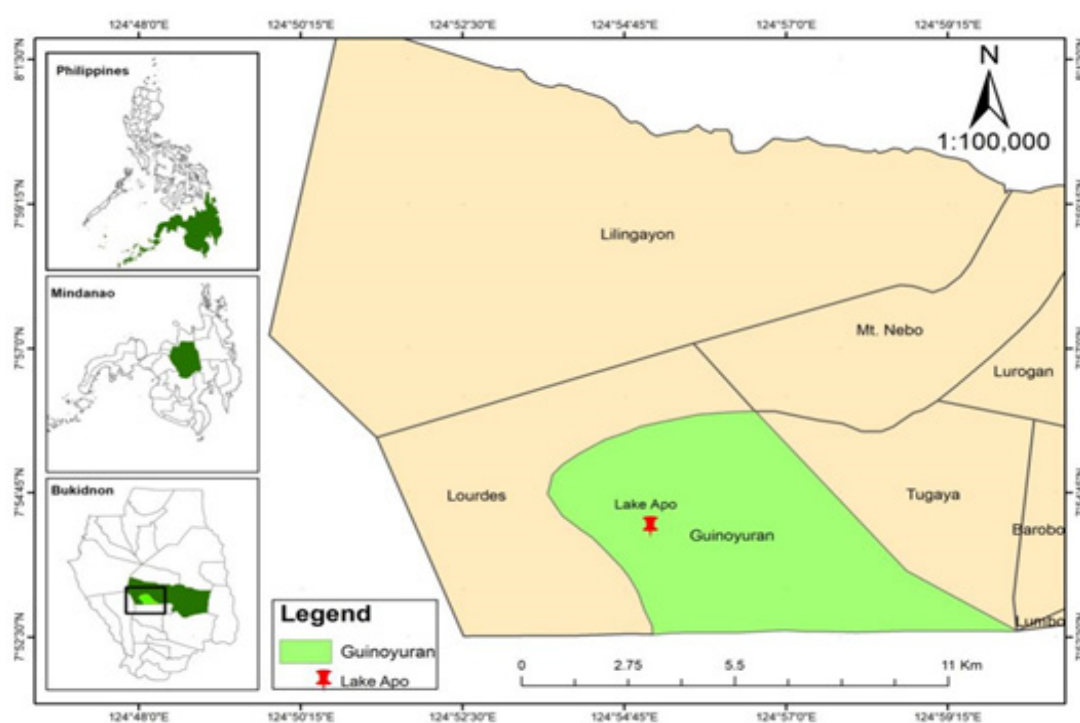


Figure 1. map of the Study Area

Lake Apo into a Tourist Destination E. Issues Confronting Lake Apo. Some of the questions raised to the respondents were: How do you describe your relationship with the lake? How important is Lake Apo to you? What benefits have you gained from the lake? How is the lake managed as a tourist area? Likewise, 60 tourists were interviewed. The questions revolved around their assessment on Lake Apo as a tourist destination, the activities they do in relation to the lake, and the amenities they avail in Lake Apo. Some of the questions raised include: How do you describe and rate Lake Apo as a tourist destination? What can you suggest to help improve the lake? What amenities do you avail? Would you recommend Lake Apo to your friends? The interviews happened in the first week of July 2019 (i.e., July 2-7, 2019) on daily basis for six (6) consecutive days with a quota of 10 respondents per day. The FGD had 6 participants. They were identified by the Barangay Captain based on their functions in relation to the lake. They were the Tourism Officer, SK Chairman, and 4 barangay kagawad. The discussion revolved around LGUs vision, activities, and programs for Lake Apo, and on issues concerning the lake. Some of the questions were raised were: How do you envision Lake Apo years from now? What activities, programs, and strategies are initiated by the LGU to realize the vision? What are the issues confronting the lake and how are these issues dealt with? Likewise, the KII had 6 respondents. They were the stakeholders, managers, and the casual employees of Lake Apo. The discussion revolved around the development, activities, and issues confronting Lake Apo. Some of the questions raised were: Can you describe the appearance of Lake Apo before it was opened to tourism? What benefits has Lake Apo contributed to you and the locals? What is your vision for Lake Apo? Can you describe how you and other stakeholders manage Lake Apo? What issues confront the Lake? How are these issues addressed?

Overall, the research produced quantitative and qualitative data. The former were analyzed through frequency count and percentages while the latter were analyzed through thematic analysis. Qualitative data were categorized in matrix form to identify discernible patterns and were revised based on emerging themes. To come up with an analysis, SWOT (Strength, Weaknesses, Opportunities and Threats) method was used. The questions were imbedded in the FGD and KII.

The research was conducted observing research ethics. A permission to conduct the study was sought from the barangay captain and from the Sitio Leader, and an Institutional Ethics Review Committee (IERC) Permit was secured from CMU before the conduct of the study. Likewise, the interviewers explained to the respondents the nature and purpose of the study conducted and assured them that their identity would be kept anonymous. They were asked to participate, but were also made aware of their right not to answer questions which they believe were offensive or discriminatory, or forego their participation should they feel uncomfortable in the course of the activity. The study was anchored on the principles of ecotourism, a sub-category of tourism that tries to conserve the status of the natural resources used while affording livelihood to the locals. Hence the questions in the study were derived largely on how the locals use and develop the lake to

become a good source of livelihood, and their initiatives of conservation to make the lake still available for their children and for future generations.

RESULTS AND DISCUSSION

A. Biographical Data

Most of the respondents (26.67%) are from ages 36-45. Most (61.67%) are male and married (85%). Most of them (46.67%) have attended high school level only and only few (5%) are college graduates. Most of the locals (88.33%) are Seventh-day Adventist (SDA) and most (48.33%) have 3-5 children. Only few (21.67%) claim to have a regular monthly income, which ranges from seven to eight thousand pesos. Other respondents are primarily home-makers who just take turns in serving the lake as guest attendants (53.3%), and others (25%) do farming (Table 1).

Most of the tourists (26.67%) are from ages 21-30. They are mostly male (60%) and single (68.33%). Most of them (68%) are college graduates and are currently working. Most (60%) of the tourists are embracing Roman Catholicism. Most (63.3%) are local tourists outside Bukidnon, they come from Cagayan de Oro City, Cotabato City, and Davao City. There are also "balik-bayan", Filipinos who are permanently staying in the United States of America (5%) and United Kingdom (3.33%) This implies that Lake Apo is not only famous locally, it has as well brought its name internationally. (Table 2).

B. Utility of the Lake

The respondents consider Lake Apo to be of great importance. If during the past, it only served as a pond to carabaos, a place for washing clothes, and a dumping area for household garbage, it has become a good source of livelihood to many families since it was developed into a tourist area. It came out during the interview that each household near Lake Apo is given the privilege to guard or serve as caretakers of the lake by rotation for three weeks. Others serve as raft-rowers. Likewise, some locals run sari-sari stores, others vend kakanin to tourists. There is an average of 30 tourists a day. During peak seasons like summer, All Souls Day, December and other holidays, visitors reach a number of 180 persons per day. Many occasions like family reunions, class reunions, birthdays, and wedding anniversaries are celebrated in the lake. Likewise, the place is now a favorite destination for pre-nuptial footages and pictorials. This is because the lake is picturesque and has good ambiance. As one tourist puts it "The place is unique and outstanding. The air is refreshing. The landscape gives a foreign feel/aura. The water and the breeze could ease minds. Over-all, this place is amazing".

Lake Apo, primarily serves as a tourist destination. Its operation has provided livelihood to the locals. Likewise, the lake also serves as sources of protein. Fishing does not appear vibrant, but the catch is enough to supplement the family's need for protein. The average catch for a fisherman fishing for 4 hours is 2 kilos. The catch is just enough for food. However, there are cases when a couple of fishermen is able to have a catch of 10 kilos. But this rarely happens.

Table 2. Biographical Data of Tourists Visiting Lake Apo, July 2019.

Variable	Frequency	Percentage
Age		
26-35	11	18.33
36-45	15	25
46-55	16	26.67
55-65	10	16.67
66+	8	13.33
Sex		
Male	37	61.67
Female	23	38.33
Civil Status		
Single	2	3.33
Married	51	85
Widow	7	11.67
Educational Attainment		
Elementary Level	10	16.67
Elementary Graduate	6	10
High School Level	28	46.67
High School Graduate	5	8.33
College Level	8	13.33
College Graduate	3	5
Religion		
Seventh-day Adventist	53	88.33
Roman Catholic	7	11.67
Number of Children		
0-2	26	43.33
3-5	29	48.33
6-8+	5	8.33
Monthly Income		
7-8k	13	21.67
Sources of Income		
Guest attendants	32	53.33
Farming	15	25

Nevertheless, the locals acknowledge the significance of fishing for their daily survival. "Maka-abag-abag pud sa inadlawng panginahanglanon" (It helps us answer our basic daily needs). Using hook and line (pamingwit), the catch of fishermen are more on Tilapia (*Tilapia nilotica*), Karpa (*Cyprinus Carpio*), and Kasili (*Anguilla australis australis*).

Fishing in Lake Apo however does not appear attractive to most locals, hence there are no full-time fishermen in the area. In-fact, only 5% of the locals claim to be part-time fishermen. Other than tourism and fishing, the lake also serves as a laundry place to some locals. Though with the development of tourism, washing of dirty clothes in the lake is prohibited, there are still some locals practicing it. Though, they do it only at the water-exit portion of the lake.

Above everything, the lake is a place for leisure

among the locals. It gives them the privilege to go rafting, angling, swimming or boating. This is for them the greatest contribution of the lake to their lives. They are thankful that they are blessed with a beautiful lake where they can celebrate their special occasions without spending a penny for the venue. The locals are free to use the place. This is one of their privileges.

B.1. Residents' Relationship with Lake Apo

The residents' relationship with Lake Apo is best described with their dependency on the Lake. The graph below presents respondents' perception on the degree of their dependency on the lake (Fig. 3).

The lake has contributed to the income of the locals, primarily because of tourism. It is also their main source of protein. It is where they fish. Likewise, it is their venue for recreation. Hence, data reveal that 65% of the

Table 2. Biographical Data of Tourists Visiting Lake Apo, July 2019.

Variable	Frequency	Percentage
Age		
21-30	32	53.33
31-40	11	18
41-50	7	12
51-60	6	10
61+	4	6.67
Sex		
Male	36	60
Female	24	40
Civil Status		
Single	41	68.33
Married	17	28.33
Widow	2	3.33
Educational Attainment		
Student	18	30
College Graduate	41	68
Post Graduate (PHD)	1	2
Religion		
Baptist	9	15
Seventh-day Adventist	15	25
Roman Catholic	36	60
Number of Children		
Bukidnon	3	28.33
Non-Bukidnons	2	63.3

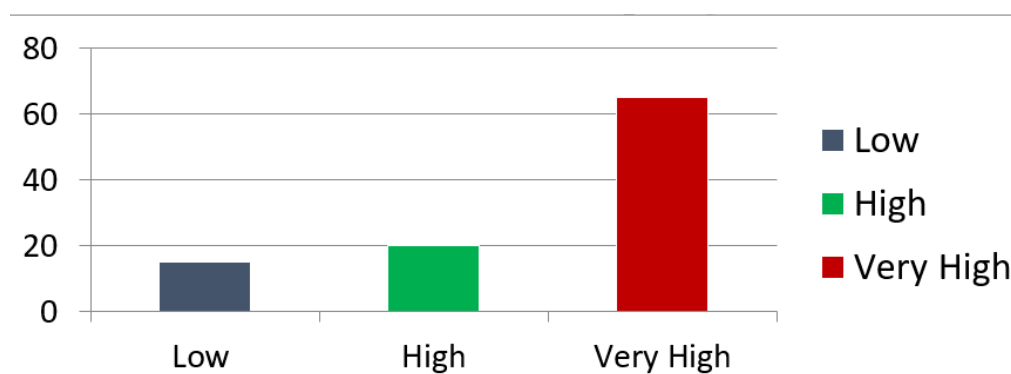


Figure 3. Perceived Dependency of the Respondents on Lake Apo

local residents claim they are very dependent on the lake; 20% consider themselves dependent, while only 15% say that they are less dependent. None among the respondents say they are not dependent. Thus, feeling blessed, all of the respondents believe that Lake Apo is created by God, not only for themselves but for all humanity, and they consider stewardship of the lake as their role. Likewise, all of the residents consider themselves as part of the lake and believe that if they harm it, the lake will harm them back. "Gatinabangay gayud ang mga tao diri (babae o lalaki) sa pagbantay ug pag-implement sa mga polisiya diha sa Lake Apo kay para raman sad na sa amoa" (Both men

and women help each other in maintaining and guarding the Lake because it is for our own good). In general, the residents are concerned of the lake. They strongly believe that it is their obligation to protect and conserve it. Hence, they actively participate in tree planting, clean-up drive, and in guarding the lake. They do this to preserve the beauty and the serenity of the place not only for them but also for their children, the future generations.

C. Tourists' Assessment on Lake Apo

Crompton (1979) described the push and

pull factors of tourism. Like some authors before him, he primarily operates on a foundation of the socio-psychological characteristics of tourists, and the culture and attractiveness of the actual destinations. He stressed that individuals travel because they are pushed to do so by factors related to themselves, but at the same time they are pulled by tangible factors such as natural and cultural resources, and the benefits that they may get from the place of destination. In the case of Lake Apo, 86.67% of the tourists visited the lake for relaxation. The lake is a good break from their hectic everyday life, while 55% of the tourists choose the place because of its natural beauty and climatic conditions.

Despite the inadequacy of the services of Lake Apo as presented earlier, the tourists are more than satisfied with what the lake offers. Generally, tourists express with awe over Lake Apo and consider their experiences and stay in the lake truly worthwhile. They describe it to be "enchanted, too perfect, and beyond compare". They see it to be a good place for "relaxation", and "meditation". It is a beautiful escape from the hassles and annoyances of the busy cities. "It is a place where every soul can freely move without limits", said one tourist. "It is a lovely place that one feels like a bit of heaven", says another. "When it comes to the real beauty of nature, nothing beats the shining aura of this beautiful place", says one Balik-bayan. "Philippines never ceases to amaze me. Lake Apo is a natural world God created for us", says another Balik-bayan. Indeed, Lake Apo appears to be relaxing, consoling, and meditative to many tourists.

For most tourists (53.33%), the beauty of the lake is excellent, while it appears good to others (46.67%). None rated it poor nor terrible. Likewise, 30% of the tourists

rated Lake Apo as excellent in terms of personal safety and security while most of them (70%) rated it as good. In terms of cleanliness of the surroundings, 13.33% rated it with excellent while 75% rated it as good and 11.67% as poor. For the cleanliness of the water in the lake, 16.67% of the residents rated as "excellent" and most of them (78.33%) as "good" while there is 5% as "poor". Most (83.33%) rate their over-all experience in Lake Apo with "good", while 11.67% of the tourists' rate "excellent", and 5% rate their experience as "poor".

However, most of the tourists (82%) are not aware of any policies established by the management of the lake. They said, no one orients them about it. Some tourists (18%) say they know some basic policies such as "Don't throw your garbage in the lake" and "Alcoholic drinks are prohibited", but these rules are based on their own perspectives only. According to them, there are no personnel/staff in the area that guide or instruct them on the prescriptive and proscriptive norms when in the lake. Likewise, the tourists offer some suggestions for the improvement of tourism in Lake Apo such as establishment of food and beverage stalls, renovation of the cottage rafts, improvement of comfort rooms, proper waste disposal (trash bins) and improvement of the Dologon route road. Nevertheless, most of the tourists would like to recommend the lake to their friends and family. They find it to be a good place for relaxation with its serene environment and amusing ambiance. For them, its beauty is relieving.

D. Initiatives of Conservation

The LGU of Barangay Guinoyoran envisions for a more beautiful and captivating lake that would attract more tourists while conserving it at the same time. Hence,

Table 3. Lake Apo Development Plan for 2019-2022.

Project	Total Projected Cost	Funding Source
Construction of Information/Pasalubong Center	300,000.00	City, National, Province
Construction of Floating Cottages	200,000.00	City/Province
Landscaping/Beautification of the Lake	100,000.00	Brgy, City, Province
Tree Growing	10,000.00	Brgy/City
Purchase Life Jacket	100,000.00	Brgy/City
Zip Line	500,000.00	Brgy, City, Province
Total	1,210,000.00	

As of October 2019, what has been realized from the plan is Tree Growing (Fig. 3).

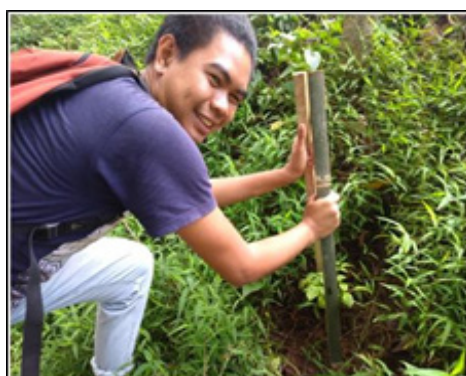


Figure 4. Tree Planting Activities

it crafted a 3-year Development Plan for the lake (Table 3). The following are the components of the plan:

Last June 26, 2019, the LGU of Barangay Guinoyoran conducted tree planting activity. The local officials in partnership with City Environment & Natural Resources Office (CENRO) and Provincial Environment and Natural Resources Office (PENRO) planted 200 seedlings of Golden Trumpet Tree (*Handroanthus chrysanthus*) around the 20-meter easement of the lake. The LGU chose Golden Tree for it appears very attractive to most people's eyes. Likewise, the barangay also conducts clean-up Drive. This is facilitated every first Tuesday of the month, participated by the locals, Barangay Tanod, Barangay Health Workers, Bantay-bayan, and the business sector.

Likewise, there are private individuals who are taking initiatives to help conserve Lake Apo. As recalled by the respondents, in 1980s, the lake was just a pond where carabaos used to wallow. It was dirty, with tons of garbage. In 1990s, some visionary locals initiated the cleaning of the lake. Then, one entrepreneur started building rafts, floating cottages, and rest-houses. The place became attractive and it drew tourists to visit the place. Since then, Lake Apo gained prominence.

Indeed, the LGU and some private individuals have initiated necessary steps to promote and help conserve Lake Apo. Its endeavors however are seen insufficient. The management on lake Apo is loose and below satisfactory. It needs improvement. Some inadequacies mentioned by the respondents include the absence of a unified ticketing booth and the absence of proper entrance-exit routes. There are two gates leading to the lake, one collects 50Php (\$1) for entrance, while the other collects only 25 Php (\$.50). But no tickets are issued upon entrance. Likewise, some tourists complain about toilets that are not presentable, life jackets that are already worn-out, the absence of trash bins, and the absence of tourist guides orienting tourists about proscriptive and prescriptive norms while in the lake. Some resident-respondents also complain about garbage that are not regularly collected. They are junked near the toilets.

The situation of the opposite bank however presents a different scenario. The lawns are well-manicured, and no garbage could be seen around. The proprietor of

the rest-houses is able to maintain the cleanliness of the place.

E. Issues Confronting Lake Apo

Lake Apo is a good tourist destination. Despite its inadequacies in terms of facilities and regulations, most tourists (83.3%) rate their visit in the lake to be good, and most (53.3%) rate its beauty to be excellent. Most tourists are appreciative of the place. They describe it to be enchanting, a perfect place for relaxation and meditation. Hence, it is important to identify and analyze the issues confronting it, so that each could be properly addressed.

1. Water Quality

One resident-respondent said "Hinlo man kaau ni ang tubig diri ug pwede gani mainom ang tubig sa tunga sa lake" (The water here is very clean and the water in middle portion of the lake is potable). In contrast to the claim, an agroforestry project conducted by the CMU College of Forestry and Environmental Science (April 2016) revealed that the lake's water is not healthy for human consumption. It contains bacteria and substances that can harm human's health and may cause diseases to the person who drinks on it. The result of their study is presented below.

The bacteria named above are harmful. Citrobacter may cause meningitis to adults or older children; *Proteus mirabilis* can cause urinary tract infection (UTI), intra-abdominal, and bloodstream infections; *Enterobacter aerogenes*, *Enterobacter agglumerans* may cause urinary tract infections (UTI) and bacteremia. Likewise, *Serratia* are widespread in the environment. They are capable of thriving in diverse environments, including water, soil, and the digestive tracts of various animals. They can cause infections in the bloodstream, lower respiratory tract, urinary tract, surgical wounds, and skin and soft tissues in adults. Whereas, *Proteus* usually infects urinary tract, blood and abdominal wound, groin, neck and ankle (Eichhoff *et al.*, 1966).

DAO-34 series of 1990 set the standard of nitrate of about 10mg/L and the nitrate level in the lake Apo is higher than the standard, while in the spring is lower than the standard. Nitrates are a form of nitrogen and essential plant nutrients, but in excess amounts they can cause

Table 6. Bacteria Analysis Result, Lake Apo, April 2016.

SAMPLE AREA	RESULTS OF ANALYSIS			REMARKS	ISOLATED BACTERIA
	Total Caliform (MPN /100ml)	Fecal Caliform (MPN /100 ml)	HPC (CFU/ ml)		
Shoreline	>8.0	>8.0	281	FAILED	<i>Enterobacter aerogenes</i> ; <i>Serratia sp.</i> ; <i>Proteus mirabilis</i>
Middle	>8.0		228	FAILED	<i>Proteus mirabilis</i>
Spring	>8.0	>8.0	678	FAILED	<i>Enterobacter aerogenes</i> ; <i>Enterobacter agglumerans</i> ; <i>Citrobacter diversus</i> ; and <i>Proteus morganii</i>
PNSDW 2007 AO 2006-0024	<1.1	<1.1	<500		

Table 7. Water Analysis Result, Lake Apo, April 216

PARAMETER	LAKE	SPRING	DAO-90-34 STANDARD
Nitrate	12.8	7.8	10mg/L
Phosphate	0.25	0.01	Not to exceed 0.05 nor maximum 0.1 mg/L

significant water quality problems. If you drink water that is high in nitrates, it can interfere with the ability of your red blood cells to transport oxygen and have difficulty in breathing since their bodies are not receiving enough oxygen. Sources of nitrates include wastewater treatment plants, runoff from fertilized lawns and cropland, failing on-site septic systems, runoff from animal manure.

Likewise, DAO-34 series of 1990 set the standard of phosphate not exceeding an average of 0.05 mg/L nor is a maximum of 0.1 mg/L. The level of phosphate both in the lake and in the spring is within the standard. Phosphates are chemicals containing the element phosphorous, and they affect water quality by causing excessive growth of algae. Phosphates enter water systems naturally by dissolving out of rock, but phosphates are also mined and made into chemical fertilizers to grow crops. Applying chemical fertilizers to soil already saturated with phosphates and spreading excessive amounts of manure on land causes phosphates to run off during heavy rainfall and pollute nearby water sources.

E.1. Farming Activities

The farming activities around Lake Apo may have contributed to its water quality. Among the respondents, 25% are farmers. Most of the farmers (21.67%) only own less than a hectare of farmland and most (23.33%) plant corn crop. They use fertilizers like urea (46-0-0) and complete (16-16-16) and only few (13.33%) used ammonium phosphate (16-20). They also use herbicide such as Triple 8 (25%), Ground Plus (15%), and Tower (8%). Synthetic fertilizers and herbicides are generally classified as persistent organic pollutants (POP's) both have common properties such as persistence in the environment, and since they are not biodegradable they have the ability to bio-magnify and bio-accumulate in ecosystems, and once integrated to the food chain will create significant negative impact to human health as well as the environment.

2. Carrying Capacity

Carrying capacity refers to the number of individuals who can be supported in a given area within natural resource limits, and without degrading the natural, social, cultural and economic environment for present and future generations (<http://www.gdrc.org/uem/footprints/carrying-capacity.html>). In the case of Lake Apo, the LGU and stakeholders have no idea on the carrying capacity of the lake. The office will still determine it, since they lack manpower and knowledge to do it. Carrying capacity maybe computed using the given formula.

$$\text{Carrying Capacity} = \frac{\text{Area used by tourists}}{\text{Average individual standard}}$$

$$\text{Rotation Coefficient} = \frac{\text{Number of daily hours area is open to tourists}}{\text{Average time visit}}$$

$$\text{Total Daily Visit} = \text{carrying capacity} \times \text{rotation coefficient}$$

3. Solid Waste Management

Republic Act 9003, also known as "Ecological Solid Waste Management Act of 2000", describes solid waste management as a discipline associated with the control of generation, storage, collection, transfer and transport, processing, and disposal of solid wastes. It also states that there should be a separate container required for each type of waste for on-site collection properly marked as "compostable", "non-recyclable", "recyclable" or "special waste". The residents of Lake Apo claim they practice waste segregation. The problem however is on waste collection. "Usahay ra naay gakuha ug basura diri" (Garbage collector comes here very seldom) and "Usahay maabtan ug bulan ug masobra-an pa jud ayha ma-kolekta ang mga basura" (Sometimes, collecting of garbage would reach a month or more before the collector comes). One of the respondents say that "Kung dugay maka anhi ang mga ga-kolekta, usahay amo nalang ginalabay sa suok-suok layo diri kay gatam-ok naman gud siya" (If the garbage collector does not come, we sometimes just throw our garbage in the sides. This is a huge problem because the presence of garbage may adversely affect the environment and may give health hazards to the residents.

4. Inadequate Operation Management

Tourism in Lake Apo is still very young hence its management is still loose and inadequate. As mentioned by the respondents earlier, the lake has no ticket booth and no proper entrance-exit routes. There are two gates leading to the lake, but no tickets are issued upon entrance. The place is also devoid with presentable toilets. Garbage are not regularly collected. The roofs of the cottage-rafts are rotten and life-jackets are already worn-out. There are no trash-bins in the rafts. Likewise, there are no trained tourist guides. Hence, the crew know less about the standards of tourism.

5. Issue on Easement

The problem on easement is the biggest issue tearing apart Lake Apo. This controversy is between a prominent stakeholder versus the Local Government Unit of Guinoyoran, Valencia City. Allegedly, a part of the titled lots of one stakeholder belongs to "easement", which means the lands cannot be privatized because they belong to the state. This is a very big issue because the LGU wants to develop this portion of the lake, but it cannot take action because it is privately owned. The situation provokes

heated arguments between the two camps. Hence, the plans of the LGU cannot be implemented. This issue came out during FGD and KI.

The LGUs claim is based on Article 51 of PD 1067 otherwise known as "The Water Code of the Philippines which stated that "The banks of rivers and streams and the shores of the seas and lakes throughout their entire length and within a zone of three (3) meters in urban areas, twenty (20) meters in agricultural areas and forty (40) meters in forest areas, along their margins are subject to the easement of public use in the interest of recreation, navigation, floatage, fishing and salvage. No person shall be allowed to stay in this zone longer than what is necessary for recreation, navigation, floatage, fishing or salvage or to build structures of any kind". Moreover, explanation of the "Easement Rule" under the revised implementing rules and regulation (IRR) further stated that: "For purposes of Article 51 of the Code, all easements of public use prescribed for the banks or rivers and the shores of seas and lakes shall be reckoned from the line reached by the highest flood which does not cause inundation or the highest equinoctial tide whichever is higher. Any construction or structure that encroaches into such easement shall be ordered removed or cause to be removed by the Board in coordination with DPWH, LGU or appropriate government agency or "local government unit".

On the other hand, the owner/stakeholder based his ownership claim on "Riparian Rights". Riparian rights are awarded to landowners whose property is located along flowing bodies of water such as rivers or streams. Landowners typically have the right to use the water as long as such use does not harm upstream or downstream neighbors (Investopedia.com). The landowners have access to "reasonable use" of the water that abuts, or flows through or over their properties (Legal Dictionary). Examples of riparian rights includes swimming, boating, or fishing in the area.

Water rights in the Philippines were founded based on two major water laws during the Spanish regime: the Spanish Law of Waters (August 3, 1866) and the Spanish Civil Code. These two laws recognized the duality of water ownership- that waters are owned publicly and privately. Hence, the said laws are consolidated on the Water Code of the Philippines, Article 51 of PD 1067 (Kho and Saño,2005).

CONCLUSION AND RECOMMENDATIONS

Lake Apo is a promising tourist destination. With its beauty and serenity, it receives positive assessment from tourists. Local residents are highly dependent on the lake. It gives them casual employment, and it is their source of leisure and protein. Transforming the lake into a vibrant ecotourism site is viable. The local-residents and the LGU are desirous to achieve a sustainable ecotourism industry. However, young as it is, tourism in Lake Apo is beset with issues like poor and inadequate operation management, poor natural-resource management, adverse anthropogenic activities that affect the lake, and ownership controversy. However, the stakeholders are open for negotiation and appropriate action.

For Lake Apo to successfully rise as an ecotourism site, the efforts and dedication of the various stakeholders are vital and necessary. Hence, the following recommendations are addressed to the following institutions and individuals:

1. Local Government of Guinoyoran

Based on the principles of ecotourism, the Local Government is encouraged to craft a tourism plan that is participatory, with the community, non-government Organizations, local government units, national government agencies (i.e. academe. DOT, etc.) ecotourism specialists, and the private sectors. This may be undertaken aside from the on-going 3-year Development Plan. Likewise, the "Lake Apo Sustainable Agroforestry and Natural Growing" (LASANG) proposed project of a particular stakeholder in Lake Apo is seen to be holistic, culture-sensitive, resident-responsive, and eco-friendly. It is suggested for the LGU to work out its coordination with this stakeholder. Likewise, the LGU has to continue its Clean-up Drive, establish a unified or uniform ticket booth, improve the toilets, monitor water quality, check farming activities, determine the carrying capacity, and improve solid-waste management.

2. Academe

The local officials of Barangay Guinoyoran acknowledge that they need the assistance of the academic institutions. They need scientific knowledge and empirical findings to support their tourism program.

3. Residents

The residents are the ultimate recipients and end users of Lake Apo. Hence, they are encouraged to be active and participative in the programs concerning the lake. The state of Lake Apo affects themselves.

4. Tourists

Tourists are encouraged to visit Lake Apo and enjoy the beauty of the place. But they should follow the basic principles of tourism like "Take nothing but pictures, leave nothing but footprints, bring nothing but memories". Likewise, they are encouraged to invite their friends to visit the lake, and to give suggestions and feedbacks, as these may help guide the management and the LGU in improving Lake Apo.

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Prevalence of Dog Bites and Risk Factors Among Residents of Maramag, Bukidnon

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ABSTRACT

Around 2,000 cases of animal bites are reported every year in animal bite centers in Maramag, Bukidnon. The study aimed to determine the prevalence and risk factors associated with dog bite victims in selected barangays of Maramag, Bukidnon, Philippines. A face-to-face interview was carried out using a pre-tested questionnaire among 402 residents in Maramag, Bukidnon, to determine the prevalence and risk factors of dog bite victims of the municipality. Ten barangays were grouped into the rural and urban type of community. The results showed that the apparent prevalence of dog bite victims among residents of Maramag, Bukidnon was 23.6% (95/402). The urban barangays had a prevalence of 26.2% compared to rural barangays with 21%. The gender of victims, civil status, educational attainment, and dog-ownership are the risk factors that are statistically significant in dog bites. The study revealed that dog bite victims of Maramag, Bukidnon are prevalent with 23.6%, and this result does not depend on the type of community. Furthermore, the study shows that being male, single, have low educational attainment, and dog-ownership increases the risks of being bitten by dogs.

Keywords: dog bite, prevalence, risk factors

INTRODUCTION

Bite injuries to humans, mainly caused by dogs, is a global problem, as it poses a threat to public health because it can lead to infection, disfigurement, incapacity, post-traumatic stress syndrome, and even death. Humans keep canines as a companion and best friend. However, human-canine interaction is not always without friction, and dog bite-related injuries are still considered a public health issue (Seligsohn, 2014). There are many complications of a dog bite, and the most common disease is rabies. Rabies is a fatal but preventable viral infection commonly transmissible to humans through the bite of an infected animal. The World Health Organization (2013) estimates that rabies claims almost 55,000 lives every year. Dog bites cause approximately 99% of these deaths (Yousaf, 2012).

Dog bites can also result in a significant financial burden for treatment, hospitalization, and post-exposure prophylaxis for rabies. More than 15 million people receive rabies treatment due to dog bites and the majority of these cases are in developing countries (Tenzin, 2011).

Animal bites occur whether provoked or unprovoked by the victims (Tenzin, 2011). There are many reasons and causes of dog bites. The dogs may either be scared or threatened, and dogs will bite as a reaction to a stressful situation. Also, when they are sick or startled, and to protect themselves, their puppies, or their owners (Wilson, 2017).

Risk factors for dog bites include several factors such as sex, health, socialization and training, reproductive status, early experience, and quality of ownership, among

others. Chained dogs are 2.8 times more likely to bite than unchained dogs (University of Minnesota, 2006). Children are more at risk of getting bitten by dogs than adults due to lower physical strength and smaller size. Children also have lower awareness and lesser knowledge of safe behavior around dogs. Low-income background and rural areas are well-known risk factors for dog bites (Seligsohn, 2014).

Dogs appear to be more defensively aggressive to men than women (Wells et al., 1999), possibly because men are usually bigger, taller, less gentle, and have lower toned voices than women (Frangakis et al., 2001). Boys engaged in outdoor activities thus more vulnerable to dog attacks (Mcheik et al., 2000).

This study aimed to determine the prevalence and risk factors associated with dog bite victims, including their socio-demographic profile, pet ownership, exposure to a dog bite, and other risk factors.

Poor awareness of dog bite is a hindrance to the elimination of rabies infection. It is essential to determine specific risk factors that can provoke a dog to bite. Furthermore, the data collected from the study will help raise awareness about the disease and a vital step to plan out necessary measures and to generate a more effective control program to eradicate rabies in the community.

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Received 3rd June 2020; Accepted 13th November 2020

METHODOLOGY

Study Area

Ten barangays of Maramag, Bukidnon were used for the conduct of the study. The ten barangays were grouped into two areas according to the location, and a simple random sample was used to determine the barangays included in the study. The five urban barangays selected are North Poblacion, South Poblacion, Dologon, Base Camp, and Camp One, while selected rural barangays are Panalsalan, Dagumbaan, Kisanday, San Roque, and Danggawan. The list of households was based on the records provided by the municipality.

Determination of Sample Size

The sample size estimation of the prevalence of dog bite victims was computed using the general formula of Canon and Roe (1982) to determine the sample size. The following assumptions were used: an expected prevalence of 50%, a 95% confidence level, and a marginal error of 5%. Three hundred seventy-eight respondents have been determined to comprise the sample size and were later adjusted to 402.

Selection of Respondents

A simple random sampling procedure was used to select households for this study. The researcher compiled a list of households from the ten chosen barangays of Maramag, Bukidnon. Forty households from each barangay were randomly selected. If the selected household was found closed, their house was not accessible, or the residents are away, the next household in the list was automatically made a substitute for the interview as a selected household. At each household, any of the members who have a history of dog bite within the last five years were included and interviewed for the determination of prevalence and to identify risk factors. If there is an absence of a dog bite victim in the household, the head of the household was automatically selected for the interview. The interview was done upon the approval of the respondent by signing the consent form.

Study Design

A cross-sectional study was carried out among 402 respondents in ten selected barangays of Maramag, Bukidnon. A quantitative survey was used as a method for the risk factors that targeted the dog bite victim in the household or the household heads in the absence of a dog bite victim. There were 40 households selected from each barangay, with a total of 402 respondents due to the number of victims in the household. The selection of the households was done randomly.

Determination of Risk Factors

Before the conduct of the study, a permit was sought from the Institutional Ethics Review Committee. The researcher carried out face-to-face interviews using well-structured and pre-tested questionnaires. The questionnaires included items regarding their socio-

demographic profile, dog ownership status, and exposure history to dog bite to assess the potential risk factors of dog bites. The questionnaires were translated into the vernacular. Data collectors were recruited and trained to administer the questionnaires by moving to the selected houses.

Computation of Apparent Prevalence

The apparent prevalence of dog bite victims in Maramag was computed using the formula:

$$\text{Apparent Prevalence} = \frac{\text{\# of Dog bite victims}}{\text{Total respondents}} \times 100$$

Statistical Analysis

The Chi-square test was used to analyze the prevalence of dog bites between barangays. Odds ratio and univariate analysis with the Chi-square test were used to determine the potential risk factors. The lowest level risk factor was considered as the no-exposure referent in all analyses.

RESULTS AND DISCUSSION

Prevalence of Dog Bite among the Residents of Maramag, Bukidnon

Table 1 shows the prevalence of dog bites among residents in selected barangays of Maramag. Among the barangay population interviewed, the prevalence of dog bites is 23.6% (95/402), in which 95 were victims among 402 individuals interviewed.

The prevalence of dog bites in Maramag, Bukidnon (23.6%) is higher compared to the dog bite victims (2%) reported in Animal Bite Treatment Center at BPH, Maramag in 2017. This result implies that some victims failed to avail of post-exposure treatment at the BPH after a dog bite incident since there was a lower prevalence compared to the survey conducted.

The prevalence estimates among the barangays varied significantly, implying that the prevalence of dog bite is location-dependent. The differences in the prevalence rate of dog bites in the present study could be due to the total population in the barangays who were at risk of dog bites. Philippine Standard Geographic Code (2015) reported that the highest total population among the barangays were in barangay Dologon and barangay North Poblacion. These two barangays had the highest prevalence of dog bites among the other barangays in Maramag.

Also, the Municipal Agriculture Office in Maramag, Bukidnon in the year 2017 reported that the highest number of dog population estimates was in barangay San Roque with 799 dogs and followed by Dologon with 519 dogs. These two barangays have 27.5% and 40% prevalence, respectively, while barangay Base camp with

Table 1. Prevalence of dog bite victims in selected barangays of Maramag, Bukidnon

Barangay	No. of respondents	No. of dog bite victims	Apparent Prevalence (%)
Urban Barangay			
Dologon	40	16	40
North Poblacion	42	16	38.1
San Roque	40	11	27.5
South Poblacion	40	9	22.5
Base Camp	40	4	10
Rural Baranagay			
Danggawan	40	10	25
Kisanday	40	8	20
Dagumbaan	40	8	20
Camp one	40	7	17.5
Panalsalan	40	6	15
Total	402	95	23.6

Legend: CI- confidence interval

Population:

Dologon-14,093; North Poblacion-14,799; San Roque-3,126; South Poblacion-12,165; Base Camp-7,569; Danggawan-1,680; Kisanday-2,599; Dagumba-an-7,638; Camp I-4,852; Panalsalan-2,344 (Philippine Standard Geographic Code, 2015)

Table 2. Prevalence of dog bite victims among selected residents in urban and rural barangays of Maramag, Bukidnon

Type of Barangay	No. of respondents	No. of dog bite victims	Apparent Prevalence (%) (95% CI)
Urban	202	53	26.2 ^{ns} (20.2-32.3)
Rural	200	42	21 (15.4-26.6)
TOTAL	402	95	23.6 (19.5-27.8)

$p=0.317$; ns, not significant; CI, confidence interval

the lowest prevalence (10%) had 244 dogs. Dog population in a particular barangay was considered to be a reason for a higher prevalence compared to the other barangays. According to Buso et al. (2016), due to the high number and extensive contact with dogs, the official number of people bitten by dogs in Brazil reached 424,092. The number of dog bites may rise with an increase in the dog population (Ehimieyin et al., 2014).

In this study, there is a higher prevalence of dog bites in urban than rural barangays in Maramag due to the higher population living in urban barangays - 56,264 - compared to rural barangays - 14,601 (Philippine Standard Geographic Code, 2015). Other factors such as the population density of the residential areas of each barangay, number of homeowners with dogs (Love & Overall, 2001), and the socio-demographic factors peculiar to each barangay, in particular men and children which are more likely to be bitten by dogs (Vinay et al., 2014; Samanta et al., 2016), can also influence the prevalence of dog bites in each barangay.

Prevalence of Dog Bites among the Residents of Maramag, Bukidnon based on the type of community

The type of community, classified as rural or urban, was also assessed. Ten barangays were grouped into two areas according to the location, and a simple random sample was used to determine the barangays included in the study. The five barangays selected were North Poblacion, South Poblacion, Dologon, Base camp, and Dagumbaan were the urban barangays. In comparison, the other five barangays were Panalsalan, Camp 1, Kisanday, San Roque, and Danggawan were rural barangays. The urban barangay had a prevalence of 26.2% (53/202) as compared with the rural barangays with 21% (42/200) as shown in Table 2. However, there was no significant difference between the two. According to Pattanayak et al. (2017), animal bites, particularly dog bites possesses a public health problem in the urban area. In urban settings, dogs and cats are the most commonly involved animals compared to rural areas where most people focus on farm animals.

The results of this study do not agree with the other researchers, which shows the majority of dog bites are from rural areas. Consequently, Ehimiyein et al. (2014) argued that a substantial increase in rabies transmissions and associated deaths may happen in rural areas where dogs are unvaccinated, unleashed, and have free movement, increasing the risk of exposure of man to dog bites. Mehndiratta (2012) added that the higher density of dogs and the higher number of stray dogs increased the exposure to dogs for residents in the rural area. Some people living in rural areas and low-income societies are more exposed and affected by the disease than those living in town and cities (Masthi et al., 2014). However, in a similar study in Delhi covering 500 households in a slum area, dog bite incidence is higher in urban than rural slums (Sharma et al., 2016).

Risk Factors Associated with Dog Bite Victims

The potential risk factors for dog bite are shown in Tables 3 and 4. Among the risk factors evaluated, the gender of the victim, civil status, educational attainment, and dog-ownership were found to be statistically significant. The majority of the victims were males with 31.8% compared to females with 18.7% based on the prevalence. These results conform to the study of Lakestani (2007) and Mcheik et al., (2008). It was reported that in most countries, men are more likely to be bitten than women (Lakestani, 2007). According to Mcheik et al. (2008), this may be due to more engagement of males in outdoor activities and they are more vulnerable to dog attacks. The higher prevalence of animal bites in males than in females can be attributed to

their more frequent exposure, conscious risk-taking, and a more considerable amount of time spent outside the home. Sharma et al. (2016) have a similar report justifying that males are the main earners in the family and have longer exposure to stray dogs outside their homes.

The single respondents had a prevalence of 46.94% (46/98). The group of respondents who are single were five more times at risk of being bitten by dogs than those that are married. In terms of employment status, most respondents who do not have work had mostly been bitten by the dogs (27%).

The group of single and unemployed respondents in the study were mostly children and teenagers that are very active in school and other activities. A meta-analysis of 1215 studies in Iran agreed with the results of the present study and revealed that the incidence of dog bites is highest in students as compared to other occupations (Abedi et al., 2019). This is supported by the results of Evangelio et al. (2020) which shows that age group 5-14 have the highest incidence of dog bites.

The elementary and high school level respondents were mostly the victims of dog bites. The odds of the elementary level respondent being bitten by a dog are 3 times higher than the college graduates. This was maybe due to a lack of awareness and knowledge about the disease and also have a lack of knowledge regarding the behavior of dogs, which made them more at risk. Respondents with high educational levels may have a higher level of knowledge on rabies control and prevention than those

Table 3. Risk factors associated with 95 dog bite victims of Maramag, Bukidnon.

Risk Factors (household respondent)	Number of Respondents	No. of Victims	Prevalence (%)	Odds Ratio (95% CI)
Gender of Victim				
Male	151	48	31.8	2.02 (1.27, 3.23)
Female	251	47	18.7	
Civil Status				
Single	98	46	46.94	4.60 (2.79, 7.60)
Married	304	49	16.1	
Employment				
None	215	58	26.98	1.50 (0.94, 2.39)
Employed	187	37	19.79	
Education				
Elementary level	122	43	35.25	2.8 (1.53, 5.25)
High School level	162	33	20.37	1.33 (0.72, 2.48)
College level	118	19	16.10	
Monthly Income				
16,000-32,000	20	6	30	2.71 (0.75,9.83)
Less than 8,000	338	83	24.6	2.34 (0.95,5.73)
8,000-16,000	44	6	13.6	
Dog-ownership				
Owners	297	80	26.9	2.21 (1.21, 4.05)
Non-owners	105	15	14.3	

CI, confidence interval

Table 4. Risk factors associated with dog bite victims among dog-owners of Maramag, Bukidnon.

Risk Factors	No. of Respondents	No. of Dog bite Victims	Prevalence (%)	Odds Ratio (95% CI)
Duration of dog-owning				
Less than a year	53	17	25.8	1.36 (0.71, 2.58)
More than a year	244	63	32.1	
Number of dogs per household				
6 dogs above	14	5	35.7	1.55 (0.50,4.84)
3-5 dogs	82	22	26.8	1.02 (0.57,1.83)
1-2 dogs	201	53	26.4	
Dogs being kept				
Free-roaming	138	41	29.7	1.63 (0.66, 4.04)
Leashed/Caged	125	32	25.6	1.33 (0.53, 3.34)
Fenced-in	34	7	20.6	
Dogs Vaccinated				
No	117	35	29.9	1.28 (0.76,2.15)
Yes	180	45	25.0	

CI, confidence interval

who only finished primary school, high school, and those who had never reached college.

There was no significant difference in the monthly income of dog bite victims. In the study, the majority of the victims belong to the highest income level, 16,000-32,000 pesos. The results of the study revealed that dog-owners had a higher chance of dog bite (84.2%) compared to non-dog owners (15.8%). Among 80 dog owners, there were 62.5% bitten by their dogs while only 20.1% were bitten by other dogs. Around 80% to 90% of dog bites are caused by a dog familiar to the victim, and in about 30% of the cases, the injuries were caused by the family pet (Lakestani, 2017). Moreover, this factor had a significant difference. Among the 30 victims bitten by their dogs, 65% were bitten only once, and 55% of the victims were bitten many times. The Center for Disease Control and Prevention (2018) stated that owning a dog increased the likelihood of being bitten than not having a dog. According to Seligsohn (2014), owning a dog is significantly correlated with being bitten as well as displaying unsafe behavior when engaging with dogs. Pet ownership was shown to be a strong risk factor for pet-related injuries.

The study also revealed that the duration of owning a dog, the number of dogs in the household, and how they were kept did not matter in the likelihood of being bitten. The increased odds of being bitten for new pet owners, having more than 6 dogs, and having a dog that is a free-roaming or caged/leashed did not reach statistical significance.

Most biting dogs that were owned are vaccinated (56%), but there were still unvaccinated (43.7%), although this risk factor had no significant difference. Ehimiyen et al. (2014) explained that most of the owned dogs were unvaccinated, which may be due to a lack of awareness of the disease or due to poverty.

CONCLUSION AND RECOMMENDATIONS

From the barangays selected in Maramag, the apparent prevalence of dog bites is 23.6%. Urban barangays had a higher prevalence of 26.2% as compared to rural barangays with 21%, however, there is no significant difference between the types of community. Among the identified risk factors, the socio-demographic profile such as the gender of the victim, civil status, educational attainment, and dog-ownership are associated with dog bites.

In conclusion, the results indicate that there is a prevalence of dog bites in Maramag, Bukidnon which is 23.6%, and the type of community {whether rural or urban} do not affect dog bite incidence. There is a direct correlation between the increase in dog population in the barangays and the incidence of dog bites. Furthermore, factors such as being male, single, low educational attainment, and dog-ownership increases the risks of being bitten by dogs. In this study, the prevalence of dog bite victims of Maramag, Bukidnon was higher compared to the dog bite victims who were administered with Post-exposure prophylaxis in Animal Bite Treatment Center in the year 2017. The results implied that several dog bite victims failed to avail post-bite treatment in the appropriate office.

Based on the results of the study, it is therefore recommended that local government and concerned agencies should continue the vaccination for dogs and proper post-exposure management in its health policy. This should, however, be coupled with information campaigns on responsible dog ownership, dangers of rabies, and proper actions needed to be taken following dog bites. Public awareness should be strengthened through the Information, Education, and Communication (IEC) campaign among the vulnerable population, and Responsible Pet Ownership shall be promoted.

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ACKNOWLEDGEMENT

The authors would like to thank the residents and the Local Government Unit of Maramag, Bukidnon for the assistance in the conduct of the study and to Central Mindanao University, for funding the study.



Online Learning Preparedness and Preferences Among Central Mindanao University Veterinary Medicine Students

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ABSTRACT

The COVID-19 pandemic has affected all sectors of the society, especially the education system, which now has to design a flexible learning environment. This study aimed to assess the level of preparedness towards online learning among veterinary medicine students at the College of Veterinary Medicine, Central Mindanao University, and to determine their online learning attitude, styles, and preferences through mixed methods approach. The study utilized a survey and interviews in data collection. The results show that a majority (62.13%) of the students were well-prepared for online learning. A majority (60.43%) of them had a neutral attitude towards online learning. The students mostly preferred visual learning (30.64%), with 40.0% leaning towards non-interactive teacher or learner-centered online instruction. A significant relationship between online learning experience with preparedness and attitude toward online learning was found. Veterinary students in the study are capable of conducting an online learning method, and most have the necessary technology access, internet, and software skills, and social support. However, they still have doubts about this method of learning. A longitudinal survey is suggested to be conducted in future studies to determine improvements in the students' attitudes since online learning experience is significantly associated with it.

Keywords: COVID-19, E-learning, Higher Education, Philippines

INTRODUCTION

Over the past few years, digital media have improved the teaching and learning experiences and have become commonplace with university students and teachers (Alper & Gülbahar, 2004). In light of rising concerns about the spread of COVID-19, most higher education institutions have stop in-person classes. The current pandemic has revealed vulnerabilities in schools and the need for a flexible and resilient education systems is clear to face unpredictable futures (Houlden & Veletsianos, 2020).

While digital technologies enable people to work and learn from home, online learning in the Philippines still faces some barriers. A study conducted by Marcial et al. (2015) reveals that internet cost and access and technical problems are substantial barriers to online learning. Moreover, little is known about learners' preferences and styles in online environments. Previous studies revealed that if the instruction is delivered in the preferred methods of a student, an increase in motivation and achievement can be observed (Fahy & Ally, 2005; Manochehri & Young, 2006; Offir et al., 2007). Thus, it is essential to evaluate first the accessibility of online learning and then identify the students' online learning styles and online instructional preferences to present learners with an effective and efficient environment that enhances learning.

This study will provide information on whether the implementation of online learning is accessible among CMU-Veterinary Medicine students, especially in times

of crisis that will not permit the traditional face-to-face learning. The study will also help identify the students' preparedness and attitudes towards online learning, determine their online learning styles, online instructional preferences, and online learning experience for the basis of designing online learning environments in the future that considers individual differences.

METHODOLOGY

Data Collection

The study employs mixed method in data collection. A survey was conducted and follow up interviews were done. A modified questionnaire adopted from Mercado (2008), Alper and Gülbahar (2004), and Toni Mohr et al. (2012) were used in the survey. This questionnaire included items about the respondents' demographic profile, level of online learning preparedness, attitude towards online learning, online learning styles, and instructional preferences. The factors included in preparedness were technology access, which was answerable by yes or no, internet/online skills, software application skills, and social support, which can be answered using a 5-points Likert scale. The rest of the questionnaire was also answerable by a 5-points Likert scale.

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Received 27th July 2020 ; Accepted 27th November 2020

A communication letter was first sent to the respondents through an online messaging application and short message service (SMS) requesting them to join the survey and then asked their preferred way to answer the survey – either online or through a recorded phone call. For respondents who chose to answer online, a URL of the survey was sent to them, and for those who preferred the other method, the researcher made a recorded phone call. The first part of the online survey and recorded phone call was the informed consent, where the respondents had the option to participate or decline and then followed by the survey questions. After completing the survey, a follow-up question through an online messaging application was done for clarification and discussion purposes.

Sample size

The sample size was determined using a prevalence study formula for the finite population by Daniel (1999). The following assumptions were used: population size of 482 according to the official list of students enrolled in the current semester, 95% confidence level ($Z = 1.96$), the expected proportion of 50%, and 5% precision. The result sample size was 214, and 10% was added to address the null-response making a final sample size of 235 students.

Selection of Respondents

Proportionate stratified sampling was used to determine the number of respondents each year level. It was obtained by dividing the number of students per year level with the total population size (482 students) and multiplying it with the derived sample size in which in this case was 235. The number of male and female respondents were determined in the same manner. The names of the respondents involved per year level were identified through randomization using the Microsoft Excel program.

Statistical Analysis

The data for this study was encoded in Microsoft

Excel and was analyzed using the Statistical Package for Social Science (SPSS). Descriptive statistics were used to illustrate the demographic profile of the respondents and their level of preparedness. Chi-square test of independence was used to determine the relationships between the respondents' gender and year level to their online learning styles, online learning style to their online instructional preference, and online learning experience with online learning preparedness and attitudes.

RESULTS AND DISCUSSION

Level of Preparedness and Attitude Towards Online Learning

The respondents' preparedness scores were determined in categories as poorly prepared, fairly prepared, and well-prepared. The factors included in assessing preparedness were technology access, internet/online skills, software application skills, and social support. Meanwhile, attitude levels were identified as positive, neutral, and negative.

In online learning preparedness, 62.13% of the students were well-prepared, 37.02% were fairly prepared, and the remaining 0.85% were poorly prepared (Figure 1). In general, the respondents were well-prepared to engage in an online learning environment. Being well-prepared means that the students have the necessary technology for learning online, have the skills to use the internet and associated software, and have enough social support from their parents, teachers, and school to motivate them to learn online. The subtopics below describe the result of each factor considered in assessing online learning preparedness.

Technology Access

Under this category were technologies commonly used in online learning such as a computer, printer, internet

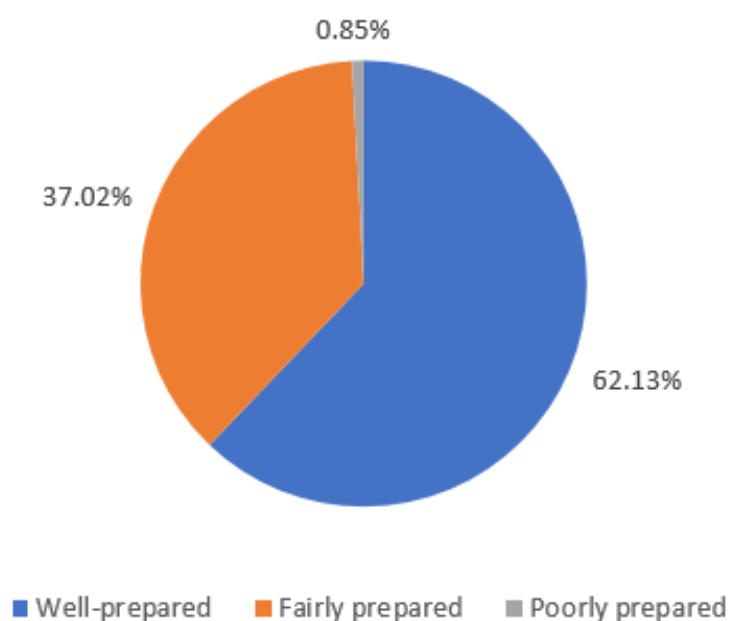


Figure 1. Distribution of the level of online learning preparedness among CMU-Veterinary Medicine students.

access either through mobile data or Wi-Fi, and access to fast internet.

More than half of the respondents agreed to have access to the said technologies (57.36%). In detail, 96.6% of the students owned a computer or smartphone capable of online learning, but most of them (65.5%) did not have printers installed with their computers. There was also a high percentage (96.17%) of students with internet access – 78.72% of these students had access through mobile data, 55.74% had access through Wi-Fi, and 38.30% had access through both. Even though most students could access the internet, the majority (78.7%) did not have fast internet. This result is similar to the study conducted in Turkey by Akaslan and Law (2011), where the majority of the respondents reported that they have access to the internet at their residence and university but the speed of the internet that the students used at the place they live and at university were not sufficient. According to Akaslan and Law (2011), this result can be interpreted that students' access to the internet was not enough for e-learning and must be improved before embarking on e-learning.

According to Oye et al. (2011), bandwidth (colloquially referred to as internet speed) is a significant issue in the deployment of e-learning. The content and services that can be accessed through the internet are dictated by the bandwidth available. Moreover, having fast internet will result in high perceived ease of use, which, in turn, plays a significant part in shaping user behavior in using e-learning technology. Several studies concur that when users perceive an e-learning tool to be easy to use, they would also see it to be useful (Garcia, 2017).

3.1.2 Internet/Online Skills

This category included skills such as sending emails with file attachments, ability to use web browsers confidently, knowledge on fixing surfing errors, knowledge on accessing online library and other resource databases, and ability to use asynchronous online learning tools such as discussion boards, chat tools, YouTube, blogs, and digital library.

The mean score of the respondents was 3.83, and that is equivalent to "agree," which means that they were affirmative of having the earlier said internet/online skills. However, there were two statements that the respondents only scored "neutral." That was on the ability to resolve common errors while surfing the internet like "page cannot be found" or "connection time out" and knowledge on accessing online library and other resource databases. These observations of neutrality were also found in the study conducted by Lamarca (2019) at the University of Northern Philippines. The said study showed inadequate knowledge of the faculty and students on resolving common errors while surfing the net. According to them, there is a need to provide more training programs and mentors to improve the respondents' ICT skills.

3.1.3 Software Application Skills

This category included skills like using Microsoft office programs and alike; knowledge on PDF files and

ability to view and download them; ability to use several programs simultaneously and move between them; knowledge on using video conferencing software and messaging/chat applications.

The mean score of the respondents was 4.2, corresponding to a descriptive score of "agree". Thus, the respondents generally have the necessary skills in using associated software for online learning, which will help make the implementation much easier. This result was most probably due to the respondents being millennials and "generation Z/Gen Z", which means that they were born when the internet was first commercialized. Scholars described the latter generation as "digital natives" and "net generation" (Dimock, 2019). Moreover, secondary education systems in these generations have subjects on Information and Communication Technology, which provided them enough knowledge of computer software (Ramos, 2010; Tomaro, 2018).

3.1.4 Social Support

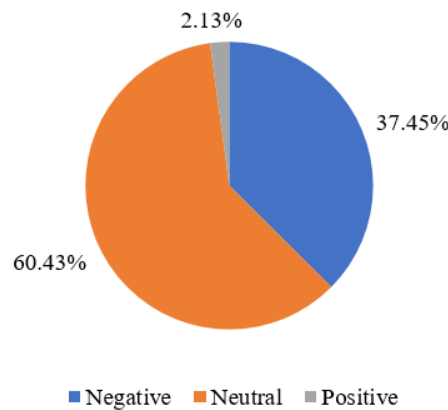
Factors included in social support were those coming from the respondents' parents, teachers, and friends. These included encouragements to use the internet and associated electronic devices for online learning and provision of the school/institution with e-learning materials and the opportunity to learn online.

The mean score of the respondents was 3.76, corresponding to a descriptive score of "agree". This result implies that the students have enough support from their parents, teachers, and friends to use the internet and electronic devices to learn online. This support could be through financial assistance to purchase the required materials/devices/equipment or through encouragements if the necessary devices are already present. However, there was one statement where the mean score was only "neutral" (3.39), and that was on the provision of the school of e-learning materials and the opportunity to learn online.

The respondents' neutral perception on the said statement was because most of the instructors/professors provided their handouts or learning materials in forms of hardcopy or through sharing of softcopy in flash drives. The respondents were also enrolled in a Veterinary Medicine curriculum, where the instructors/professors usually advise them to read or learn from their reference books. Moreover, due to the unexpected outcomes of the crisis, most of the faculty were not prepared at the time of the survey to migrate to online learning. The available learning materials were mostly for conventional instruction.

3.2 Attitude Towards Online Learning

This section contained statements of the advantages and disadvantages of online learning. Illustrated in Figure 2 is the distribution of the respondents by their attitude towards online learning. It shows that most (60.43%) of the respondents had a neutral attitude towards online learning. Being neutral means that the respondents neither agree nor disagree that online learning is beneficial to them. The result also indicates that although most (62.13%) of the respondents were well-



prepared, there were still factors that made them doubtful in learning online. In the conducted follow-up interviews, the respondents' primary reason was due to the slow internet in their localities and the country in general. It was also described in the data in which 96.17% of the students had internet access, but most of them (78.7%) had no access to fast internet.

The Speedtest Global Index (2020), as of April, shows that the Philippines ranked 121st out of 139 surveyed countries on mobile speed and 110th out of 174 countries on fixed broadband. The global average speed in mobile internet is 30.89 Mbps for download and 10.50 Mbps for upload, while in fixed broadband is 74.74 Mbps and 39.62 Mbps, respectively. However, the Philippines has only 12.09 Mbps download, and 5.23 Mbps upload speed for mobile internet, while 21 Mbps download and 20.18 Mbps upload in fixed broadband.

Moreover, the Philippine economic update by the World Bank (2017), shows that internet speed in Mindanao is much slower than in the rest of the country and significantly slower than in Metro Manila. In cities throughout Mindanao, average Internet speeds range from 141 kbps in Marawi to 2.4 Mbps in Cagayan de Oro, compared to 3.6 Mbps in Makati. According to the report, Davao users have to pay about 1.5 times more to get the same speed as in Makati, and Marawi users have to pay 26 times more. This data shows the inequitable accessibility and inconsistency of the internet speed across the country.

To further broaden the understanding of the respondents' perception of online learning, follow-up interviews were conducted. Some respondents have a strong preference for traditional face-to-face learning. They were already used to conventional teaching because it has been the way they were taught since their younger years. It further means that they lack experience in learning online. The idea of shifting to online modes of instruction is an abrupt change for them, and they have no idea how the learning experience will be, which caused the doubt and neutral attitude. They also prefer the physical interaction between their teachers and other students. They think that physical interaction makes it easier for them to ask clarifications on the topics being discussed directly. According to them, the lack of physical presence

of their instructors/professors will be a great challenge for them since it will be like learning independently. In line with this, they think that online learning will only result in poor guidance and limited feedback or a delay in response, which will lose their momentum of interest. Some of them also prefer actual notes or books that they could read and highlight than just reading e-books. Nonetheless, some of them are still open to the idea of learning online.

The respondents also said that the home does not provide a conducive learning environment. One of the mentioned examples to this is the presence of distractions when learning at home, most notably when they think that they will do household chores afterward. The respondents also pointed out that learning in front of their devices makes it easier for them to procrastinate. Aside from that, they also think that home provides so much comfort that it cannot give enough pressure to the students to submit or finish their assigned tasks on time. Without enough pressure, the students will tend to submit their requirements for compliance purposes only, and in this case, the students will not be learning.

Moreover, the respondents were neutral because they think that we are unprepared to engage in online learning since there is no equitable access to a fast and stable internet. According to them, some places do not have a signal or any internet connectivity at all. The students living in these areas are most likely to be forced to go outside and find a place where they can get an internet connection, which is inconvenient if it will be the routine.

The respondents also mentioned the financial problem. According to them, not everyone has a privileged life to afford technological devices and access to the internet like Wi-Fi, which is more convenient for online learning than using mobile internet. This incapacity also made some of them not technologically-oriented. Some students also mentioned that they know some of their classmates who only owned a keypad phone, which is incapable of online learning. Further, if online learning is pushed through, some will be obliged to expend money to buy load for internet access though coming from a low-income family. The privileged students also sympathize with those who cannot access the internet, so they chose to be neutral.

Meanwhile, some respondents think that their instructors and professors should make changes and decisions, and it is not for them to decide whether or not we should conduct online learning. Due to the complications brought by the health crisis, the students believe that they do not have a choice but to engage in online learning, and this results in a neutral attitude towards it. Furthermore, some think that learning online in a veterinary medicine course can compromise their knowledge. According to the respondents, veterinary medicine is not only knowledge-based but also skill-based, which cannot be easily learned online. The subjects are also particularly hard to learn if there is no physical or hands-on experience to supplement the learning. Some of them even said that others might have the suspicion that their answers will influence the school's future trajectory; that is why a neutral option is the safest choice.

These statements were similar to the result of the study conducted in Pangasinan State University, Lingayen Campus, where it aimed to reveal the students' sentiments in view of synchronous online instruction (Pastor, 2020). The majority of the respondents forecasted that they might face issues while using the proposed online learning method, and they were worried about internet connectivity in their area. Other stated problems were background noises, fairness in grading, and expensive mobile loads/financial issues. The research further shows that most of the respondents had negative sentiments followed by neutral sentiment, and only a few had positive sentiments towards the proposed method of online instruction.

Meanwhile, illustrated in Figures 3 and 4 are the distribution of the respondents' attitudes on the positive and negative statements regarding online learning, respectively. In the positive statements, the respondents were in the range of being neutral to agree except for the statement "online learning is easily accessible," where the responses were tied (69 points) at disagree and neutral. In the negative statements, most of the respondents answered

strongly agree, except for the statement "learning online does not have the opportunity to meet peers and make relationships," wherein most of the respondents were neutral.

Statement topics:

1. Students who are too shy can use online materials to get the help they need.
2. Online education allows learning at a person's own pace and convenient time.
3. Online learning is easily accessible.
4. Learning online allows for a pressure-free environment.
5. Online learning allows working alone and helps focus on understanding the parts that need to spend more time on.

Statement topics:

6. Online learning makes it easier to procrastinate.
7. Online learning provides less guidance and assistance on the learning material such that students who are confused and have questions may fall even further behind.
8. Online learning relies on the internet that may crash and a disadvantage for those who are unfamiliar with technology.
9. Learning online does not have the opportunity to meet peers and make relationships.
10. There is no instant feedback between professors and students when learning online.

3.3 Online Learning Style and Instructional Preference

The online learning styles used in this study were those described by Alper and Gülbahar (2004), which is composed of eight dimensions - individual/solitary, social/collaborative, auditory, visual, abstract, concrete, logical, and sensual learning. It is a learning style model often used

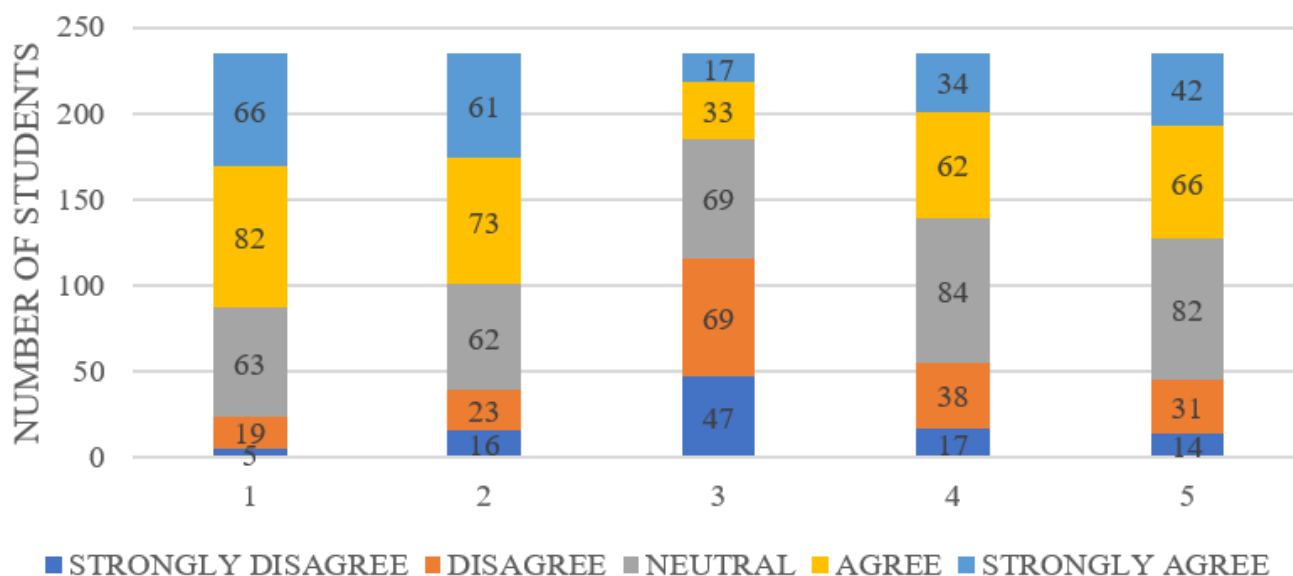


Figure 3. Distribution of respondents by their attitude on each positive attitude statement towards online learning (n = 235).

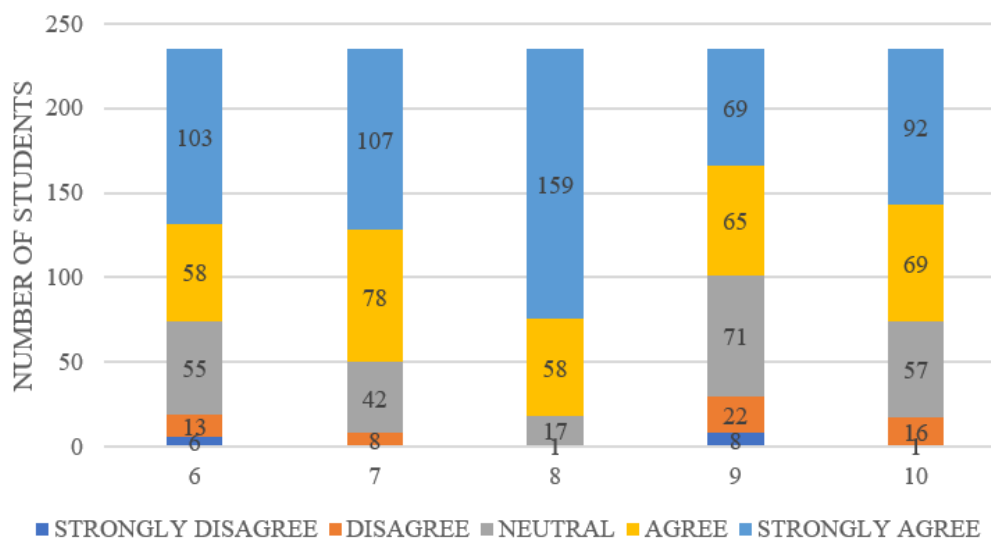


Figure 4. Distribution of respondents by their attitude on each negative attitude statement towards online learning (n = 235).

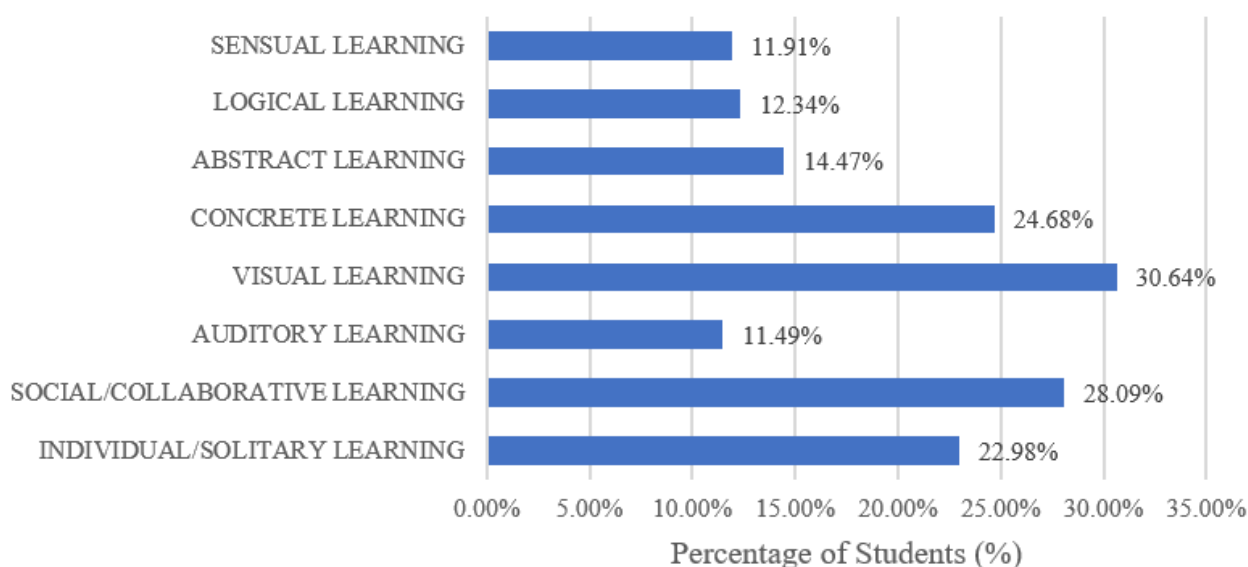


Figure 5. Distribution of online learning styles among CMU-Veterinary Medicine students (n=235).

in technology-enhanced learning previously designed for traditional learning (Graf et al., 2007).

The most preferred online learning style among the respondents was visual learning at 30.64% (Figure 5). Among year levels, most of the first years, second years and sixth years preferred visual learning at 34%, 38%, and 38% respectively, most third years and fourth years preferred social/collaborative learning at 75% and 33% respectively, while the fifth years preferred concrete learning at 34%. In comparison between genders, males mostly (31.11%) preferred visual learning, while females preferred both social/collaborative learning and visual learning at 30.34%.

Online learning instructional preference was determined using the online instruction methods described by Toni Mohr et al. (2012). These include interactive, non-interactive teacher-centered, and non-interactive learner-centered online learning.

The veterinary medicine students mostly preferred

non-interactive online instruction at 40% in both methods. However, non-interactive learner-centered is much higher of about 3.40% than non-interactive teacher-centered since there were students with multiple instructional preferences in which non-interactive learner-centered was also included (Figure 6). In general, non-interactive learner-centered online instruction was preferred by most of the respondents at 47.66%.

Among the year levels, first years and fifth years preferred non-interactive learner-centered at 56.70% and 47.73% respectively, while the second years, third years, fourth years, and sixth years preferred non-interactive teacher-centered at 47.62%, 50%, 55.56%, and 43.59% respectively. Comparing the instructional preference between genders, males mostly preferred non-interactive learner-centered (46.67%) online instruction while females mostly preferred non-interactive teacher-centered (44.14%) online instruction.

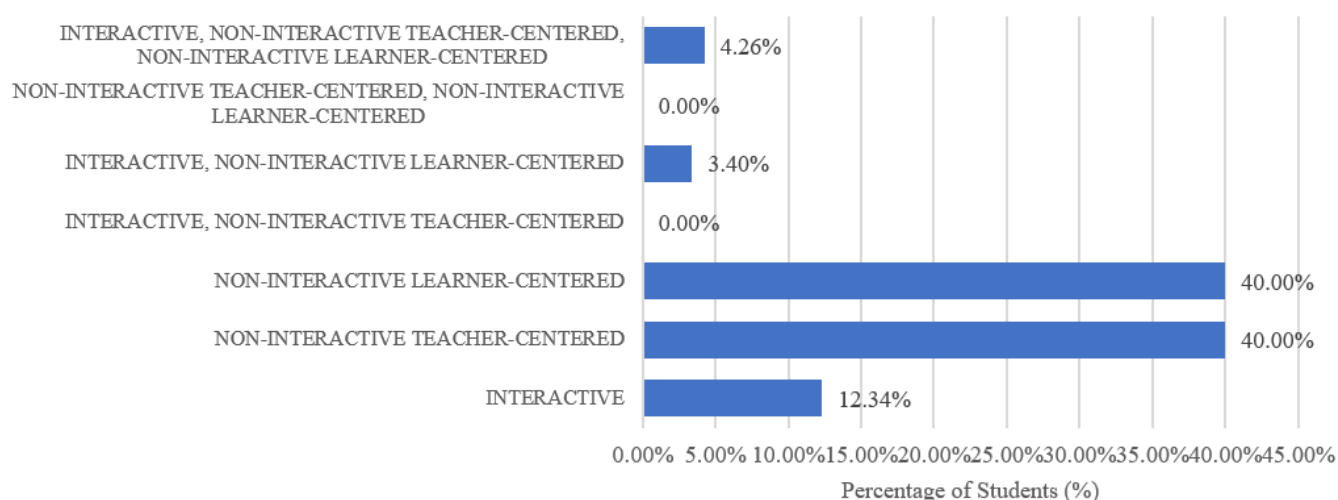


Figure 6. Distribution of online instructional preference among CMU-Veterinary Medicine students (n=235).

In the conducted follow-up interviews, it was discussed why the veterinary medicine students chose non-interactive learner-centered online instruction over the other methods. According to the respondents, they preferred non-interactive learner-centered online instruction because it will allow them to learn at their own pace or have control over how they manage their time. It is essential for them because there were times that they could not cope with the instructor/professors' pace of teaching. Methods of non-interactive learner-centered online instruction like web-assignments will allow them to show up more of their imaginative or creative side since they will have more time. Having time control will make it easier to understand concepts since it will allow them to give themselves more time to think, rationalize, and follow the lessons. They will also have more time to search for more facts from the internet to enhance their learning. Some respondents also see it as fun because it will allow them to develop their learning style and probably improve their other abilities. They also like it because it does not require an immediate response to the questions being asked by the instructors. They also think that learning on their own will make finishing a specific task easier than sharing it with others due to lack of cooperation. Non-interactive learner-centered online learning also allows them to evaluate their knowledge of the topics being tackled. It also does not require a fast and stable internet for a particular time like interactive online learning. They were also unsure of the audio and video quality produced by interactive online learning because of the slow and unstable internet. Interactive online instruction like video conferencing also consumes a lot of data, increasing its cost. Some students even mentioned that they have low device specifications causing lags, which will make them unable to cope with interactive learning. According to them, methods of interactive online learning like listening to the instructor's discussion alone is somewhat ineffective because the students tend to get bored, and learning in chat rooms can be quite noisy and distracting as well. Some first-years also have fear to voice their ideas in interactive online instruction, especially when they think that there will be other students online listening or watching. The students were even considering that everyone has different learning

styles, so they tend to learn on their own so that no one will adjust with one another. Meanwhile, some respondents that preferred interactive online learning think that other students might have good comprehension. That is why it is easier for them to understand the lessons without any discussion from their instructors and professors.

Based on the online learning instructional preference and follow-up interviews, it is therefore recommended to adopt blended learning, mainly a combination of non-interactive online instruction and the traditional teaching method. The implementation of non-interactive online instruction will address the issue of slow internet connectivity. Unlike interactive online learning, the students can access the learning materials any time when a good connection is already established. Moreover, those in the minority that does not have computers and smartphones will also have more time to find ways they can access the materials. Fully-online education is not also advisable because of the laboratory subjects that need to be practically performed. The respondents also mentioned that they prefer hands-on experience to supplement the learning. Blended learning has also proved to overcome various limitations related to online learning and face-to-face instruction (Alammary et al., 2014). A meta-analysis of more than 1,100 empirical studies published between 1996 and 2008 concluded that blended learning is more effective than online learning or face-to-face instruction (Means et al., 2009).

3.4 Relationship Between the Respondents' Online Learning Style to Their Online Instructional Preference

The relationship between the respondents' online learning style and their instructional preference was measured using the Chi-square test of independence (at $\alpha=.05$). The result showed no significant difference, $\chi^2(228, N = 235) = 173.07, p = .997$. It implies that online learning style and online instructional preference are independent with each other. In other words, the choice of a learning style does not necessarily affect the inclination towards an online learning instruction and vice versa.

3.5 Relationship Between Gender and Year Level to Respondents' Online Learning Style

The relationship between the respondents' gender with their online learning styles was determined using a Chi-square test of independence at $\alpha=.05$. The result showed that the relation between these variables was insignificant, $X^2 (57, N = 235) = 74.25, p = .06$. This result was also observed in the study conducted in Ethiopia by Yemane et al. (2017) ($\alpha = .05; p = .37$). Thus, the respondents' learning style preference is independent of the respondent's gender.

Meanwhile, the relationship between the respondents' year level and their online learning styles using the chi-square test of independence (at $\alpha=.05$) revealed no significant relationship, $X^2 (285, N = 235) = 209.73, p = 1.0$. This result means that being at a specific year level does not follow a particular learning style preference.

3.6 Online Learning Experience and its Relationship to the Respondents' Online Learning Preparedness and Attitude

Out of the 235 respondents, more than half (61.28%) had no previous online learning experience, while 38.72% had enrolled or experienced online course/learning sessions. Their online learning experience was conducted through various methods such as non-interactive teacher-centered like streaming videos; non-interactive learner-centered like submission of requirements online, answering online quizzes and activities; lastly, interactive online learning using video conferencing software and online messaging applications.

A chi-square test of independence indicated significant association between online learning experience and online learning preparedness with a small to medium strength of relationship, $X^2 (2, N = 235) = 17.62, p < .001, V = .26$. This result implies that the respondents' online learning preparedness is dependent on whether or not they have a previous online learning experience. Moreover, the relationship between online learning experience and attitude towards online learning also showed a significant association with a small strength of relationship, $X^2 (2, N = 235) = 7.87, p = .02, V = .18$. This result means that the respondents' attitude towards online learning is dependent on whether or not they have experienced online learning. This data can be a basis for conducting a longitudinal survey if online learning or blended learning is to be implemented to determine if there will be improved attitude and preparedness among the respondents. A follow up survey is very essential considering that in the study of Okwumabua et al. (2010), 52% of the respondents admitted that their negative attitudes toward online learning will not change even if they become accustomed to the approach.

CONCLUSION AND RECOMMENDATION

The findings of this study show that the implementation of online learning in CMU-College of Veterinary Medicine is feasible. Most of the students were

well-prepared in engaging online learning. They have access to technology, have internet and software application skills, and social support necessary for learning online. Although most students were neutral towards online learning, this can change since attitude is significantly associated with an online learning experience. It also shows that most of the students were visual learners, which means they prefer watching when learning. In the method of online learning instructions, most of them preferred non-interactive learner-centered due to their preference for independent learning, and they want to have control over how they manage their time when learning.

Although online learning is feasible, it is recommended to do non-interactive online instruction and blend it with face-to-face instruction, as it is also essential to develop students' practical skills, especially in Veterinary Medicine. Non-interactive online instruction will help to address the issue of the slow internet connection of the students since it will allow them to access the learning materials when a good internet connection is already established.

Moreover, before the implementation of blended learning, it is essential to determine first the average internet speed used by the students. This information is necessary because it will serve as the basis of the learning materials' data rate, and it should be lower than the student's average internet connection. Future studies should also venture on the assessment of preparedness among the faculty since they will be the ones who will implement the learning instruction.

The neutral attitude can be dealt with by providing mechanisms to inform and orient learners on the learning system to be implemented, which may be in the form of course packages for students and accessible through offline and online modes. It will address the students' confusion on how the proposed learning continuity plan will work, which is a factor of the neutral response. Since most of the respondents are visual learners, the learning instructional media and materials that can be utilized in this form of learning are videocasts, video visuals of sample cases and scenarios, simulations, and graphic organizers; these can be taught through demonstration and presentation.

The unprecedented impacts of the COVID-19 pandemic are indeed leading educational systems to a new normal period in human history. Other courses or degrees within the university must also assess their students' and faculty's preparedness for online learning before its implementation to minimize complications; however, it is inevitable during this uncertain time. Higher education institutions thereby need to seize the opportunity to develop a resilient education system responsive to the needs of the changing times and be prepared when another crisis comes in the future.

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Antibacterial activity of the crude ethanolic extracts of *Etlingera elatior* and *Etlingera philippinensis*

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ABSTRACT

Due to the emergence of multidrug resistant bacteria, researchers are on search for a new source of antimicrobial agents such as plants. This study reports the antibacterial activities of the leaves and rhizomes of *E. philippinensis* and *E. elatior* against Gram-positive (*M. luteus*, *S. aureus* and *S. marcescens*) and Gram-negative bacteria (*E. coli* and *P. aeruginosa*, *B. cereus*). Disc diffusion method was employed in determining the antibacterial activity of the plant ethanolic extracts with concentrations of 3000 ppm and 10000 ppm. Highest antibacterial activity was exhibited by the leaves and rhizomes of the Philippine endemic *E. philippinensis* (10000 ppm) against *M. luteus* (12.00 ± 0.56) and *P. aeruginosa* (11.50 ± 0.45), respectively. Of all extracts, only the leaves *E. elatior* (10,000 ppm) showed antibacterial activity against *S. marcescens* which is 6.57 ± 0.49 .

Keywords: Antibacterial, *Etlingera elatior*, *Etlingera philippinensis*.

INTRODUCTION

The rampant emergence of multidrug resistant bacteria is one of the many ever-growing concerns that continues to challenge the healthcare sector in both developing and developed countries. In fact, multidrug-resistant microorganisms cause almost 50% of the worldwide hospital-acquired infections, thus the World Health Organization warns of a 'post-antibiotic era' (O'Neill 2014; WHO 2014; Othman et al., 2019; Khameneh et al. 2019). This has necessitated a search for a new source of antimicrobial substances such as plants as they produce a variety of bioactive compounds of known therapeutic properties (Tomovo et al., 2015; Manandhar et al., 2019). However, the composition, quantity, quality of bioactive compounds and antimicrobial activities of plants belonging to different regions of the world can be affected by many factors such as climate, age and vegetation cycle stage, plant-microbiome interaction, soil composition (macro and micro minerals) and environmental stress including drought, acidity, salinity and heavy metal contaminants (Masotti et al., 2003; Angioni, 2006; Noumedem et al., 2013). Thus, studies of bioactive components and antibacterial activities of plants in different parts of the world is greatly recommended.

Etlingera elatior (Jack) R. M. Smith, also known as torch ginger, is widely distributed and is popular in Southeast Asia (Krajarng et al., 2017) wherein its inflorescences are traditionally used for culinary and medicinal purposes. Methanolic extracts of the leaves of *E. rubrostriata* and *E. elatior* revealed antibacterial activity against Gram-positive but not Gram-negative bacteria (Chan et al., 2007). Study on the phytochemical profile of *E. elatior* revealed that it contains a high amount of vitamin C, total phenolic, and flavonoid contents (Sungthong et al., 2018; Rachkeeree et al., 2018). Essential oils from *E. elatior* could be potentially used as a new source of

natural antioxidant and antibacterial in the food and pharmaceutical industries (Abdelwahab et al., 2010). Furthermore, Juwita et al. (2018) reported that both leaves and rhizome of *E. elatior* exhibit antibacterial, antioxidant, antiproliferative and apoptotic activities.

Etlingera philippinensis is endemic in the Philippines. It was discovered in 1905 in the district of Davao, Mindanao, Philippines by E.B. Copeland. Its basionyms include: *Hornstedtia philippinensis* Ridl., *Amomum philippinense* (Ridl.) Merr., *Achasma philippinensis* (Ridl.) B.L. Burtt & R.M. Sm. (Newman et al., 2004).

Phytochemical analysis of *E. philippinensis* plant extract revealed the presence of alkaloids, flavonoids, saponins, tannins and steroids. High DPPH radical scavenging activities were also observed in the water extracts of *E. philippinensis* (Barbosa et al. 2016). Moreover, leaves of *E. philippinensis* were found to contain chlorogenic acid (Barbosa et al., 2017). Mabini and Barbosa (2018) reported that *E. philippinensis* showed high antioxidant activity and total phenolic content.

Over the years, multidrug resistant bacteria are one of the most important threats to public health (Van Duin and Peterson, 2016; Stefanović, 2018). These multidrug resistant bacteria includes the methicillin-resistant *Staphylococcus aureus* (Van Duin and Peterson, 2016), multidrug-resistant *Pseudomonas aeruginosa* (Stefanović, 2018), *Escherichia coli* (Dautle et al., 2004), causative of catheter-associated infections *Serratia marcescens* (Ray et al., 2017), one of the common food-borne pathogen

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Received 10th March 2020; Accepted 14th May 2020

Bacillus cereus (Shawish and Tarabees, 2017; Gao et al., 2018) and *Micrococcus luteus* (Rind and Khan, 2000). According to Izah (2018) these multidrug resistant bacteria are the most commonly studied organisms for antimicrobial susceptibility pattern using plant extract. Hence, this study aims to investigate the antibacterial property of *Etlingera elatior* and *Etlingera philippinensis* against these select multidrug resistant bacteria, that is, *S. aureus*, *P. aeruginosa*, *E. coli*, *S. marcescens*, *B. cereus*, and *M. luteus*.

METHODOLOGY

Plant Materials Collection

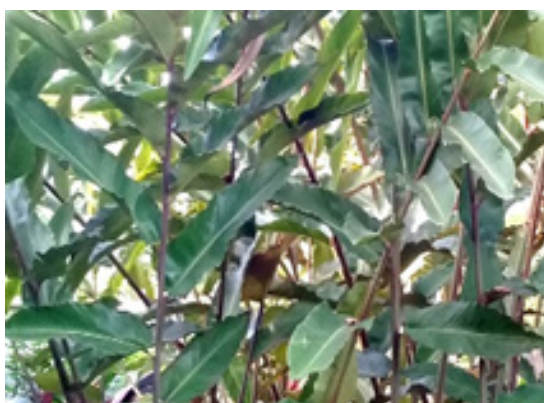
Bulk plant leaves and rhizomes of *E. elatior* and *E. philippinensis* were collected in Musuan, Maramag, Bukidnon, and Barangay Gutapol, Kibawe, Philippines, respectively in January 2019. Representative photographs of the samples are presented in Figure 1. Identification of the collected samples were done by Dr. Florfe M. Acma, a taxonomist of the Central Mindanao University (CMU) Herbarium, Center for Biodiversity Research and Extension in Mindanao CEBREMO, CMU, University Town, Musuan, Bukidnon, Philippines.

Plant Material Preparation

The fresh leaf samples were washed with tap water then sterilized using 10% Sodium hypochlorite. Final rinsing was done with distilled water three times (Ang et al, 2019). The rhizomes were peeled and grated to fine pieces. The washed leaf and grated rhizome samples were air-dried for four weeks under shade at ambient temperature, 29 °C. The dried leaf samples and grated rhizomes were finely powdered using a heavy duty blender and stored inside airtight Ziploc bags prior extraction.

Extraction

The powdered dried leaf and rhizome samples (250g) of *E. elatior* and *E. philippinensis* were soaked in absolute ethanol (Scharlau,) for 48 hours and filtered twice, using cheese cloth first then finally with Whatman No.1 filter paper. The filtrate (ethanol extract) was rotary-evaporated under vacuum at 40 °C to remove ethanol. Fresh crude ethanolic extracts were then used to make 3000 ppm and 10000 ppm for antibacterial analyses that were submitted to the Microbiology laboratory, College of Veterinary Medicine (CVM) in Central Mindanao University (CMU), University Town, Musuan, Bukidnon.



(A)



(B)



(C)



(D)

FIGURE 1. Photographs of *E. elatior* plant (A), *E. philippinensis* plant (B), *E. elatior* rhizome (C), and *E. philippinensis* rhizome (D).

Antibacterial Activity Determination

Test organisms

Six bacterial species were used as test organisms, namely: Gram-positive (*S. aureus*, *M. luteus* and *B. cereus*) and Gram-negative (*E. coli*, *S. marcescens* and *P. aeruginosa*). *B. cereus* (BIOTECH 1509) was incubated in 30 °C, aerobic for 24 hours in nutrient agar containing beef extract, peptone, and sodium chloride. *M. luteus* (BIOTECH 1793) and *E. coli* (BIOTECH 1634) were incubated at 37 °C with an incubation period of 24 hours in nutrient agar containing beef extract, peptone, and sodium chloride. *S. aureus*, *S. marcescens* and *P. aeruginosa* were isolated by Microbiology Laboratory, CVM, CMU, all in nutrient agar and incubated at 35 °C at 24 hours.

Antibacterial Assay

The antibacterial activity determination of the crude extracts was limited only to concentrations 3000 ppm and 10000 ppm when assayed against the select abovementioned bacteria. Paper Disc Diffusion Method on Mueller Hinton agar medium as described by Guevarra (2005) with slight modification was employed in this assay.

Briefly, the bacterial inoculum was swabbed over the entire surface of the Mueller Hinton agar plate using a sterile cotton swab. A sterile six (6) mm filter paper disc, previously soaked in the crude extract for 24 hours, was placed on the surface of the Mueller Hinton agar. After 24 hours of incubation at 37 °C, the diameter of the zones of inhibition of bacterial growth was measured in millimeters using a caliper. The assay was done in three replicates per sample.

Statistical Analysis

The antibacterial activity test results obtained in this study were statistically analyzed using t-test to compare the antibacterial activity of *E. elatior* from *E. philippinensis* against the test organisms. The same statistical test was performed on the results to compare the antibacterial activity of the leaf extracts from the rhizome extracts of each plant species. The t-test is used to compare whether the two means differ significantly from each other at 0.05 level of significance or whether their difference can be accounted for merely by random variations.

RESULT AND DISCUSSION

There is urgency to search for more antibacterial agents from plant source due to the growing concern on antibiotic resistance of most pathogenic organisms. There are still very limited scientific data on antibacterial activity of *E. elatior* and *E. philippinensis*. To fill this gap even at least partially, this study was conducted.

The antibacterial activity of the ethanolic extracts of the leaves and rhizomes of *E. philippinensis* and *E. elatior* are presented in Table 1. Concentrations of 3,000 ppm and 10,000 ppm were based on the study of Prakash and Karmegam (2012) and Wejinyake et al., 2016 with slight modification, respectively. Thirty micrograms of amikacin

(22.7±4.45-26.3±4.45) and absolute ethanol (0) were used as positive and negative control, respectively. The zone of inhibition was measured in millimeter. Antibacterial activity tests were done in three trials.

Antibacterial activity of *E. philippinensis*

At 3000 ppm, *E. philippinensis* was only active against *M. luteus* (6.70 ± 0.87-leaves, 6.37 ± 0.64- rhizome) and *P. aeruginosa* (7.33 ± 1.04-rhizome). Both leaves and rhizome of *E. elatior* at 3,000 ppm did not show any antibacterial activity on the select bacteria. The leaves of *E. philippinensis* at 10,000 ppm showed a considerable antibacterial activity against *P. aeruginosa* (10.60 ± 0.55), *E. coli* (4.68 ± 0.85), *M. luteus* (12.00 ± 0.56), *B. cereus* (8.23 ± 0.32). *E. philippinensis* rhizome at 10,000 ppm showed antibacterial activity against *P. aeruginosa* (11.50 ± 0.45), *M. luteus* (7.07 ± 0.38) and *B. cereus* (7.20 ± 0.30). The highest antibacterial activity was exhibited by the leaves and rhizomes of *E. philippinensis* (10,000 ppm) against *M. luteus* (12.00 ± 0.56) and *P. aeruginosa* (11.50 ± 0.45), respectively.

Antibacterial activity of *E. elatior*

For *E. elatior* at concentration 10,000 ppm, the antibacterial activities against *M. luteus* and *B. cereus* are 6.67 ± 0.58 (leaves) and 6.67 ± 0.58 (rhizome), respectively. Of all extracts only the leaves *E. elatior* (10,000 ppm) showed antibacterial activities against *S. marcescens* which is 6.57 ± 0.49. Both plants, *E. philippinensis* and *E. elatior*, were not active against *S. aureus*.

Interpretation of Antibacterial assay results

Guevarra (2005) interpreted the antibacterial activity of the crude extracts as inactive if the zone of inhibition is <10 mm; partially active if 10-13 mm; active if 14-19 mm; and very active if >19 mm. Based on this criteria, the ethanolic extracts of *E. philippinensis* at 10,000 ppm is considered partially active against *M. luteus* (12.00 ± 0.56 – leaves and *P. aeruginosa* (10.60 ± 0.55 – leaves; 11.50 ± 0.45 – rhizomes) while the rest of the extracts are inactive. It is important to note, however that these extracts are still crude and purification of the extracts may increase the antibacterial activity. A study of Policegoudra et al. (2006) on mango ginger rhizome has shown that the isolated compound has a more pronounced increase in antibacterial activity than the source extract.

The interpretative range in the zone of inhibition for the antibacterial activity of 30 g Amikacin antibiotic disc was □ 14 mm for resistant, 15-16 mm for intermediate sensitivity, and □ 17 mm for sensitive. Amikacin gave □ 17 mm zones of inhibition (22.7 - 26.3) against all test organisms implying that these organisms are all sensitive to amikacin.

There are many contributing factors affecting the antibacterial efficacy of plants. Some of these factors include environmental factors (time of harvesting, weather and botanical source), method of extraction, choice of solvent used metabolism and adaptation strategies of the microbes which also includes the type, genus, species

and strain, biochemistry of the plant (composition of the bioactive compounds, hydrophilicity, lipophilicity, concentration of the plant extract, pH value), plant species, age and parts used. (Li et al., 2017; Abdalla and Abdallah, 2018; Stefanović, 2018; Izah, 2018; Ellof, 2019). These best explains the variation of the results obtained in this study. For instance, *E. elatior* showed no antibacterial activity against all the bacteria tested at 3,000 ppm but its leaves showed antibacterial activity against *M. luteus* and *S. marcescens* at 10,000 ppm. It's rhizomes also showed antibacterial activity against *B. cereus* at 10,000 ppm.

Chan et al. (2007) reported no antibacterial activity of the methanol extracts of *E. elatior* leaves on the Gram-negative bacteria *E. coli*, *P. aeruginosa*, and *Salmonella choleraesuis*. In this present study, *E. elatior* leaves and rhizomes have no antibacterial activity in both 3000 ppm and 10000 ppm against the Gram-negative *E. coli* and *P. aeruginosa*. Interestingly, it has antibacterial activity against Gram-negative *S. marcescens* at 10000 ppm. Gram-negative bacteria are generally less susceptible to plant extracts than the Gram-positive bacteria (Chan et al., 2007). The outer membrane of Gram-negative bacteria consists of lipoprotein and lipopolysaccharide which is selectively permeable and thus regulates access to the underlying structures (Chopra and Greenwood, 2001).

Amikacin, positive control, is a member of aminoglycosides. A group of antibiotics used since the 1940s to primarily treat a broad spectrum of bacterial infections. In this study, amikacin exhibited greater antibacterial activity against gram-positive; *S. aureus*, *M. luteus* and *B. cereus* and Gram-negative; *E. coli*, *S. marcescens* and *P. aeruginosa*, ranges from 22.7 ± 4.45 – 26.3 ± 4.45 mm, as compared to both the root and leaf extracts of *philippinensis* and *E. elatior*. This is to be expected since the extracts have various impurities as compared to the drug that is a purified and semi-synthetically processed molecule (Ramirez and Tolmasky, 2017; Otto et al., 2014).

Furthermore, it is interesting to note, that despite being just a crude extract, both plants displayed antibacterial activity on selected test organisms. This result warrants further purification and biological activity testing of *E. philippinensis* and *E. elatior*.

CONCLUSION AND RECOMMENDATION

Crude ethanolic extracts of *E. elatior* and *E. philippinensis* showed antibacterial activity against selected test organisms. The Philippine endemic *E. philippinensis* leaves and rhizomes possessed the highest antibacterial activity against *M. luteus* and *P. aeruginosa*, respectively. Further purification and biological activity testing of *E. elatior* and *E. philippinensis* is recommended. Moreover, it is recommended that antibacterial studies on more varied extract concentrations and antifungal studies be done on these plants.

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Table 1. Antimicrobial activity as zone of inhibition (mm) of *E. philippinensis* and *E. elatior* ethanolic extracts against selected bacterial strains. Results are expressed as Mean of three replicates \pm SD; 0.00 = No Zone of Inhibition; Gram-negative (G-); Gram-positive (G)

Microorganisms	Plant Extract Concentration								Zone of Inhibition, mm	
	3000 ppm				10000 ppm				Positive Control (Amikacin, 30mcg)	Negative Control (Ethanol, Absolute)
	<i>E. philippinensis</i>		<i>E. elatior</i>		<i>E. philippinensis</i>		<i>E. elatior</i>			
	L	R	L	R	L	R	L	R		
<i>P. aeruginosa</i> (G-)	0.00	7.33±1.04	0.00	0.00	10.60±0.55	11.50±0.45	0.00	0.00	23.0± 4.81	0.00
<i>E. coli</i> (G-)	0.00	0.00	0.00	0.00	4.68 ±0.85	0.00	0.00	0.00	22.7± 4.45	0.00
<i>M. luteus</i> (G+)	6.70±0.87	6.37±0.64	0.00	0.00	12.00±0.56	7.07±0.38	6.67±0.58	0.00	24.2± 2.33	0.00
<i>S. marcescens</i> (G-)	0.00	0.00	0.00	0.00	0.00	0.00	6.57±0.49	0.00	23.5± 3.32	0.00
<i>B. cereus</i> (G+)	0.00	0.00	0.00	0.00	8.23±0.32	7.20±0.30	0.00	6.67±0.58	26.3± 4.45	0.00
<i>S. aureus</i> (G+)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.4± 1.98	0.00

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Quantum Description of a Damped Coupled Harmonic Oscillator via White-Noise Analysis

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ABSTRACT

In this paper, the quantum mechanical dynamics of a particle subjected to a damped coupled harmonic oscillator potential was investigated by solving its quantum propagator using the Hida-Streit formulation—also known as the White-Noise analysis. A coordinate transformation to decouple the system was also performed. After the decoupling process, the authors obtained a separate expression of the Lagrangian for a one-dimensional damped harmonic oscillator. Then, the obtained Lagrangian was cast to the classical action and evaluated their propagator using the white noise path integration. The full form of the propagator was solved by taking the product of the individual propagator, and from that, the wave function, particularly the ground state wave function was extracted by symmetrization and setting the quantum number $n_1 = n_2 = 0$. The result agrees with the propagator of a coupled harmonic oscillator without damping (Pabalay et.al, 2007) as the damping factor γ is turned off.

Keywords: Propagator, White-Noise Analysis, Coupled Oscillators, Quantum Mechanics

INTRODUCTION

Due to its wide application in understanding the dynamics of the universe, studies in oscillatory motion had been dramatically growing throughout the years. It is viewed from the fact that oscillations are present in all systems in nature—from microscopic to macroscopic point of views. There are classifications of an oscillatory motion; we have simple harmonic, damped harmonic, coupled harmonic oscillations, among others. These systems have many interesting applications, for example, in the context of the general theory of relativity, it was shown in (Ben-Aryeh, 2008) that the general theory of time-dependent harmonic oscillator—harmonic oscillator with time-dependent frequency and time-dependent mass—is applied for studying certain quantum effects in the interferometers for detecting gravitational waves.

In this article, we will study the coupled harmonic oscillator system with isotropic mass and time-independent frequency. Coupled harmonic oscillation is close to a non-ideal system, for it represents a natural system for two or more particles interacting with each other and exhibits a transport of energy due to their interaction. Many physical phenomena illustrate coupled oscillations. For instance, when a solid material was subjected to extreme temperature, the electron in the material oscillates rapidly, which causes the electron to interact with another electron such that the individual movements of each molecule are now influenced by the other molecule. Hence, they are coupled.

The system of coupled oscillations has been extensively studied by many authors in the past decade (de Souza Dutra, 1992) and until this very moment (Pabalay et.al, 2007; Rangaig et.al, 2017; Butanas et.al, 2016; Gallo et.al, 2019). Aside from the fact that it is an interesting system to deal with, there are many physical

situations wherein the principles of coupled oscillations can be applied. For instance, in meteorology, in 2017 (Muraki, 2017), a coupled harmonic oscillator was used to model the solar activity and El Niño-Southern Oscillation (ENSO) in Japan. Also, coupled oscillators are applied in the context of coupled semiconductor lasers (Dente et.al, 1990), in which the system is subjected to additional effects such as time delays which arises by introducing additional degrees of freedom to the system.

The quantum representation of the coupled harmonic oscillator system has already been investigated. See for example the paper of Pabalay and Bornaes (Pabalay et.al, 2007) wherein they obtained an expression for the quantum mechanical propagator for a coupled harmonic oscillator with coupling constant λ ; Rangaig et al. (Rangaig et.al, 2017) in which they solved the quantum dynamic propagator of a harmonic oscillator with the uniform electric field in N-multimode harmonic oscillator bath; Dutra (de Souza Dutra, 1992) where the quantum propagator for a driven coupled harmonic oscillator is solved; and many others (Butanas et.al, 2017; Macedo et.al, 2012; Bernido et.al, 2012).

In solving the quantum propagator, one way is by path integration introduced by Feynman, in which the sum of over-all possible trajectories of a particle is taken. However, even though it describes the system correctly, the formulation is mathematically ill for its lack of rigor. Fortunately, there is a method that casts the Feynman path integral formulation to a more rigorous approach, and here comes the Hida-Streit formulation also known as white-noise path integration. This formulation has been successful in solving many quantum systems (Butanas

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Received 28th August 2020; Accepted 12th January 2021

et.al, 2017).

Here in this paper, the authors describe a specific coupled oscillatory motion in which an additional parameter known as the damping parameter γ was introduced. The damping alters the behavior of a coupled harmonic oscillator considered in (Pabalay et.al, 2007). It can be thought of as friction or a dissipative force applied to a coupled harmonic oscillator with coupling constant λ . The authors want to obtain its quantum propagator using the Hida-Streit approach.

METHODOLOGY

Decoupling Procedure

The Lagrangian of the damped coupled harmonic oscillator is given by

$$L = \left[\frac{1}{2} m (\dot{x}_1^2 + \dot{x}_2^2) - \frac{1}{2} m \Omega^2 (x_1^2 + x_2^2) - \lambda x_1 x_2 \right] e^{\gamma t} \quad (1)$$

where λ is the generalized coupling factor treated as constant, x_1 and x_2 are the generalized coordinates, m is the mass, Ω is the frequency, and γ is the damping factor. The heart of this paper is mainly due to the introduction of the damping parameter. The main goal here is to decouple the Lagrangian L given in Eq. (1). One can decouple L by performing a coordinate transformation given by

$$\begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = \begin{pmatrix} \cos \phi & \sin \phi \\ -\sin \phi & \cos \phi \end{pmatrix} \begin{pmatrix} y_1 \\ y_2 \end{pmatrix}. \quad (2)$$

Using equation (2), one can rewrite equation (1) as

$$L_T = \left[\frac{1}{2} m (\dot{y}_1^2 + \dot{y}_2^2) - \frac{1}{2} m \Omega^2 (y_1^2 + y_2^2) - \lambda \left(\frac{y_2^2 - y_1^2}{2} \sin 2\phi + y_1 y_2 \cos 2\phi \right) \right] e^{\gamma t}. \quad (3)$$

Equation (3) has coupling in y coordinates and there is a need to eliminate it. With that, one needs to impose the condition,

$$y_1 y_2 \cos \phi = 0, \quad (4)$$

which gives us the relation given by

$$\phi = \left(\frac{n}{2} + \frac{1}{4} \right) \pi. \quad (5)$$

Using equations (4) and (5), one can rewrite the transformed Lagrangian L_T as follows

$$L_T = \left(\frac{1}{2} m \dot{y}_1^2 - \frac{1}{2} m \Omega_1^2 y_1^2 \right) e^{\gamma t} + \left(\frac{1}{2} m \dot{y}_2^2 - \frac{1}{2} m \Omega_2^2 y_2^2 \right) e^{\gamma t} \quad (6)$$

where

$$\Omega_1^2 = \Omega^2 - \frac{\lambda}{m} \quad (7)$$

$$\Omega_2^2 = \Omega^2 + \frac{\lambda}{m}. \quad (8)$$

Notice that from equation (6), we can write $L_T = L_{T1} + L_{T2}$ where

$$L_{T1} = \left(\frac{1}{2} m \dot{y}_1^2 - \frac{1}{2} m \Omega_1^2 y_1^2 \right) e^{\gamma t} \quad (9)$$

$$L_{T2} = \left(\frac{1}{2} m \dot{y}_2^2 - \frac{1}{2} m \Omega_2^2 y_2^2 \right) e^{\gamma t}. \quad (10)$$

At this point, the problem is reduced into two damped harmonic oscillators.

Brief review on the Hida-Streit approach

In this section, some of the main points in using the Hida-Streit formulation will be reviewed to solve the quantum mechanical propagator of the system.

Describing the system's propagator in the quantum mechanics regime amounts to solving the Feynman path integral given by

$$K(x', x''; t', t'') = \int D[x] e^{iS/\hbar} \quad (11)$$

where $D[x]$ is the Lebesgue measure and S is the classical action expressed in terms of the Lagrangian given by,

$$S = \int L dt. \quad (12)$$

Now, to recast the Feynman path integral in the context of white-noise analysis, one needs to perform the following main steps:

- First, parametrize the particle's path in terms of the Brownian motion $B(t)$, given by

$$x(t) = x_o + \sqrt{\frac{\hbar}{m}} B(t) \quad (13)$$

- Second, take the correspondence between the Lebesgue $D[x]$ and Gaussian measure $d\mu \omega$

$$D[x] = \exp \left[\frac{1}{2} \int \omega^2(t) dt \right] d_\mu \omega. \quad (14)$$

- Last, fix the endpoint of the particle's path by introducing a Donsker delta function $\delta(x(t) - x1)$, where $x(t)$ is the parametrized path of the particle.

After performing these main steps, one must express the path integral in terms of the white noise variable ω and then take the T -transform (Bernido et.al, 2012) and solve for the propagator.

The Propagator of a damped harmonic oscillator

The propagator of a damped harmonic oscillator

was solved by (Cubero et.al, 2010) using white noise analysis. In this section, the authors utilize it to solve the propagator of a damped coupled harmonic oscillator. In our case, the Lagrangian is given in equations (9) and (10). Now, the parametrization of the path of the particle is given by,

$$y_1 = \sqrt{\frac{\hbar}{m e^{\gamma t}}} B_1. \quad (15)$$

Incorporating Eq. (15) to Eq. (12), it yields the following expression of the classical action, S , given by,

$$S = \frac{\hbar}{2} \left[\int \omega_1^2 dt - \int \Omega_{1\gamma}^2 B_1^2 dt - \int \gamma \omega_1 B_1 dt \right], \quad (16)$$

where

$$B(t) = \int \omega(t) dt. \quad (17)$$

Given the expression for the classical action S in Equation (16), the exponential term in equation (11) can be written as,

$$\exp\left(\frac{iS}{\hbar}\right) = \exp\left(\frac{i}{2} \int \omega_1^2 dt - \frac{i\Omega_{1\gamma}^2}{2} \int B_1^2 dt - \frac{i\gamma}{2} \int B_1 \omega_1 dt\right), \quad (18)$$

where

$$\Omega_{1\gamma}^2 = \Omega_1^2 - \frac{\gamma^2}{4}. \quad (19)$$

The first term in the exponent of equation (18) can be written as

$$\frac{i}{2} \int \omega_1^2 dt = \frac{1}{2} \langle \omega_1, i\omega_1 \rangle. \quad (20)$$

Using equation (15), one can rewrite the second term in the exponent of equation (18) as

$$-\frac{i\Omega_{1\gamma}^2}{2} \int B_1^2 dt = -\frac{i}{\hbar} \int V_1(y) dt, \quad (21)$$

where

$$V_1(y) = \frac{m\Omega_{1\gamma}^2 \exp(\gamma t)}{2} y_1^2. \quad (22)$$

Furthermore, equation (21) can be rewritten as

$$-\frac{i\Omega_{1\gamma}^2}{2} \int B_1^2 dt = -\frac{i}{\hbar} S_1, \quad (23)$$

where

$$S_1 = \int \frac{m\Omega_{1\gamma}^2 \exp(\gamma t)}{2} y_1^2 dt. \quad (24)$$

Using Taylor series expansion, equation (24) is expanded to

$$S_1(y) \approx S_1(y_0) + \int \omega_1(\tau) \frac{\delta S_1(y_0)}{\delta \omega_1(\tau_1)} d\tau + \frac{1}{2} \int \omega_1(\tau_1) \omega_2(\tau_2) \frac{\delta^2 S_1(y_0)}{\delta \omega_1(\tau_1) \delta \omega_1(\tau_2)} d\tau_1 d\tau_2 + \dots, \quad (25)$$

and employing the theory of Quadratic Lagrangian, this expansion expands only up to its third term and the rest becomes zero, hence the second term of equation (18) becomes

$$-\frac{i\Omega_{1\gamma}^2}{2} \int B_1^2 dt = -\frac{i}{2\hbar} \int \omega_1(\tau_1) \omega_1(\tau_2) S_1''(y_0) d\tau_1 d\tau_2 \quad (26)$$

$$= -\frac{1}{2} \langle \omega_1, i\hbar^{-1} S_1''(y_0) \omega_1 \rangle,$$

where

$$S_1''(y_0) = \frac{\hbar}{m \exp(\gamma t)} \int V_1'' dt. \quad (27)$$

Lastly, the third term in the exponent of equation (18) can be re-expressed using direct integration. Letting $u=B_1$, hence, $du=B_1' dt$. Since $B(t)=\int \omega(t)dt$, then $du=\omega_1(t)dt$, therefore the third term of equation (18) becomes,

$$-\frac{i\gamma}{2} \int B_1 \omega_1 dt = -\frac{i\gamma}{4} \left[\frac{m \exp(\gamma t_1)}{\hbar} y_{11}^2 \right]. \quad (28)$$

Combining all the re-expressed terms back equation (18), the exponential term of the Feynman path integral reads as,

$$\exp\left(\frac{iS}{\hbar}\right) = \exp\left[-\frac{i\gamma}{4} \left(\frac{m \exp(\gamma t_1)}{\hbar} y_{11}^2\right)\right] \times \exp\left[\frac{1}{2} \langle \omega_1, i\omega_1 \rangle - \frac{1}{2} \langle \omega_1, i\hbar^{-1} S_1''(y_0) \omega_1 \rangle\right]. \quad (29)$$

Introducing the Donskers delta function and taking the correspondence between the Lebesgue and Gaussian measure, one can write the Feynman path integral in the context of the Hida-Streit formulation as follows

$$K(0, y_1; 0, t_1) = \int D[x] \exp\left(\frac{iS}{\hbar}\right) = \int_{-\infty}^{+\infty} \sqrt{\frac{m \exp(\gamma t_1)}{\hbar}} \exp\left[\frac{1}{2} \langle \omega_1, (i + 1)\omega_1 \rangle\right] \exp\left[-\frac{1}{2} \langle \omega_1, i\hbar^{-1} S_1''(y_0) \omega_1 \rangle\right] \times \exp\left[-\frac{i\gamma}{4} \left(\frac{m \exp(\gamma t_1)}{\hbar} y_{11}^2\right)\right] \delta\left(B_1 - \sqrt{\frac{m \exp(\gamma t_1)}{\hbar}} y_{11}\right) d_\mu(\omega_1). \quad (30)$$

Taking the T -transform of equation (30) solves the quantum mechanical propagator of a particle in a damped harmonic oscillator potential. Following the calculation in (Bernido et.al, 2012; Baybayon et.al, 2019; Cubero et.al, 2010), the quantum mechanical propagator of a damped harmonic oscillator is given by

$$= \sqrt{\frac{m \Omega_{1\gamma} \exp\left(\frac{\gamma t_1}{2}\right)}{2\pi i \hbar \sin \Omega_{1\gamma t_1}}} \exp\left[\frac{im\Omega_{1\gamma}}{2\hbar \tan \Omega_{1\gamma t_1}} y_{11}^2 \exp(\gamma t_1)\right] \exp\left[-\frac{im\gamma}{4\hbar} y_{11}^2 \exp(\gamma t_1)\right] \quad (31)$$

Equation (31) agrees with the result of (Cubero et.al, 2010; Pepore, et.al, 2006; Grosche et.al, 1998).

The propagator of a damped coupled harmonic oscillator

In this section, the full form of our system's propagator which is the damped coupled harmonic oscillator will be presented. Since the Lagrangian of the damped coupled harmonic oscillator is separable into equation (9) and equation (10), the full propagator of the system can be solved by taking the product of the individual propagator of the decoupled oscillator (Pabalay et.al, 2007; Butanas et.al, 2016). Hence,

$$K = K_1 K_2 \quad (32)$$

where K_2 is of the same form as in equation (31) but with subscript 2 instead of 1. Thus, the propagator is equal to

$$K = \frac{m}{2\pi i \hbar} \sqrt{\frac{\Omega_{1\gamma} \Omega_{2\gamma} \exp\left(\frac{\gamma t_1}{2}\right)}{\sin \Omega_{1\gamma} t_1 \sin \Omega_{2\gamma} t_2}} \exp\left[\left(\frac{im\Omega_{1\gamma}}{2\hbar \tan \Omega_{1\gamma} t_1} - \frac{im\gamma}{4\hbar}\right) y_1^2 \exp(\gamma t_1)\right] \times \exp\left[\left(\frac{im\Omega_{2\gamma}}{2\hbar \tan \Omega_{2\gamma} t_1} - \frac{im\gamma}{4\hbar}\right) y_2^2 \exp(\gamma t_1)\right]. \quad (33)$$

Reversing the decoupling process from the variable $y_1 \rightarrow x_1$ in equation (2), the full propagator of the damped coupled harmonic oscillator is given by

$$\sqrt{\frac{\Omega_{1\gamma} \Omega_{2\gamma} \exp\left(\frac{\gamma t_1}{2}\right)}{\sin \Omega_{1\gamma} t_1 \sin \Omega_{2\gamma} t_2}} \exp\left[\left(\frac{im\Omega_{1\gamma}}{4\hbar \tan \Omega_{1\gamma} t_1} - \frac{im\gamma}{8\hbar}\right) (x_1 - x_2)^2\right] \times \exp\left[\left(\frac{im\Omega_{2\gamma}}{4\hbar \tan \Omega_{2\gamma} t_1} - \frac{im\gamma}{8\hbar}\right) (x_1 + x_2)^2 \exp(\gamma t_1)\right] \quad (34)$$

Now, turning off the damping factor γ , equation (34) reduces to the propagator of a coupled harmonic oscillator given by (Pabalay et.al, 2007)

$$K_{HO} = \frac{m}{2\pi i \hbar} \sqrt{\frac{\Omega_1 \Omega_2}{\sin \Omega_1 t_1 \sin \Omega_2 t_2}} \exp\left[\left(\frac{im\Omega_1}{4\hbar \tan \Omega_1 t_1}\right) (x_1 - x_2)^2\right] \times \exp\left[\left(\frac{im\Omega_2}{4\hbar \tan \Omega_2 t_1}\right) (x_1 + x_2)^2\right]. \quad (35)$$

THE TIME-DEPENDENT WAVEFUNCTION

In this section, the method in calculating the quantum wave function of a damped coupled harmonic oscillator will be presented. The propagator can be represented in terms of the time-dependent wavefunction, given by

$$K(0, x; t_1) = \sum_{n_1, n_2 \in \mathbb{N}} \Psi_{n_1 n_2}^*(0, 0) \Psi_{n_1 n_2}(x_1, x_2; t_1). \quad (36)$$

Now, defining the following quantities

$$\sin \Omega_{l\gamma} t_1 = \frac{1}{2i} \left(\frac{1 - z_l^2}{z} \right) \quad (37)$$

$$\cos \Omega_{l\gamma} t_1 = \frac{1}{2} \left(\frac{1 + z_l^2}{z} \right) \quad (38)$$

$$z_l = \exp(-i\Omega_{l\gamma} t_1) \quad (39)$$

where $l=1$ and 2. Using these definitions, one can rewrite equation (34) as

$$K_{DCHO} = \frac{m}{\pi \hbar} \exp\left(\frac{\gamma t_1}{4}\right) (\Omega_{1\gamma} \Omega_{2\gamma} z_1 z_2)^{\frac{1}{2}} (1 - z_1^2)^{-\frac{1}{2}} (1 - z_2^2)^{-\frac{1}{2}} \times \exp\left[-\frac{m\Omega_{1\gamma}}{4\hbar} (x_1 - x_2)^2 \exp(\gamma t_1) \left(\frac{1 + z_1^2}{1 - z_1^2}\right)\right] \times \exp\left[-\frac{m\Omega_{2\gamma}}{4\hbar} (x_1 + x_2)^2 \exp(\gamma t_1) \left(\frac{1 + z_2^2}{1 - z_2^2}\right)\right] \times \exp\left[-\frac{im\gamma}{8\hbar} (x_1 - x_2)^2 \exp(\gamma t_1)\right] \times \exp\left[-\frac{im\gamma}{8\hbar} (x_1 + x_2)^2 \exp(\gamma t_1)\right]. \quad (40)$$

Using Mehler's formula given by

$$(1 - z^2)^{-\frac{1}{2}} \exp\left[\frac{4xyz - (x^2 + y^2)(1 + z^2)}{2(1 - z^2)}\right] = \exp\left(-\frac{x^2 + y^2}{2}\right) \sum_{n=0}^{\infty} \frac{\left(\frac{z}{2}\right)^n}{n!} H_n(x) H_n(y), \quad (41)$$

and with

$$x = 0 \quad (42)$$

$$y_l = \left(\frac{m\Omega_{l\gamma}}{2\hbar}\right)^{\frac{1}{2}} (x_1 - x_2) \exp\left(\frac{\gamma t_1}{2}\right), \quad (43)$$

one can see that

$$(1 - z_l^2)^{-\frac{1}{2}} \exp\left[-\frac{y^2}{2} \left(\frac{1 + z_l^2}{1 - z_l^2}\right)\right] = (1 - z_l^2)^{-\frac{1}{2}} \exp\left[-\frac{m\Omega_{l\gamma}}{4\hbar} (x_1 - x_2)^2 \exp(\gamma t_1) \left(\frac{1 + z_l^2}{1 - z_l^2}\right)\right] = \sum_{n_l=0}^{\infty} \frac{\left(\frac{z_l}{2}\right)^{n_l}}{n_l!} H_{n_l} \left(\left(\frac{m\Omega_{l\gamma}}{2\hbar}\right)^{\frac{1}{2}} (x_1 - x_2) \exp\left(\frac{\gamma t_1}{2}\right) \right) \times \exp\left[-\frac{m\Omega_{l\gamma}}{4\hbar} (x_1 - x_2)^2 \exp(\gamma t_1)\right]. \quad (44)$$

for $l=1$ and 2. Incorporating equations (37), (38), (39), and (44) to equation (40), yields the following equation given by

$$K_{DCHO} = \exp\left(\frac{\gamma t_1}{4}\right) \exp\left[-\frac{im\gamma \exp(\gamma t_1)}{8\hbar} ((x_1 - x_2)^2 + (x_1 + x_2)^2)\right] \times \exp\left[-\frac{m \exp(\gamma t_1)}{4\hbar} (\Omega_{1\gamma} (x_1 - x_2)^2 + \Omega_{2\gamma} (x_1 + x_2)^2)\right] \sum_{n_1, n_2 \in \mathbb{N}} \frac{m(\Omega_{1\gamma} \Omega_{2\gamma})^{\frac{1}{2}}}{2^{n_1+n_2} \pi \hbar n_1! n_2!} \exp\left[-it_1 \left(\frac{\Omega_{1\gamma} + \Omega_{2\gamma}}{2} + \Omega_{1\gamma} n_1 + \Omega_{2\gamma} n_2\right)\right] \times H_{n_1} \left(\sqrt{\frac{m\Omega_{1\gamma}}{2\hbar}} (x_1 - x_2) \exp\left(\frac{\gamma t_1}{2}\right) \right) \times H_{n_2} \left(\sqrt{\frac{m\Omega_{2\gamma}}{2\hbar}} (x_1 + x_2) \exp\left(\frac{\gamma t_1}{2}\right) \right), \quad (45)$$

where H_n is the Hermite polynomial given by

$$H_n(x) = (-1)^n e^{x^2} \frac{d^n}{dx^n} e^{-x^2}. \quad (46)$$

Some of the first few Hermite polynomials are

$$H_0(x) = 1 \quad (47)$$

$$H_1(x) = 2x \quad (48)$$

$$H_2(x) = 4x^2 - 2 \quad (49)$$

$$H_3(x) = 8x^3 - 12x \quad (50)$$

Finally, comparing equation (45) to equation (36), one can extract the time-dependent wave function of the damped coupled harmonic oscillator given by

$$\begin{aligned} \Psi_{n_1, n_2} = & \left(\frac{m(\Omega_{1Y}\Omega_{2Y})^{\frac{1}{2}}}{2^{n_1+n_2}\pi\hbar n_1! n_2!} \right)^{\frac{1}{2}} \exp\left(\frac{\gamma t_1}{4}\right) \exp\left[-\frac{im\gamma \exp(\gamma t_1)}{8\hbar}((x_1-x_2)^2 + (x_1+x_2)^2)\right] \\ & \times \exp\left[-\frac{m \exp(\gamma t_1)}{4\hbar}(\Omega_{1Y}(x_1-x_2)^2 + \Omega_{2Y}(x_1+x_2)^2)\right] \\ & \times \exp\left[-it_1\left(\frac{\Omega_{1Y} + \Omega_{2Y}}{2} + \Omega_{1Y}n_1 + \Omega_{2Y}n_2\right)\right] \\ & \times H_{n_1}\left(\sqrt{\frac{m\Omega_{1Y}}{2\hbar}}(x_1-x_2) \exp\left(\frac{\gamma t_1}{2}\right)\right) H_{n_2}\left(\sqrt{\frac{m\Omega_{2Y}}{2\hbar}}(x_1+x_2) \exp\left(\frac{\gamma t_1}{2}\right)\right). \end{aligned} \quad (51)$$

The ground state wave function

In this section, the ground state wave function of a damped coupled harmonic oscillator is presented. This ground state wave function corresponds to the lowest energy state of the system. We set $n_1=n_2=0$, then equation (51) becomes

$$\begin{aligned} \Psi_{0,0} = & \left(\frac{m(\Omega_{1Y}\Omega_{2Y})^{\frac{1}{2}}}{\pi\hbar} \right)^{\frac{1}{2}} \exp\left(\frac{\gamma t_1}{4}\right) \exp\left[-\frac{m \exp(\gamma t_1)}{4\hbar}(\Omega_{1Y}(x_1-x_2)^2 + \Omega_{2Y}(x_1+x_2)^2)\right] \\ & \times \exp\left[-\frac{im\gamma \exp(\gamma t_1)}{8\hbar}((x_1-x_2)^2 + (x_1+x_2)^2)\right] \exp\left[-it_1\left(\frac{\Omega_{1Y} + \Omega_{2Y}}{2}\right)\right]. \end{aligned} \quad (52)$$

One can write equation (52) in terms of its real and imaginary parts using the identity

$$e^{i\theta} = \cos \theta + i \sin \theta.$$

Then, it can be written as

$$\Psi_{0,0} = \text{Re}[\Psi_{0,0}] + i \text{Im}[\Psi_{0,0}]$$

where

$$\begin{aligned} \text{Re}[\Psi_{0,0}] = & \left(\frac{m(\Omega_{1Y}\Omega_{2Y})^{\frac{1}{2}}}{\pi\hbar} \right)^{\frac{1}{2}} \exp\left(\frac{\gamma t_1}{4}\right) \exp\left[-\frac{m \exp(\gamma t_1)}{4\hbar}(\Omega_{1Y}(x_1-x_2)^2 + \Omega_{2Y}(x_1+x_2)^2)\right] \\ & \times \cos\left[\frac{\Omega_{1Y} + \Omega_{2Y}}{2}t_1 + \frac{m\gamma \exp(\gamma t_1)}{8\hbar}((x_1-x_2)^2 + (x_1+x_2)^2)\right] \end{aligned} \quad (53)$$

and

$$\begin{aligned} \text{Im}[\Psi_{0,0}] = & \left(\frac{m(\Omega_{1Y}\Omega_{2Y})^{\frac{1}{2}}}{\pi\hbar} \right)^{\frac{1}{2}} \exp\left(\frac{\gamma t_1}{4}\right) \exp\left[-\frac{m \exp(\gamma t_1)}{4\hbar}(\Omega_{1Y}(x_1-x_2)^2 + \Omega_{2Y}(x_1+x_2)^2)\right] \\ & \times -\sin\left[\frac{\Omega_{1Y} + \Omega_{2Y}}{2}t_1 + \frac{m\gamma \exp(\gamma t_1)}{8\hbar}((x_1-x_2)^2 + (x_1+x_2)^2)\right], \end{aligned} \quad (54)$$

respectively. Figure 1 shows the graph of the value of the ground state wavefunction of a damped coupled harmonic oscillator at a point where $x_1=0$ and $x_2=1$. The authors vary the damping coefficient, γ , from 0 to 0.9 and set the values of frequencies, $\Omega_1=0.75$ and $\Omega_2=0.50$. It shows in the figure that for a system with damping, the amplitude of the wavefunction decreases as you increase the time. Damped coupled harmonic oscillator is a dissipative system that loses energy from time to time. The decrease of the amplitude is due to the energy lost by the system. Also as you increase the value of the damping coefficient γ , the rate of the decrease of the amplitude is increasing. The larger the value of the damping, the shorter the time needed to stop the motion of the object.

CONCLUSION

To conclude, the authors have shown the white-noise analysis as an effective tool in evaluating the propagators of quantum systems. Here, the authors studied the quantum dynamics of a damped coupled harmonic oscillator wherein friction is added to a coupled harmonic oscillator system. The authors also derived the time-independent wave function directly from the obtained propagator. The time-dependence of the wavefunction arises from the fact that our system is dissipative and it implies that the mechanical energy is not conserved. Lastly, this study shows the flexibility of the Hida-Streit approach in the field of complex systems.

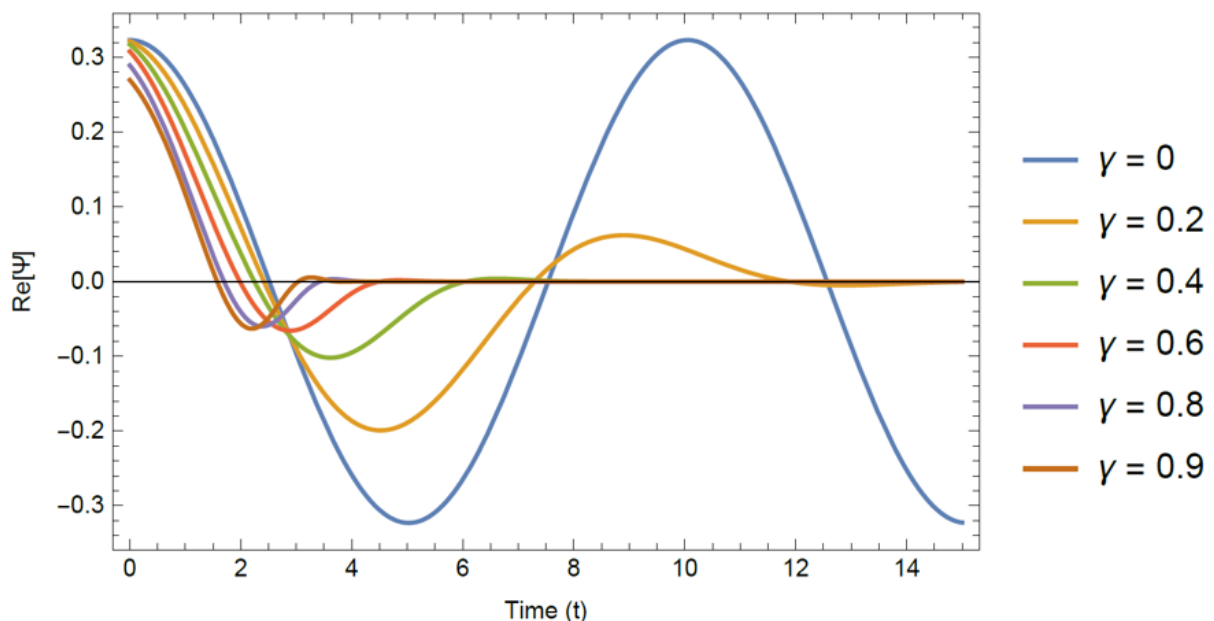


Figure 1. The 2D plot of the ground state wavefunction

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