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Bridging the Last Mile through Shared Mobility towards an Integrated Mobility System

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ABSTRACT

As the population of urban centers grows, there is a significant challenge of adjusting the transportation needs of urban mobility, as well as pursuing environmental protection strategies and ensuring social inclusion. The major bottleneck of urban mobility includes the constant traffic congestion in major cities because of excessive use of private cars. Developing an accessible, attractive transportation system that caters to people's individual mobility needs and preferences is one possible solution to these problems. It is important to have a coordinated system connecting the various modes of transportation so that people's homes and destinations can be reached with ease. The first and last miles of commuters, which are the weakest linkages in the transportation network, should be developed first before the system can be integrated. Shared mobility which involves using a shared vehicle (car, bike, scooter, etc.) often serves as a first or last mile connection to other modes of transportation such as public transit. Understanding the factors that influence the adoption of shared mobility services is crucial to ensuring that they become a significant component of the urban mobility system. This paper provides an overview of existing and emerging last mile solutions, particularly in the concept of shared mobility. The objective of this study is to add and enrich knowledge in the area of shared mobility in bridging the last mile toward an integrated mobility system.

Keywords: Last Mile, First Mile, Shared Mobility, Urban Mobility, Transportation

INTRODUCTION

Mobility challenges are one of the most serious concerns in urban areas which have resulted in a deteriorated quality of life. Cities face a growing number of motor vehicles leading to air pollution, noise from traffic, environmental degradation, scarcity of green spaces, and a rise in overall carbon emissions. Transportation demand and distance traveled have increased as continuously grow and travel patterns have changed. In India, for instance, continuous urbanization entails rapid urban modernization and a consistent increase in travel demand. As a result, there is more traffic, more consumption of fuel, and more inequality in terms of access to transportation. Moreover, the growth of population in urban areas and vast urban expansions have exacerbated this challenge. Sixty percent (60%) of the world's population will reside in urban areas by 2030. With this, the expansion of the transportation network proves to be a critical transportation objective. People regularly move from one place to another which necessitates a reliable infrastructure that can accommodate multiple mobility options. Urban development must take into account the emerging urban networks that connect residents to the rest of the city. However, expanding and improving transportation networks is a challenging endeavor especially in developing cities and their towns. This is identified as a huge gap in the transportation network. Different companies and startups attempted to address this gap with new technologies and solutions. The challenge for mobility stakeholders is to create a

seamless mobility offering that can effectively respond to rising mobility needs while also having a significant impact on traffic congestion, environmental sustainability, and livability in our cities. To do this, it is imperative to reduce the frequency of motorized trips, increase the share of nonmotorized trips (such as walking and cycling), and reduce motorized trip distances. The creation of an easily accessible, attractive, and sustainable transportation system that satisfies people's needs, preferences, and desires for mobility is one possible solution to transportation-related "urban diseases." Moreover, an integrated system connecting the different modes of transportation is likewise significant that must easily connect people's homes with their destinations. Public transportation must be the foundation of any integrated mobility and sustainable transport system. In general, an integrated system promotes safe, effective, dependable, and practical movement of people and goods known as an integrated mobility system. All users—pedestrians, bikers, drivers, professional drivers, transit patrons, etc.—benefit from an integrated mobility system.

Mobility or transport integration is not a new concept although there is no universally agreed-upon definition of an integrated transportation system. Past

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and recent studies have explored this concept as well as strategies to achieve sustainability in transportation. For instance, the study of Potter and Skinner (2000) articulates this concept serves as a guiding principle in developing several transport policies in different countries. The study focuses on the integration of private and public modes of transportation that will lead to a higher level of sustainability. Brand et al. (2017) developed a framework to evaluate multi-modal bus network integration and discusses factors and system variables that influence integration. Additionally, Bruzzone et al. (2021) suggested important performance measures to assess possible improvements in the operational, environmental, and social performance of integrated systems as compared to the existing transportation systems. The ongoing challenge of enhancing public transportation (PT) networks, particularly the first and last mile trips, must be taken into consideration if urban areas are to become more livable and sustainable. However, transitioning to more environmentally sustainable transportation has been challenging, especially in suburban regions. There are a variety of constraints and limitations in traveling sustainably for individuals in society. These roadblocks include a lack of available modes of transportation and routes, public transportation costs, wider cultural norms, and the difficulty of combining long-distance intercity travel with short-distance urban travel, among others. Other problems include lack of sidewalk networks, badly maintained sidewalks, missing curb ramps, lack of crosswalks and crossing lights, inaccessible bus stops, and lack of amenities such as shelters, seats, and lighting at bus stops. Combining these is the 'last mile' problem. The first mile/last mile (FMLM) trips are the biggest challenge for commuters when using public transit.

The first mile is defined as the first leg or trip of a commuter, from starting point to a mass transit station. The last mile, on the other hand, is the last leg of a journey or the distance between a mass transit station and the final destination. The last mile is also defined as the potential distance between a traveler's primary access point for transportation (bus stop, subway station) and their house, workplace, etc. The trips from work to home and vice versa are taken into account. These trips are crucial in the transit planning process because the effectiveness of transit is contingent on adequate access to and from transit stops. Problems in the first and last mile can be a limitation to increasing public transportation usage. For instance, people may not choose to walk or opt to use a direct travel mode such as a personal vehicle because of the distance between transit stations and their origin/destinations. This makes urban areas more inaccessible. The last mile for many cities in Asia and the Pacific is served either by a strenuous walk or by three-wheelers, generally known as rickshaws. In developing countries, the last mile problem is more acute because of the poor connection between public transportation with other modes of mobility. Moreover, pedestrian and bike infrastructure are lacking in these countries. FMLM issues such as these that go unaddressed contribute to unsafe travel situations, which can increase anxiety and reduce mobility. The quality of the first and last mile journey has an impact on the passenger's overall experience in public transportation. Even with high-quality transit service provided, the inability to transport passengers from point of origin to destination discourages

transit use. Hence, a commuter's first and last miles should be developed first before the integrated system can be established. It is important to make them more attractive to travelers to encourage the use of public transportation being an important part of a person's journey.

Transit agencies and advocates in cities across the world are attempting to bridge the gaps in the first and last mile toward improving public transportation services, and promoting personal mobility thereby increasing its use and reducing car dependence. Citizens will travel to and from public transportation by car or motorcycle until there is a safe, secure, comfortable, and affordable way to do so. Moreover, researchers and planners of public transportation have recently paid close attention to the coordination of bicycle and transit modes. For instance, the study by Flamm and Rivasplata (2014) surveyed cyclist-transit users (CTU) in the American cities of Philadelphia and San Francisco to define their characteristics and assess their travel patterns and behavior. In European cities, commuting by bicycle has shown to be a viable means of transportation to and from their workplace. Cycling is a first, last, and only mile alternative that can be used to complement train travel that is extremely efficient. While some cities in developed countries have a well-established infrastructure, others, usually in developing countries lack this. Hence, there is less mobility from network to network as well as network congestion. For instance, developing countries in the Latin region such as Bogota, São Paulo, Rio, and Buenos Aires have the worst traffic. Therefore, there is an overlap of multiple and sophisticated systems in these ecosystems to provide people with mobility alternatives.

Shared mobility is the short-term use of shared vehicles, bicycles, and other modes of transportation "as needed". It is one of the solutions to the first and last mile problems that help commuters get to and from a location in a safe, convenient and efficient way. It is often connected to other modes such as public transportation. Shared mobility services include carsharing, bike-sharing, scooter sharing, on-demand ride services (e.g. ride-hailing/ ride-sourcing) and ridesharing (i.e. carpooling or vanpooling microtransit), and courier network services (CNS). Shared mobility is an emerging trend that can help reduce traffic congestion, reduce carbon emissions, providing an environmentally friendly mode of transportation. Moreover, it is more economical compared to the use of individual private vehicles.

Travel behavior has changed as a result of socio-demographic trends and recent economic development patterns, which requires a more flexible and accessible public transportation option. Important information to encourage more sustainable travel behavior can come from understanding different perceptions and attitudes of commuters relating to their journeys in the last mile. For instance, poor last mile design may be preventing people from riding public transportation, walking, or cycling. This paper provides a review of the existing and emerging last mile solutions specifically in the context of shared mobility. Moreover, a synthesis of the factors influencing the adoption of these services in different countries will be presented. The paper aims to enrich and strengthen knowledge in bridging the last mile through shared mobility toward an integrated mobility system.

Shared Mobility Services

The mobility industry is undergoing a significant shift in order to improve efficiency, and this evolution has significant economic and societal implications. However, developments in mobility also contribute to global warming and health concerns due to pollution, traffic congestion, and social inequity. With this, more research has been focused on addressing these issues through novel mobility solutions and alternatives, a shift in societal behavior, and autonomous vehicles, among others (Turienzo et al. 2022). These services are essentially different and more advanced than traditional modes of transportation (Calderon and Miller 2020). In most cities, traditional forms of mobility include walking, cycling, and taking a bus, subway, or taxi among others (Hussin et al. 2021). Traditional public transportation, which uses fixed routes and schedules, is designed to serve densely populated urban areas with concentrated travel patterns. Over the last few years, rapid advancements in automated vehicle technology have opened the possibility of new modes of transportation. The self-driving automobile, which was once a futuristic concept but is now being developed in many forms, provides many safety, societal, and infrastructure-related benefits (Zellner et al. 2016). The emergence of new forms of transportation has a noticeable impact on the development and sustainability of urban mobility. New mobility services have emerged providing a range of options for a variety of personal trips. Instead of having only one option, the new modes allow people to select the most appropriate and available mode for them (Hussin et al. 2021). Combined with a well-developed public transportation system, these mobility services enable people to get to work, run errands, and get to places without the use of a personal vehicle (Shared-Use Mobility Center, n.d).

New emerging trends are happening in the sharing economy that shapes the modern world's cultural, economic, and social landscape. The sharing economy has already made an impact on urban mobility, with more city dwellers opting for a car and ridesharing instead of owning a car (Ohnemus and Perl, 2016). In recent years, there have been various definitions of the sharing economy, but no single definition has been widely recognized by researchers and practitioners in the field (Novikova, 2017; Botsman, 2013). Nevertheless, the concept of sharing economy has been used in a variety of contexts including production, consumption, finance, and education among others. With so many variations of the sharing economy concept growing in a variety of fields, the area of shared mobility has emerged as a forerunner of these developments. Shared mobility is the shared use of transportation services and resources, such as a car, bicycle, or other modes that enable users to quickly access different modes of transportation as needed (Novikova, 2017; Shaheen & Chan, 2016). It includes automobile-based modes (carsharing, rides on-demand, and micro transit), micro-mobility (bike sharing, scooter sharing), commute-based modes or ridesharing (carpooling and vanpooling), and e-Hail (taxis). Shared mobility can support cities in reducing the number of private vehicles on the road, conserving energy in the transportation sector, and ensuring the success of the energy transition (Burghard and Scherrer 2022). It has grown in popularity in major cities throughout the world

as an innovative transportation mode that improves urban mobility. Aside from this, it is also considered a feasible solution for connecting the first-and-last mile trips with public transportation. It has the potential to expand the reach of public transportation crucial in bridging the gap in the existing transportation network. Moreover, the utilization of shared mobility encourages multimodality for first and last mile trips.

Shared Mobility as Last Mile Solutions

New development of framework and terminologies are required to address the first and last mile connectivity to public transit. Concepts such as Mobility as a Service (MaaS), Mobility on-Demand (MoD) Flexible Transportation Systems (FTS), among others have been developed by the academic communities (Calderon and Miller 2020). For instance, developed countries have conducted studies on MaaS and found that it has the potential to influence the mobility of people toward an efficient and sustainable transport system for the future (Hasselwander and Bigotte 2022). This system organizes, distributes, and integrates both private and public transportation alternatives through the use of intelligent digital technologies. Integration takes place in various physical modes of travel such as public transit, carsharing, ride-hailing, bike-sharing, etc. This is possible by bringing together the services that are often controlled individually, such as scheduling, paying, and booking tickets into a single user interface. At the local and national levels, MaaS aspires to bridge the gap between public and private transportation carriers, shifting away from personally owned modes of transportation toward providing mobility as a service. The primary idea behind MaaS is integrated and seamless mobility providing travelers with mobility options tailored to their specific travel requirements (Kamargianni et al. 2016; Esztergár-Kiss, 2020; Alyavina et al. 2020;). It is a practical mobility option that most likely will be crucial in the reform of urban transportation in the future.

The same concept of mobility is also at the center of the study of Ohnemus and Perl (2016) but their focus is on shared mobility for the last/first mile in suburban and low-density areas where traditional public transport services fail to provide high levels of service. They point out that future mobility in these areas depends much on the extent to which deployment of autonomous vehicle technology is shared or not. Shared autonomous vehicles (SAVs) would keep door-to-door service while eliminating the cost and congestion associated with single-occupant vehicles. Integrating SAVs with public transportation systems might significantly boost synergies between vehicles and transit because of their ability to connect the first and last mile of trips in areas of low density. As SAVs preserve accessibility to auto-dependent sites during times of climate and energy disruption, low-density land use could be protected against climate and oil vulnerability. Some public transit firms in New Cairo, Egypt, are using information and communication technology (ICT) in their operations. The modal share of New Cairo demonstrated the efficiency of ICT integration. The second most popular mode of transportation is ride-hailing apps, which rely heavily on this technology to provide their services. Although they are new to Cairo's mobility system, peak-

only mass transit services and buses like Mwaslat Misr may compete for ridership (Hussin et al, 2021). Moreover, other solutions include implementing shared mobility services like shared bicycles or scooters which can be electric or non-electric. As a first and last mile mode option, 25.9% of poll respondents in New Cairo chose this mobility service. In some circumstances, ride-hailing is also seen as a solution to the first and last mile problem to promote the use of public transportation instead of using private cars. In the Netherlands, the biking infrastructure is already well-developed, hence people have been using this option. In terms of mobility of people, having a last mile solution is a significant factor for people to choose a more sustainable mode of transportation instead of just using a car when traveling.

Last mile connectivity is critical for increased integration and accessibility of public transportation networks to the public. New mobility services have emerged such as shared mobility which is characterized by innovative technologies. The potential integration of these with mass transit allows for bridging the first and last mile gap. For instance, using the opening of a metro station in Bangalore as a case study, Kanuri et al. (2019) found that there is a first and last mile modal shift from the usage of personal cars to the use of new mobility solutions. Moreover, the study revealed that sustainable and seamless urban mobility requires public-private collaboration. This can be done by supporting regulatory frameworks and increasing multimodal integration of transportation. In recent years, the Asian Development Bank (ADB) has brought together some of the world's leading experts on the pedal- and electric-powered vehicles to develop a modern, efficient, and low-cost three-wheeler vehicle that may serve the last mile of trips in Asia-Pacific cities. The team created a concept for an "e-pedicab," a three-wheeler with a pedal and an electric motor. The e-pedicab was first tested in Lumbini, Nepal which aims to attract tourism in a sustainable way that respects local traditions while encouraging the use of low-carbon economic development. E-pedicabs have proven to be an effective way to connect the town with the temple district, which attracts an estimated 1.2 million visitors each year. The ADB Lumbini project also includes

an electric bus fleet that will connect the city to a planned new international airport. Other cities and ADB projects have expressed an interest as well. Other ADB-financed BRT projects considered e-pedicabs and bicycle-sharing systems as integrated solutions for last mile connection. Passengers with disabilities will be able to use the updated design.

One of the key solutions in terms of mobility of people in the last mile for urban travel is sharing vehicles, the development of infrastructure for walking and biking, bike/scooter/electric vehicle parking, and a good public transportation system. Infrastructure development encourages active transportation, such as walking and cycling, as a solution to the first and last mile problem. In New Cairo, this is the most chosen mode by 66% of the total survey respondents according to the findings of Hussin et al. (2020). For private-car users, shared mobility services specifically micro-mobility are considered another solution. Because of the financial and environmental benefits, shared mobility is becoming increasingly popular. Hence, it is crucial to understand its integration into urban transportation networks and how to improve it from a social, environmental, and economic standpoint (Machado et al. 2018). Several advantages come from incorporating shared mobility into current transportation infrastructures. The use and ownership of private vehicles have been reduced, which would help to minimize parking congestion and improve road traffic conditions. Another is that it is more environmental-friendly wherein it contributes to a decrease in carbon emissions, fuel use, and transportation costs. With this, policies and measures are crucial to make sharing services more attractive, accessible, and viable for system users.

Shaheen and Chan (2016) categorize shared mobility services according to what is shared: a vehicle, a passenger ride, or a delivery ride. The sharing of a vehicle and sharing of a passenger ride is commonly linked to public transit. Hence, these will be the focus of this study. Sharing a vehicle includes carsharing and bike-sharing. A recent variation of this model is scooter sharing which is included in the study of Shaheen et al (2016). The same study indicated that the sharing of a ride is enabled by

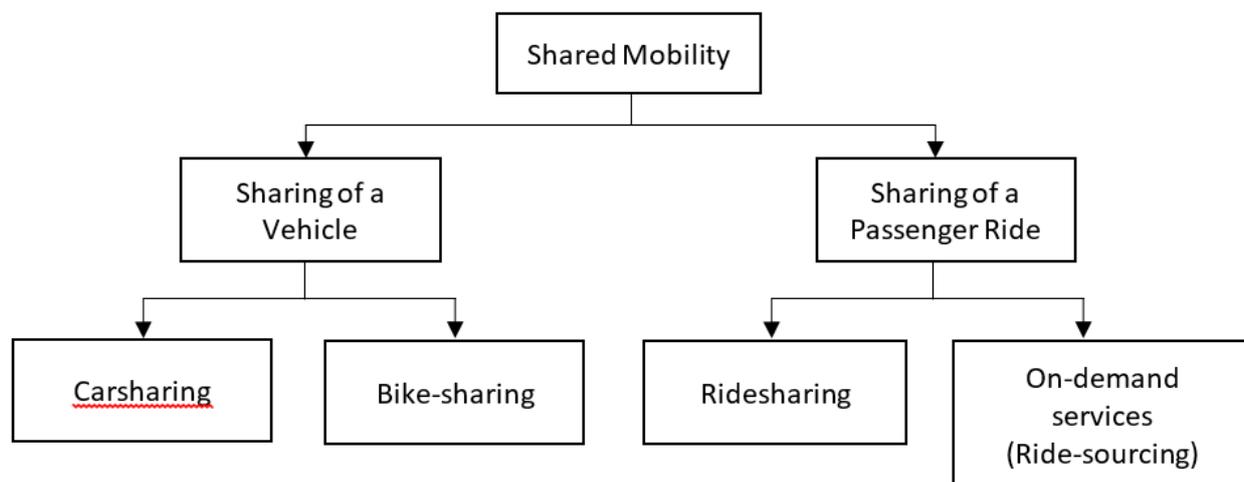


Figure 1. Types of Shared Mobility directly linked to Public Transit

ridesharing, on-demand ride services such as ride-sourcing, ridesplitting, e-hail services, and microtransit. However, this paper will only tackle ridesharing and ride-sourcing under this model.

Sharing a Vehicle

Vehicle sharing services such as bike-share, carshare, and e-scooters, allow for an increase in accessibility and mobility for underprivileged populations (Dill and McNeil, 2021). Using a vehicle sharing system, users can rent a vehicle for a short period. Typically, the length and duration of a trip dictate its cost. The most popular applications of this service include bike-sharing, electric car-sharing, and carsharing systems (Ataç et al. 2021). The establishment of a vehicle sharing system allows keeping the benefits of owning a car while reducing costs. Carsharing is introduced as one of the earliest forms of vehicle sharing system. It has become common, especially in Europe. In 1948, a cooperative in Zurich, Switzerland called "Sefage" (Selbstfahrgemeinschaft) had been one of the earliest users of a carsharing system. This is driven by economics wherein people who cannot afford to buy cars resort to sharing one (Shaheen et al. 1998). Since then, the industry continues to grow over the years.

Carsharing models include two-way/roundtrip carsharing, one-way carsharing, and personal vehicle sharing. Roundtrip carsharing includes giving members hourly access to a shared service fleet. These vehicles must be picked up and dropped off at the same place. On the other hand, one-way carsharing, commonly referred to as free-floating or point-to-point carsharing allows customers

to borrow and return vehicles at different locations inside a designated service area. Lastly, personal vehicle sharing allows customers to have short-term access to private vehicles which differs from operator-owned vehicles. Each of these models provides first and last mile connections to other means of transportation (Shaheen and Chan, 2016). A recent variable of the vehicle-sharing model is scooter sharing. It provides roundtrip and one-way short-term vehicle sharing services that come with insurance and helmets. Two scooter-sharing programs existed in Europe in 2015 (Shaheen and Chan, 2016). In 2018, an estimated 38.5 million rides were provided by e-scooters in numerous cities, compared to the 52 million rides on shared bikes. However, there is limited data available on the use of e-scooter (Dill and McNeil, 2021). Lastly, bike-sharing involves the use of bikes for a limited period of time as a means of public transportation. Although the concept has been around since the 1960s, more than 800 cities now offer bikeshare, up from a mere handful in the late 1990s (Fishman, 2016). In general, the main types of this system include public bike-sharing, closed campus bike-sharing, and peer-to-peer (P2P) bike-sharing. Public bike-sharing programs originated in Europe and have become increasingly popular over the last decade. This system becomes more mainstream and is open to the general public and acts as a means of transportation (Parkes et al. 2013). Closed-campus bike-sharing programs are increasingly being implemented at college and corporate campuses; these programs are solely accessible to the specific campus population they serve. Bike owners can use P2P bike-sharing services in urban areas to rent out their unused bicycles to other people. These services are growing as a result of businesses like Spinlister and Bitlock

Table 1. Factors influencing the adoption of a vehicle sharing system

Service	Study	Place	Influential Factors
Carsharing	Luca and Pace (2014)	Southern Italy	Level of service and utility of available transportation; weekly trip frequency, travel distance; familiarity; bus riders
	Becker et al. (2017)	Basel, Switzerland	Greater receptivity to innovative services and societal advancements
	Safdar et al. (2022)	Pakistan	Travel time, cost, waiting time, privacy
	Burghard and Scherrer (2022)	Germany	Psychological factors (perceived compatibility with daily life)
Bike-sharing	Li et al. (2018)	Jiangsu, China	Education, the cost of daily transit, the ease of pick-up, and parking, health contribution
	Bachand-Marleau (2012)	Montreal, Quebec, Canada	Distance of home to docking stations
	Shen et al. (2018)	Singapore	Fleet size, built environment, weather conditions, cycling infrastructure
	Guo et al. (2017)	Ningbo, China	Ownership of household bicycles and e-bikes, trip type, travel distance, location of bike-sharing stations, and user perceptions

(Shaheen and Chan, 2016).

These vehicle sharing systems are considered a sustainable transportation alternative, and thus, will likely receive more attention as they continue to expand through technological innovations. Transit agencies and researchers looked more closely at the integration of these systems with transit modes. Carsharing, for instance, has a direct impact on most aspects of urban and transportation planning in terms of modal choice, travel patterns, and vehicle occupancy, among others (Cohen and Shaheen, 2016). Moreover, several studies investigated the factors that affect the adoption of people in using shared mobility, particularly the sharing of a vehicle as a mode of transportation in the last mile. The table below shows some of the influential factors identified in some literatures on carsharing and bike-sharing.

Carsharing

Over the past two decades, carsharing has grown to be one of the most widely used services for facilitating smart mobility solutions, which has helped to minimize traffic and air pollution (Safdar et al. 2022). It is a new type of shared mobility that enables users to access vehicles for a limited amount of time when needed (Degirmenci and Breitner, 2014). With carsharing, people can enjoy the advantages of having a private vehicle without the cost and responsibility of owning one such as the cost of fuel, maintenance, and insurance (Shaheen et al. 1998; Shaheen and Chan, 2019).

Since it was first introduced in the late 1940s, carsharing has existed as a specialized service that has failed to attract a large share of the urban population. This is because carsharing programs are considered to be inflexible and that car ownership has been valued in society. However, due to the advancement of information technology, it has grown to be more user-friendly and has seen an increase in acceptance as a result of social attitudes that value sharing over ownership (Becker et al. 2017). Today, it is one of the most well-known and commonly utilized sharing economy applications in personal mobility (Novikova et al. 2017). Many countries have embraced carsharing services as a solution to social issues such as air pollution, high traffic congestion, and vehicle kilometers/miles traveled (Safdar et al. 2022). Russia, Germany, China, and Italy were the top carsharing countries in the world in 2018. The percentage of users in the mentioned countries for the observed period was calculated to be 3%. By 2018, only 1% of the Japanese population had used carsharing services (Melkadze, 2021). Daimler's Car2Go and BMW's DriveNow have been established as carsharing services in Germany in 2008 and 2011, respectively. In 2018, these two auto manufacturers merged their carsharing business and since then have expanded globally (Guyader, 2021). Between 2004 and 2014, carsharing in the United States grew 2,500 percent from 52,000 to 1.3 million users (Shaheen and Cohen, 2015).

Several aspects of travel behavior that affect the use of carsharing are examined in the review of literature conducted by Degirmenci and Breitner (2014) by way of its implication in the Information Systems (IS) research

community. These aspects include carsharing members' attitudes, motivations for using the service, and frequency of use. Results suggest that the Geographic Information System (GIS) is an important domain to consider to further understand the user's travel behavior such as the carsharing motives (e.g. shopping, medical, leisure, work-related). Jain et al. (2020) used a qualitative method to investigate how carsharing affects the mobility and travel preferences of the different user segments. The study categorized car share users into 4 user segments namely: car dependents, car avoiders, car sellers, and car limiters. Car dependents are those who use private cars on most of their trips and only use carsharing services for a specific purpose for a limited period of time such as moving furniture, among others. Car avoiders, on the other hand, are people who did not previously own a private vehicle and do not plan to do so. They are the most active users of active travel or public transportation with connectivity to car share. They also use care share for specific purposes such as out-of-town travels, road trips, and bulk purchases, among others. In the absence of this service, they use ride-sourcing or car rentals. Thirdly, car limiters are those who had some prior access to private vehicles and join carsharing to relieve mobility stress from contextual changes (e.g. change in family size, job location, residential location, etc.). Car share keeps them from purchasing another vehicle in response to these changes. Lastly, car aspirers are those who want to own a car eventually. Carsharing allows them to use a car while they save to buy one.

The attitude of users toward carsharing was examined in the study of de Luca and Pace (2014) conducted in Southern Italy (between Salerno and Baronissi). The study focuses on examining the tendency of users to use a carsharing system which is a unique and understudied component of users' behavior. The satisfaction variable, socio-economic and activity-related attributes were analyzed in order to analyze the interest of residents in carsharing concerning the level of service provided by other modes of transportation, as well as the socio-economic and activity-based characteristics of the users. Results suggest that the tendency for carsharing is influenced by the utility of the available transportation options as well as the quality of those options' service. As is well known, the utility includes socioeconomic and activity-based factors in addition to the level of service features. The weekly trip frequency and the distance traveled together with the satisfaction criterion lower individuals' likelihood to use a carsharing system. Lastly, interest grows among those who are already familiar with the service and those who frequently take buses.

The socio-psychological variables such as perceived usage-related attributes are also examined by Burghard and Scherrer (2022) on how they influence the acceptance and adoption of the use of carsharing. The study revealed that Compatibility strongly affects the attitude and acceptance of the use of carsharing. That is, individuals are more inclined to use new services that complement their existing daily routines and mobility behavior. Therefore, situational and contextual considerations such as the types of transportation that are (or are likely to become) available near a person's home can influence the perceived compatibility. Another factor

is the Ease of use which positively affects attitude but not directly acceptance. The third factor is Triability which has a positive influence on acceptance. This means that it is critical that new mobility services are visible in people's actual mobility experiences and that their first use is both encouraged and made as simple as possible. In terms of socio-demographics, the free-floating carsharing scheme in Basel, Switzerland is mostly attractive to younger and well-educated couples who live in homes with few private vehicles (Becker et al. (2017)). It is also attractive to younger men who earn more and whose house is not easily accessible by public transportation. In particular, from the sample selection approach, it is found that there's a high likelihood for university graduates to join carsharing services though they may not use them as frequently. Station-based carsharing is more likely to be adopted by those who are self-employed due to its flexibility. Safdar et al. (2022) however found some contrasting results in their study. For instance, the age factor revealed that those who are aged 39 years old and above are more likely to use carsharing services. Moreover, those who are in high school and below are also more inclined to utilize this service. But in terms of income, the result affirms that of Becker et al. (2017) wherein high earners earning more than 60,000 PKR per month are more likely to use this service. Another finding is that weekly travel is positively significant, showing that those who traveled for longer than 2 days were more inclined to use carsharing services. Furthermore, results in the study of Becker et al. (2017) suggest that carsharing membership correlates with more openness to new services and societal advances in Switzerland. In Lahore, Pakistan, a variety of service characteristics, including trip distance, pricing, waiting time, and privacy, have a big impact on how widely used carsharing services are. This is also one of the findings in the study of Safdar et al. (2022) on the public views and acceptance of the carsharing system. These attributes are negatively correlated with the adoption of the carsharing system. This means that as travel time and costs increase, people are less likely to use the system. The privacy aspect, on the other hand, has a positive correlation, indicating that Lahore residents prioritize the security and safety of their transportation. These findings were aligned with the goal of carsharing, which offers a similar alternative form of transportation for private vehicles without the expense and obligations of car ownership. In addition, Sharma (2020) investigated the role of one-way (free-floating) carsharing in serving the first and last mile to/from public transit in the case of a carsharing platform in Vancouver. This study suggests a possibility of one-way carshare usage for commute trips, which is consistent with earlier studies analyzing one-way carshare journeys. Additionally, it implies that, depending on the likelihood, some of these trips may have involved first or last mile connections to public transportation.

Bike-sharing

Non-motorized transportation such as cycling, walking, pedicabs, and other human-operated vehicles are most commonly used as a means of transportation in many developing countries, particularly in Asia and Africa. In general, bicycles are more popular in developing countries than in developed countries (Pojani and Stead, 2015).

With the growing globalization, social modernization, and economic boom, a bicycle is not a top choice as a mode of transportation in most countries (Yao et al. 2019). Despite this, the usage of bicycles has increased globally during the last 30 years (Shaheen et al. 2010). Cycling is becoming more widely recognized as a clean, sustainable means of transportation that has the potential to replace cars for short-distance travel in cities (ECMT, 2004). In the Philippines, the Metropolitan Manila Development Authority (MMDA) encourages cycling as a mode of transportation as part of its commitment to promoting urban mobility through sustainable transportation, particularly in regions with the potential to generate tourism-related income. Hence, bicycles are widely acknowledged as a solution to urban problems such as traffic congestion, high cost of living, land use, and environmental and health issues (Vassi and Vlastos, 2014). Public transit planners and researchers have paid close attention to bicycle and public transit integration which has been a subject in many recent studies. With this, the term 'cycle-transit users' (CTUs) have emerged (Flamm and Rivasplata, 2014) – those who travel by bicycle and public transportation in one trip (Meenar et al. 2019). In North America, transit authorities have made significant expenditures in the coordination of bicycle and public transportation services since the 1990s. Moreover, several European countries such as the Netherlands, Denmark, and Germany mostly have integrated cycling with public transport, recognizing the key role of the bicycle in improving the efficiency of public transportation (Pucher and Buehler, 2008). One of the main objectives of this integration is to improve the number of users of public transportation by expanding the geographic region from which riders may reach transit stops and stations easily and quickly (Flamm et al. 2014).

Bike-sharing is a new mode of transportation that is gaining popularity in cities all around the world (Parkes et al. 2013; Zhang and Mi, 2018; Shang et al. 2021). It has expanded across four continents since 1965, including Europe, North America, South America, Asia, including Australia (Shaheen et al. 2010). Bicycle sharing systems (BSS) have recently been introduced into urban areas as a new on-demand transportation option providing reliable, practical, and sustainable urban mobility (Faghieh-Imani et al. 2017). By integrating the flexibility of cycling with the reliability of public transportation, bike sharing is generally acknowledged to have the potential to encourage sustainable travel (Radzimski and Dzięcielski, 2021). In general, the term "bike-sharing" refers to a service that serves as a form of public transit by allowing users to share bicycles for a certain amount of time (Parkes et al. 2013; Goodman et al. 2014). Bike-sharing allows people to ride bicycles "as-needed" without having to own one completely, avoiding the expense and maintenance that comes with ownership. In general, bike-sharing provides environmental, social, and transportation-related benefits to its users (Shaheen et al. 2010; Zhang and Mi et al. 2018; Cheng et al. 2021). For instance, in their study of BSS in Shanghai, China, Zhang, and Mi (2018) revealed that there is a significant reduction in the consumption of petrol by 8,358 tonnes. Consequently, there were significant reductions in carbon dioxide and nitrogen oxide of 25,240 and 64 tonnes, respectively. Bike-sharing systems can become an everyday travel mode in low-cycling areas

that provides a safe, practical, and sustainable mode of transportation. The use of bike-sharing systems can be complementary to other modes of public transportation and the benefits of the integration can be higher than using either one. Furthermore, bike-sharing can be used to supplement transportation needs in case of a complete transit shutdown enhancing the resiliency of urban transportation systems (Cheng et al. 2021).

Bicycle on-train policies, among other things, have been established by transport agencies all over the world, along with the increasing installation of bicycle racks on transit vehicles. These initiatives are also geared towards integrating bicycle and transit modes to address the first mile and last mile gaps (Flamm and Rivasplata, 2014). Theoretically, bicycle-metro integration is considered to be an excellent solution to improving the efficiency of the last mile of public transportation in cities (Zhang et al. 2019). Hence, it is expected that bike-sharing extends and integrates cycling into transportation systems enabling it to become a more common means of transportation (Shaheen et al. 2010). As part of its Sustainable Transport Initiative, the Asian Development Bank (ADB) is actively promoting bicycle sharing in different locations in the Asia Pacific. In the Philippines, ADB launched a bike-sharing initiative in 2012 called Tutubi ("dragonflies" in Tagalog). Tutubi provides a solution to the growing demand to make cities greener and more livable, and it offers numerous potential solutions to Manila's smog problem (Inquirer.net, 2012). This initiative is hoped to be implemented on a wider scale such as in the whole Metropolitan region of Manila. Students of the University of the Philippines Diliman in Quezon City launched a bicycle sharing system in 2016 wherein students in the university can use the system in traveling around the campus. Recently, Caponga et al. (2021) explored the feasibility and practicality of operating a hybrid BSS at the University of the Philippines Los Baños (UPLB). The study presented a preliminary design for the system for free-floating and station-based systems which served as a basis for large initiatives involving bike-sharing systems in the university. The study's findings indicated that the middle campus should be provided with a free-floating system, while the upper campus and the animal science department at UPLB should be assigned a station-based system. Additionally, it was determined that 35 station-based bikes and 301 free-floating bikes are needed to satisfy the identified demand.

In recent years, China's bicycle-sharing systems (BSS) have grown significantly which were seen as viable answers to the first/last mile problem. Fan et al. (2019) conducted an empirical study in Beijing China and it was found that the most important factors prior to the implementation of BSS are gender, bicycle availability, and trip frequency. Since it was introduced, BSS has become the preferred mode of transportation for first and last mile trips with a 45.9% mode share. Gender, the availability of bicycles, and accessibility are significant determinants for the middle-aged group. These factors are not important for either young people or the elderly. In Ningbo, China, Guo et al. (2017) found twelve variables that are statistically significant in the usage of bike-sharing services. These variables include trip mode such as public transit, bicycle; familiarity with bike-sharing; location of bike-sharing

docks; encouragement of sustainable traveling; significant effort in introducing the system; travel time, gender, flexible route, time wasted by bike-sharing, bicycle and e-bikes ownership; satisfaction with bike-sharing fees. A dockless bike-sharing service also called free-floating bike-sharing (FFBS) was the focus of the study of Li et al. (2018). It was found that the usage of FFBS in Jiangsu province in China was influenced by several factors such as education, daily transportation cost, the convenience of pick up and parking, and contribution to the user's health. That is, higher education levels, higher daily transportation costs, ease of pick-up and parking, and benefits to users' health might encourage the use of FFBS, whereas broken bicycles and a lack of rules were key roadblocks to its expansion. In Singapore, the usage of dockless bike-sharing is influenced by fleet size, built environment, and weather conditions. According to the results, bike use is favorably correlated with the dockless bike fleet. However, as the fleet size increases, the marginal impact drops, meaning that each additional bike may result in fewer additional trips. Another important factor is the built environment. Greater economic diversity, narrower street blocks, and more densely populated commercial areas all have a beneficial impact on the adoption of dockless bikes. Bike use is also encouraged by favorable cycling infrastructure and improved transportation systems. Unsurprisingly, reduced bike use may be caused by rain and extreme heat (Shen et al. 2018). In the survey conducted by Bachand-Marleau et al. (2012), for users of the system in Montreal, Quebec, Canada, the proximity of one's home to docking stations is of greatest impact on the likelihood of usage of the shared bicycle system.

Bike-sharing is a carbon-free solution to the last mile problem (Yao et al. 2019). It has the potential to help bridge the gap in existing transportation networks while also encouraging people to use different modes of transportation (Shaheen et al. 2019). Its various features make it an appealing alternative for first and last mile trips. When used in combination with public transportation, private bicycles have a variety of drawbacks. For example, they may not be permitted to use public vehicles at peak hours or even throughout the day. Shared bicycles, on the other hand, could be a viable solution to this problem if they are available at the terminal station (Radzimski and Dzięcielski, 2021). In the study of Parkes et al. (2013), the interview responses revealed that the bike-sharing systems help in solving the last mile problem. Cities such as Antwerp, Dublin, Cardiff, and San Francisco saw that the system helps in the integration of their transportation systems by connecting a rider's last mile with the existing public transit infrastructure. In New Cairo, the study by Hussin et al. (2021), 370 responses or 66% of the survey respondents chose bike-sharing systems as the most suitable solutions for the first and last mile problems. As bike-sharing continues to grow, new program entries, possible program mergers, continuous technology innovation, and policy advancements will continue to define bike-sharing in the coming years. Furthermore, as a result of growing gasoline prices, public health concerns, smart-growth programs, and climate-change worries, public bike-sharing will certainly garner more attention as a sustainable transportation alternative (Parkes et al. 2013).

Sharing a Passenger Ride

Sharing a passenger ride is relatively new than vehicle sharing. Innovations in this area have just recently emerged, hence, the term is still unclear (Shaheen and Chan, 2016). Traditional ridesharing includes vanpooling and carpooling. Vanpooling involves the use of a van where a group of 7-15 people commutes together, while in carpooling, there are only groups of 7 or fewer traveling together in one car (Shaheen and Chan, 2016). Another type is the on-demand ride services wherein passengers book rides through a mobile device and applications such as ride-sourcing and ridesharing services. The rapid growth of these services has been made possible by the recent integration of mobile internet technology into our daily lives. Companies such as Uber, Lyft, Grab, Didi, Careem, and Ola were able to leverage internet-based platforms to provide e-hailing services in different cities around the world. For instance, the largest ride-sourcing company, Uber has attracted more than 50 million riders since its creation in 2009. In 2016 alone, it recorded more than 3 billion trips (Yan et al. 2018). Moreover, it has expanded to provide a one-stop mobile transportation platform that offers a variety of services in over 700 urban areas across 65 countries (Wang and Yang 2019).

Early ridesharing company growth was fueled by personal rides, which were traditionally provided by private cars, taxis, and rental cars. Ride-sourcing services stand out from more established transportation options like taxis and paratransit because they can instantly identify, match, and accommodate individual travelers' needs (Yan et al. 2018). Different studies have explored the socio-economic and demographic variables characteristics of the users of these services that affect the usage of these systems. For instance, Habib (2019) identified in his study that there is a significant difference in the socio-economic profiles of the users of the traditional taxi and ride-sourcing services (Uber, in particular). That is, older people prefer taxis

while younger ones prefer Uber. This is also one of the findings in the study of Dias et al. (2017). Aside from the younger population, users of these services are typically well-educated working adults with high incomes who live in densely populated areas. According to Alemi et al. (2018), older millennials who are highly educated also have a greater likelihood of using on-demand ride services.

Ridesharing or pooled rides has recently drawn a lot of attention as is considered a sustainable mode of transportation because of its contribution to reducing carbon emissions, congestion, accessibility, and parking in urban areas. The advantages of shared rides will, however, only become a reality if enough people are willing to use them (Alonso-González et al. 2021). Wang et al. (2020) identified several factors that are associated with the user's intention to use ridesharing services. Positively correlated factors include perceived innovativeness, environmental consciousness, and perceived usefulness while the perceived risk is negatively correlated with the consumer's intention to use ridesharing services. Moreover, the fare discounts, the extra travel time required, and the (un)willingness to share the journey with other passengers are the three key factors that influence whether someone chooses a pooled transport over an individual alternative (Alonso-González et al. 2021).

To effectively market these services, it is critical to recognize the factors that influence user intent. The following table shows the factors that affect the choice of ride-sourcing and ridesharing systems as a mode of transportation.

Ride-sourcing

Ride-sourcing (transportation network companies) is evolving and is becoming more popular. This mode of transportation offers car access without car ownership, reducing transit use by encouraging people to hail rides

Table 2. Factors influencing the adoption of sharing a passenger ride as a mobility option

Service	Study	Place	Influential Factors
Ride-sourcing	Aguilera-García et al. (2022)	Spain	Tech-prone behavior; socio-demographic variables (age, income, education, and residential location)
	Yan et al. (2018)	Michigan, Ohio, USA	Waiting time, in-vehicle travel time
	Alemi et al. (2018)	California	Greater land-use mix, regional auto accessibility; willingness to adopt new technologies
Ridesharing	Stoiber et al. (2019)	Switzerland	Cost, time, and comfort
	Alonso-González et al. (2021)	Netherlands	Current travel patterns, personal income, time, cost, number of co-riders
	Amirkiaee and Evangelopoulos (2018)	United States	Economic benefit, time benefit, transportation anxiety, trust
	Sarriera et al. (2017)	United States	Travel time, travel cost, comfort

instead of having to ride transit. Moreover, it makes public transportation more accessible to current or potential riders since getting to and from stations becomes easier (Brown et al. 2021). In recent years, it experienced significant growth in urban mobility as it provides a convenient, on-demand door-to-door service through app-based real-time trip information with flexible prices (Aguilera-García, et al. 2022). Ride-sourcing firms have been able to use internet-based platforms to offer e-hailing services in numerous cities across the world (Wang and Yang, 2019). The rapid growth and popularity of mobile and wireless communication technology have allowed for the emergence of this new mode of transportation. Uber, Lyft, Didi, Grab, Careem, and Ola are among the companies that connect riders and drivers in real-time disrupting the transportation industry, as it competes directly with the traditional taxi industry in providing door-to-door trips (Wang and Yang, 2019; Yan et al. 2018; Aguilera-García, 2022).

The two fundamental components of the ride-sourcing market are passenger demand and driver supply. On the demand side, potential passengers evaluate ride-sourcing services depending on their attributes and behavior such as the value of time, and willingness to pay, with temporal and spatial characteristics. In making travel decisions, passengers evaluate service quality such as waiting time, and fare, and compare these against other travel modes such as traditional taxis and other public transportation services. Suppliers of ride-sourcing services, on the other hand, decide on whether they work on the platform, and how long (if so) based on their attributes, qualifications, and behavior (e.g., vehicle operation, cost of fuel, and reservation wage as an opportunity cost) in response to many variables and factors unique to each platform. Another critical factor, the level of income is also being compared with other job options. Other comparative factors are terms of the working environment and working hours, job security, comfort, work pressure, and risk exposure, among others (Wang and Yang 2019). In terms of

In recent years, TNCs have vigorously competed with for-hire vehicle and taxi services in most cities, introducing a radically different business model. Companies such as Uber or Lyft offer smartphone apps where riders can 'source' rides by connecting with available drivers using their phone's GPS and getting a for-hire ride to their destination (Ngo, 2015). Following the success of private companies such as Uber and Lyft, transit agencies have started to consider integrating ride-sourcing services with public transit providing on-demand, app-driven ridesharing services to enhance the transit system. The advent of these services has addressed the first-last mile problems (Brown et al. 2021). Ride-sourcing has the potential to improve the transportation system in two ways: by replacing underutilized routes and by providing last mile connections to expand the service area. These services can complement public transportation by improving last mile transit access (Yan et al. 2018). In some circumstances, this mode of transportation can be employed as a first and last mile solution to persuade private-car users to refrain from using their cars and use public transportation. In New Cairo, ride-hailing is found

to be the second most used mode in moving across the city. Using a multinomial logit model, results revealed that gender is a significant factor that affects the choice of main mobility mode. That is, females are more inclined to use ride-hailing services than males. Moreover, they prefer to use ride-hailing services than public transportation services. Moreover, the distance between destinations affects the usage of this type of service. Users prefer to travel using ride-hailing modes over public transportation for medium-length trips, with the benefit diminishing as the trip goes shorter or longer (Hussin et al. 2021).

A large-sample survey was conducted by Yan et al. (2018) to investigate how commuters felt about MTransit, a proposed integrated transit system at the University of Michigan Ann Arbor campus. An RP-SP mixed logit model was used to assess the primary factors influencing the selection of commuting mode from the data gathered on revealed preferences (RP) and stated preferences (SP). The model's findings demonstrate that transfers and additional pickups are significant barriers to MTransit adoption. Another significant finding in this study is that ride-sourcing can significantly increase the use of public transportation if employed to provide convenient last mile connections between a traveler's points of origin/destination and transit terminals. A survey campaign was also conducted in Spain in 2018 by Aguilera-Garcia et al. (2022) where they investigated the individual's preferences when selecting between ride-sourcing and conventional taxi services. The roles of individual sociodemographic and household variables, mobility-related characteristics, user perspectives, and psychological attributes were examined as influencing factors in an individual's decision to choose ride-sourcing. It is found that those who are open to technological innovation are more likely to use ride-sourcing services more often than traditional taxis. Findings also point to a larger propensity for ride-sourcing among women, young people, and individuals who use hailing services for social, recreational, or leisure activities. It's interesting to note that those who have used both taxis and ridesharing in Spain prefer to rate ride-sourcing's performance in terms of quality of service (driver and/or vehicle fleet) higher than that of taxis. The study of Alemi et al. (2018) also found that technology-oriented individuals are more inclined to use on-demand services. Aside from this, it is found that the built environment where a person lives and the land-use mix affects this decision. The study confirms that people who are younger, more educated, and of non-Hispanic origin are more likely to use on-demand ride services.

Ridesharing

Another type of shared mobility is ridesharing. It is not the same as carsharing wherein carsharing individuals typically charge a fee in exchange for the use of a single car among multiple drivers. In ridesharing, users share a route rather than a vehicle. Multiple passengers get to their destination using a single vehicle such as a car or van going to the same route or direction. In this way, there is less need for cars on the road reducing traffic congestion level. This system is also similar to carpooling and vanpooling in which it makes multiple stops along a route to pick up and drop off passengers with little or no added

mileage. However, ridesharing is a more flexible kind of transportation that doesn't require the kind of advanced arrangement that carpoolers make with one another. Unlike most kinds of carpooling, ridesharing involves a price, although it's usually reasonable.

Ridesharing is now easy to access because of the availability of smartphone apps. For instance, most recently, Trinity Metro in Texas introduces ZIPZONE as a first/last mile solution. It aids workers in the Mercantile region traveling to work. This is accomplished by linking commuters to take the bus and TEXTrail to the Mercantile Center Station (APTA, 2019). Alonso-González (2021) designed a stated preference survey to quantify the willingness to share rides of Dutch urban individuals towards ridesharing services. Results revealed that less than one-third of respondents have strong preferences against sharing their rides. This suggests that the use of ridesharing can still grow significantly and those who currently rely heavily on a car are less likely to switch to more shared modes of transportation. Those who prefer to share ride primarily considers the time-cost trade-off rather than the discomfort associated with ridesharing. Current travel patterns and personal income affects the preference of individuals to share rides. Findings also suggest that the number of additional passengers affects people's willingness to share rides. In Switzerland, sixty-one (61%) of the respondents in the study of Stoiber et al. (2019) preferred pooled rides than using private cars. According to the stated preferences, comfort, cost and time are major considerations in the likelihood of usage of this service. Sarriera et al. (2017) confirmed this finding in which time and costs are primary considerations. In contrast to walking and using public transit, the majority of dynamic ridesharing users are driven by ease, speed, and comfort; (e) safety in shared rides is a crucial problem, especially for women, who frequently report feeling unsafe and prefer to ride with other women. Lastly, social factors such as social interactions such as a networking opportunity or having a good conversation with other passengers are one of the study's most significant findings.

Some psychological and emotional considerations in choosing between ridesharing and driving alone are examined in the study of Amirikiaee and Evangelopoulos (2018). Transportation anxieties such as a feeling of worry, uneasiness, nervousness because of heavy traffic, a long trip, or a lack of parking space are examined. These are commonly called "commuting stress" or "traffic anxiety" and have been acknowledged to have motivated ridesharing or carpooling. The study revealed that a person's attitude toward ridesharing is positively correlated with economic advantage, time benefit, transit anxiety, and trust. Additionally, there is a strong correlation between reciprocity and the desire to use ridesharing.

SUMMARY AND CONCLUSIONS

In the context of ongoing urbanization, private car ownership poses issues in terms of pollution, high energy costs, and limited and expensive parking. Companies are creating innovative mobility alternatives to private car ownership in response to these negative effects (Degirmenci and Breitner, 2014). The emergence of new forms of transportation has a noticeable impact on the

development and sustainability of urban mobility. Instead of having only one option, the new modes allow city people to choose the most appropriate and available mode for them. Many recently developed mobility options shared one of two fundamental characteristics. Technology-based solutions, including ride-hailing services like Uber and Careem and carpooling, are the first feature. Another is having privately-owned buses that operate side-by-side with the public buses, like SWVL and Uber Bus, or micro-mobility options like sharing electric bikes and electric scooters, etc. (Hussin et al. 2021). Low-cost technologies like on-demand transportation or parking payments already exist in developing countries and might be employed more frequently to promote new inventive types of urban transportation services. (Pojani and Stead, 2015).

People will typically walk by public transportation if it is close enough. However, the origin or destination on either end of a public transit route could be challenging or impossible to reach by a short walk. The distance from public transportation to the last destination is known as the last mile connection. The concept is broadly relevant to improving access to public transportation for everyone who wants to use it, regardless of whether they live within a mile of a station. An alternative mode of transportation is needed in order to solve the first and last mile gap. This can be through multimodal trips that are facilitated by conventional or new and shared mobility options such as micro-transit, carpooling, cycling, bike-sharing, on-demand shuttle services, and ride-hailing, among others (Sharma, 2020). Shared mobility involves the use of a vehicle, bicycle, or other low-speed means by a group of people to provide short-term access to transportation modes when needed. This is usually connected to public transportation as a first or last mile connection. This paper focuses on shared mobility, particularly the key areas of shared mobility such as carsharing and bike-sharing (sharing of a vehicle) and ridesharing and on-demand services such as ride-sourcing (sharing of a passenger ride) as the last mile solution. Several factors that influence the adoption of shared mobility services in different countries were reviewed and presented.

The traditional transportation sector is evolving due to shared mobility services. Through the application of technology, shared mobility has paved the way toward social environmental, and economic efficiency (Machado et al. 2018). This alternative mode of transportation has grown in popularity in major cities throughout the world as an innovative transportation mode that improves urban mobility. Aside from this, it is also considered a feasible solution for addressing first and last mile connectivity with public transit. It has the potential to expand the reach of public transportation crucial in bridging the gap in an existing transportation network. Incorporating it into the current transportation infrastructure will allow for a decrease in private ownership of vehicles which will help in minimizing parking congestion and improve traffic conditions. The utilization of shared mobility services promotes multimodal travel for first and last mile trips. Another benefit is that it is more environmentally friendly as a result of lower carbon emissions, less fuel consumption, and lower transportation expenses (Burghard and Scherrer, 2022). Therefore, the

adoption of shared mobility programs has the potential to improve urban efficiency, competitiveness, social equity, and quality of life (Machado et al. 2018). To increase the attractiveness, accessibility, and sustainability of sharing services for system users, policies and measures are essential. The topic of what factors influence the adoption of individual services is crucial if the objective is to make shared mobility an important component of the mobility system (Burghard and Scherrer, 2022).

Some of the most common factors that are crucial in choosing a mobility solution include time, cost, and perceived convenience or comfort (Novikova et al. 2017; Sarriera et al. 2017; Stoiber et al. 2019). Safdar et al. (2022) added waiting time and privacy as influential factors in choosing carsharing as a mode of transportation. In China, where bike-sharing is popular across the country, familiarity with the service, and accessibility/convenience of docking stations increases the likelihood of its adoption (Guo et al. 2017; Li et al. 2018). Several different factors also affect the use of ride-sourcing and ridesharing services. In terms of attitudinal factors, familiarity with and willingness to adopt new is found to be a primary influence in ride-sourcing adoption (Aguilera-García et al. 2022, Alemi et al. 2018). In the study of Amirkiaee and Evangelopoulos (2018), it is found that there's a positive relationship between economic benefit, time benefit, transportation anxiety, and trust in a person's attitude towards ridesharing. Moreover, there is a positive relationship between reciprocity and the intention to participate in ridesharing. In the use of public transport, it is generally acknowledged that socio-demographic factors, such as income, gender, and marital status; transit network characteristics, such as network size, wait times, and ride costs; built-environment factors, such as accessibility and availability; infrastructure design factors, such as the size and qualities of transit infrastructure,

influence modal choice. Transit networks and the built environment surrounding public transportation can either promote or hinder more sustainable travel behavior especially in choosing the modes for the first/last mile (Tilahun et al. 2016).

Transportation planners, policymakers, shared mobility service providers, and marketers who are interested in investing in this industry can all benefit from this review paper. For instance, with trust being the main influencing factor to consider in ridesharing, providers and policymakers should focus on building and maintaining it. They should provide a reliable system that ensures consumers feel safe and secure in using the system. This study aims to contribute to the extensive body of knowledge on shared mobility that will help in the successful adoption of these systems for a sustainable urban transportation system. Future research in this area can include more review of related literatures on other modalities of shared mobility services and on how they can be integrated with other traditional modes of transportation. Lastly, the effects of the adoption of shared mobility as a last mile solution in reducing traffic congestion, and pollution, among others can also be explored.

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Gall Rust Disease Incidence and Severity in a Falcata (*Falcataria moluccana* (Miq.) Barneby & J.W.Grimes) Plantation Grown from Select Mother Trees in Mindanao, Philippines

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ABSTRACT

It remains unknown whether there are available gall rust resistant seed sources of Falcata (*Falcataria moluccana* (Miq.) Barneby & J.W.Grimes) in the country or elsewhere. This study was conducted to obtain baseline data for future progeny selection of gall rust resistant clones of Falcata in the region. The objectives were to determine whether there are available seed sources or mother trees in the region that are resistant to gall rust, and whether gall rust infection has negative effects on the growth of Falcata. The trial (with 130 mother trees as treatments and four replications) was assessed in November 2020- or five-years following establishment in 2015. Mean percent incidence ($15.0 \pm 5.0\%$ to $80.0 \pm 14.1\%$) and severity ($3.75 \pm 1.25\%$ to $35.0 \pm 16.95\%$) of gall rust varied significantly among treatments indicative of genetic diversity among mother trees. The incidence ranged from 'occasional' to 'widespread' while severity ranged from 'low' to 'high' with mother trees 99 (Mutia, Zamboanga del Norte) and 106 (Magsaysay, Baliangao, Misamis Occidental) emerged as the most resistant of all. Height and diameter were positively related to gall rust incidence and treatments only, although none of the mother trees with resistant traits had superior growth. There was however indication of growth and disease tolerance tradeoff where trees with higher gall rust incidence tend to grow bigger perhaps to compensate for any negative impacts from gall rust infection.

Keywords: *Falcataria moluccana*, gall rust, incidence, severity, seed sources

INTRODUCTION

Commercial tree plantations, commonly referred to as Industrial Tree Plantations (ITPs), are important sources of wood and income for wood industries and tree farmers in the Asian region beside other important functions for the environment such as carbon sequestration and soil protection. However, the monoculture-type of planting of commercial tree plantations often expose them to disease infestation or outbreak especially from disease-causing parasites that are usually restricted to parasitizing a few or single host family, genus, or species. Falcata (*Falcataria moluccana* (Miq.) Barneby & J.W.Grimes), for instance, is the only known host plant to falcataria gall rust fungus (*Uromycladium falcatarium* sp. nov. Doungsa-ard, McTaggart & Shivas) (Doungsa-ard et al., 2015). This fungus is identified as closely related to acacia gall rust fungus (*U. tepperianum* (Sacc.) McAlpine), which has over 100 known host plants although mostly from Mimosoideae clade (Morris, 1987). *Uromycladium falcatarium* is distinguished from other *Uromycladium* species by the presence of three one-celled fertile teliospores on the pedicel (McAlpine, 1905 as cited by Doungsa-ard et al., 2015). The germination percentage of *U. falcatarium* spores was observed to reach up to 100% just within three hours from infection (Rahayu et al., 2020). The typical

symptoms of rust fungus include a "rust-coloured" (often orange or yellow) pustule on plant shoots or leaf, petiole and rachis deformation, die-back of seedlings, stunting of affected trees or death in more extreme cases (e.g. massive defoliation of tree crowns) (McKenzie, 1998; McTaggart et al., 2015; Rahayu et al., 2018). The devastating impact of *U. falcatarium* infestation in Falcata plantations has been reported in Malaysia and Indonesia (Rahayu et al., 2010), and Timor-Leste (Old & Dos Santos Cristovao, 2003). The disease was first detected in the Philippines in 1988 and since then the control measures are limited to removal of infected trees or cessation of planting of Falcata in high elevation areas (i.e., >250 m above sea level) (Anino, 1994; Braza, 1997) as incidence/severity of the disease is known to increase with elevation.

Like other countries in the south-east Asia, the Philippines is heavily dependent on commercial tree plantations for wood, which means that the impact of disease infestation on wood production has wide-

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ranging effects both for the economy and livelihood of small-holder tree plantation farmers. About 82% of wood production in the country are coming from commercial tree plantations especially Falcata as part of the Philippine government's management effort to reduce pressure on remaining natural forests. Falcata is a valuable multi-purpose tree species, and with the moratorium on the cutting and harvesting of timber in natural and secondary forests in the Philippines (cf. Executive Order No. 23), most wood industries especially in Mindanao have been utilizing wood mainly from Falcata tree plantations to produce lumber, veneer, and plywood (PCAARRD, 2010). In terms of exports, Falcata lumber comprises the bulk or 72% of the country's forest-based exports (PCAARRD, 2010).

Most tree plantations in the country even overseas (cf. Baird, 2014; Lugo, 1997; Semwal et al., 2013) are established in degraded lands to facilitate forest successions or where cultivation of agricultural crops is not anymore suitable and profitable to farmers. Such practice along with the vulnerability of monocultures to disease infestation is likely responsible for the country's poor wood production rate from tree plantations that is below the national and global standards. Wood production rate in the country is only about 632,574 m³ or 0.006 m³ per capita (Forest Management Bureau-DENR, 2019), which is about twice lower than the world's average production rate of 0.5 m³ per capita (Bruinsma, 2002).

It remains unknown whether there is available gall rust resistant Falcata population or seed sources in the country. Such resistant population or seed sources is critical for long-term breeding program and in reducing gall rust impacts in Falcata plantations. Moreover, current knowledge is also not clear whether gall rust infestation in Falcata plantations has negative impact on growth to warrant a massive effort especially in breeding for resistance. Previous experience with other rust diseases of major plantation species in Australia and India indicates that without selection for resistant traits, breeding programs could result in highly susceptible population of trees (Old et al., 2000).

This study was conducted to assess the incidence

and severity of gall rust disease in a Falcata plantation established from a select number of mother trees or a total of 130 seed sources in Mindanao. Specifically, the objectives of the study were to determine: 1) whether there are available seed sources or mother trees in the region that are resistant to gall rust, and 2) whether gall rust infection has negative effects on the growth of Falcata. The results of this study will provide a benchmark for future selection of resistant clones and to achieve maximum productivity.

METHODOLOGY

Study Site

This study was conducted in November 2020 in an existing Falcata progeny trial established in 2015 within Central Mindanao University landholding in Musuan, Bukidnon, Philippines (07° 52' 51" North and 125° 03' 48" East) (Figure 1). The study site which is about three hectares has an elevation of around 600 m above sea level. The area had an average annual rainfall of 6.18 mm based on the four-year climate data (2017-2020) from the nearest weather station. The mean annual temperature ranged from 19.89°C to 33.80°C, while relative humidity ranged from 90.86% to 92.85%.

Sampling design

The Falcata progeny trial was established in a randomized complete block design (RCBD) (Appendix Figure 1) with progenies of 130 different mother trees (as treatments) from 36 different locations in Mindanao (Table 1). Mother trees from the same origin were treated as different treatments in this study as they were kilometers away (at least 2 kilometers away) from each other. The treatments were replicated four times with each treatment or mother tree consisted of five trees. A total of 2,600 Falcata trees were assessed in the study excluding three rows of buffer trees around the trial. The plantation has a 2 m x 3 m spacing and because of this proximity, each replication was divided into 13 plots to facilitate the measurement of incidence and severity of gall rust disease on a per plot basis. Each plot had a dimension of 10 m x 30 m and covered a total of 50 Falcata trees with a random

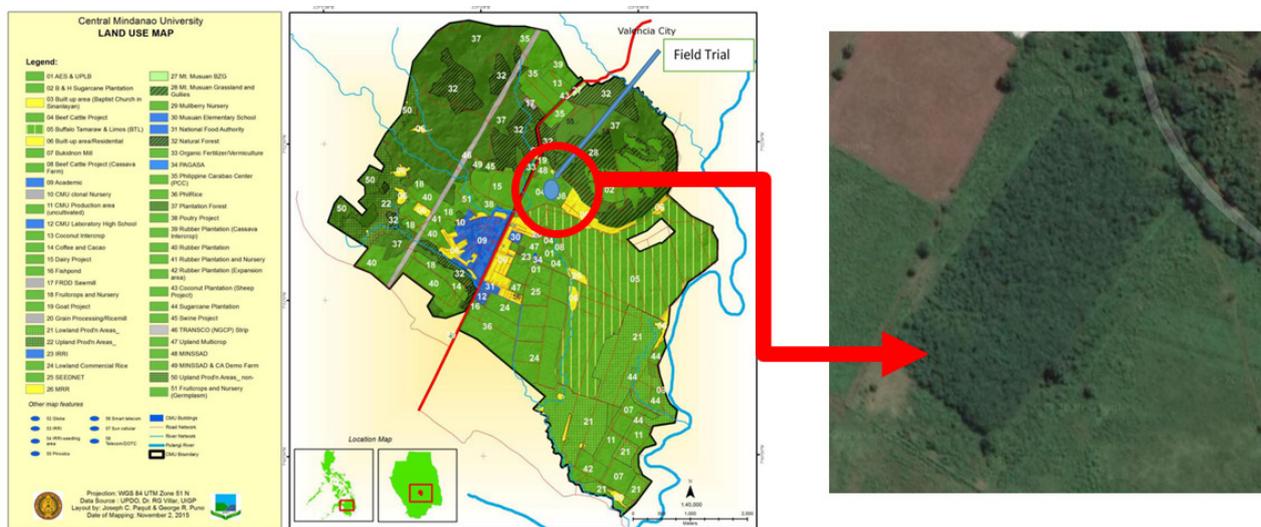


Figure 1. Location of the Falcata field trial in Musuan, Maramag, Bukidnon.

Table 1. Place of origin of the different mother trees in the Falcata progeny trial in CMU, Musuan, Bukidnon. The number in the first column represent the number code of each mother tree in the trial. Note that mother trees from the same origin were treated as different treatments in this study as they were kilometers (at least 2 kilometers) away from each other.

Mother Tree	Origin
1	Brgy. Rawari Kitaotao Bukidnon
2	Brgy. Rawari Kitaotao Bukidnon
3	Brgy. Rawari Kitaotao Bukidnon
4	Brgy. Rawari Kitaotao Bukidnon
5	Dalirig, Manolo Fortich, Bukidnon
6	Dalirig, Manolo Fortich, Bukidnon
7	Dalirig, Manolo Fortich, Bukidnon
8	Miaray, Dancagan, Bukidnon
9	Dalirig, Manolo Fortich, Bukidnon
10	Dalirig, Manolo Fortich, Bukidnon
11	Dalirig, Manolo Fortich, Bukidnon
12	Dalirig, Manolo Fortich, Bukidnon
13	Miaray, Dancagan, Bukidnon
14	Miaray, Dancagan, Bukidnon
15	Dalirig, Manolo Fortich, Bukidnon
16	Dalirig, Manolo Fortich, Bukidnon
17	Himaya Colambugon, Maramag, Bukidnon
18	Himaya Colambugon, Maramag, Bukidnon
19	Himaya Colambugon, Maramag, Bukidnon
20	Himaya Colambugon, Maramag, Bukidnon
21	Guinoyoran, Valencia City Bukidnon
22	Miaray, Dancagan, Bukidnon
23	Guinoyoran, Valencia City Bukidnon
24	Guinoyoran, Valencia City Bukidnon
25	Minsapinit, Gingoog City Misamis Oriental
26	Minsapinit, Gingoog City Misamis Oriental
27	Guinoyoran, Valencia City Bukidnon
28	Guinoyoran, Valencia City Bukidnon
29	Guinoyoran, Valencia City Bukidnon
30	Guinoyoran, Valencia City Bukidnon
31	Guinoyoran, Valencia City Bukidnon
32	Guinoyoran, Valencia City Bukidnon
33	Guinoyoran, Valencia City Bukidnon
34	Maribucao, Gingoog City Misamis Oriental
35	Tagpako, Gingoog City Misamis Oriental
36	Minsapinit, Gingoog City Misamis Oriental
37	Minsapinit, Gingoog City Misamis Oriental
38	Minsapinit, Gingoog City Misamis Oriental
39	Kabulakan, Balingoan Misamis Oriental
40	Kabulakan, Balingoan Misamis Oriental
41	Kabulakan, Balingoan Misamis Oriental
42	Mapua, Talisayan Misamis Oriental
43	Mapua, Talisayan Misamis Oriental
44	Mapua, Talisayan Misamis Oriental
45	Mimbunga, Gingoog city Misamis Oriental
46	Bangbang, Medina Misamis Oriental
47	Hubang, San Francisco Agusan del Sur
48	Hubang, San Francisco Agusan del Sur
49	Hubang, San Francisco Agusan del Sur
50	Sukailang, Surigao del Norte
51	Sukailang, Surigao del Norte
52	Sukailang, Surigao del Norte
53	Sukailang, Surigao del Norte
54	San Jose, Prosperidad, Agusan del Sur
55	San Jose, Prosperidad, Agusan del Sur

Mother Tree	Origin
56	Hubang, San Francisco Agusan del Sur
57	Hubang, San Francisco Agusan del Sur
58	Hubang, San Francisco Agusan del Sur
59	Poblacion, Prosperidad Agusan del Sur
60	Poblacion, Prosperidad Agusan del Sur
61	Poblacion, Prosperidad Agusan del Sur
62	Poblacion, Prosperidad Agusan del Sur
63	San Vicente, Bislig City Surigao del Sur
64	San Vicente, Bislig City Surigao del Sur
65	San Vicente, Bislig City Surigao del Sur
66	San Vicente, Bislig City Surigao del Sur
67	San Vicente, Bislig City Surigao del Sur
68	Maharlika, Bislig City Surigao del Sur
69	New Bataan, Compostela Valley
70	New Bataan, Compostela Valley
71	Mawab Compostela valley
72	San Isidro Davao Oriental
73	San Isidro Davao Oriental
74	San Isidro Davao Oriental
75	San Isidro Davao Oriental
76	San Isidro Davao Oriental
77	San Isidro Davao Oriental
78	San Isidro Davao Oriental
79	San Isidro Davao Oriental
80	San Isidro Davao Oriental
81	San Isidro Davao Oriental
82	San Isidro Davao Oriental
83	San Isidro Davao Oriental
84	San Isidro Davao Oriental
85	San Isidro Davao Oriental
86	Tubac, Mutia Zamboanga del Norte
87	Tubac, Mutia Zamboanga del Norte
88	Tubac, Mutia Zamboanga del Norte
89	Tubac, Mutia Zamboanga del Norte
90	Tubac, Mutia Zamboanga del Norte
91	Mutia, Zamboanga del Norte
92	Mutia, Zamboanga del Norte
93	Sibula, Lopez Jaena Mis. Occ.
94	Sibula, Lopez Jaena Mis. Occ.
95	Sibula, Lopez Jaena Mis. Occ.
96	Sibula, Lopez Jaena Mis. Occ.
97	Sibula, Lopez Jaena Mis. Occ.
98	Sibula, Lopez Jaena Mis. Occ.
99	Poblacion, Mutia Zamboanga del Norte
100	Mahayahay Lopez Jaena, Mis. Occ.
101	Mahayahay Lopez Jaena, Mis. Occ.
102	Dampalan Lopez Jaena Mis. Occ.
103	Tuyabang Alto, Oroqueta City
104	Pulanco, Zamboanga del Norte
105	Pulanco, Zamboanga del Norte
106	Magsaysay, Baliangao Mis. Occ.
107	Magsaysay, Baliangao Mis. Occ.
108	Magsaysay, Baliangao Mis. Occ.
109	Misom, Baliangao Mis. Occ.
110	Misom, Baliangao Mis. Occ.
111	Misom, Baliangao Mis. Occ.
112	Masubong, Sapang Dalaga, Mis. Occ.
113	Masubong, Sapang Dalaga, Mis. Occ.
114	Masubong, Sapang Dalaga, Mis. Occ.
115	Masubong, Sapang Dalaga, Mis. Occ.

Mother Tree	Origin
116	Masubong, Sapang Dalaga, Mis. Occ.
117	Masubong, Sapang Dalaga, Mis. Occ.
118	Masubong, Sapang Dalaga, Mis. Occ.
119	Masubong, Sapang Dalaga, Mis. Occ.
120	Dapacan Calamba Misamis Occidental
121	Dapacan Calamba Misamis Occidental
122	Dapacan Calamba Misamis Occidental
123	Dalirig, Manolo Fortich, Bukidnon
124	Dalirig, Manolo Fortich, Bukidnon
125	Minsapinit, Gingoog City Misamis Oriental
126	Liloy, Zamboanga Sibugay
127	Liloy, Zamboanga Sibugay
128	Liloy, Zamboanga Sibugay
129	Liloy, Zamboanga Sibugay
130	Bunawan, Agusan del Sur

mix of different mother trees.

used by Lacandula et al. (2017) and Łakomy and Iwańczuk (2010).

Gall rust incidence and severity assessment

All trees in each plot in the four blocks were assessed and inspected for the presence of gall rust fungus in the main stem, branches, and shoots. The percent incidence of gall rust disease was then computed for each plot by counting the total number of infected trees, divided by the total number of trees per plot and multiplied by 100. The incidence status was determined using the rating scale used by Palma et al. (2020) (Table 2).

Table 2. Rating scale for gall rust disease incidence per plot.

Percent Incidence	Status
<10	Rare
10 - <25	Occasional
25 - <50	Common
50 - <75	Very common
>75	Widespread

The severity of gall rust disease or the percent area of the whole tree infected by the disease was estimated using a scoring and rating system (Table 3) previously

Percent severity index of the disease was computed using the following equation:

$$\text{Severity index} = \frac{\text{sum of all the disease rating}}{\text{total number of ratings} \times \text{max. disease grade}} \times 100$$

Table 3. Rating scale of gall rust severity per tree.

Rating	Percentage of crown with galls	Qualitative Rating
0	No symptoms	Nil
1	< 10%	Low
2	11-25 %	Moderate
3	26-60%	High
4	> 60%	Critical

The assessment of gall rust incidence and severity in taller trees was conducted with the aid of binoculars (Figure 2).

Growth parameters measurement



Figure 2. Gall rust assessment in the Falcata field trial in Musuan, Maramag, Bukidnon. Inset (top right) is a photo of globose and elongated galls that formed on infected branches.

Total height (m) and diameter at breast height (dbh, cm) of all trees in each plot were measured using a clinometer and diameter tape, respectively. The volume of each tree expressed in cubic meters was then computed using the following equation:

$$\text{Tree volume (m}^3\text{)} = 0.7854 \times [\text{dbh (m)}]^2 \times \text{total height (m)}$$

Growth parameters measurement

Total height (m) and diameter at breast height (dbh, cm) of all trees in each plot were measured using a clinometer and diameter tape, respectively. The volume of each tree expressed in cubic meters was then computed using the following equation:

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Data analysis

Differences in the percentages of gall rust disease incidence and severity due to the effect of mother trees (treatments) were assessed using generalized linear mixed-effects model (GLMM) with a binomial distribution and default logit link function, applying the glmmTMB function in glmmTMB package (Brooks et al., 2017). The number of blocks or replicates were included as random effects in the GLMM models. To test the significance of the parameter in each model, a Wald Chi-squared test in car package (applying the Anova function) was carried out. Post hoc tests were conducted using the emmeans package (Lenth, 2018). All statistical analyses were performed in R software (R Core Development Team, 2018).

Differences in growth parameters (i.e., dbh, total height, and volume) of trees due to mother trees, gall rust

disease incidence and severity were modelled using linear mixed effect models (LMMs), applying the lmer function in lme4 package, with plots nested in replications as random effects. Volume data were log transformed prior to analysis to improve the residual fit of the model. Significance of the parameters in the LMM models was assessed using a Wald Chi-squared test and post hoc tests were conducted using the emmeans package.

RESULTS & DISCUSSION

Gall rust disease incidence

Mean percent incidence of gall rust disease varied among treatments ($W_2[129] = 191.53, P < 0.001$) and ranged from $15.0 \pm 5.0\%$ to $80.0 \pm 14.1\%$ or from an occasional to widespread incidence among treatments (Figure 3). Most trees or about 94% (i.e., 122 out of 130 mother trees) had common to very common incidence. The occasional incidence of gall rust in the study was observed in trees from mother trees number 48 ($15.0 \pm 9.57\%$), 99 ($15.0 \pm 5.0\%$), and 106 ($15.0 \pm 9.57\%$). On the other hand, the widespread incidence of gall rust disease was recorded in trees from mother trees number 30 ($80.0 \pm 8.2\%$), 74 ($80.0 \pm 8.2\%$), and 108 ($80.0 \pm 14.1\%$). The minimum incidence recorded in this study (i.e. $15.0 \pm 5.0\%$) was lower than the minimum incidence reported by Palma et al. (2020) for Falcata plantations in Misamis Oriental (Philippines) and by Lestari et al. (2013) for Falcata stands in Indonesia, which had mean incidence of 47% and 20.99 to 47.22% among trees examined, respectively.

Although the study site is located in an elevation (600 m asl) considered as prone to gall rust incidence (Lacandula et al., 2017; Paquit & Rojo, 2018), some trees still showed resistance to gall rust disease. Post hoc test revealed

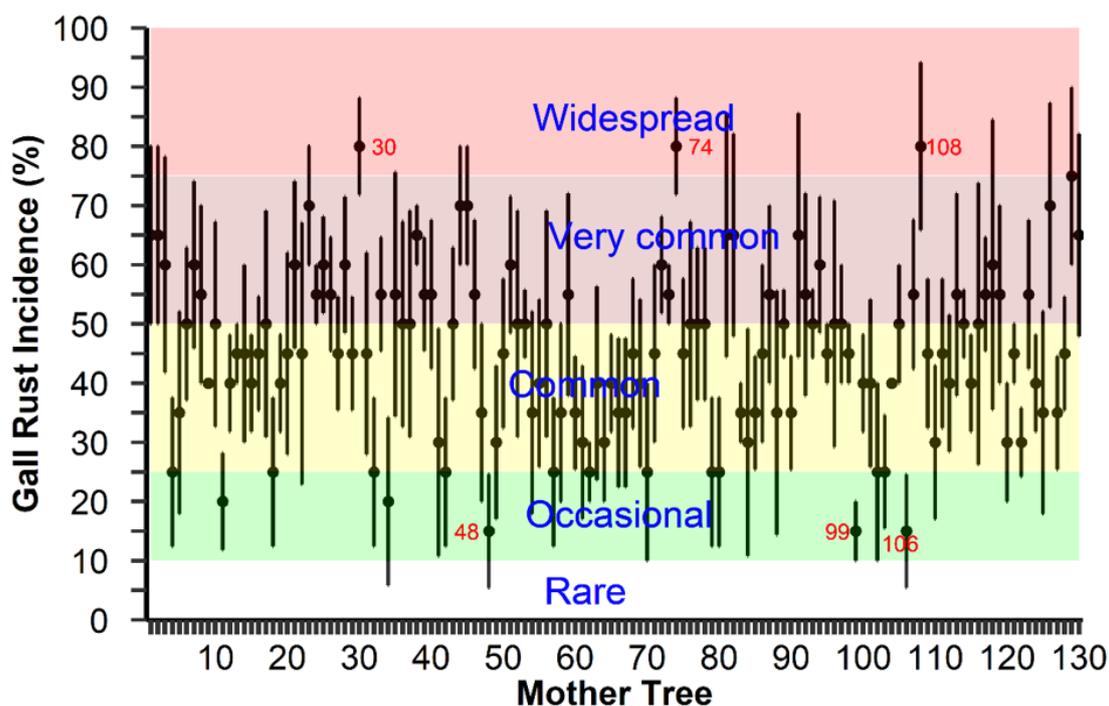


Figure 3. Mean gall rust disease incidence (%) in the Falcata progeny trial in Musuan, Bukidnon as influenced by mother trees. Numbers in red color represent the mother trees with the widespread (30, 74, and 108) and occasional (48, 99, 106) incidence level. Error bars represent \pm SE.

significant differences between trees with occasional and widespread incidence (Appendix Table 1), which may indicate resistance to gall rust infection particularly among trees with occasional incidence. These mother trees can be exploited for future breeding of resistant clones of *Falcata* in Mindanao, although it is possible that different mother trees from different sources or origins may vary in their susceptibility even if they are not completely resistant (Baskorowati et al., 2012). However, even partial resistance to the disease is critical to reduce the infections by the pathogen, increase the latency period, reduce the lesion expansion or sporulation, or any combination of these processes (Gullino et al., 2020).

Gall rust disease severity

Mean percent gall rust severity among treatments in the study ranged from low ($3.75 \pm 1.25\%$) to high severity ($35.0 \pm 16.95\%$) with most of the trees or more than 72% (i.e., 94 out of 130 mother trees) had moderate severity. Similar to incidence data, the severity of gall rust varied significantly among treatments ($W2[129] = 1512.76$, $P < 0.001$) (Figure 4), which also highlights the important influence of mother trees against gall rust infestation. Such variation is probably due to differences in the susceptibility of different mother trees in the trial – a likely indication of high genetic diversity among treatments. Low genetic diversity usually lead to a very 'high' or 'critical' gall rust disease infestation of all trees as observed in *Falcata* plantations elsewhere (cf. Rahayu et al., 2009).

In the present study, the lowest mean percent severity was observed in trees from mother trees number 34 ($5.00 \pm 3.54\%$), 99 ($3.75 \pm 1.25\%$), and 106 ($3.75 \pm 2.39\%$).

While the trees with high mean gall rust severity were observed from mother trees number 3 ($35.0 \pm 16.95\%$), 74 ($35.0 \pm 16.71\%$), and 81 ($35.0 \pm 12.25\%$). Interestingly, the severity observed in the study had not reached the critical level and was even lower than the severity reported by Rahayu et al. (2018) for *Falcata* plantations in Malaysia (10 to 80%). The result was comparable to the severity level (10.29 to 20.99%) of gall rust in *Falcata*-based agroforestry systems in Indonesia reported by Lestari et al. (2013) perhaps due to diversity of species planted which reduced the infection by the pathogen.

Aside from host and pathogen, environmental factors both aerial and edaphic have traditionally been considered to have the major impact on disease development (Keane & Kerr, 1997). Factors including topography, fog, age, altitude, humidity, and wind speed greatly influence the incidence and severity of gall rust (Rahayu et al., 2018). However, in this study, environmental factors may be similar since all samples were taken in one site. The variation in the severity of gall rust per mother tree can therefore be attributed to susceptibility or resistance of mother trees to the gall rust causing pathogen.

The most consistent mother trees in the present study in terms of low incidence and severity of gall rust infection were tree number 99 and 106, suggesting the more superior resistant traits of these mother trees against gall rust disease infection. These mother trees can be exploited in the long-term breeding for resistant clones of *Falcata*. Experience in other countries (e.g. Australia and India) with gall rust diseases in major plantation species suggests that without selection for resistant traits, breeding programs could result in highly susceptible population of

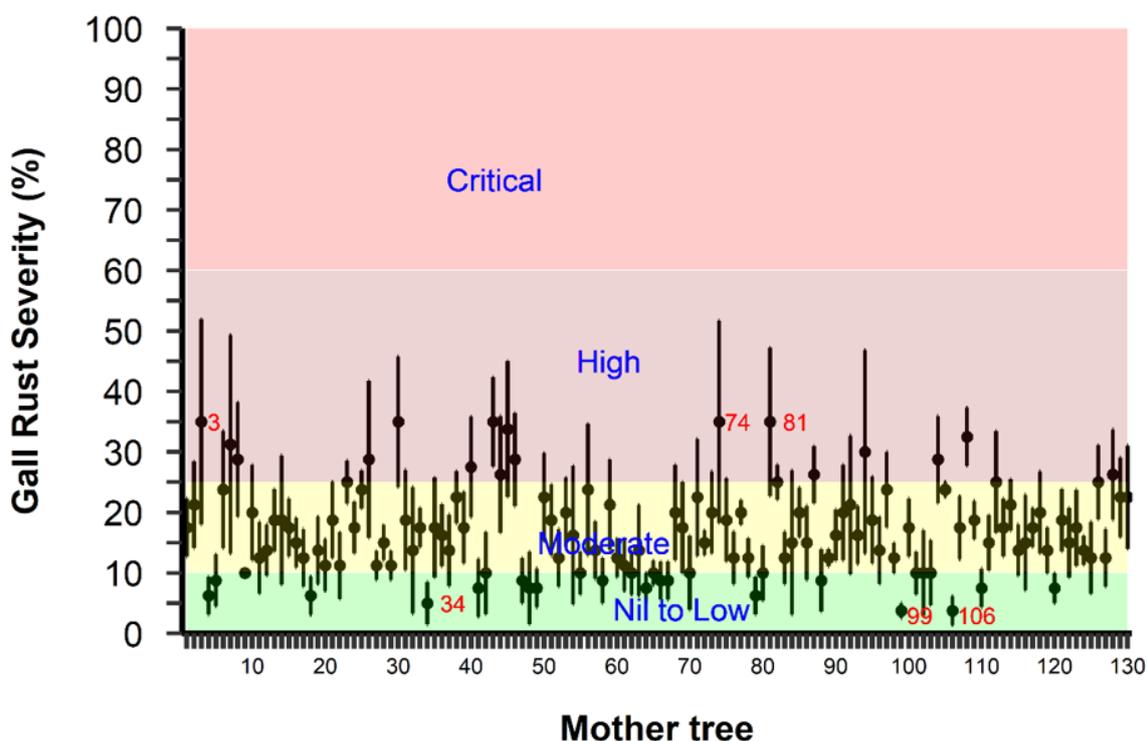


Figure 4. Mean gall rust disease severity (%) in the *Falcata* progeny trial in Musuan, Bukidnon as influenced by mother trees. Numbers in red color represent the mother trees with high (3, 74, and 81) and low (34, 99, 106) severity level. Error bars represent \pm SE.

trees (Old et al., 2000).

Influence of gall rust disease incidence, severity, and mother trees on growth

Total log(volume) (in cubic meters) of individual trees in the trial differed significantly but was due to the influence of gall rust incidence only ($W^2[1] = 16.56$, $P < 0.001$). There were no significant variations in tree log(volume) associated with treatments ($W^2[1] = 141.33$, $P = 0.216$) or gall rust severity ($W^2[1] = 3.71$, $P = 0.054$). Data on tree height and absolute diameter varied significantly due to treatments ($W^2[129] = 177.26$, $P = 0.003$) and gall rust incidence ($W^2[1] = 16.51$, $P < 0.001$). The severity of gall rust had also no significant effect on tree height ($W^2[129] = 2.90$, $P = 0.089$) and absolute diameter ($W^2[129] = 3.24$, $P = 0.072$).

Surprisingly, none of the mother trees that indicated resistant traits against gall rust infection had superior growth. Among the treatments, mother trees number 24 (Guinoyoran, Valencia City, Bukidnon), 35 (Tagpako, Gingoog City, Misamis Oriental), and 93 (Sibula, Lopez Jaena, Mis. Occ.) had the more superior height growth (Figure 5a), while mother tree number 35 had the

more superior diameter growth of all (Figure 5b). All these mother trees however had 'very common' incidence of gall rust infection that ranged between $50 \pm 5.8\%$ and $55 \pm 20.6\%$ suggesting that gall rust infection is not a concern for growth of mature Falcata trees. This result is supported by the relationship between growth parameters (volume, height and dbh) and incidence data, which indicated positive or better growth even at higher incidence of gall rust disease (Figure 6). While the influence of genetic diversity or variation in the present study still need to be verified, the result is consistent with the study of Baskorowati et al. (2012) that found strong positive relationship between growth (including diameter) and gall rust incidence in Falcata plantations in Indonesia. Baskorowati et al. (2012) explained that the positive relationship between growth and gall rust incidence in their study was likely due to the observed genetic variations among trees that included 80 families or mother trees. On the other hand, it is also likely that such positive relationship is indicative of the presence of growth and disease tolerance tradeoff i.e., trees need to grow bigger or better to compensate for any negative impacts from gall rust infection. However, this aspect needs to be assessed further via long-term observations of growth against the effect of gall rust disease as results in other studies (e.g. Lacandula et al.,

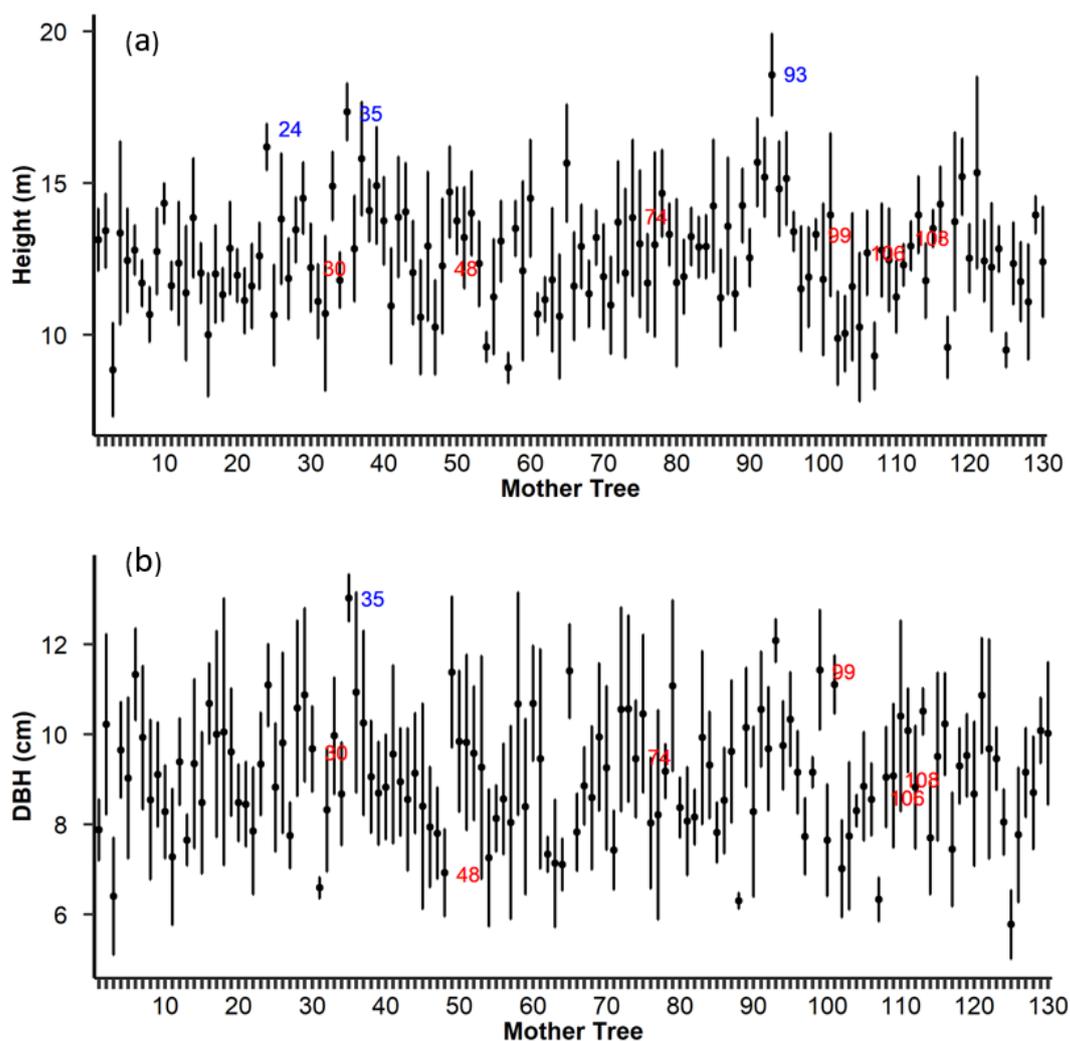


Figure 5. a) Mean total height (m) and b) mean diameter at breast height (cm) of Falcata trees from different mother trees. Also indicated are the mother trees with superior growth (blue number) and mother trees with low and high gall rust incidence (red number). Error bars represent \pm SE.

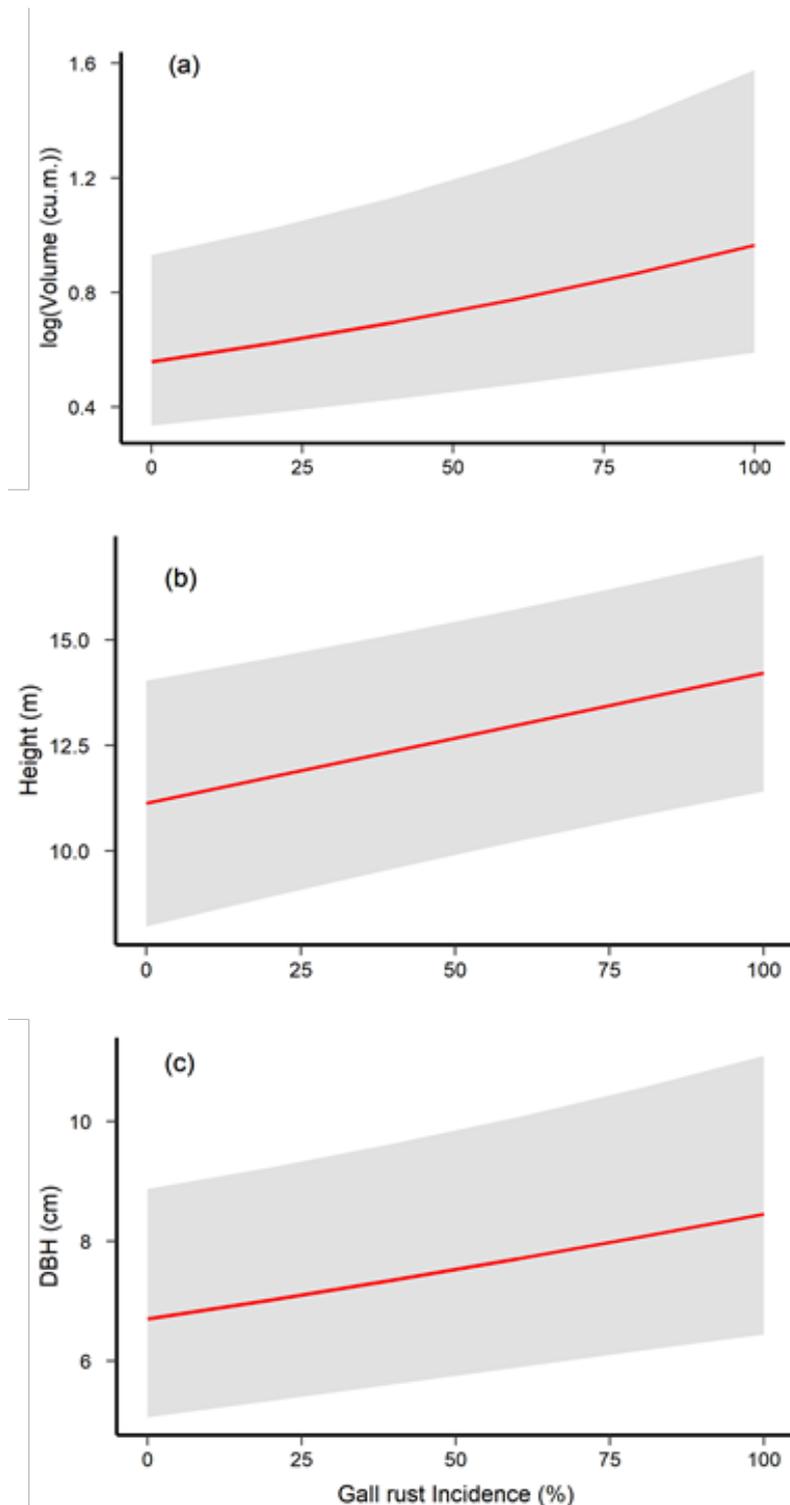


Figure 6. Fitted absolute growth of trees in the Falcata progeny trial in CMU as influenced by gall rust incidence (%): a) volume (m³), b) height (m), and c) diameter at breast height (cm). The area shaded with gray represents $1 \pm SD$.

2017; Rahayu et al., 2018) indicated negative relationship between incidence and diameter growth, although such differences are likely due to variations in age or density of planting. Previous studies observed gall rust disease to be host density dependent i.e., where the host is densely planted, incidence of mature trees could be up to 100% with severity increasing exponentially with increasing tree size (Wood, 2012). Nonetheless, the results of the study suggest that height or diameter at breast height may be used as criteria for selection of mother trees or provenances that are resistant against gall rust infection.

CONCLUSIONS AND RECOMMENDATION

The study demonstrated significant variations in incidence and severity of gall rust disease among the mother trees including the presence of gall rust resistant traits in trees with low incidence and severity of gall rust infection. Such variation was an indication of genetic diversity among mother trees in the study. Trees from mother trees number 99 (Poblacion Mutia, Zamboanga del Norte) and 106 (Brgy. Magsaysay in Baliangao, Misamis Occidental) emerged as the most resistant of all trees in the trial and can be exploited for future breeding

of resistant clones. Apart from these trees, a few more mother trees viz., mother trees number 48 (Hubang, San Francisco Agusan del Sur) and 34 (Maribucan, Gingoog City Misamis Oriental) also showed superior resistance to gall rust disease infection.

Growth performance (particularly height and diameter) was positively related to the independent influence of gall rust incidence and treatments (or mother trees), although none of the mother trees with resistant traits had superior growth. Among the treatments, mother trees number 24 (Guinoyoran, Valencia City Bukidnon), 35 (Tagpako, Gingoog City Misamis Oriental), and 93 (Sibula, Lopez Jaena Mis. Occ.) had the more superior height growth, while mother tree number 35 had the more superior diameter growth of all. All these mother trees had 'very common' incidence of gall rust infection suggesting that gall rust incidence is not a concern for the growth of *Falcata* trees in the study. The result provided an indication of the presence of growth and disease tolerance tradeoff where trees with higher gall rust incidence tend to grow bigger perhaps to compensate for any negative impacts from gall rust infection. However, this aspect needs to be assessed further via long-term observations (e.g., 10 years or one rotation period) as results in other similar studies indicated negative relationship between incidence and growth parameters, although such differences are likely due to variations in age or density of planting.

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Achieving Food Security during the Pandemic: A case of the Rural Women in the Upland Province of Bukidnon, Southern Philippines

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ABSTRACT

The growing number of people affected by hunger and food insecurity, especially during the pandemic, is one of the biggest challenges in the rural areas. A livelihood project was implemented from 2019 to 2021 among the 33 members of a women's association in a disadvantaged upland community in Bukidnon province, Southern Philippines, for inclusive development. This study aimed to determine the effectiveness of the livelihood intervention in changing income, knowledge about farming, social capital, and food security amidst the pandemic. The project implemented facilitated extension activities and surveys considering the health protocols imposed by the government. The technical training has resulted in a positive change in the knowledge level, promoted the production of vegetables in the households which generated additional income vital during the pandemic. Besides, there was a significant increase in the social capital of rural women during the last two years. Though not statistically significant, the project has caused an increase in food availability, accessibility, and utilization in the household during the pandemic. The findings indicated that a livelihood intervention can effect changes in the social and economic situation of the rural women even during the pandemic which could be promoted to other members of the community.

Keywords: food security, social capital, livelihood intervention, rural women, pandemi

INTRODUCTION

According to the United Nations Committee on World Food Security, a person is considered "food secure" when s/he has the physical, social and economic access to sufficient, safe and nutritious food based on his/her dietary needs and food preferences for an active and healthy life (OECD, 2021; IFRI, 2021). The FAO et al. (2020) reported however, that world hunger and malnutrition have grown with COVID-19 pandemic and related containment measures. Consequently, the pandemic negatively affected poor people's quality of diet and make healthy diets less accessible.

Food security, and therefore food insecurity, was generally recognized as multidimensional. Food insecurity started with the loss of jobs that happened during the pandemic, leading to significant decline of living standards. Poverty limited the ability of people to search for work which contributes to a long-term unemployment trap. Lack of income due to unemployment contributed to food insecurity and social exclusion problems (Toit et al., 2011). To be food secure, four (4) dimensions should be fulfilled simultaneously: physical availability of food; economic and physical access to food; food utilization; and stability throughout the time. A household or individual must have access to adequate food at all times and should not

risk losing this access due to sudden disturbances (e.g., an economic, health or climatic crisis), or cyclical events (e.g., seasonal food insecurity). Meade and Thome (2017) referred to stability as both the availability and access of food security.

The Food and Agriculture Organization (2010) recognized the increasing number of people suffering from hunger and food insecurity as one of the biggest challenges of the world population. In 2015, the Food and Agriculture Organization of the United Nations State of Food Insecurity (FAO-UNSF) reported that an unacceptably large number of people still lack the food they need for an active and healthy life despite the continues fight against hunger (FAO et al., 2015). In 2020, world hunger has increased to 9.9% from 8.4% under the shadow of the COVID 19- pandemic (FAO et al., 2020). Singh et al (2021) found that food insecurity was a critical problem among low-income and disadvantaged families during the COVID-19 pandemic.

Being one of the most populous countries globally,

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the Philippines is regarded as a country with inequality and vulnerability despite its middle-income status (DAFF, 2015). As agriculture production a priority program of the Philippine government, substantial resources were channeled towards the attainment of food security and agricultural efficiency. However, there were still many existing policy, and institutional constraints hindering the realization of a "food-secure" country (Cabanilla et al., 2006).

On the other hand, the idea of social capital has been considered an essential element of many community development strategies. The World Bank (2011) and Grootaert et al. (2004) identified six (6) dimensions of social capital: groups and network, trust and solidarity, collective action and cooperation, information and communication, social cohesion and inclusion and empowerment and political action. Putnam (2000) referred to social capital as the connections among individuals, social networks and the norms of reciprocity and trustworthiness that arise from them. Warren (2009) explained that a robust social capital provides a foundation for community organizing. However, Murphy and Cunningham (2003) argued that community organizing is effective if it includes and enhances existing social capital and social networks. Woolcock (2001) stressed that social capital as an asset must be recognized by theorists, policymakers, and practitioners in helping rural communities.

Bukidnon was identified as one of the 10 poorest provinces in the Philippines (PSA, 2015), having a poverty incidence of 54.1% (PSA, 2018). According to the Philippine Statistics Authority, the Bukidnon province has a poverty threshold level of Php10,503.48 and a food threshold level of Php7,334.58 in 2017 (PSA, 2018). Of the 20 towns of Bukidnon, Maramag township has a relatively low incidence

of poverty (47.90%), with about 30% of its households have income below the food threshold level. However, the 2017 survey has identified Barangay Kiharong as one of the poorest barangays in Maramag, with food and poverty threshold level lower than that of the provincial average. As such, Barangay Kiharong was identified as a Geographically, Economically and Socially Disadvantaged (GESDA) community with a poverty incidence of 64.90%, and a low food threshold level among 54.2% of its households. The barangay has 1,588 population at 52:48 male-female sex ratio (CBMS Core Indicators, Barangay Kiharong, 2017).

The Department of Science and Technology (DOST), through the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD) has funded the S&T Community-based for Inclusive Development (STC4iD) through the Community-based Livelihood Improvement for Bukidnon or Project CLImB in Barangay Kiharong, Maramag, Bukidnon in Southern Philippines for three (3) years starting 2019 through the College of Agriculture of Central Mindanao University (CMU) similarly situated in Bukidnon. It was a demonstration of an extension delivery service in a disadvantaged community, and social group in the agriculture, aquatic and natural resource (AANR) sector for inclusive development by establishing a sustainable and resilient community-based livelihood. Swanson (2008) reported that improving livelihoods requires extension and advisory services to be more carefully focused on the needs of different clientele within the rural communities. The extension activities sought to enhance the efficiency of the farm by increasing production and improving the standard of living of the farm family. Extension does not only seek to improve the productivity, but also develop farmers' abilities to direct their future development.

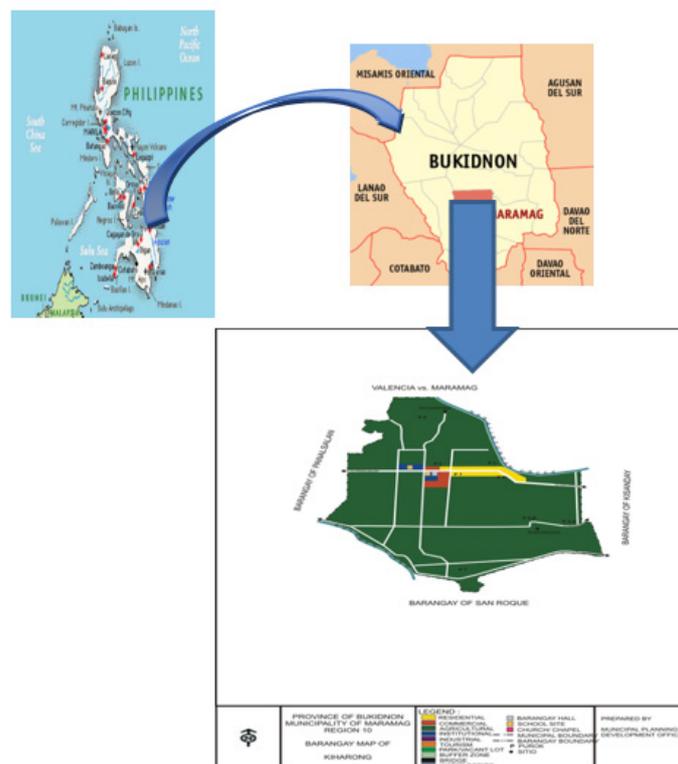


Figure 1. Map of the Philippines showing the location of Brgy. Kiharong

It is therefore, necessary to assess the effectiveness of the livelihood intervention of the Project CLImB in achieving food security among the members of the Kiharong Women's Association, especially during the pandemic. Specifically, this paper sought to describe the socioeconomic attributes, and changes in the knowledge level in farming, income, social capital and food security of the rural women during the pandemic particularly food availability, food accessibility, food utilization, and food stability.

METHODOLOGY

As shown in Figure 1, the Project CLImB was implemented in Barangay Kiharong, Municipality of Maramag, province of Bukidnon in close coordination with the concerned local government and the Kiharong Women's Association (KWA). The KWA was registered with the Department of Labor and Employment (DOLE) in 2016 with 53 women members.

Surveys on the socioeconomic attributes of women, social capital and food security were conducted in 2019 and 2020 using purposive sampling from the 33 KWA members who participated in Project CLImB. Data were analyzed descriptively, while t-test was used to determine significant differences between indicators before and during the pandemic.

In early 2019, community profiling and community needs assessment was conducted among randomly selected residents of Barangay Kiharong and validated through focus group discussion with the local officials and officers of the KWA. The KWA officers and the local government officials identified five (5) livelihood interventions viz: organic vegetable gardening, vermicomposting, mushroom production, Natural Farming Technology System (NFTS), and goat production. Technical training along with the identified livelihood interventions was conducted among the 33 KWA women participants by the Project CLImB in mid-2019. The percentage change in the knowledge level was measured using pretest and post-test given before and after the conduct of training by the Project CLImB staff.

Besides, the KWA women developed an enterprise development plan for mushroom production in 2020 and established the communal vegetable garden and individual backyard home garden starting the third quarter of 2019. These backyard home gardens were done through vertical gardening using recycled materials because of the very limited area. In 2020, two (2) KWA members received two (2) pregnant does each for goat production. The Project CLImB has provided agricultural inputs to the KWA members in terms of seeds, seedlings, vermicompost, and inoculated fruiting bags for mushroom production. On the other hand, the KWA women provided the farm labor as their counterpart. The activities in the communal garden were highly affected, while home gardening started during the lockdown in April 2020 with the onset of the rainy season. Monthly revenue from the home gardens was based on the actual monetary value of all vegetables harvested, either consumed, sold or given as determined by the KWA members and retrieved every end of the month by the Project staff. No cost and return analysis was done as agricultural inputs were provided free thus, taken as non cash expenses. Revenue from the communal garden and mushroom center was used for their continued operation and not included in the findings of the study.

On the other hand, the six dimensions of social capital including groups and network, trust and solidarity, collective action and cooperation, information and communication, social cohesion and inclusion and empowerment and political action were measured following the World Bank Social Capital-Integrated Questionnaire (Grootaert et al., 2011) using indicators answerable by a 1 to 5 scale and described through weighted means.

The food security questionnaire which consisted of food availability, accessibility, utilization and stability was adapted from the US Household Food Security Survey Module (ERS, 2012). This comprised a revised series of questions about behaviors and experiences associated with difficulty in meeting food needs of the KWA household. Figure 2 shows the conceptual framework of the study indicating the social preparation, facilitated extension intervention and community enterprise implemented to establish a sustainable, and resilient community-based livelihood among the women farmers in a Geographically, Economically and Socially Disadvantaged (GESDA)

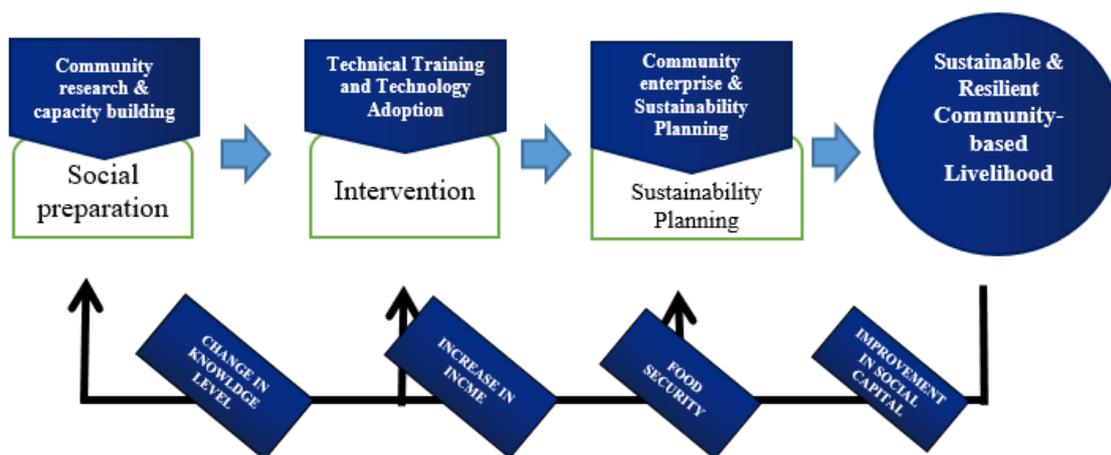


Figure 2. The Framework of the Study

Table 1. Socioeconomic Attributes of the KWA Women

ATTRIBUTES	Results (n=33)	
	Mean	%
Marital status:	Married	91%
Age	46 years old	
Household size	5 members	
Educational attainment:		
High school graduate		27%
College graduate		21%
Ethnic Origin: Cebuano (Central Philippines)		89%
Main occupation/source of income: Farming		93%
Household Monthly income	2019	2020
	Php6,583.64 (US\$ 131.67) (Php50:US\$1)	Php8,536.70 US\$170.73 (Php50:US\$1)

Table 2. Income Realized from the KWA Women’s Home Garden, July-December 2020

MONTH (2020)	Average Monthly Income (Php) (n=33)
July	648.75
August	495.50
September	541.56
October	462.54
November	469.83
December	541.38
Overall Mean	526.59

community. The effectiveness of a sustainable and resilient community-based livelihood through Project CLImB is dependent on the changes in the knowledge level, income, social capital, and food security in the women farmers attributable to the activities of the project.

RESULTS AND DISCUSSION

Socioeconomic Attributes of KWA Women

From the survey, majority (91%) of the KWA women were married, 46 years old with five (5) household members. They have attained primary education, with some of them graduated from high school (27%) and college (21%). Most of them were migrants from Central Philippines (89%). Their primary source of income was farming (93%), where they obtained less than US\$200 a month in 2020 (Table 1), which was lower than the poverty threshold of the province. In comparison, the KWA women obtained a monthly income of Php6,583.64 (US\$131.67) in 2019 which was 29% lower than in 2020.

Increase in Income from Vegetable Gardening

In 2019, the KWA women have an annual income of Php6,583.64 without the home garden. In 2020, the KWA women realized an annual income of Php8,536.70

with the home garden. From July to December 2020, the KWA women realized a mean monthly income equivalent to US\$10.52 (US\$1: Php50) from their home gardens based on the actual value of vegetables consumed, given, and or sold (Table 2). This income was considered as early economic gain generated by the KWA women from Project CLImB. The additional monthly income from gardening represented 27% of the total increase in their household income in 2020. The findings means that vegetable gardening provided opportunities for women to engage in economic activities despite the pandemic.

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in economic activities despite the pandemic.

This also suggested that despite the pandemic, the women were able to produce food for their household and generate an additional income for their other needs.

Change in Knowledge Level in Farming

Table 3 depicted a positive change in the knowledge level of the KWA women in all the technical training conducted by Project CLImB, particularly in mushroom production (30%) and vermicomposting (23%). The results suggested that the women were more interested in mushroom production and vermicomposting than rapid composting and goats health and nutrition. The findings indicated that the training has enhanced the knowledge of the women in farming which facilitated the adoption and practice of these technologies in their community and home gardens. Moreover, the women have reported having shared their knowledge in farming gained from the training with their neighbors and friends, suggesting networks and potential diffusion of the technologies necessary to sustain the livelihood intervention in the locality.

Change in the Social Capital of the Kiharong Women's Association

In this study, social capital was taken as the social ties between and among KWA women, developed through constant interaction which is considered as a social asset. Table 4 demonstrated an overall increase of 9.76% in the social capital of the KWA women in the last two years (2019-2020). Of the six dimensions of social capital, the KWA women perceived an improvement in their groups and network (15.47%), information

and communication (14.09%), and trust and solidarity (11.23%). The result indicated that the women were able to establish linkages and continue information-sharing even during the pandemic. However, empowerment and political action received the slightest increase of 0.6%, while social cohesion and inclusion have the highest mean score of 4.63. Understandably, the pandemic has limited the local political activities and the participation of the women in these activities, though they were able to maintain the connection with their group and members. The t-test results showed a highly significant difference in groups and networks, trust and solidarity, information and communication, and social cohesion and inclusion before and during the pandemic. The findings showed an increase in collective action, trusts, togetherness, and access to information and communication that helped strengthen the bonds that link each member of the KWA together especially during the pandemic. Based on the comments of the KWA members, Project CLImB has united the group and improved the relationship between and among members.

The Extent of Food Security among the Kiharong Women's Association Members Before and During the Pandemic

Food Availability

In this study, food availability was considered as the sufficient quantities of appropriate quality of food in the KWA household supplied locally or imported. Table 5 showed a minimal increase in the food availability among the KWA members before (overall mean: 4.0) and during (overall mean: 4.1) the pandemic. The t-test result does not show significant difference in food availability of the KWA households before and during the pandemic. Nevertheless,, the women were able to provide three meals a day, the needs and wants of their children, mid-snacks twice a day,

Table 3. Change in the Knowledge Level of the KWA Women from the Technical Training Conducted by the Project CLImB

TRAINING CONDUCTED	Mean Pre-test Score (n=33)	Mean Post Test Score (n=33)	% change
Vermicomposting	5.89	7.26	23.26
Natural/Rapid Composting	6.25	7.25	16.0
Mushroom Production	6.83	8.89	30.16
Goats' Health & Nutrition	6.25	7.25	16.0

Table 4. Change in the social capital of KWA, 2019 and 2020

INDICATOR	MEAN		P (T<=t) two-tail	Descriptive Rating
	2019	2020		
Groups and Networks	3.75	4.33	2.56352E-05**	Highly Significant
Trust and Solidarity	3.74	4.16	0.0027782**	Highly Significant
Collective action and Cooperation	4.00	4.18	0.021232227ns	Not Significant
Information and Communication	3.62	4.13	0.003910232**	Highly Significant
Social cohesion and Inclusion	4.17	4.63	0.004080169**	Highly Significant
Empowerment and Political action	3.50	3.52	0.932432888ns	Not Significant

** p≤0.01

ns- not significant

Table 5. Extent of Food Availability among the KWA Members in 2019 and 2020

INDICATOR	WEIGHTED AVERAGE	DESCRIPTIVE RATING	WEIGHTED AVERAGE	DESCRIPTIVE RATING
A. Availability	2019 (n=33)		2020 (n=33)	
1. My family does not eat three meals a day.	4.9	Never	5.0	Never
2. My family does not prepare kits with complete kinds of medicine.	4.0	Rarely	4.2	Rarely
3. I cannot provide the needs and wants for the children.	4.0	Rarely	4.2	Rarely
4. I cannot provide mid-snacks twice a day for my family.	4.0	Rarely	3.7	Rarely
5. I cannot provide the go, grow and glow foods for my family.	4.0	Rarely	3.6	Rarely
6. I cannot assure that my family could eat meat twice a week.	3.0	Occasional	3.9	Rarely
7. In the last 12 months, my family cannot afford to buy imported goods.	4.0	Rarely	3.8	Rarely
8. In the last 12 months, my family did sleep at night hungry because there was not enough food.	5.0	Never	5.0	Never
9. In the last 12 months, my family had a tightened food budget.	4.0	Rarely	4.0	Rarely
10. I am worried that my household would run out of food.	3.0	Occasional	3.1	Occasional
OVERALL MEAN	4.0	Rarely	4.1	Rarely

P (T<=T) two-tail 0.61054214^{ns}

Ns - not significant

Legend:

4.51-5.00 Never or it happened once only

3.51-4.50 Rarely (it happens 2-3 times)

2.51-3.50 Occasionally (it happens 4-5 times)

1.51-2.50 Often (it happens 6-7 times)

1.00-1.50 Always (it happens 8 or more times)

Food Secure At All Times

Rarely Food Insecure

Occasionally Food Insecure

Oftentimes Food Insecure

Food Insecure At All Times

and go, grow and glow foods for their households. They rarely ate meat and bought imported goods during the pandemic.

In terms of food sources, t-test result showed significant difference in the sources of food among the KWA women before and during the pandemic (Table 5). The KWA women obtained food from their farms and home gardens with decreasing dependence on the public market. The income obtained from their farm and labor provided monetary source to buy food for the household from the market and local sari-sari store.. They also sourced food from their locally raised livestock and chicken.. The findings showed that the KWA women relied heavily on domestic food sources for their household. The results suggested more food sources among the KWA households during the pandemic than before, implying an increase in food availability with the livelihood intervention of Project CLImB.

Food Accessibility

This study considered food accessibility as the ability of the KWA women to obtain adequate resources to acquire appropriate food for a nutritious diet. Data in Table 6 revealed no significant difference in KWA women's access

to food in 2019 and 2020. However, the KWA members observed an increase in their food accessibility in 2020 . In particular, the KWA members have access to information on the proper sanitation at home, nutrition-related programs in the barangay, balanced meal during the last 12 months, and a whole day meal. Though not statistically significant, the increasing access to food among the KWA members during the pandemic could be attributed to their home gardens which started in mid 2020.

Food Utilization

This study defined food utilization as the proper biological use of food in a diet of the KWA members with sufficient energy, nutrients, potable water and sanitation. The data in Table 7 showed no significant difference in 2019 and 2020 in terms of food utilization in the KWA households.. The data however revealed that the KWA members were rarely food insecure in 2019, and were food secured at all times during the pandemic in 2020 in terms of food utilization. In particular, the KWA members utilized pure and clean water, safe and right amount of food for their healthy children. The livelihood intervention of Project CLImB has to some extent increased the food utilized by the household during the pandemic.

Table 5. Sources of Food for the Households, Before and During the Livelihood Intervention

INDICATOR	Before Project CLImB (2018) %	During Project CLImB (2019-2020) %
Own farm	48	91
Own livestock and poultry	52	55
Public market	76	67
Local shop/sari-sari store	88	88
Labor/wage	21	21
Household garden	-	60
P(T<=T) two-tail	7.28886E-08**	
** p≤0.01		

Table 6. Extent of Food Accessibility among KWA Members Before and During the Pandemic

INDICATOR	WEIGHTED AVERAGE	DESCRIPTIVE RATING	WEIGHTED AVERAGE	DESCRIPTIVE RATING
	2019 (n=33)		2020 (n=33)	
B. Accessibility				
1. My children do not have access to weekly child care from the barangay health station.	4.7	Never	4.1	Rarely
2. My family does not have access to information regarding proper sanitation at home.	4.0	Rarely	4.6	Never
3. My family does not have access to nutrition-related programs in the barangay.	4.0	Rarely	4.3	Rarely
4. In the last 12 months, my family had not afforded to eat a balanced meal.	4.0	Rarely	4.9	Never
5. In the last 12 months, my family did not eat for a whole day because there wasn't enough money for food.	4.0	Rarely	5.0	Never
6. In the last 12 months, my family does not have access the free medical check-up.	4.8	Never	4.5	Rarely
7. In the last 12 months, my family does not have sufficient money to provide for all of our needs.	4.0	Rarely	4.2	Rarely
8. In the last 12 months, my children do not have access to feeding programs in the school.	4.2	Rarely	4.2	Rarely
OVERALL MEAN	4.2	Rarely	4.5	Rarely

P (T<=t) two-tail 2.364624252^{ns}

NS - not significant

Legend:

4.51-5.00 Never or it happened once only

3.51-4.50 Rarely (it happens 2-3 times)

2.51-3.50 Occasionally (it happens 4-5 times)

1.51-2.50 Often (it happens 6-7 times)

1.00-1.50 Always (it happens 8 or more times)

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Oftentimes Food Insecure

Food Insecure At All Times

Table 7. Food Utilization among KWA Members Before and During the Pandemic

INDICATOR	WEIGHTED AVERAGE	DESCRIPTIVE RATING	WEIGHTED AVERAGE	DESCRIPTIVE RATING
C. Utilization	2019 (n=33)		2020 (n=33)	
1. My family does not get water from pure and clean water.	4.7	Never	5.0	Never
2. My family suffers from getting a wise food.	4.0	Rarely	4.0	Rarely
3. My family feels uncomfortable with the safe food intake.	4.0	Rarely	5.0	Never
4. My family does not follow the recommended proper nutritional requirement.	4.0	Rarely	4.0	Rarely
5. My family does not eat the right amount of food necessary to the body.	4.0	Rarely	4.8	Never
6. I am not assured that my children have healthy condition.	4.0	Rarely	4.8	Never
7. I do not have adequate and updated information on basic nutritional facts from the health station.	5.0	Never	3.8	Rarely
8. In the last 12 months, my children suffer from illnesses due to improper food intake.	4.0	Rarely	4.9	Never
9. In the last 12 months, I did not experience illnesses due to food toxicity.	5.0	Never	4.0	Rarely
OVERALL MEAN	4.3	Rarely	4.5	Rarely

P (T<=t) two-tail 0.532032136 ^{ns}
 NS - not significant

Legend:

4.51-5.00 Never or it happened once only	Food Secure At All Times
3.51-4.50 Rarely (it happens 2-3 times)	Rarely Food Insecure
2.51-3.50 Occasionally (it happens 4-5 times)	Occasionally Food Insecure
1.51-2.50 Often (it happens 6-7 times)	Oftentimes Food Insecure
1.00-1.50 Always (it happens 8 or more times)	Food Insecure At All Times

Food Stability

To be food secure, the KWA household must have access to sufficient food at all time. The data in Table 8 showed no significant difference in the food stability among the KWA women before (2019) and during the pandemic (2020). During both years, there was high stability in the money to buy the required quality and quantity of the food in the household. The findings suggested that the KWA members have rarely experienced food instability before, and during the pandemic.

Overall, the findings indicated that while the food was stable among the KWA members before and during the pandemic, food was more available, accessible and utilized during the pandemic than before, though not statistically different. The findings further implied that during its short period of implementation, Project CLImB has endeavored to increase the amount of food as well as the access and utilization of food among the KWA members, especially during the pandemic.

Effectiveness of the Livelihood Intervention to Improve Food Security among the KWA Women during the Pandemic

Being identified as a GESDA community, the DOST-PCAARRD through Project CLImB has provided livelihood intervention to improve food security among the members of the Kiharong Women's Association since 2019. Though it is quite early to find significant differences in the food security of the KWA brought about by the livelihood intervention, the data indicated positive outcome attributable to Project CLImB despite the social and economic disturbances brought about by COVID-19. The World Bank (2021) has recognized the severe and widespread global food insecurity due to COVID-19, which affected the vulnerable households in almost every country, which may continue through 2022. The health crisis has caused a reduction in incomes and increase in the prices of some foods, putting food out of reach for many, and undermining the right to food (Committee on World Food Security, 2020). With the loss of jobs and

income, and limited access to food brought about by the pandemic (Kim et al (2020)), Project CLImB was able to provide additional source of food for the rural poor. As food access was most affected by the crisis triggered by lockdown which similarly influenced food stability in the market (HLPE, 2020), the home garden of the KWA women served as source of food for their households.

In addition, the findings showed that the facilitated extension activities of Project CLImB have increased the knowledge on farming and generated additional income of the KWA households. These preliminary outcomes indicate the effectiveness of the livelihood intervention, and its potential sustainability in the project site. The 2008 FAO report reiterated the significant role of agriculture in achieving food security in the country, particularly in the rural areas. The ability of family farming and smallholder agriculture to promote growth by increasing productivity differs, however it is critical in reducing poverty and hunger. Change in family farming and smallholder agriculture has significant effects on the livelihoods of the poor by increasing food availability and income (FAO et al., 2015). Food production is an essential prerequisite for food security (Misselhorn et al., 2012) which includes home and

community gardens (Singh et al., 2021). With new global food security challenges, Elias & Jambor (2021) argued for a stronger emphasis on poverty reduction and raising the wages of low-income households.

Livelihood Intervention Improved the Social Capital of KWA Amidst the Pandemic

The study results demonstrated a significant difference in the social asset of the KWA before and during the pandemic. The findings indicated a favorable influence of the livelihood interventions on the social capital of rural women. With the capacity-building and technical training conducted by Project CLImB, the KWA women experienced an improvement in their collective action,, common trust, access to information and communication, social unity and togetherness within the association in 2020, despite the social restrictions during the health crisis. Vegetable gardening has made the neighborhood closer with the sharing of information as well as their harvest. The result suggested that Project CLImB's activities have enhanced the trust and developed the bonds between, and among the KWA members.

Table 7. Food Utilization among KWA Members Before and During the Pandemic

INDICATOR	WEIGHTED AVERAGE	DESCRIPTIVE RATING	WEIGHTED AVERAGE	DESCRIPTIVE RATING
D. Stability	2019 (n=33)		2020 (n=33)	
1. The food that I bought just did not last and I didn't have money to get more.	4.3	Rarely	4.7	Never
2. I am worried that our food would not run out before we got money to buy more.	4.0	Rarely	3.5	Often
3. My family does not provide long-term and nutritious quality food.	4.0	Rarely	4.5	Never
4. My children do not have monthly check-up from our barangay health station.	4.0	Rarely	4.0	Never
5. In the last 12 months, my family skips meals because there was not enough food.	5.0	Never	4.8	Never
6. In the last 12 months, my family felt hungry because we couldn't afford enough food.	5.0	Never	4.9	Never
7. In the last 12 months, my family eats a smaller meal than we felt we needed because there was not enough food.	5.0	Never	5.0	Never
OVERALL MEAN	4.5	Rarely	4.5	Rarely
P (T<=t) two-tail	0.916007505 ^{ns}			
NS - not significant				
Legend:				
4.51-5.00	Never or it happened once only	Food Secure At All Times		
3.51-4.50	Rarely (it happens 2-3 times)	Rarely Food Insecure		
2.51-3.50	Occasionally (it happens 4-5 times)	Occasionally Food Insecure		
1.51-2.50	Often (it happens 6-7 times)	Oftentimes Food Insecure		
1.00-1.50	Always (it happens 8 or more times)	Food Insecure At All Times		

The training conducted by the Project increased their knowledge about farming, and the sharing of information with neighbors strengthened their bond as a community. Woolcock (2001) explained that friends and family comprise the safety net during hard times. Similarly, Abad (2005) observed that Filipinos often rely on a network of family and close friends to fulfill needs and reach goals. With access to information, poor communities have a stronger voice in matters affecting their welfare (World Bank, 2002). Woolcock and Narayan (2000) stressed that fellowship, sympathy and social interaction help structure a unit within society. They argued that social capital accumulates when a neighbor contacts other neighbors to satisfy social needs.

The effect of social capital on increasing the availability of food in the KWA household was critical, especially during the pandemic. Liang et al. (2018) observed that each dimension of social capital has a significant and positive impacts on the economic performance of cooperatives. Recent studies promoted econometric analysis to demonstrate quantifiable effects of social capital on economic outcomes (Engbers et al., 2016). In general, the findings indicated that social capital helps the KWA address the problem of food security, especially during difficult time. Conversely, economic activities improve the social capital of the KWA. To Woolcock (2001), communities with strong social networks and civic associations will be in a better position to address poverty and vulnerability and, or take advantage of new opportunities. Social relationships between KWA members enable productive outcomes as trust increases their ability to work together (Hutagalung, 2016). Thus it is critical that the activities of the poor are not only spread, but are also scaled up (Woolcock, 2001). McCabe et al. (2013) confirmed that social networks are essential in surviving poverty.

CONCLUSION

The KWA women were middle-aged mothers of large households who attained primary education with income below the poverty, and food threshold levels. Amidst the pandemic, the Project CLImB has implemented a livelihood intervention which provided food and income and improved the knowledge of the women about farming. These activities made them more trusting, cohesive, cooperative and informed. Overall, the project's activities significantly enhanced the social capital of the Kiharong Women's Association. Consequently, the social capital increases the efforts of KWA members to generate additional income for their households. Though not statistically significant, the livelihood intervention of Project CLImB has resulted to an early increase in food availability, food accessibility and food utilization among the KWA women especially during the pandemic. These preliminary and early results showed the effectiveness of, and provided potential indicators for, the sustainability and resiliency of the community-based livelihood intervention of Project CLImB.

RECOMMENDATION

The increase in the food security among the KWA

women may indicate the need to sustain the activities of the project in the locality beyond its lifetime. There is a need to upscale the technologies promoted by the project to other members of the community outside of the Kiharong Women's Association. Adoption of these technologies may be facilitated by issuing a local ordinance by the Barangay Council enjoining the local people to establish home gardens using local and indigenous materials. As part of the sustainability plan, the Central Mindanao University should include Barangay Kiharong in its extension areas, particularly after the termination of PCAARRD support. This effort could help sustain the livelihood intervention established by Project CLImB in the barangay and strengthen the extension activities of the University.

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Grammatical Deviations As Features Of Philippine English In Local Newspaper Editorials

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ABSTRACT

This study identified the grammatical features of Philippine English in local newspaper editorials. Specifically, the study determined the frequency of occurrence of deviant cases in terms of subject-verb agreement, articles, and prepositions. Through non-probability sampling, a total of forty-five (45) editorials were retrieved from the websites of three local newspapers and were interpreted and analyzed to identify grammatical deviations. To ensure the validity of the deviations found in the editorials, the researcher, along with three grammar raters, verified all the texts that contained the grammatical deviations. The specifics of the frequency counts showed that most of the deviations in subject-verb agreement were due to the use of a special noun (collective, clausal), while most of the deviant cases in article usage were associated with a missing definite article. For preposition usage, most of the deviations were linked to a missing preposition. Grammatical deviations as features of Philippine English in local newspaper editorials is a manifestation that a certain variety of English can be used as a medium to relay information and influence people's opinions within a specific context.

Keywords: data analysis, grammatical deviation, grammatical feature, newspaper editorial, Philippine English

INTRODUCTION

Jenkins et al. (2017) believes that the English language has been formed and adapted by Asians, both linguistically and culturally. English has become a global language; hence, it is no longer exclusive to countries where it is used as a first language. This idea shows that English is the lingua franca that Asians use and share with the rest of the world as a second language or foreign language. Such a language phenomenon has paved the way for the development of Asian Englishes such as Singaporean English, Brunei English, and Malaysian English. In the Philippines, according to Yumol-Florendo (2012), due to the existence of bilingualism and multilingualism, the use of English along with other local languages has led to the emergence of a more innovative variant of English called Philippine English. Bautista (2000) defines Philippine English (PhE) as a nativized variety of English that is used by Filipinos in different sectors of society. Such a variety of English has syntactic features which deviate from and are unique to the standards such as American English, British English, and other World Englishes.

Rañoso-Madrurnio (2004) asserts that certain varieties of English such as Philippine English and Singaporean English possess unique syntactic features. The study of Rañoso-Madrurnio (2004) was geared towards identifying linguistic signals such as personal reference pronouns, modal verbs, attitudinal or evaluative adjectives, and passive constructions occurring in the written texts of the aforementioned varieties of English. The findings showed that the letters of complaint to editors as published in Philippine Daily Inquirer and Straits Times illustrated syntactic features which deviated from the standard

American English.

In an earlier study conducted by Bautista (2000), she claims that nonconformities to Standard American English are present in the corpus of Philippine English data. Bautista (2000) states that the deviations need to be identified from published material produced by people of a certain status and educational background. The deviations, as studied by Bautista, are the grammatical features of Philippine English in written texts. The common grammatical features are deviations in subject-verb agreement, article usage, and preposition usage.

Aside from the deviations identified by Bautista (2000), the study of Dita (2009) determined another type of grammatical deviation as a feature of Philippine English. Dita (2009) investigated how adverbial disjuncts are used in Philippine English grammar. The study was based on the Philippine component of the International Corpus of English (ICE). Dita discovered that the usual positions for most disjuncts are initial, medial, and final. Examples of these disjuncts are adverbs that end in *-ly* such as *apparently*, *surprisingly*, and *unfortunately*. The syntactic feature of adverbial disjuncts in Philippine English also reveals deviant cases from the standard American English.

The existence of the distinctive features of Philippine English has evolved through time. Grammatical deviations are not only apparent in printed materials but also in online texts. Such a claim is supported by the study

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of Esquivel (2019). Tweets were analyzed to highlight the distinctive features of Philippine English in a digital age. Specifically, the tweets were examined for lexical and grammatical features, and comparative analyses were made to characterize the features of Philippine English as a dialect of International English. Through textual analyses, the results showed that prominent lexical, grammatical, and linguistic features such as localized spellings, syntax, translated idioms, and innovated lexical items were evident.

As an extension of the previous studies on Philippine English, the researcher considers the relevance and the significance of conducting a study on grammatical deviations as features of Philippine English in written texts. The researcher believes that written texts, specifically local newspaper editorials, which can be accessed online, exhibit certain grammatical features that can influence a reader's perspective on how the English language can be structured in a particular context.

Shahzada, Mahmood & Uzair (2012) believe that newspapers display language variation of a certain culture. Due to such variation, newspapers can display a language variant, and the variation that causes differences is a basis in "institutionalizing a variety of English" (Hinkel, 2011). By carefully looking at language use in newspaper editorials, specifically grammatical deviations, a specific variety of English can be identified.

Newspapers are intended to communicate messages. A certain style of language must be applied to aid, interest, and persuade readers. Due to such strategy, certain linguistic features such as grammar can be observed in sentence construction. Consequently, the existence of grammatical features of a certain variety of English in newspapers is due to the influence of local languages and how local newspaper writers approach the audience in

using the English language. Also, the nonconformities to native norms of English can contribute a certain degree of influence on the language of newspaper readership (Shahzada et al., 2012).

Though newspapers can manifest grammatical features of a language variant, still, a newspaper includes an organization of word structures and grammatical means to inform, entertain, and even persuade people. According to Farrokhi & Nazemi (2015), editorial writers have the means of utilizing a variety of language devices in constructing texts. Such a perception implies that when it comes to persuasion, newspaper editorials can greatly influence readers. Since written language is used in giving comments and opinions as well as drawing conclusions, the nature of grammatical constructions can also influence the readers.

Considering the role of newspapers in shaping a certain variety of English, the researcher recognizes the need to study the grammatical features of Philippine English in local newspaper editorials. Based on the framework of Bautista (2000) on Philippine English as used in this study, the common grammatical features of Philippine English in written texts are deviations in subject-verb agreement, article usage, and preposition usage. Therefore, this study is of great significance in understanding and appreciating the distinctive features of Philippine English that are unique to other English varieties.

The Theoretical-Conceptual Framework of the Study

Figure 1 shows the flow of study. The study is anchored on Kachru's (1997) Theory on World Englishes and Kachru's (2005) Concentric Circles of Asian Englishes. Kachru's (1997) Theory on World Englishes affirms the fact that the English language has been used as a global

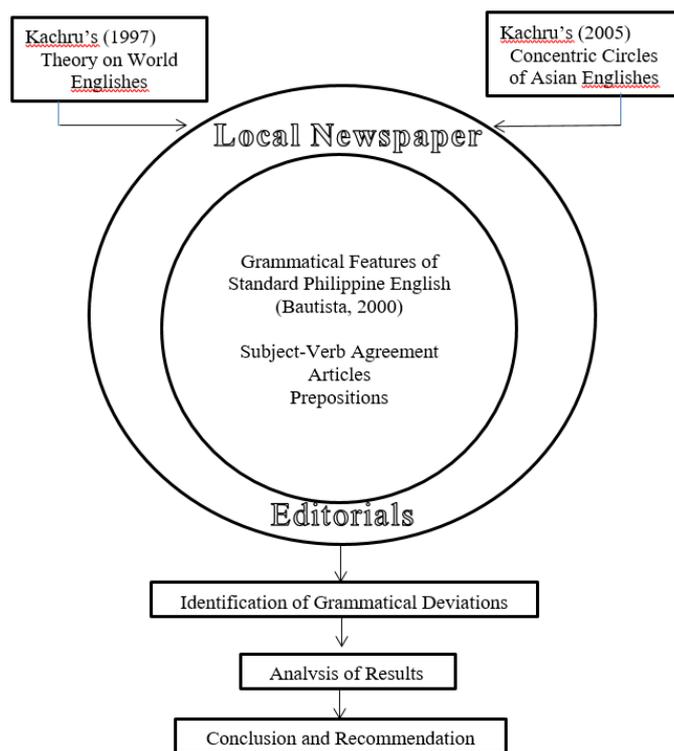


Figure 1. Theoretical-Conceptual Framework of the Study

language for communication. English is not only the language among native speakers but also a lingua franca used by different nationalities worldwide. Kachru's (2005) Concentric Circles of Asian Englishes, on the other hand, recognizes the spread of English in Asian countries through colonization and the acknowledgement of English as an international language. The English language in these countries plays an important second language or foreign language role in chief institutions in a multilingual setting. From the perspective of the two frameworks, non-native speakers of English have used the language according to the demands of their culture that have been influenced by colonization.

Kachru (1997) asserts that while native speakers of English may take ownership of the language, the vast majority of the people around the world who use English as a second language may claim ownership of English based on how it is used in their respective cultures. Similarly, Tupas (2004) believes that there are more people in the world who use English as their second language than those who use English as their native language. Such a claim suggests that second language speakers have contributed to the development of World Englishes including Asian Englishes such as Singaporean English, Malaysian English, Sri Lankan English, Indian English, and Philippine English. Each English is distinct since it has evolved from a unique culture and a different historical experience. The English language, therefore, takes on many functions and features depending on the contexts of their use.

In the Philippines, one of the most significant contributions to the concept on World Englishes is the work of Ma. Lourdes S. Bautista (2000) on Philippine English. Based on her own study of a large corpus of data produced by 'educated' Filipinos, Bautista has come to the conclusion that Philippine English, which has certain grammatical features, does exist. Based on Bautista's (2000) model on Grammatical Features of Standard Philippine English, editorials from local newspapers were carefully studied to identify grammatical deviations in terms of subject-verb agreement, article usage, and preposition usage. The results were analyzed to come up with conclusions and recommendations.

The Purpose of the Study

The study determined the grammatical features of Philippine English in local newspaper editorials anchored on Bautista's (2000) model.

Specifically, this study provided answers to the following questions:

1. What is the frequency of occurrence of deviant cases in terms of the following grammatical classifications:
 - 1.1. subject-verb agreement;
 - 1.2. articles; and
 - 1.3. prepositions?
2. What is the frequency of occurrence of deviant cases in terms of the following grammatical classification types:
 - 2.1. subject-verb agreement;
 - 2.1.1. special noun (clausal, collective, amount, mass),
 - 2.1.2. pronoun antecedent,

- 2.1.3. indefinite pronoun,
- 2.1.4. compound subject, and
- 2.1.5. relative clause antecedent
- 2.2. articles; and
 - 2.2.1. missing indefinite article,
 - 2.2.2. missing definite article, and
 - 2.2.3. wrong article
- 2.3. prepositions.
 - 2.3.1. wrong preposition,
 - 2.3.2. missing preposition, and
 - 2.3.3. inserted preposition?

METHODOLOGY

By adopting a non-probability convenience sampling, a total of 45 editorials were retrieved from the websites of three local newspapers. The editorials contained 400 to 450 words on average, and covered various topics such as politics, business, and social environment. Specifically, 15 covered politics, 15 discussed issues on business, and 15 dealt with social environment concerns. For research ethics, the names of the three local newspapers, the details of the editorials, and the writers' profiles were kept confidential.

Data analysis was done to identify grammatical deviations in subject-verb agreement, articles, and prepositions. To ensure the validity of the deviations found in the editorials, the researcher, and three grammar raters who have doctoral degrees in English Language Teaching (ELT) verified all the sentences containing the grammatical deviations. The three grammar raters had an interrater reliability score of 82% as assessed by an external statistician. According to McHugh (2012), most texts recommend 80% as the minimum acceptable interrater agreement. Such a notion proves that the deviations found in the editorials as identified by the three grammar raters were valid and reliable.

Each of the editorials was subjected to four rounds of careful analysis. The first, second, and third readings were to identify deviations in subject-verb agreement, articles, and prepositions, respectively. The fourth reading was intended to recheck all the identified deviations and corresponding grammatical classifications. To properly guide the researcher and the three grammar raters in verifying the deviations found in the editorials, Celce-Murcia & Larsen-Freeman's (1999) *The Grammar Book* and Rosal's (2010) *Communication Arts* book served as references. After a series of deliberations, the researcher and the three grammar raters came up with a list of deviations. The results were then presented in tabular form showing the frequency and the percentage of the type of deviations on grammatical classification found in the local newspaper editorials.

RESULTS AND DISCUSSION

The following tabular presentations reveal the grammatical features of Philippine English that are evident in the editorials of the three local newspapers.

Table 1 shows that the deviations found in the editorials of the three local newspapers fall in the

Table 1 Number of Deviations Found for Each Grammatical Classification

Grammatical Classification	Number	Percent
Subject-Verb Agreement	14	35
Articles	20	50
Prepositions	6	15
Total	40	100

Table 2 Number and Percentage for Each Type of Subject-Verb Deviation

Type of Subject-Verb Deviation	Number	Percent
Special noun (clausal, collective, amount, mass)	4	29
Pronoun antecedent	4	29
Indefinite pronoun	2	14
Compound subject	2	14
Relative clause antecedent	2	14
Total	14	100

classification of Articles (49%), followed by Subject-Verb Agreement (34%) and Prepositions (17%).

The correct use of articles is a challenge for English language learners. Shoebottom (2013) states that there are four options to consider in determining the right article to use because in some cases a certain article is not necessary, which makes the correct use of article complicated. Also, the use of articles, according to Sun (2016) creates confusion among ESL learners because their first language (L1) does not have the same article system with their second language (L2). For instance, Filipinos do not use the indefinite articles *a* and *an* and the definite article *the* in their local languages.

Regarding subject-verb agreement, it is tricky because of some intervening words in a sentence that cause confusion in identifying the subject and the verb. One must make subject, and verb agree when words come between them, and reach agreement especially when the subject is an indefinite pronoun (Norquist, 2019). Moreover, according to Corral (2017), the difficulty on establishing correct agreement between subject and verb can be attributed to the fact that the learners' first language does not have definite rules on subject-verb agreement. To point out, in the local languages of the Philippines, there is no rule which states that a singular subject requires a singular verb, or in some cases the verbs do not change even their subject is singular or plural.

Preposition usage, on the other hand, requires knowing the relationship of words in the sentence. Alwan & Yosuf (2019) state that "prepositions are not limited to meaning expressed by nouns; instead, they go beyond to include the meanings that been conveyed by adverbs and adjectives such as wh-questions: how, where, when, why, who among others" (p.36). Prepositional phrases, for instance, can function as noun modifiers, as adverbials, and as complements to adjectives or verbs. In addition, according to Tanpoco et al. (2019), the use of English prepositions is confusing for most Filipinos since prepositions in L1 are very few compared to L2 that can have varied uses. For instance, the prepositions *in*, *on*,

and *at* can be used in three different ways to indicate the position of an object: *in a corner*, *on a corner*, and *at a corner*. On the contrary, in L1, the three combinations can be structured using the preposition *sa*, as in *sa sulok*.

Table 2 reveals that most of the deviations in subject-verb agreement are due to the use of a special noun and a pronoun antecedent. Each of the two types of subject-verb deviation registers a deviation of 29%. Here are some examples of the deviations:

1. What people say about them, even maliciously and intentionally, do [does] little to distract the purpose...
2. No wonder the Catholic Church is struggling to be relevant to the youngest of their [its] flock.

The other deviant cases are linked to indefinite pronoun, compound subject, and relative clause antecedent. Each of the three types of subject-verb deviation constitutes 14% of the total deviation. The following are some of the deviations:

3. Anyone with a fear of or a disdain of numbers would be swamped by the Rama administration's proposed allocations for *each department* and *projects* [project].
4. Anyway, *Pe* and *Osmeña* (*Pe* can't defend himself and has been quiet all along until *Osmeña* came to his aid) wants [want] the matter resolved...
5. But it's not only some media people that has [have] gone overboard but so too some priests and Catholic faithful.

The deviations in subject-verb agreement can be attributed to the proximity of the subject to the verb or vice-versa and the presence of an intervening expression or phrase between the subject and the verb.

The use of a special noun and a pronoun antecedent is at times confusing. Especially when used in long sentences, the placement can lead to a challenge in determining the singularity or plurality of the subject. An indefinite pronoun should agree with the noun right after it, while a compound subject automatically takes the plural

form of the verb.

According to Nurjanah (2017), the English language has its own patterns that complicate the rules on subject-verb agreement. Moreover, one must be careful with dealing with trickier cases in subject-verb agreement most especially when the subject is an indefinite pronoun or when words or phrases come between subject and verb such as intervening expressions and modifiers (Nordquist, 2019).

The findings as presented in Table 2 reaffirm the claim of Nurjanah (2017) and validate the idea of Nordquist (2019).

As shown in Table 3, the deviations in article usage are due to a missing definite article (90%), while each of the use of a wrong article and a missing article constitutes a minimal deviation of 5%. Some of the deviations are as follow:

1. Not every comment about [a] *people* carries the gene of *racism* in it.
2. This time, [the] *police* said the likely motive was a rejected business proposal...
3. ...the young ones who sleep on the sidewalks, beg for alms from passing motorists, sing for money in jeepneys, or worse, rob from pedestrians, sniff Vulcaseal to get a [the] high and be oblivious to *the* pangs of hunger or are picked up by players in child trafficking.

Incorrect article usage can be associated with the uncertainty of a noun's indefiniteness or definiteness. According to Gaibani (2015), deviations in the correct use of articles are due to deletion and substitution. This observation suggests that the presence or absence of an article before a noun can make the latter general or specific. Moreover, Shoebottom (2013) states that the correct use of an article is challenging because there are instances when an article is not necessary. This perception implies four options to consider in using the correct articles, which makes it more confusing.

As presented in Table 3, the findings support the

Table 3 Number of Deviations Found for Each Type of Article Usage

Type of Article Usage Deviation	Number	Percent
Missing indefinite article	1	5
Missing definite article	18	90
Wrong article	1	5
Total	20	100

Table 4 Number of Deviations Found for Each Type of Preposition Usage

Type of Preposition Usage Deviation	Number	Percent
Wrong preposition	2	33
Missing preposition	3	50
Inserted preposition	1	17
Total	6	100

study of Gaibani (2015) and the idea of Shoebottom (2013).

Table 4 shows that 50% of the preposition usage deviations are associated with an incorrect preposition. On the other hand, using a wrong preposition and an inserted preposition comprises the remaining 33% and 17% of the deviations, respectively. The following are the sample deviations:

1. In Cebu, at least two libel cases in court are a result of alleged defamatory postings *in* [on] Facebook.
2. Each camp has its justifications for drafting a budget [in] a particular way.
3. ...which led to the Oct. 25 arrest of another Korean trader who allegedly wanted to collect *on* [null] a P4 million gambling debt.

Preposition usage deviation can be linked to the nature of Standard American English in which verbs can co-occur with prepositions as in phrasal verbs and idiomatic expressions such as *think of*, *fill in*, and *come up with*. In addition, a certain preposition can have a lot of uses, which causes confusion in identifying the right preposition to use in the right context.

Monaikul & Di Eugenio (2020) believe that second language writers tend to commit errors in the use of preposition due to interlingual errors. This is due to the fact that the target language has a diverse set of prepositions. Furthermore, prepositions can have different meanings depending on the relationships of words in a sentence. According to Alwan & Yosuf (2019), prepositions are not limited to pairing up with nouns but they can also express different meanings when structured with adverbs and adjectives.

The findings as shown in Table 4 validate the ideas of Monaikul & Di Eugenio (2020) and Alwan & Yosuf (2019).

CONCLUSION AND RECOMMENDATION

Due to the use of English as a second language, variations from the standard American or British English are apparent in Philippine context (Tupas, 2004). Filipinos

manage to accommodate the norms of the standard English, at the same time, establish a sort of independence from the standards of the native speakers which results in grammatical deviations. These grammatical deviations are simply variations from the prescribed grammar of a native speaker; however, are considered to be features of Philippine English because such variations are acceptable, recognized, and used by educated Filipinos (Bautista, 2000). In reference to this study, the common grammatical features identified are deviations in the correct uses of subject-verb agreement, articles, and prepositions. These features are observable because second language writers use English with a broad set of rules and structures that can result in inconsistencies in grammatical construction. Moreover, the production of English is influenced by the transfer of knowledge in the first language to the target language that can lead to interlanguage errors.

Though these features are deviations from the standard, they still keep the sense of the editorials in place without compromising the writers' views. Such a claim is supported by the views of Gibbs & Pollard (2020) that small grammatical deviations do not interrupt the delivery of meaning. Therefore, having a precise grammar based on a certain standard is not necessary to fully convey an idea. The presence of grammatical features in local newspaper editorials manifests that a particular variety of English can be used as a medium to relay information and influence people's opinions within a specific context. Since the editorials used in this study are localized, the grammatical features of Philippine English in written texts may vary by regional location. English is used in the different parts of the Philippines. Each region has its local languages, contributing to grammatical deviations in disseminating information and influencing people's opinions.

The grammatical deviations are features of Philippine English (Bautista, 2000). In the context of this study, the familiarity of the rules on subject-verb agreement and the correct uses of articles and prepositions can help second language writers and learners understand the grammatical features of a culture's English variety that is significant in relaying and understanding information. By developing a sense of critical language awareness, learners are able to gain respect and appreciation to other English varieties helping them develop their communicative competence (Chabo, 2021).

As an extension of this study, research that identifies Philippine English's grammatical features in social media posts may be conducted. Social media is a platform that enables people to express their views and opinions on specific topics allowing them to influence other people's perspectives. Esquivel (2019) claims that distinctive features of Philippine English in a digital age are evident. Moreover, studies that determine grammatical features as well as phonological features in oral transcripts such as speeches, commentaries, debates, and other forms of oral presentation that can be live or recorded may be undertaken. These types of communication can also impact the way people shape their thoughts and beliefs about certain issues. Tayao (2004) and Villanueva (2016) state that Philippine English doesn't only possess grammatical features but also exhibits phonological features.

Since the researcher of this study is involved in language instruction, the existence of grammatical deviations as features of Philippine English can pose certain pedagogical and curricular implications. Madrunio (2010) emphasizes that it is significant for English teachers to teach their students the unique features of Philippine English and compare them with the standards of American English and other varieties. English teachers should emphasize to their students the distinction between "deviation" and "feature". By making students aware of such language phenomenon, English language learners are able to understand the grammatical features of their first language as well as those of the target language. In addition, the teaching and application of grammar rules in the classroom that involves corrective feedback should be observed for students to effectively learn and master the grammar rules of the target language. Through feedback, errors are identified; hence, deviations as features are recognized. Finally, language teachers should educate students that Philippine English may not be taken as an inferior version of the standard English. Instead, Philippine English is now considered as a variant of the English language that is accepted, recognized, and used by a certain speech community.

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Peri-pandemic Physical Activity in Southeast Asia: A Narrative Review

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ABSTRACT

To stifle widespread transmission of the COVID-19 virus, Southeast Asian governments initiated lockdowns and quarantines that severely limited human mobility and people's engagement in healthful and sufficient physical activity (PA). What was the state of PA in Southeast Asia during the pandemic? This narrative review answered this major question by reviewing relevant studies identified through a keyword search in online research databases, the results of which were then filtered according inclusion criteria and topic relevance before the final set of articles were summarized and synthesized. The findings of 13 studies, covering only five Southeast Asian nations, make up the bulk of this narrative review. Some of the studies reported associations between PA and mental health (especially anxiety and depression), health literacy, Health-Related Quality of Life, and sleep. Other studies discussed the use of technology for PA, problems related to physical activity, and the importance of PA to the elderly during the pandemic. More studies need to be done about peri-pandemic PA, particularly about the factors, systems, and technologies affecting PA levels and sedentary behavior from pre- to peri-pandemic periods so that stakeholders can improve maintenance-level PA, preserve increased PA levels, increase PA levels where such have decreased, and keep sedentary behavior low all throughout. Peri-pandemic sedentary behavior also needs more attention, since physical inactivity and sedentary behavior, although distinct from each other, usually accompany each other, are correlated, and have significant impact on human health.

Keywords: physical activity, sedentary behavior, COVID-19, pandemic, Southeast Asia

INTRODUCTION

Every human being needs to maintain a certain level of physical activeness to reap the health benefits of physical movement (U.S. Centers for Disease Control and Prevention, 2021). Living an active life contributes much to physical and mental health, promotes overall well-being, and improves one's quality of life (Nowak et al., 2019; Velten et al., 2018). Physical activity, for example, is associated with lower risks of depression, anxiety, and other mental illnesses (Hu et al., 2020). It is also said to provide short- and long-term benefits for mood and sleep (Chan et al., 2019; Wang & Boros, 2021).

Unfortunately, the COVID-19 pandemic has thrown the whole world into disarray and has greatly affected many people's normal ways of living. Attempts to contain the virus and prevent further widespread transmission compelled many Southeast Asian countries to restrict human mobility by enforcing curfews, quarantines, and lockdowns (AseanTodayTV, 2020). Such restrictions also had the real potential to severely limit people's usual pre-pandemic physical activities.

The World Health Organization provides a very simple definition of physical activity — "any bodily movement produced by skeletal muscles that requires energy expenditure" (2020, para. 2). How much health-maintaining physical activity to engage in per day or per week depends on one's age and health or physical

conditions (e.g., pregnancy and postpartum period, chronic conditions, and disabilities). The recommended amount or level ideally combines both moderate- and vigorous-intensity physical activities. One is considered physically active if she or he meets at least the minimum recommended amount of physical activity for one's age and/or condition.

Even during a stressful and restrictive period such as the COVID-19 pandemic, people should still strive to reach at least the minimum levels of physical activity for their population grouping, or else they might not receive the health benefits that sufficient physical activity can bring and that they will need to navigate successfully through the stresses of the pandemic.

How have the COVID-19 pandemic and the community responses to it (e.g., lockdowns) affected Southeast Asians' engagement in physical activity and exercise? Were they able to maintain their levels of physical activity as before the pandemic, or did the standstill provide them more time to be physically active? What adaptations did people make to their usual physical activities just to achieve the recommended amount? How did their levels

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of peri-pandemic physical activity affect other aspects of their health? What factors or variables made Southeast Asians increase, decrease, or maintain their engagement in sufficient physical activities? These kinds of questions prompted me to carry out this narrative review. In a nutshell, I wanted to find out what the current literature at that time said about the general state of physical activity, especially people's performance of it, among Southeast Asians during the COVID-19 pandemic.

METHODOLOGY

This study is a non-systematic review, better known as a narrative review, the purposes of which are to objectively identify and summarize current knowledge of a topic based on what has already been published about it and to determine aspects of the topic that existing research has not addressed (Ferrari, 2015; Green et al., 2006). Consequently, readers will find in such a review a comprehensive and contextualized overview of the topic. The Methods or Methodology section is optional for narrative reviews, but its presence in the narrative review can clarify the key messages of the review article (Ferrari, 2015). Further, since bias is more prone to manifest in the

literature search process (i.e., the "Methods") of a non-systematic review might use – is recommended (Ferrari, 2015). My narrative review employed such a structured approach.

Although no standardized or acknowledged guidelines have been established for narrative reviews, I tried to increase the study's objectivity and lessen the possibility of bias by incorporating some of the features from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses, better known as the PRISMA (Page et al., 2021), as a general guide and framework. The PRISMA flow of information consists of several phases: identification of sources, screening of records, retrieval of reports, assessing eligibility of reports, and inclusion of reports. My study's process followed a similar path, as shown in Figure 1.

The first step identified potential sources from the research databases ERIC, PubMed, ProQuest, and Scopus. The key concepts of the study's topic became primary keywords for the search; other topic-relevant keywords synonymous with the primary ones were also used. Every search session used a combination of the concept or

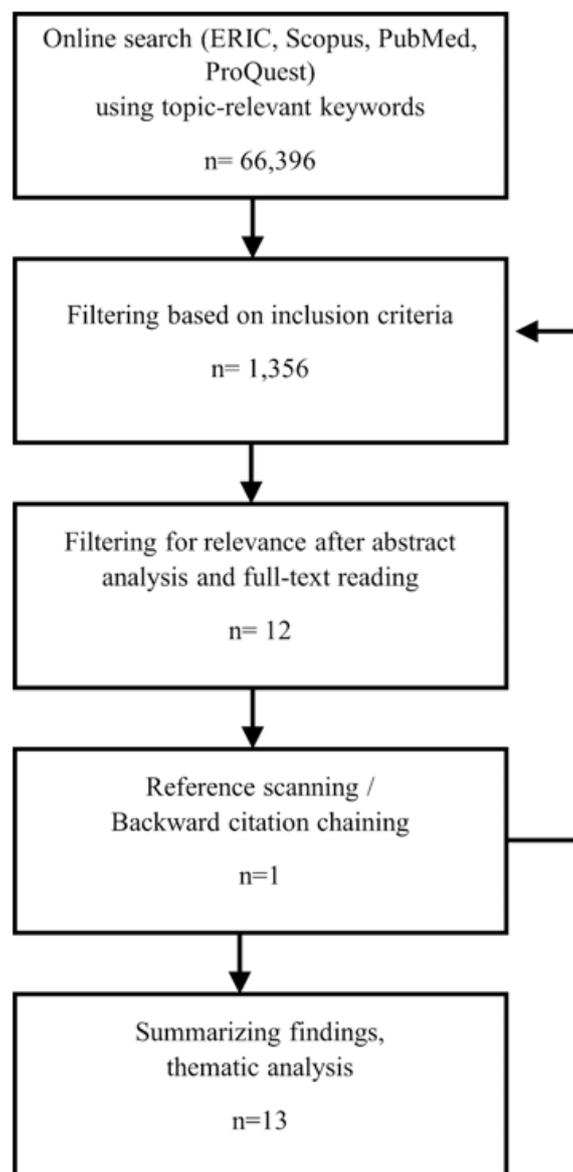


Figure 1 Studies selection and filtering process in the narrative review.

topic-relevant keywords and the names of the Association of Southeast Asian Nations members: "physical activity," "exercise," "pandemic," "COVID," "Southeast Asia," "Brunei," "Myanmar," "Cambodia," "Timor-Leste," "Indonesia," "Laos," "Malaysia," "Philippines," "Singapore," "Thailand," and "Vietnam." The same keyword combinations were used for each of the databases accessed.

This study originally intended to limit its scope to only the Philippines, but after the initial search was done, not one article fit the study's selection criteria. So the net had to be cast wider, resulting in the expansion of the study's coverage to the whole of Southeast Asia. The expanded database search produced 68 results from ERIC, 20 results from PubMed, 70 results from Scopus, and 66,238 results from ProQuest - a total of 66,396 hits.

The second step narrowed down the initial set of sources according to several selection criteria. Abstracts only (without accessible full text), previews, preprints, letters to the editor, and the like were excluded. Only full-text peer-reviewed journal articles published online in English from 2020 (i.e., the start of the pandemic) to May 12, 2021 (last day of searching) were selected for relevance screening in the third step. Because they did not meet the inclusion criteria, 65,025 items were discarded, leaving a total of 1,373 candidates for possible inclusion. Although the review and publication process made it impossible to extend the last day of searching, the narrative review of the articles published within the limited period can sufficiently provide a snapshot of the general state of physical activity in Southeast Asia, albeit only during the limited period.

In the third step, an assistant evaluator and I screened out any source that did not explicitly include or discuss physical activity as a study factor or variable, or was not directly or exclusively about it. In other words, we screened the sources for relevance and pertinence to the topic of this narrative review. We did this by first assessing whether the article title showed relevance. If so, we then checked the abstract, and if it also showed relevance, we finally examined the whole article. If the full article was found relevant, it was considered eligible for inclusion. This was the only step in the process where an extra hand was used.

After assessing 1,373 candidates, only 12 were found relevant and pertinent to the study topic, and, thus, suitable for inclusion. The references of these sources were also mined for other additional sources that fit the inclusion criteria for this study. One more source was found in the citation chaining process, thus bringing this study's total number of sources to 13.

In the fourth and last step of the process, the findings from the final set of sources were then summarized and synthesized. The discussion is organized according to topics that recurred across several sources. The next section presents the results of the summarization and synthesis.

RESULTS AND DISCUSSIONS

Table 1 lists the 10 member states of the Association of Southeast Asian Nations (ASEAN) and the authors of studies related to peri-pandemic physical activity in those countries.

Peri-pandemic State of Physical Activity in Southeast Asia

The studies reviewed in this paper presented non-uniform findings about the changes to pre-pandemic and peri-pandemic physical activity engagement among Southeast Asians. Some authors reported an observed increase in physical activity levels during the pandemic; others reported a decline. Yet, some others reported sustained levels of physical activity. No sources were found for Brunei, Cambodia, Laos, Myanmar, and the Philippines under the search parameters used in this study.

Indonesia.

Thahir et al. (2020) found that only 43.9% of their study's participants (undergraduate and postgraduate students) performed moderate to vigorous physical activities during the pandemic, while the rest of the 56.1% engaged in little to no physical activities during the pandemic. Of those who did moderate to vigorous physical activities, 21.8% did exercise only, 39.3% did house cleaning only, and 38.9% did both exercise and house cleaning. On average they exercised for 4.03 (± 2.12) days for 31.39

Table 1 Study authors on peri-pandemic physical activity in ASEAN states

Country (n=10)	Studies Found (n=13)	Authors
Brunei	0	
Cambodia	0	
Indonesia	2	Anggraini, 2020; Thahir et al., 2020
Laos	0	
Malaysia	3	Ibrahim et al., 2021; Jailani et al., 2020; Murukesu et al., 2021
Myanmar	0	
Philippines	0	
Singapore	1	Lim et al., 2021
Thailand	3	Katewongsa, Potharin, et al., 2021; Katewongsa, Widyastari, et al., 2021; Topothai et al., 2020;
Vietnam	4	Do, Nguyen, et al., 2020; Do, Tran, et al., 2020; Nguyen et al., 2020; Tran et al., 2020;

(±33.04) minutes each time. These figures from the study do not indicate whether the physical activity levels of Indonesians during the pandemic increased, decreased, or remained the same. Neither do they indicate whether the amount of physical activity performed was sufficient (i.e., reached the recommended daily or weekly minimum amount).

Malaysia.

Murukesu et al. (2021) studied the physical activity patterns, psychosocial well-being, and coping strategies of 42 community-dwelling elderly individuals ≥60 years old with cognitive frailty during the lockdown period (a.k.a. Movement Control Order period) in Malaysia during the COVID-19 outbreak. The study's respondents were also participants of the randomized control for the WE-RISE intervention, which consisted of multi-component physical exercises, cognitive training, nutritional counseling, and psychosocial support all intended to reverse cognitive frailty among the elderly (Murukesu et al., 2020).

Participants in the intervention group spent significantly higher MET-minutes per week (metabolic equivalent task scored in minutes per week) in walking activities and performed more moderate physical activities (e.g., cycling, lifting light weights, gardening, and other moderate exercises) during the lockdown than those in the control group (Murukesu et al., 2021). The three-month home-based component of the WE-RISE program may have facilitated the development of independent exercise habits among the participants (Murukesu et al., 2021). The participants' exposure to WE-RISE may have increased their knowledge of the importance of an active lifestyle, and this increased awareness could have motivated them to engage in some form of physical activity at home during the lockdown (Murukesu et al., 2021).

In contrast, the control group spent more time per week in passive activities (e.g., sitting or lying down) than the intervention group did during the lockdown; that is, the control group exhibited engaged in more sedentary behavior than did the intervention group. Moreover, about 9.5% of those in the control group reported the onset of back pain, which they did not have before the lockdown. Studies have shown that mobility restrictions tended to increase the elderly's likelihood to engage in sedentary behavior, which has been associated with chronic back pain among the elderly.

Even before the COVID-19 pandemic, the elderly have usually been the least physically active members of the population and could hardly meet physical activity guidelines tailored for them. So, there is little reason to expect them to increase their physical activity during the pandemic. The decrease in physical activity and the increase in sedentary behavior among the elderly during the lockdown in Malaysia, particularly in the study's control group, could be attributed to the mobility restrictions imposed by the Malaysian government in response to the COVID-19 pandemic (Murukesu et al., 2021), potentially hampering the management of these elderly people's cognitive frailty, further degrading their functionality, or causing further disability over time if allowed to persist

continuously.

Singapore.

The cross-sectional survey by Lim et al. (2021) found that Singaporean school children's time spent on physical activity decreased from an average of 1.13 hours pre-lockdown to 0.91 hours during the lockdown. The reduction was similar across schools and at all school levels. The decline in physical exercise apparently also proved detrimental to Singaporean children's sleeping duration during the lockdown, as shall be discussed in a subsequent section.

Thailand.

Another study that reported a decrease in physical activity during the pandemic was that by Katewongsa, Widyastari, et al. (2021), who analyzed datasets from Thailand's Surveillance on Physical Activity for the years 2019 and 2020. Their study determined a decline in the prevalence of physical activity sufficiency in Thailand — fewer people (57.0%) performed sufficient moderate to vigorous physical activity in 2020 (i.e., during the pandemic) than the 74.6% who did so in 2019 (i.e., before the pandemic). Sufficient physical activity refers to the World Health Organization's recommendation of either 75 minutes of vigorous physical activity per week or a combination of moderate and vigorous physical activities totaling 150 minutes per week.

The cumulative duration of moderate to vigorous physical activity also decreased from 580 minutes pre-pandemic to 420 minutes peri-pandemic, with the lowest observed average duration of 414.1 minutes occurring at the height of the lockdown in Thailand from March 29 to May 2 (Katewongsa, Widyastari, et al., 2021). Even after the lockdown was eased somewhat from May 2 onwards, the average duration of moderate to vigorous physical activity among adult Thais hovered just somewhere around 425.36 minutes. The cumulative duration of work-, transport-, and recreation-related physical activities also declined during the pandemic period.

Further, the study's multivariate analysis also found that sufficiency of moderate to vigorous physical activity had statistically significant associations with gender, age, occupation, chronic disease, area of residence, and exposure to the Fit from Home campaign (a government-initiated intervention for sedentary behavior). Thai males did more physical activities in both pre- and peri-pandemic periods and were 1.3 times more likely to have sufficient moderate to vigorous physical activity than females during the pandemic. More middle-aged adults (40 to 64 years old) than young adults (18 to 39 years old) had sufficient moderate to vigorous physical activity in both pre- and peri-pandemic periods and middle-aged adults were 1.2 times more likely to have sufficient physical activity than young adults.

Urban residents were 13% less likely to get sufficient moderate to vigorous physical activity than non-urban residents. Those with chronic diseases were 27% less likely to meet the recommended physical activity level

during the pandemic. Compared to those working in agriculture, the unemployed were 27% less likely to have sufficient physical activity.

Finding similar trends for physical activity in Thailand, the study by Katewongsa, Potharin, et al. (2021) focused on sedentary behavior among the Thai population. The study found that 69.2% of the Thai population accumulated >13 hours of sedentary behavior per day in 2020; this was an increase from 65.9% in 2019. Likewise, the average duration of non-sleeping sedentary state increased to 875 minutes per day in 2020 from 824 minutes per day in 2019 (Katewongsa, Potharin, et al., 2021). The highest sedentary behavior was observed during the maximum curfew period (i.e., between March 29 and May 2, 2020), but it decreased slightly when the curfew was relaxed. High degrees of sedentary behavior are usually accompanied by insufficient moderate to vigorous physical activity, as was the case in the 2019 sample, but in the 2020 data, the prevalence of high sedentary behavior was nearly equal between those with sufficient and insufficient physical activity (Katewongsa, Potharin, et al., 2021). Also, the study determined that sedentary behavior did not correlate with either sufficiency of physical activity or the government-initiated intervention for sedentary behavior.

Topothai et al. (2020) analyzed the magnitude of daily step counts of the 186,653 individuals (18 to 80 years old) who participated in the first season of the Thailand National Steps Challenge, which encouraged participants to walk or run for ≥ 60 km within 60 days and to report their performance data back to organizers via a smartphone application. Analysis of the data captured between February 21, 2020, and March 31, 2020, revealed an average daily step count of 1,301 steps, which was way below the recommended minimum physical activity level of 7,000 steps a day (Topothai et al., 2020, p. 9). The highest overall average daily step count of 1,674 was recorded in the period between February 21 to 27 (Period 1), but this drastically dropped to 633 by Period 5 (March 23 to 31). Katewongsa, Widyastari, et al. (2021) also similarly observed a 55% decline in physical activity levels in Thailand from March 2020 to May 2020.

Topothai's team offered no explanation about why all the study's participants did not or could not reach the recommended daily step count of 7,000. However, they provided several explanations for the steady drop of the average daily step count from Period 1 to Period 5. One reason was underreporting, since some participants might not have been carrying their smartphones throughout the day, or they might have only reported the extra steps on top of their baseline. The second possible reason was the participants' behavioral decay caused by the overemphasis of competition rather than positive reinforcement in the step challenge's design. The third possible reason was the disruption in domestic physical activity because of the COVID-19 pandemic. The World Health Organization officially declared the COVID-19 global pandemic on March 11, 2020, which fell right in the middle of the study's Period 3 (March 9 to 15).

Surprisingly, health care workers recorded a lower overall average daily step count than the average

of those from the general population. This is a worrying outcome because those in the health care field ought to be exemplars of physical activeness and fitness. The research team explained that selection bias may have been a possible reason for this outcome: the health care workers might have had weaker motivation to do the step challenge than those from the general population who self-selected themselves into the program.

Another unexpected outcome was the lower overall average daily step count of the younger crowd (18 to 45 years old) compared with the average of those in the older age group (46 to 80 years old). The researchers supposed that technology such as pedometers and smartphones may have exerted a motivational influence upon the older adults, causing them to have moderate to high engagement with the initiative, as earlier studies have similarly demonstrated.

The women, obese participants, and rural residents also registered lower overall average daily step count than their respective counterparts.

In terms of percentage decrease between Period 1 and Period 5, the following populations showed a larger percentage decrease in their average daily step count than their respective counterparts' percentage decrease: health care workers (64% vs. 57%), females (64% vs 55%), younger participants between 18 and 45 years old (71% vs 55%), obese participants (65% vs 60%), and rural residents (63% vs 60%).

Vietnam.

In Vietnam, 61.6% of the 7,124 health care workers who participated in the study by Tran et al., (2020) reported maintaining at least their pre-pandemic physical activity levels during the pandemic, with some participants indicating an increase in their physical activity levels. Do, Tran, et al. (2020) found a comparable percentage (68.2% of 5,209 respondents) in their study on the relationship between health literacy and the eHealth Literacy Scale (eHEALS) and adherence to lifestyle changes (i.e., smoking, drinking, physical activity, and eating).

Effects on Anxiety, Depression, and Mental Health

This narrative review's reference reports that also investigated the effects of physical activity—especially sufficient or increased physical activity—on mental health uniformly reported positive benefits, especially regarding the likelihood of anxiety and/or depression.

Tran et al., (2020) determined that physical activity was a protective factor for the mental health of the health care workers involved in the COVID-19 response (i.e., the frontliners) in Vietnam. Those with unchanged or increased levels of physical activity succumbed less to anxiety and depression. Among those with zero, ceased, or decreased physical activity levels during the pandemic, the frontliners were 5.26 times more likely to become anxious and 4.42 times more likely to become depressed than non-frontliners with the same physical activity levels. In contrast, those who maintained or increased their physical

activity levels showed less likelihood for anxiety (50% lower likelihood for frontliners and 65% for non-frontliners) and depression (60% lower likelihood for frontliners and 46% for non-frontliners).

The evaluation by Nguyen et al. (2020) of the physical activity level of 3,947 Vietnamese outpatients of ages 18 to 85 years old found that those who had at least 748.5 MET-min/week (metabolic equivalent task scored in minutes per week) of physical activity — i.e., those considered to have had “more physical activity” — showed significantly lower odds of depression (odds ratio of 0.56 - 0.59).

The participants of the study by Thahir et al. (2020) who did not engage in moderate to vigorous physical activities, 34.1% were found to be possibly depressed, and 65.9% were found to be probably not depressed, while among those who did engage in such activities, only 27.1% were found to be possibly depressed and 72.9% were found to be probably not depressed. Thahir et al. (2020) did not find any relation between the duration of the physical activity and the depression status of the students, but they did observe a difference in the proportion of depression between those who performed moderate to vigorous physical activities during the pandemic and those who did not. The prevalence of possible depression was lower (by seven percentage points) and the prevalence of probable absence of depression was higher (also by seven percentage points) among those who engaged in moderate to vigorous physical activities. Although, among those who did not perform moderate to vigorous activities, almost two-thirds (65.9%) were found to be probably not depressed — still outnumbering those who were possibly depressed.

The study by Ibrahim et al. (2021) examined the feasibility of using virtual technology for delivering a group exercise intervention to community-dwelling elderly Malaysians. The anxiety scores and depression scores of those who had fewer than 14 sessions of the intervention were higher than the scores of those who had ≥ 14 sessions. Their post-intervention scores for anxiety and depression decreased from their pre-intervention scores but remained higher than their baseline scores (except for those with < 14 sessions, whose post-intervention score for depression was lower than their baseline score).

Effects on Health-Related Quality of Life Score

Two studies explored the associations between physical activity and Health-Related Quality of Life (HRQoL), a measure for evaluating the impact of illnesses, disorders, and disabilities on several domains of health, particularly the physical, mental, social, and environmental aspects (Arab-Zozani et al., 2020; Choi et al., 2021). HRQoL also pertains to how a person perceives his or her health and is associated with increased chances of negative outcomes due to illness, such as the inability to work and mortality (Choi et al., 2021).

Tran et al., (2020) found a strong positive association between physical activity and the HRQoL of the health care workers involved in the COVID-19 response (i.e., frontliners)

in Vietnam. Those who sustained or increased their levels of physical activity during the pandemic had significantly higher HRQoL scores than those who didn't, as was shown in the higher HRQoL scores (2.08 for frontliners and 6.29 for non-frontliners) of those who maintained or increased their physical activity levels. In contrast, frontliners who had zero, ceased, or decreased physical activity levels had 3.31 lower HRQoL scores than non-frontliners reporting similar physical activity levels.

The study by Nguyen et al. (2020) reported similar findings. Those who had more physical activity — i.e., those who spent at least 748.5 MET-min/week (metabolic equivalent task scored in minutes per week) of physical activity — showed significantly higher HRQoL scores of between 70.7 and 72.7 points, which is a high score, considering that 100 is the maximum.

The foregoing two studies provide evidence of the link between HRQoL and physical activity. In general, these studies showed that higher levels of physical activity correlated with higher HRQoL during the pandemic.

Effects on Sleep

Lim et al. (2021) found that the correlation between exercise duration and sleep duration among Singaporean school children before and during the lockdown was, respectively, $r^2 = 0.03$ ($p = 0.47$) and $r^2 = 0.13$ ($p < 0.01$), a correlation that they attributed to the increased number of children ($n=114$) who did not exercise during the lockdown and the overall reduction of exercise during the lockdown, such that a slight change in exercise amount could exert a significant influence on sleep duration during the lockdown. The authors also noted an increase in screen time and a corresponding decrease in exercise, both of which could be explained by the lockdown restrictions imposed during the pandemic and the consequent increase in time and presence at home.

Health Literacy and Physical Activity

Two studies in this review found positive associations between health literacy (HL) scores (or similar constructs) and physical activity.

In Vietnam, health care workers with higher HL scores and higher eHealth Literacy Scale (eHEALS) scores showed a greater likelihood for engaging in sustained or increased physical activity during the lockdown (Do, Tran, et al., 2020). Among health care workers, significantly higher HL and eHEALS scores occurred more among male doctors with better ability to pay for medication and who had epidemic containment experience. Do, Tran, et al. (2020) suggested integrative and multidisciplinary approaches to improve both scores, which would consequently improve healthy behaviors, including physical activity, among health care workers.

Do, Nguyen, et al. (2020) found similar results in their study. The elderly (60 to 85 years old) with suspected COVID-19 symptoms who had higher HL scores not only reported more physical activity but also ate healthier diets and had a lower likelihood for depression. The

authors observed this significant association between HL and physical activity only in the said subpopulation of participants. According to the authors, such a population faces a higher risk of severe COVID-19, so they “arguably have the most to gain from practicing healthy lifestyles (e.g., healthy dietary intake and more physical activity) to protect and improve their health-related quality of life” (Do, Nguyen, et al., 2020, p. 7).

Technology for Physical Activity

Two studies focused on leveraging technology to help Southeast Asians improve their physical activity levels both peri- and post-pandemic.

The first one by Anggraini et al. (2020) proposed an exercise and performance learning assistant system (EPLAS) for people in Indonesia, Japan, and Taiwan who needed to practice exercises or learn performances by themselves at home during the COVID-19 pandemic. The system presents the user with a video guide of an instructor demonstrating the proper execution of some exercise or performance such as yoga, tai chi, or dance. The user is expected to follow along and mimic the correct execution. Afterwards, using the opensource software known as OpenPose, the system rates how well the user accurately imitated the movements, positions, or postures demonstrated in the video. This rating system is supposed to be the feedback mechanism of EPLAS. To evaluate the EPLAS, Anggraini’s team ran tests for five static yoga poses among 41 individuals (between 13 and 78 years old) from Indonesia, Japan, and Taiwan. OpenPose was used to objectively evaluate every user’s pose by comparing it with the instructor pose as a reference. The yoga instructor and 19 users also conducted subjective evaluation of the 41 volunteer users. The subjective results were compared with the system results. Anggraini’s team found a strong positive correlation (0.746) between the average thresholds reported by the OpenPose software and the average subjective rating results, thus leading the team to consider the proposed EPLAS valid and effective.

The second study by Ibrahim et al. (2021) investigated the feasibility of using virtual technology to deliver a four-week group exercise intervention to community-dwelling elderly Malaysians to help them stay in shape during, and even long after, the COVID-19 pandemic. The 43 individuals, ≥ 60 years old and recruited through social media messaging, needed to attend a 30-minute virtual group exercise class every day for four weeks during which they were guided to perform muscle-strengthening exercises tailored for the elderly, or else perform the exercises privately with the help of an exercise booklet and video. The participants tracked their exercise through a diary.

Among those who attended at least 14 sessions, the mean attendance was 16.43 sessions. Among those who attended less than 14 sessions, mean attendance was 4.36 sessions. Mean overall attendance was 10.26 sessions. Only 60.5% ($n=26$) of the total participants returned their exercise logs or diaries. The research team found a significant difference in mean attendance between participants in both groups who returned and did not

return the diary.

The study by Ibrahim et al. (2021) demonstrated the possibility of recruiting elderly Malaysians via social media messaging for such events or activities as virtual group exercise classes. However, the authors noted possible sample selection bias for their study, since those who agreed to participate were tech-savvy elderly Malaysians, whereas most others could hardly install applications without help although they know how to use social media messaging. Although the study recorded a dropout rate of 23%, the authors found this acceptable, considering dropout rates ranged from 7.5% to 31.9% in some face-to-face exercise intervention studies, online studies with population sample ≤ 200 , and one large study with $n=36,373$.

Physical Activity as a Problem

Jailani et al. (2020) surveyed 278 pre-university students to determine their most prevalent self-perceived problems as students of a public research university in Malaysia. Survey results showed an overall low level of self-perceived problems among the participating students, as indicated by the total average score of 150.78 ($SD=88.03$) out of a maximum score of 220 in the Mooney Problem Checklist. The participants recorded a mean score of 13.23 for the category pertaining to health and physical development, which was ranked the sixth most interfering problem, although the top reported items in this category did not include anything related to physical activity, such as not getting enough exercise or not being as strong and healthy as one should be. The category of problems pertaining to social and recreational activities was ranked the ninth most interfering problems, with participants recording a mean score of 11.89 for this category. The most reported items that can be argued as related to physical activity included the lack of time for fun and leisure, having very few opportunities for pursuing enjoyable activities, and lacking time for sports. Although the two aforementioned problem categories do not rank high on the list, they can still interfere with students’ lives. Jailani et al. (2020) explained that these problems potentially arose from students’ overloaded schedules, which the researchers feared could deprive the students of enough rest and consequently cause health issues.

Physical Activity and the Elderly

Murukesu et al. (2021) noted that physical activity is inversely associated with immunosenescence (i.e., the decline of immune functions as one ages). So, increased and regular physical activity among the elderly could strengthen their immune system, consequently reducing, suppressing, and/or delaying their risks for chronic diseases, frailty, mortality, reduced efficacy of vaccines, and cognitive decline. Further, the authors also recommended immunity-boosting in physical activity among elderly Malaysians to mitigate the potential adverse outcomes, some of which can be lethal, of the COVID-19 vaccine. Lastly, the authors considered physical activity along with the preservation of psychosocial well-being among the Malaysian elderly, especially during trying times such as the COVID-19 pandemic, to be crucial in increasing their

resilience, extending functional independence, delaying deterioration of physical and cognitive reserves, and preparation for immunization.

CONCLUSION

The Association of Southeast Asian Nations has 10 member states, yet only 13 studies on physical activity during the COVID-19 pandemic were done in and for them. Some countries even did not yield any study on this same topic at all. Apparently, only a few scholars were interested in studying peri-pandemic physical activity despite the clear need to maintain sufficient levels of it with or without an ongoing pandemic. Even those who did bother to delve into this topic focused more elsewhere and somehow skirted any inquiry into the prevalence of sufficient physical activity per age group or special population.

None of this study's sources also studied or explained the factors or causes of any observed increase, decrease, or maintenance of pre- and peri-pandemic physical activity levels. Studying which factors or variables enabled individuals or populations to at least maintain minimum healthy levels of physical activity even under extreme circumstances such as pandemic-instigated quarantines and lockdowns would have allowed one to pinpoint those variables, situations, conditions, and/or practices that need to be retained or maintained when another pandemic or a similar disruption occurs to large populations of people. Similarly, identifying those factors or variables that cause the decline of participation in healthful levels of physical activity can assist policy makers and other persons in authority to mitigate or eliminate those same hindrances the next time a disturbance such as a pandemic occurs.

Of the 13 studies included in this narrative review, only one explored peri-pandemic sedentary behavior. More studies ought to be done about peri-pandemic sedentary behavior, not only on account of its distinction from physical inactivity or insufficiency of physical activity but also on account of the gravity of the negative impact upon multiple aspects of human health, an impact that the stresses of a pandemic can exacerbate. Novel systems and technologies that can impact PA and sedentary behavior in Southeast Asia also ought to be explored and developed, and existing ones ought to be reviewed so that they can be improved.

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RESPONSE OF 'CARABAO' MANGO (*Mangifera indica* L.) TO 1-METHYLCYCLOPROPENE IN SACHET

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ABSTRACT

1-Methylcyclopropene (1-MCP) was tested on 'Carabao' mango harvested at 105 days after flower induction. Mature green mangoes of uniform quality were sanitized with 200 $\mu\text{L L}^{-1}$ NaOCl, air dried, and packed inside newspaper-lined bamboo baskets, then treated with different concentrations of 1-MCP (0, 1, 10, and 140 $\mu\text{L L}^{-1}$) in sachets (EthylBloc™) for 24 h under ambient room conditions (27.1 ± 2.0 °C; $87.0 \pm 8.6\%$ RH). After treatment, the mangoes were stored in a cold room (19.0 ± 1.2 °C, $90.7 \pm 9.3\%$ RH) and evaluated for ten days for weight loss, firmness, total soluble solids (TSS), visual quality, stem-end rot, anthracnose, and peel color (subjective index; L^* , a^* , b^* , chroma, and h°). Results showed that 140 $\mu\text{L L}^{-1}$ 1-MCP was able to maintain firmness and low TSS of the fruit for six days after treatment. Mango fruit treated with 1-MCP also had a better visual quality than the untreated samples until six days. 1-MCP was not able to slow down the peel color changes of the fruit but maintained the skin lightness (L^*) particularly by 10 $\mu\text{L L}^{-1}$ 1-MCP for six days. 1-MCP did not affect the fruit weight loss and occurrence of latent infection such as stem-end rot and anthracnose.

Keywords: 1-MCP, delayed ripening, firmness, peel color, total soluble solids, visual quality

INTRODUCTION

'Carabao' mango is the Philippines' prime variety and is one of the sweetest cultivars in the world (Castillo-Israel et al., 2015). The country ranked seventh among exporters of fresh and dried mangoes with a 4% share of the global markets in 2015 (Fernandez-Stark et al., 2017). Although the Philippines has been a great player in the export industry for some time, just like any other fresh produce, the shipment of mangoes has been a challenge due to its relatively short shelf life. The long-distance farms, packhouses, and distribution hubs, as well as shortcomings in the supply chain, impose constraints on its postharvest life. In addition, controlling its ripening process is a challenge because of the stimulation of ethylene biosynthesis prior to its harvest maturity at ~100 days after flower induction (DAFI) (Castillo-Israel et al., 2014a). Mango fruit should be harvested upon reaching the maturity of 105 to 130 DAFI (Philippine National Standard [PNAS], 2009). Harvesting during the mango season is at 105 to 115 DAFI while 120 to 130 DAFI is suggested during the off-season.

1-Methylcyclopropene (1-MCP) is widely used to lengthen the shelf life of many horticultural produce (Blankenship & Dole, 2003). It is an ethylene-blocker that prevents ethylene-dependent mechanisms such as ripening and senescence in many horticultural crops. As a preharvest treatment, the dual application of 1-MCP, first at 100 then at 115 DAFI was able to control the ripening of 'Carabao' mango and extend its shelf life up to four days (Castillo-Israel et al., 2014a). 1-MCP is used more often as a postharvest chemical application in mangoes. For instance, the shelf life of 'Maha Chanok' mango fruit fumigated with 1,000 nL L^{-1} 1-MCP for 12 h was extended for up to 14 days in ambient conditions (27 °C, 80% RH) (Chutichudet et al., 2016). The same treatment resulted in the least

incidence of decay during the entire storage period. The use of 1,000 or 2,000 nL L^{-1} 1-MCP in 'Baneshan' mangoes resulted in better fruit quality and longer shelf life of up to 36 days at 12.5 ± 1 °C (Kumar et al., 2015). The application of 1-MCP before hot water treatment also showed a greater ability to reduce the rate of softening in 'Keitt' mangoes (Ngamchuachit et al., 2014). 1-MCP maintained firmness and slowed down color changes in 'Nam Dokmai' (Penchaiya et al., 2006) and 'Kensington Pride' mangoes (Razzaq et al., 2015). Even a low concentration of 100 nL L^{-1} 1-MCP for 12 h resulted in the lowest respiration rates in 'Tommy Atkins' (Cocozza et al., 2004). Jiang and Joyce (2000) also reported that 1 to 100 nL L^{-1} 1-MCP was effective in 'Zihua' mangoes.

Most of the above studies used gaseous 1-MCP in air-tight sealed chambers with doses ranging from 1 to 10,000 nL L^{-1} for 12 to 24 h. This manner of application makes the adoption of 1-MCP at the commercial level difficult and very limited (Osuna-Garcia et al., 2015). To be used conveniently with produce during postharvest storage, a 1-MCP trapping system using α -cyclodextrin component has been sold under the trade name EthylBloc® (Lee et al., 2006). It uses an inert matrix material to contain 1-MCP while inside a sachet. The release mechanism of 1-MCP involves three stages: 1) the 1-MCP molecules are released into the free space within the matrix of the adsorbing agent in the sachet pouch, 2) the 1-MCP molecules pass through the film microstructure into the headspace containing the fresh produce, and 3) the 1-MCP molecules penetrate the surface of the fresh produce (Lee et al., 2006).

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Several studies on the development of 1-MCP release system through different sachet materials (Lee et al., 2006), heat pressed polymer films (Hotchkiss and Watkins, 2007), and cellulose paper packaging materials (Hu et al., 2017) were reported. Some were evaluated on its effect on fresh produce. 1-MCP in sachet extended the shelf life of broccoli florets stored at 12 °C by retarding yellowing and vitamin C losses (Yamashita et al., 2006). Also, 1-MCP sachets positioned in packages of poinsettia cuttings provided a viable means for reducing the leaf abscission following a 72 h-shipment at sub-optimal temperatures of 10 to 26 °C (Faust & Lewis, 2005).

Although several studies have been conducted with 1-MCP in relation to various mango varieties, the postharvest effect of 1-MCP, especially in sachet, on 'Carabao' mango has not yet been reported. Thus, in this study, the effect of 1-MCP in sachet was tested on 'Carabao' mango, and the optimum concentration of 1-MCP for delaying fruit ripening was also determined.

MATERIALS AND METHODS

Plant material preparation and treatment

'Carabao' mangoes (60 kg) at 105 days after flower induction (DAFI) were harvested from Digos City, Davao del Sur and transported to the Southern Philippines Fresh Fruit Corporation (SPFFC), a mango export company, where it was purchased. The maturity of the fruit was determined by counting the days after spraying potassium nitrate to induce flowering in mango trees. Commercially mature green mangoes with uniform size and quality were brought to the Postharvest Biology Laboratory in the University of the Philippines Mindanao, Davao City. The fruit were sanitized with 200 $\mu\text{L L}^{-1}$ NaOCl for 3 min, air-dried, and treated with 1-methylcyclopropene (1-MCP) within 24 h from harvest.

Fruit samples weighing 5 kg per replication were randomly distributed among four treatments: 1) control, 2) 1 $\mu\text{L L}^{-1}$ 1-MCP, 3) 10 $\mu\text{L L}^{-1}$ 1-MCP, and 4) 140 $\mu\text{L L}^{-1}$ 1-MCP. The amount of 1-MCP powder for 1 and 10 $\mu\text{L L}^{-1}$ concentrations in the package was calculated based on the

Ideal Gas Law (Semat & Katz, 1958) and packed in pilon cloth. The original sachet packaging had a concentration of 140 $\mu\text{L L}^{-1}$ 1-MCP (EthylBloc™ 0.014% 1-MCP, AgroFresh, Inc., USA). Mimicking the wholesalers' practice of traditional ripening, one 1-MCP sachet was inserted in the middle of mangoes piled inside a bamboo basket ($V = 7.46 \text{ L}$) lined with sheets of newspaper (Figure 1). The mangoes were covered with newspaper and the rim of the bamboo basket was securely tied with polypropylene twine. The baskets were held in ambient room conditions ($27.1 \pm 2.0 \text{ }^\circ\text{C}$; $87.0 \pm 8.6\% \text{ RH}$) during treatment for 24 h. After treatment for 24 h, the baskets were opened and the quality (weight loss, firmness, total soluble solids (TSS), visual quality, degree of stem-end rot and anthracnose, and peel color) of the fruit was evaluated at the opening of the baskets. All fruit samples were stored in a CoolBot-equipped cold room ($19.3 \pm 2.9 \text{ }^\circ\text{C}$, $87.6 \pm 14.9\% \text{ RH}$) for the duration of storage.

Quality evaluation

The weight loss, firmness, TSS, and visual quality were measured at initial and 3, 6, 8, and 10 days after treatment. Meanwhile, the degree of stem-end rot, anthracnose, and peel color were determined at the same time with the other parameters and daily after six days to capture the onset of the disease and changes in peel color. Weight loss was calculated as the proportional difference of final weight from the initial weight. Fruit firmness was measured using a pressure tester (Fruit Tester FT 327 Wagner Instruments, USA) on both sides of the mango fruit. The TSS content was determined by extracting the juice from mango flesh and placing one to two drops of it on the prism surface of a digital refractometer (Atago PAL-1 Atago, Japan). The values were expressed in % Brix.

Visual quality was assessed using a 1-5 rating scale designed by Ekman et al. (2019) described as 1= excellent, no symptoms of deterioration; 2= good, minor symptoms of deterioration that are not objectionable; 3= fair, evident deterioration but not serious, the limit of saleability; 4= poor, serious deterioration, the limit of usability; 5= extremely poor, unusable. The onset and degree of stem-end rot and anthracnose were evaluated using the



Figure 1. 'Carabao' mangoes piled inside a bamboo basket with 1-MCP sachet placed in the middle (A), covered with newspaper sheets, and tied with polypropylene twine (B).

scale: 1= no discoloration at the stem-end/visible spots; 2= slight infection, 1-5% on the surface; 3= moderate infection, 6-10%; 4= moderately severe infection, 11-25%; 5= severe infection, >25% (Ekman et al., 2019). Peel color was assessed using the index: 1= green; 2= breaker, trace of yellow at the stem-end; 3= turning, more green than yellow; 4= more yellow than green; 5= yellow with a trace of green; 6= fully yellow (Ekman et al., 2019). Further, the peel color was quantitatively measured using a color meter (Chroma Meter CR-400, Konica Minolta Optics, Inc., Japan) by taking the average of three measurements on the surface. The values were expressed as the color space L^* (lightness), a^* [green (-) or red (+)], b^* [blue (-) or yellow (+)], chroma, and hue angle ($^\circ$) defined by the International Commission on Illumination (CIE).

The days to reach saleability, saleable days, days to reach the table ripe stage, and shelf life were also determined. The days to reach saleability was reckoned by counting the days when the mangoes reach the peel color index of ≥ 5 , a visual quality rating of ≤ 3 , and no diseases (Lacap et al., 2019). Saleable days refer to when the fruit was considered marketable (i.e., the time when the fruit was deemed ripe until the end of shelf life). The days to reach the table ripe stage was determined by counting the days when the fruit reached the full yellow stage (peel color index of 6), soft texture, and characteristic aroma. The shelf life was determined by counting the time from the day of harvest until it goes past the limit of saleability (i.e., a visual quality rating of > 3 and the presence of disease).

Statistical analysis

The experiment was laid out in a Completely Randomized Design with three replications for each treatment. Each replication had nine fruit samples. Data were analyzed using Analysis of Variance (ANOVA) at $P < 0.05$. Differences in means were detected using Fisher's Least Significant Difference at $P < 0.05$ (Statistical Tool for Agricultural Research [STAR] 2.0.1, International Rice Research Institute, Philippines).

RESULTS AND DISCUSSION

1-MCP treatment did not affect the fruit weight loss

Weight loss in 'Carabao' mango was not affected by 1-methylcyclopropene (1-MCP) treatment (Figure 2A). Both treated and untreated mangoes lost only 0.5% to 3% of their weight over the course of 10 days. The low weight loss could be attributed to the favorable storage conditions (i.e., temperature of 19.0 ± 1.2 °C and relative humidity, RH, at $90.7 \pm 9.3\%$). The high RH lowered the vapor pressure deficit between the fruit and the environment which led to a low fruit transpiration rate thus the low weight loss. Vapor pressure deficit is responsible for moisture loss from the fruit as it tries to compensate for the difference between the amount of moisture in the air and the amount of moisture the air could potentially hold when it is saturated (Wollaeger & Runkle, undated).

1-MCP maintained fruit firmness during early storage

Fruit firmness was affected by 140 $\mu\text{L L}^{-1}$

1-MCP especially at three days after treatment where it maintained its initial firmness (9 kgf) while the other fruit already softened by two-fold (Figure 2B). After three days, mangoes treated with 140 $\mu\text{L L}^{-1}$ 1-MCP were the firmest among the treatments with 8 kgf, followed by those treated with 10 and 1 $\mu\text{L L}^{-1}$ 1-MCP with 5.2 and 4.2 kgf, respectively, while the untreated mangoes were less firm at 3.2 kgf. This suggests that the use of a high concentration, particularly at 140 $\mu\text{L L}^{-1}$, may help delay fruit softening as a consequence of the delayed ripening process. This could be a result of 1-MCP blocking ethylene from the receptors and preventing the expression of genes that code for the enzymes related to ripening such as polygalacturonase (PG), pectin-methylesterase, and β -glucanase that breaks down cell wall polymers such as cellulose, hemicellulose, and pectin which causes softening in fruit (Payasi et al., 2009; Bouzayen et al., 2010). Castillo-Israel (2012) reported that PG activity in mango fruit was inhibited by 1-MCP at the breaker and more green than yellow stages of maturity. In addition, several studies have shown that 1-MCP delayed the peak of climacteric phase, decreased ethylene production, maintained flesh firmness longer, and delayed color development in various crops (Osuna-Garcia et al., 2015).

Fruit treated with 140 $\mu\text{L L}^{-1}$ 1-MCP had lower total soluble solids during early storage

The treatment with 140 $\mu\text{L L}^{-1}$ 1-MCP in sachet slowed down the ripening of 'Carabao' mango until six days after treatment as indicated by lower total soluble solids (TSS) compared to those treated with lower 1-MCP concentrations and the control (Figure 2C). At six days of storage, mangoes treated with lower concentrations of 1-MCP (1 or 10 $\mu\text{L L}^{-1}$) as well as the control already exhibited higher TSS (9.8% to 11.4% Brix) while mangoes treated with 140 $\mu\text{L L}^{-1}$ 1-MCP were still at 7.2% Brix. After eight days, the TSS levels of the mangoes started to become uniform. Maintaining the lower TSS levels after six days in mango fruit treated with 140 $\mu\text{L L}^{-1}$ 1-MCP could also be attributed to the blocking effect of 1-MCP in delaying physiological and biochemical events pertaining to ripening including the degradation of starch into sugars. This is associated with the rise of ethylene in mango fruit which is marked by a substantial increase in amylase activity, reducing and non-reducing sugars, and a decrease in starch content (Lima et al., 2001). As ethylene plays a major role in the expression of ripening-related genes that code for the enzymes responsible for fruit ripening, blocking its receptors by 1-MCP will prevent triggering the cascade of ripening events (Sisler & Serek, 1997).

Fruit treated with 1-MCP had better visual quality during early storage

Mango fruit applied with 1-MCP in sachet had better visual quality than the untreated ones until six days of storage (Figure 2D). Regardless of the concentration, fruit treated with 1-MCP had a better visual quality with very good to excellent scores compared to the untreated samples. The lower visual quality scores garnered by the control mangoes were due to the progression of defects that goes along with the advancement in ripening. The fruit's visual quality started to decline after seven days with

a shelf life lasting from 10 to 12.4 days. The excellent visual quality exhibited by fruit treated with 1-MCP was due to slow deterioration of quality as ripening was delayed.

Degree of stem-end rot and anthracnose were not affected by 1-MCP

Treatment of 'Carabao' mangoes with 1-MCP in sachet did not affect the degree of stem-end rot (Figure 2E). Whether treated or not, the degree of stem-end rot was very low in the fruit with symptoms starting to appear only towards the end of the storage period. The low storage temperature probably hindered the early onset of latent infection and proliferation of microorganisms thus exhibiting low stem-end rot infection in mangoes. Similar to stem-end rot, the degree of anthracnose in mangoes was not affected by 1-MCP (Figure 2F). The mangoes developed anthracnose slowly which started to progress from slight to moderate infection only after 10 days. On the other hand, studies have shown that the ripening process in other varieties of mango was delayed by up to several days by delaying fruit softening and color changes

through 1-MCP (Jiang & Joyce, 2000; Coccozza et al., 2004; Wongmetha & Ke, 2012; Ngamchuachit et al., 2014; Kumar et al., 2015; Razzaq et al., 2015; Chutichudet et al., 2016; Penchaiya et al., 2016; Sakhale et al., 2018).

Degreening of mango skin color was not affected by 1-MCP

1-MCP in sachets did not affect the peel color development of 'Carabao' mango (Figure 3). Based on the subjective index (Figure 3A) and objective color measurements (Figures 3B-F), the peel color did not vary. Degreening of the mango skin progressed with time reaching the table ripe stage after 8 to 9 days. Mangoes applied with 10 $\mu\text{L L}^{-1}$ 1-MCP showed lighter peel color on the sixth day of storage however, this did not show a consistent trend over the course of storage (Figure 3B). Greenness (a^*), yellowness (b^*), and chroma (color intensity) were similar. Over time, fruit showed color development from green to yellow (Figure 3C-E). Figure 3F shows the hue angle of the mango peel color which lies on the second quadrant of the Hunter $L^*a^*b^*$ System, which is

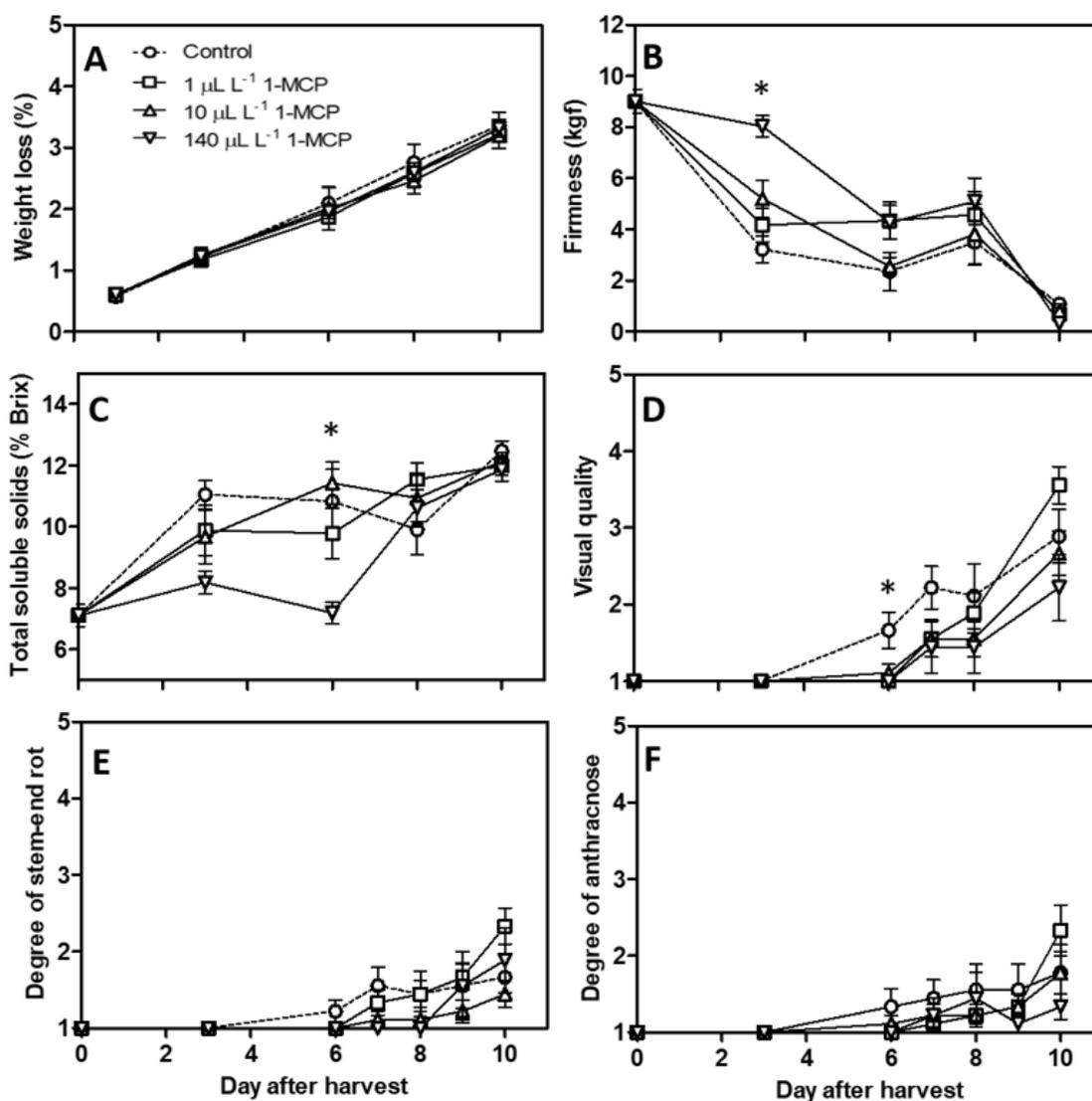


Figure 2. Weight loss (A), firmness (B), total soluble solids (C), visual quality (D), degree of stem-end rot (E), and degree of anthracnose (F) of 'Carabao' mango treated with 1-methylcyclopropene (1-MCP) in sachet for 24 h followed by storage in 19.0 ± 1.2 °C and $90.7 \pm 9.3\%$ RH. An asterisk indicates where there is a significant difference among the treatments using LSD at $P < 0.05$. Error bar represents the Standard Error of the Mean (n = 3).

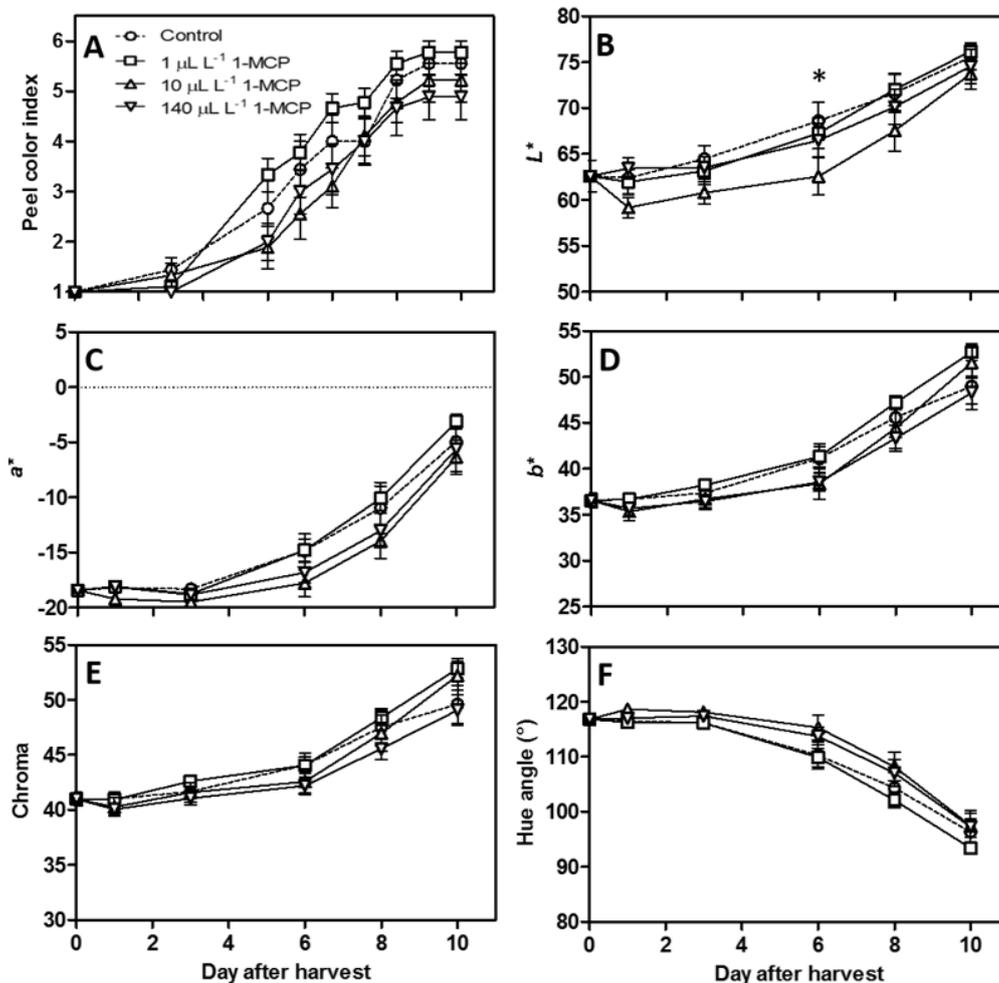


Figure 3. Peel color index (A), L^* (B), a^* (C), b^* (D), chroma (E), and hue angle (F) of 'Carabao' mango treated with 1-methylcyclopropene (1-MCP) for 24 h followed by storage in 19.0 ± 1.2 °C and $90.7 \pm 9.3\%$ RH. An asterisk indicates where there is a significant difference among the treatments using LSD at $P < 0.05$. Error bar represents the Standard Error of the Mean ($n = 3$).

between yellow (90 °C) and green (180 °C) color. The hue angle shows a declining trend over time depicting the color development from green to yellow; however, this also did not differ among treatments. Although the concentration of 1-MCP in sachet was much higher than what is usually used in fumigation (e.g., 1 to 1000 nL L⁻¹), its effect on peel color was not pronounced in this study. This could be because 1-MCP gas was not completely trapped around the mangoes for sufficient time to penetrate the produce as the newspaper lining could be permeable to 1-MCP gas.

1-MCP was not able to slow down the peel color changes in the fruit but maintained the skin lightness (L^*) especially by 10 $\mu\text{L L}^{-1}$ 1-MCP until six days of storage. The color changes from green to yellow during ripening are due to chlorophyll degradation (Bouzayen et al., 2010). In the case of 'Carabao' mango, 1-MCP has been shown to inhibit ethylene biosynthesis in fruit at pre-harvest however, the postharvest application seemed less effective because the upsurge in ethylene production had already occurred prior to its application (Castillo-Israel et al., 2014a). Attempts to delay the ripening of 'Carabao' mango fruit at the preclimacteric stage have been a challenge because ripening initiates in the mesocarp prior to full maturation and ethylene production showing a peak at about 10 days before attaining its harvest maturity (Cua, 1989). Castillo-

Israel et al. (2014a) also reported that upsurges in internal ethylene and ethylene production in 'Carabao' mango were observed at 100 days after flower induction (DAFI), suggesting that 1-MCP should be applied prior to this stage. After harvest, ethylene evolution rates from the intact 'Carabao' mango start to increase at two days after harvest with a peak at three days (Nuevo et al., 1984).

Fruit treated with 140 $\mu\text{L L}^{-1}$ 1-MCP had longer saleable days and shelf life

As ripening was delayed in mango fruit treated with 140 $\mu\text{L L}^{-1}$ 1-MCP, it took a longer time to reach a saleable stage (11.1 days) and in return had longer shelf life (12.4 days) than the mangoes applied with lower concentration of 1-MCP with days to saleability of 8.4 to 9.1 days and shelf life of 10 to 11.1 days (Figure 4). Meanwhile, the untreated fruit had 8.4 days to reach saleability and a shelf life of 11.9 days. Those treated with 140 $\mu\text{L L}^{-1}$ 1-MCP also took a longer time to reach the table ripe stage (12.9 days), though it was not significantly different with the rest of the treatments (10.7 to 12.2 days) and the control (11.1 days). The number of saleable days (1.9 to 3.6 days) did not vary among treatments as the onset of stem-end rot (6.3 to 10.4 days) and anthracnose (8.1 to 11.4 days) occurred at about the same time which contributed to the limit of

saleability of the mangoes. The fruit's shelf life (10 to 12.4 days) did not differ among treatments as it developed stem-end rot and anthracnose all at the same time (Figure 2E-F).

In this study, 1-MCP was applied in mangoes harvested at 105 DAFI which is the beginning of the recommended harvest maturity. It is surmised that most ethylene receptors are already occupied at 105 DAFI due to the observed upsurges in internal ethylene and ethylene production even before reaching the recommended harvest maturity (Castillo-Israel et al., 2014b). Further, when 1-MCP ($10 \mu\text{L L}^{-1}$) was applied pre-harvest at 100 DAFI and reapplied at 110 DAFI, it regulated the ethylene biosynthesis in 'Carabao' mango fruit as 1-MCP retarded the ethylene autocatalysis. Yang & Hofman (1984) reported that 1-MCP caused a reduction of ethylene levels in tissues, delayed the onset of the respiratory peak, and suppressed the production of 1-aminocyclopropane-1-carboxylate (ACC), the rate-limiting step in an ethylene feedback mechanism.

Hence, the time of application of 1-MCP in 'Carabao' mango is important in achieving ethylene-blocking effects (Vasquez-Celestino et al., 2016). The time at which ethylene detaches from receptors, degradation of the receptors, the synthesis of new receptors, and the possibility that 1-MCP dissociates from receptors are factors that determine the effectivity of 1-MCP treatment (Castillo-Israel et al., 2014a). It is also possible for the 1-MCP molecules to attach when new receptors are synthesized by the fruit as it matures. Kevany et al., (2007) showed that receptors are broken down by ethylene and new receptors are synthesized as the fruit maturity advances. At this time, 1-MCP could attach to newly-synthesized receptors before ethylene binds to

it. This was confirmed by Castillo-Israel et al. (2014b) when pre-harvest reapplication of 1-MCP at 110 DAFI was more effective than those treated only once with 1-MCP. It was assumed that new ethylene receptors are synthesized at 110 DAFI, and 1-MCP reapplication at this time effectively blocks ethylene from binding to the new receptors. 1-MCP was also able to demonstrate its ethylene-inhibitory effects when applied to fresh-cut 'Carabao' mango slices as the ethylene receptors were more exposed to it (Castillo-Israel et al., 2015). However, the ethylene levels in the different portions of the 'Carabao' mango do not differ significantly (Nuevo et al., 1984).

CONCLUSION

This study demonstrated the effect of 1-MCP in sachet on 'Carabao' mangoes that were harvested at 105 days after flower induction (DAFI), considered as an early harvest. 1-MCP was added in the middle of commercially mature fruit packed in bamboo baskets following the traditional method of ripening 'Carabao' mango. Based on the results, $140 \mu\text{L L}^{-1}$ 1-MCP in sachet was able to maintain firmness and total soluble solids of the fruit until six days of storage. Mango fruit applied with 1-MCP in sachet also had a better visual quality than the untreated ones for up to six days. 1-MCP was not able to slow down the peel color changes in the fruit but maintained the skin lightness (L^*) particularly by $10 \mu\text{L L}^{-1}$ 1-MCP until six days of storage. Therefore, under the conditions of the study, the use of $140 \mu\text{L L}^{-1}$ 1-MCP sachet for 24 h in mangoes harvested at 105 DAFI and packed in lined bamboo baskets best delayed the ripening characteristics such as softening and conversion of starch to sugar until six days of storage in cool conditions ($19.0 \pm 1.2^\circ\text{C}$, $90.7 \pm 9.3\% \text{RH}$).

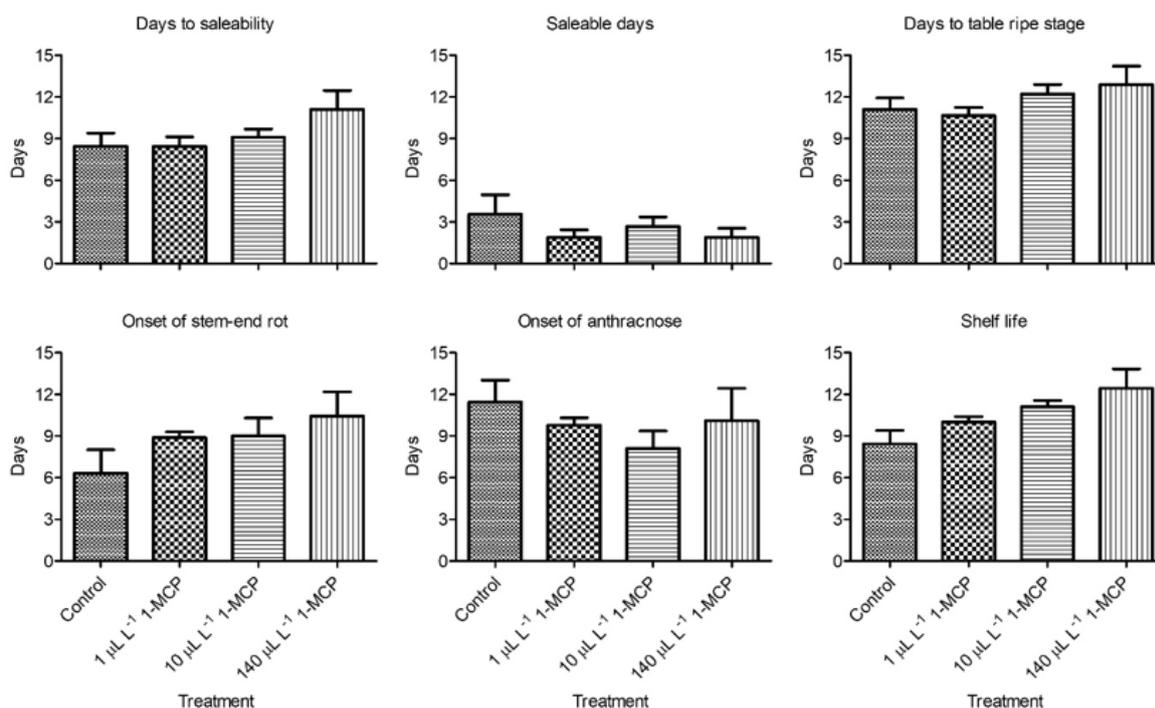


Figure 4. The days to reach saleability, saleable days, days to reach table ripe stage, onset of anthracnose, onset of stem-end rot, and shelf life of 'Carabao' mango treated with 1-methylcyclopropane (1-MCP) for 24 h followed by storage in $19.0 \pm 1.2^\circ\text{C}$ and $90.7 \pm 9.3\% \text{RH}$. Error bar represents the Standard Error of the Mean ($n = 3$).

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Students' Level Of Science Process Skills Acquisition And Academic Achievement During The Pandemic

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ABSTRACT

In the middle of the pandemic, most schools adopted the blended learning modality. As a result, dealing with the "New Normal" presented difficulties for private schools. This study aims to analyze the level of acquisition in science process skills of private junior high school students and its relationship to students' academic achievement in the subject. The researchers used a convenience sampling technique and a descriptive-correlational research design for 105 students. The researchers created and content-validated an instrument for students' acquisition and academic achievement to gather the data. With the help of SPSS 23, the study used descriptive and inferential statistics. The study showed that communicating skills got the highest and measuring skills got the lowest score. In addition, the study observed significant differences in the communication skills and academic achievements of students when grouped according to gender. Furthermore, there was also a significant difference in the students' responses in measuring skills and classifying skills when grouped according to monthly household income. Finally, there was a moderately positive relationship between science process skills acquisition and academic achievement. The researchers suggested recommendations for teachers, school heads, and the institution to help improve the students' science process skills.

Keywords: academic achievement, acquisition of skills, covid-19 pandemic, new normal, private junior high schools

INTRODUCTION

Prior to the SARS-CoV-2 virus, which causes Covid-19, and the enhanced community quarantine (ECQ), the Philippine Department of Education (DepEd) emphasized the importance of addressing issues and gaps in attaining quality primary education. This mandate follows the country's low ranking in the Programme for International Students Assessment (PISA). According to the 2018 PISA results, about 22% of Filipino students earned a Level 2 or above in science. These students can identify the correct explanation for well-known scientific occurrences and use that knowledge to evaluate if a conclusion is correct based on facts provided in basic situations. The Philippines was rated worst in reading performance by 79 OECD members and associate nations and second-last in math and science (Ciriaco, 2019). In response to the current situation, DepEd led national efforts to improve essential quality of education by implementing "Sulong Edukalidad" in four key areas: K to 12 reviews and update; improve learning facilities; improve and retrain teachers and school leaders through a transformed career development program; and work of all stakeholders for (DepEd, 2020). The science process skills are collection of aptitudes used in scientific activities. Science students with good procedural skills are more interested in their studies. Suppose teachers design the learning stage in such a manner. In that case, students will have chances to actively engage in learning (Safaah et al., 2017). Each scientific processability is a skill that students use in several circumstances throughout their lives. They are about a lot more than simply "science." (Durham et al., 2017)

In inquiry-based hands-on science learning, "doing" science involves putting the process into action. In general, the definition of science process skills is basically a summation of transferrable abilities appropriate for the scientific fields. Students apply these process skills to understand better how scientists explore and answer their questions. There are two types of Science Process Skills (SPS) classified into fundamental and integrated processes. The fundamental actions necessary in scientific inquiry are known as basic processes. These processes include observing, communicating, measuring, classifying, inferring, and predicting. They are the core abilities that underpin all scientific inquiries. On the other hand, the integrated process skills involve the control of variables, operational definition, formulation of hypothesis, model formulation, data interpretation, and experimentation. These mentioned skills are essential for students to design and conduct scientific investigation (Susanti et al., 2018). Despite this, a lack of experimental activities in the classroom for scientific learning has led to many misconceptions among students, resulting in poor science learning outcomes (Widyaningsih, 2020). Science process abilities associate with student achievement. Its purpose is to address issues and come up with effective answers. (Darmaji, et.al 2020). According to Hirca's (2013) study, Fundamental process skills will serve as the foundation for developing integrated skills. To add, the paper of Dakabesi

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and Louise (2019) defined that these science process abilities will influence students to tackle environmental challenges realistically. A significant amount of work is required to develop excellent process skills and critical thinking.

In the case of academic achievement, its development together with the child's cognitive abilities are crucial (Peng & Kievit, 2020). The teacher's professional development influences classroom instruction, hence, the academic achievement of the students as well (Fischer et al., 2018). In the paper of Lei et al. (2018), student engagement and academic achievement has a moderate positive relationship. In addition, method of reporting engagement, cultural values and gender influences the students' engagement and academic achievement. Costa and Faria (2018) also showed in their study that gender did not moderate implicit theories of intelligence and students' academic achievement but the students' middle school grade. York et al. (2015) stated the common measure for academic success were grades and GPA. Kumar et al. (2021) also gained some insights regarding the dependability of GPA as a method of academic performance evaluation. There are of course different variables or factors that affects student academic performance as well. Some of these variables are demographic characteristics that directly or indirectly affect the students' academic achievement. This idea includes age, socio-economic status, and number of study hours (Ali et al., 2013); social networking sites (Alaslani & Alandejani, 2020); burnout (Madigan & Curran, 2021); frustration tolerance (Meindl et al. 2019); and teacher efficacy (Kim & Seo, 2018). These few mentioned variables play some role in the acquisition of science process skills among students to different degrees or level depending on the set-up and circumstances.

There are works of literature that focus on specific associations between science process skills and other learning factors. For example, Zeidan and Jayosi (2015) found an association between science process skills and attitude towards science subjects. Ekon and Eni (2015) also showed that gender does not influence the acquisition of science process skills. Abungu et al. (2014) also added that the science process skills approach in teaching significantly affects the students' achievement in class. Kramer et al. (2018) emphasized that a well-designed online tutorial can effectively develop undergraduate students' science process skills from a different perspective. Finally, Suman (2020) revealed a positive relationship between science process skills and students' achievement in science. From here, one can deduct the inconsistent findings of different works of literature that focus on the science process skills of students and underlying achievements.

From the national perspective, Derilo (2019) divulges the relationship between science process skills and students' performance in science in the country. In addition, Mirana (2019) disclosed that students have a positive attitude towards science. However, their science process skills were not well-developed. However, Dapitan and Caballes (2020) revealed that the level of science process skills was satisfactory in their study. The same findings by Bete (2020) study revealed a poor process skill in one science class in grade 8 students. Barantes and Tamoria (2021) also revealed the effectiveness of a learning

technique to help improve basic science process skills. The researchers find it quite intriguing regarding students' science process skills from this literature, wherein recent studies showed low-performance levels. Although the government, particularly the Department of Education, has already worked to improve this status, results show the opposite. The researchers identified a dearth of studies on private institutions based on local studies about students' science process skills. This research gap motivated the researchers to do research that will focus on private junior high school students only. This research paper hopes to find its way to benefit more students in private schools and improve their academic performance in science subjects in the future.

In order to attain this endeavour, the researchers have the following objectives for this study:

1. To analyze the level of acquisition of science process skills (observing, measuring, classifying, inferencing, communicating, and hypothesizing) of private junior high school students (in particular, Biology subject);
2. To assess the academic performance of the students in the science subject;
3. To identify any variations in the level of acquisition of science process skills and academic achievement based on their demographic profile; and
4. To identify the underlying association between the acquisition level of science process skills and the academic achievement of private junior (grade 9) high school students.

The result of this study intends to contribute primarily to the growing literature about the Science Process skills among the students. The result of this study focused on the private secondary schools which has a dearth in the literature and emphasis. In addition, the students, teachers, the school administrator and other stakeholders also benefit from the result of this study since there are annual evaluation and tests which reflect the learnings of the students.

METHODOLOGY

Research Design

This study employed cross-sectional survey research. Cross-sectional research involves looking at data from a population at one specific time. Cross-sectional descriptive research determines how frequently, broadly, or severely a variable of interest occurs across a population. Some of the critical characteristics of a cross-sectional study include: the study takes place at a single point in time, it does not involve manipulating variables, it allows researchers to look at numerous characteristics at once (age, income, sex, etc.), researchers often use this method to look at the prevailing characteristics in a given population, and it can provide information about what is happening in a current population (Cherry, 2020).

Population and Sampling

This study used convenience sampling since it is the pandemic period, and gathering data is tricky. The

subjects are selected based on specific characteristics: (1) to determine the population; the researcher chose private schools located at Olongapo City operating for more than ten years in the education industry, (2) the sample of the study were students from each chosen private school enrolled in Grade (9) nine junior high school, (3) the private junior high school students utilizing blended learning modality in Olongapo City for the school year 2020-2021.

Research Instrument

This study determined that using the questionnaire checklist with the help of a google form is the most appropriate process in gathering the data needed. The investigators developed a questionnaire validated by the President Ramon Magsaysay State University (PRMSU) board of panel. After the validation from the PRMSU board, it also underwent reliability testing. The instrument generated an overall Cronbach alpha result of .983, which is highly reliable and acceptable. In the case of the instrument’s subscale Cronbach alpha result, it yielded the same coefficient of .983 for the observing, measuring, classifying, inferencing, communicating, and hypothesizing.

The 1st part of the instrument was to determine the level of acquisition of the grade (9) nine junior high school students from selected private schools in Olongapo City. The instrument consisted of the following: (1-5 items) observing; (6-10 items) measuring; (11-15 items) classifying;(16-20 items) inferencing; (21-25items) communicating; (26-30 items) hypothesizing. The 2nd part of the instrument is to determine the academic achievement on the primary and integrated science process skills of the Junior Grade 9 students from the private schools. The test consisted of 60 essential science process skills items. It includes Questions 1-10 for observing, 11-20 for measuring, 21-30 for classifying, 31-40 for inferencing, 41-50 for communicating, 51-60 for hypothesizing. The researcher utilized a multiple-choice test. The development of the performance test follows certain phases: These are: 1) planning, 2) preparing the test items, 3) trying out the test items, and 4) evaluating the instrument.

Data-Gathering Procedure

In the conduct of the study, permission from the office of the principal of the private schools were asked for the conduct of the research instruments to the target respondents. After the permit was granted, the researchers made the test questions by using google forms and send the link to the grade 9 students and for the science teachers, Google forms was also used to gather data. The conduct and retrieval of the research instrument lasted for a week. After a week, the data were retrieved thru the link and tallied, tabulated, analyzed, and interpreted according to the specific problem, and hypotheses set forth in this investigation. Based on the retrieval and the response from one hundred fifty respondents (150) from the selected private junior high school as targeted, only one hundred five (105) were retrieved with the percentage of seventy percent (70 %) retrieval accuracy and responds.

Data Analysis

The study used the following statistical treatments with the help of the Statistical Package for Social Sciences (SPSS) 23. To determine the general response of the students for the science process skills acquisition, the study used weighted mean. In order to determine if there are variances in the responses of the students when grouped according to their demographic profile, the study used Analysis of Variance. Then, the researchers used Pearson-r moment of correlation to establish whether there is a relationship between the science process skill acquisition and the academic achievement of the students. The researchers used a five-point Likert scale to represent the interpretation of the responses of the student-respondents in the study.

RESULTS AND DISCUSSION

This study intends to analyze the acquisition level of science process skills and academic achievement among private junior high school students in Olongapo City. The study also intends to find out variations in the responses of students and the relationship between the level of acquisition and the students' academic achievement. The

Table 1.Level of Acquisition of Science Process Skill in terms of Observing

Statements	Weighted Mean	Descriptive Interpretation
1. I can ask questions that can be done by collecting data.	3.35	Sometimes Used
2. I am able to collect and record data accurately.	3.24	Sometimes Used
3. I am able to describe the data gathered.	3.17	Sometimes Used
4. I am able to Observe data both quantitatively and qualitatively.	3.26	Sometimes Used
5. I am able to provide elaborative observation in terms of gathered data.	3.21	Sometimes Used
Overall Weighted Mean	3.25	Sometimes Used

Note: 1.00 - 1.79= Never Used; 1.80 – 2.59= Rarely Used; 2.60 – 3.39=Sometimes Used; 3.40 – 4.19= Often Used; 4.20 – 5.00=Always Used

succeeding tables present the results of the study.

Table 1 shows the level of acquisition of Science Process Skills of the students in terms of observing. As seen from the result of the study, statement 1, "I am able to ask a question that can be done by collecting data," garnered the highest weighted mean with 3.35. This result corresponds to a descriptive interpretation of "sometimes used." On the other hand, statement 3, "I am able to describe the data gathered," yielded the lowest weighted mean of 3.17, which translates to "sometimes used" as well in the Likert scale. The overall weighted mean of the acquisition level in Science Process Skills was 3.25, equating to "sometimes used" in the descriptive interpretation scale. In the study of Ting (2014), the author revealed that broadening the process of instructional learning beyond the classroom can enhance the capacity to observe. Hence, it can give chances to see, touch, feel, smell, and hear that demand all senses. Using the five senses to take note of the characteristics of objects and circumstances describes how something should be perceived as one of the science process skills according to (Chiappetta & Koballa, 2002). In comparison, a study from Indonesia by Maison et al.

(2019) revealed that 65% of the students have "good" science process skills on observation. Another study from Indonesia showed that observing garnered the highest score in a Science Process Skills test. This result corresponds to a "very good" category in the evaluation (Ilma et al., 2020). The present scenario of distance learning reflected the results to the science process skills in terms of observing, wherein students only acquired knowledge and concepts employing listening. Moreover, the answering module is far different from the delivery of the lesson face-to-face. Teachers can make laboratory-based activities, and students can use their five senses and arrive with sound observation and results-based conclusions.

Table 2 displays the level of acquisition of Science process skills of the respondents in terms of measuring. As observed, statement 7, "I have the basic knowledge in measurement required in scientific investigations aided with appropriate equipment or tools in measuring," produced the highest weighted mean with 3.21. This result is equivalent to "sometimes used" in the descriptive interpretation. However, statement 10, "I am able to describe the dimensions of an object or event beings

Table 2. Level of Acquisition of Science Process Skill in terms of Measuring

Statements	Weighted Mean	Descriptive Interpretation
1. I am able to perform computations required scientifically.	3.06	Sometimes Used
2. I have the basic knowledge in measurement required in scientific investigations aided with appropriate equipment or tools in measuring.	3.21	Sometimes Used
3. I am able to compare an object by using a standard unit of measure.	3.10	Sometimes Used
4. I am able to compare a nonstandard measure of object beings studied.	3.06	Sometimes Used
5. I am able to describe the dimensions of an object or event beings studied.	2.71	Sometimes Used
Overall Weighted Mean	3.03	Sometimes Used

Note: 1.00 - 1.79= Never Used; 1.80 – 2.59= Rarely Used; 2.60 – 3.39=Sometimes Used; 3.40 – 4.19= Often Used; 4.20 – 5.00=Always Used

Table 3. Level of Acquisition of Science Process Skill in terms of Classifying

Statements	Weighted Mean	Descriptive Interpretation
1. I am able to categorize subjects in terms of similarities and differences.	3.49	Often Used
2. I am able to classify terms interrelationship with one another.	3.27	Sometimes Used
3. I am able to classify Objects placed into rank order based on some property.	3.30	Sometimes Used
4. I am able to classify information on the basis of whether each object has or does not have a particular property.	3.12	Sometimes Used
5. I am able to do grouping or ordering of objects or events into categories based on criteria.	3.33	Sometimes Used
Overall Weighted Mean	3.30	Sometimes Used

Note: 1.00 - 1.79= Never Used; 1.80 – 2.59= Rarely Used; 2.60 – 3.39=Sometimes Used; 3.40 – 4.19= Often Used; 4.20 – 5.00=Always Used

studied," got the lowest weighted mean of 2.71, which corresponds to "sometimes used" in the descriptive interpretation. Overall, the study revealed an average weighted mean of 3.03, which translates to "sometimes used" in the descriptive interpretation of the study. Measuring expresses the amount of an object or substance in quantitative terms, as Chiappetta and Koballa (2002) stated. Measurement abilities require the use of proper equipment and do necessary calculations. It is visible to someone with a rudimentary grasp of measurement, the necessary measuring equipment or instruments, and the capacity to do scientific computation. (Ozgelen 2012; Carin et al., 2005). In a related study in Indonesia by Tonjo et al. (2018), they stated that Measuring is one of the process skills with a low achievement profile generating less than 65% of the score.

Table 3 represents the level of acquisition of Science Process skills of students in terms of classifying. Based on the table, it reflects that statement 11, "I am able to categorize subjects in terms of similarities and differences," displayed the highest weighted mean of 3.49, which corresponds to "often used" in the descriptive interpretation. Meanwhile, statement 14 gathered the lowest weighted mean with 3.12. This result corresponds to a descriptive interpretation of "sometimes used." The overall weighted mean of the level of acquisition of Science process skills in classifying was at 3.30, which translates to "sometimes used" in the Likert scale. Classifying objects and events according to their characteristics or attributes is also essential for students to grasp. According to Tanti et al. (2020) research, the importance of science process skills for junior high school students is that children learn more meaningfully. In contrast, the study of Maison et al. (2019) from Indonesia disclosed that 54.3% of the students exhibited "good" science process classification skills. From the same country in South East Asia, Ilma et al. (2020) shared that classifying got the third-highest percentage in their assessment of Science process skills among students. This result corresponds to a "very good" category. Students become aware of and actively discover concepts from existing occurrences in the environment. Significant learning comprises learners immediately learning and can

recall knowledge readily.

Table 4 displays the level of acquisition of Science process skills of students in terms of inferring. As gleaned, it was statement 18, "I am able to make an educated guess about an object or event based on previously gathered data or information," that topped the group with a weighted mean score of 3.20. The result is parallel to a descriptive interpretation of "sometimes used." Nevertheless, it was statement 19, "I am able to use inferences based on the same observations," that produced the lowest weighted mean score of 3.08, which translates to "sometimes used" in the descriptive interpretation as well. The average weighted mean score of the table was 3.15, which means "sometimes used" in the descriptive interpretation as well. Inferring is the process of providing a quantitative explanation for a specific item or substance. Prediction estimates what will happen due to an occurrence, whereas inference draws inferences from an observed event. Evidence must back up our findings. We form inferences about the causes of phenomena we witness based on data gained via observation (Aydogdu & Keserciolu, 2005). From another foreign source, it challenges the current result of the study wherein the inference got a 44.61% result from the students' Science process skill test, which equates to a "very good" interpretation in the study (Ilma et al., 2020).

Table 5 displays the level of acquisition of students in the Science process skills in terms of communicating. As per result, statement 23, "I am able to use/ communicate information that can easily be related to my experiences," produced the highest weighted mean with 3.44. This result corresponds to a descriptive interpretation of the "often used" Likert scale. On the other hand, statement 22, "I am able to develop a presentation to share observations and data collection to others," garnered the lowest weighted mean score of 3.23. This result corresponds to "sometimes used" in the descriptive interpretation. Overall, the average weighted mean for the acquisition of Science process skills was 3.34, which translates to "sometimes used" in the descriptive interpretation. Abruscato (1995) states that it is vital to human effort and fundamental to scientific labour, and pertinent concepts may be conveyed through words,

Table 4. Level of Acquisition of Science Process Skill in terms of Inferring

Statements	Weighted Mean	Descriptive Interpretation
1. I am able to analyze a scientific problem that is according with the data collection.	3.13	Sometimes Used
2. I am able to explain a result of scientific investigation that is according with the data collection.	3.18	Sometimes Used
3. I am able to make an "educated guess" about an object or event based on previously gathered data or information.	3.20	Sometimes Used
4. I am able to use inferences based on the same observations.	3.08	Sometimes Used
5. I am able to use inferences as the gathered data increases evidently that will make the study substantial	3.14	Sometimes Used
Overall Weighted Mean	3.15	Sometimes Used

Note: 1.00 - 1.79= Never Used; 1.80 – 2.59= Rarely Used; 2.60 – 3.39= Sometimes Used; 3.40 – 4.19= Often Used; 4.20 – 5.00= Always Used

Table 5. Level of Acquisition of Science Process Skill in terms of Communicating

Statements	Weighted Mean	Descriptive Interpretation
1. I am able to communicate procedures & with others	3.31	Sometimes Used
2. I am able to develop a presentation to share observations & data collection to others.	3.23	Sometimes Used
3. I am able to use/ communicate information that can easily be related to my experiences.	3.44	Often Used
4. I am able to use descriptive words for which both my fellowmen can share a common understanding	3.34	Sometimes Used
5. I am able to communicate effectively to another person by providing clear and understandable information.	3.36	Sometimes Used
Overall Weighted Mean	3.34	Sometimes Used

Note: 1.00 - 1.79= Never Used; 1.80 – 2.59= Rarely Used; 2.60 – 3.39=Sometimes Used; 3.40 – 4.19= Often Used; 4.20 – 5.00=Always Used

Table 6. Level of Acquisition of Science Process Skill in terms of Hypothesizing

Statements	Weighted Mean	Descriptive Interpretation
1. I am able to create models to explain a scientific result	2.90	Sometimes Used
2. I am able to use a result of a scientific study to answer a question to a given problem.	2.96	Sometimes Used
3. I am able to hypothesize based on both good observation and inferences made about observed events.	3.17	Sometimes Used
4. I am able to hypothesize on constructed, modified, and even rejected hypothesis based on new observations.	3.10	Sometimes Used
5. I am able to hypothesize on constructed, modified, and even rejected hypothesis based on new observations.	3.23	Sometimes Used
Overall Weighted Mean	3.07	Sometimes Used

Note: 1.00 - 1.79= Never Used; 1.80 – 2.59= Rarely Used; 2.60 – 3.39=Sometimes Used; 3.40 – 4.19= Often Used; 4.20 – 5.00=Always Used

diagrams, maps, and graphs. In contrast, Ilma et al. (2020) disclosed that the students' result was "very good" in a given Science process skill test in terms of communicating. The study of Susanti et al. (2018) also unveiled that communication skills outclassed the other process skills.

Table 5 displays the level of acquisition of students in the Science process skills in terms of communicating. As per result, statement 23, "I am able to use/ communicate information that can easily be related to my experiences," produced the highest weighted mean with 3.44. This result corresponds to a descriptive interpretation of the "often used" Likert scale. On the other hand, statement 22, "I am able to develop a presentation to share observations and data collection to others," garnered the lowest weighted mean score of 3.23. This result corresponds to "sometimes used" in the descriptive interpretation. Overall, the average weighted mean for the acquisition of Science process skills was 3.34, which translates to "sometimes used" in the descriptive interpretation. Abruscato (1995) states that it is vital to human effort and fundamental to scientific labour, and pertinent concepts may be conveyed through words,

diagrams, maps, and graphs. In contrast, Ilma et al. (2020) disclosed that the students' result was "very good" in a given Science process skill test in terms of communicating. The study of Susanti et al. (2018) also unveiled that communication skills outclassed the other process skills.

Table 6 exhibits the level of acquisition of Science process skills of the students in terms of hypothesizing. The table shows that statement 30 got the highest weighted of 3.23, corresponding to the descriptive interpretation of "sometimes used." However, it was statement 26 that produced the lowest weighted mean score with 2.90. This result equates to "sometimes used" in the Likert scale interpretation. In the end, the overall weighted mean was at 3.07, which has a similar descriptive interpretation of "sometimes used" in the Likert scale correspondingly. According to Tan and Temiz (2003), when a student develops a hypothesis, he proposes an explanation that is compatible with the observations, questions, and evidence that are accessible. In contrast, a study of Indonesian students by Maison et al. (2019) showed that 65.7% of these students have "good" hypothesizing science process

Table 7. Result of the Academic Achievement Test of Students

Academic Achievement	Overall Result	Descriptive Rating	Interpretation
Science Process Skills	M=26; SD=8	2.63	Good

Note: 1-12=Very Poor; 13-24=Poor; 25-36=Good; 37-48=Very Good; 49-60=Outstanding

Table 8. Significant Differences in the Level of Acquisition of Science Process Skills and Academic Achievement when grouped according to Profile Variables

	Gender		Age		Parent's Highest Educational Attainment		Monthly Family Income	
	t-value	p-value	F-value	p-value	F-value	p-value	F-value	p-value
Observing	-1.166	.246	0.564	.659	0.689	.659	1.864	.123
Measuring	-1.044	.299	0.929	.450	1.108	.363	2.504*	.047
Classifying	-1.514	.133	0.689	.601	0.592	.736	2.686*	.036
Inferencing	-1.598	.113	0.885	.476	0.603	.727	1.813	.132
Communicating	-2.145*	.034	0.668	.616	1.190	.318	1.511	.205
Hypothesizing	-0.901	.369	0.565	.688	1.263	.282	1.799	.135
Academic Achievement	-3.825*	.000	1.084	.369	0.945	.467	2.199	.074

*p < .05

skills.

Nevertheless, in a different study by Ilam et al. (2020), formulating a hypothesis generated a "very poor" score in a given Science process skill test. The group of Tonjo (2018) also supported this claim wherein hypothesizing generated a low achievement score of less than 65%. Formulating a hypothesis is a capacity to build models and explain outcomes or utilize a scientific study result to answer a specific situation.

Table 7 reveals the test result to evaluate the students' skills acquisition of the Science process skills. As seen, the overall result of the test got a mean score of 26 points out of the possible perfect score of 60 points. This result is further interpreted with a descriptive rating of 2.63, which has a corresponding interpretation of "good" in the Likert scale. This result somehow concurs with Derilo's (2019) findings, wherein the students' performance in science was satisfactory. In an Indonesian study, the science process skills score of the students in the post-test were categorized as "medium". This result somehow coincides with the current study's findings as well.

Table 8 displays the significant differences in the level of acquisition of Science process skills and academic achievement when grouped according to profile variables of the study. As shown from the table, for gender, only communicating garnered a significant difference among the Science process skills. The study obtained a result of $t(103) = -2.145$ which has a corresponding p-value of .034 which is significant at .05 alpha significance level. The rest of the skills, like observing, $t(103) = -1.166$, $p = .246$; measuring, $t(103) = -1.044$, $p = .299$; classifying, $t(103) = -1.514$, $p = .133$; inferencing, $t(103) = -1.598$, $p = .113$; and hypothesizing, $t(103) = -.901$, $p = .369$ did not yield enough

results to incur variations in the respondents' answers. As for academic achievement, there exists a significant difference ($t[103] = -3.825$, $p = .000$) among the group, wherein the female students ($M=2.88$; $SD=0.627$) got better scores than the male students ($M=2.40$; $SD=0.656$). This result implies that the female students have better science acquisition skills level than the male students in this study. In terms of age, there was no significant difference in the acquisition level of observing, $F(4, 100) = 0.564$, $p = .689$; measuring, $F(4, 100) = 0.929$, $p = .450$; classifying, $F(4, 100) = 0.689$, $p = .601$; inferencing, $F(4, 100) = 0.885$, $p = .476$; communicating, $F(4, 100) = 0.668$, $p = .616$; and hypothesizing, $F(4, 100) = 0.565$, $p = .688$. The same goes for the academic achievement of the students since, $F(4, 100) = 1.048$, $p = .369$, as well. There were no significant differences in the acquisition level of observing, $F(6, 98) = 0.689$, $p = .659$; measuring, $F(6, 98) = 1.108$, $p = .363$; classifying, $F(6, 98) = 0.592$, $p = .736$; inferencing, $F(6, 98) = 0.603$, $p = .727$; communicating, $F(6, 98) = 1.190$, $p = .318$; and hypothesizing, $F(6, 98) = 1.263$, $p = .282$. Even for the academic achievement among the students, there was no noticeable variation, since $F(6, 98) = 0.945$, $p = .467$. Finally, for the monthly family income, there were significant differences observed in the measuring, $F(4, 100) = 2.504$, $p = .047$ and classifying, $F(4, 100) = 2.686$, $p = .036$ for the Science process skills among the students. Other Science process skills like observing, $F(4, 100) = 1.864$, $p = .123$; inferencing, $F(4, 100) = 1.813$, $p = .132$; communicating, $F(4, 100) = 1.511$, $p = .205$; and hypothesizing, $F(4, 100) = 1.799$, $p = .135$, did not produce significant results. These ideas apply to the academic achievement of the students as well. The findings of Raj and Devi (2014) agreed and disagreed with the current results of the study. However, another study from Nigeria by the group of Achor (2018) stated that there was no significant variation between male and female students' acquisition of science process

skills. The contrasting results from the current study and the previous ones allow other researchers to explore this particular area to add more references for future utilization and comparison.

Table 9 shows the correlation matrix between the Science process skills and the students' academic achievement. Based on the study results, it was clear that there is a significant relationship between the Science process skills and the students' academic achievement. The Pearson-r computation for observing, measuring, classifying, inferencing, communicating, and hypothesizing created a moderate positive relationship based on the generated r-values of .420, .391, .400, .449, .364, and .331, respectively. This result means that if the Science process skills of students are high, so does the academic achievement in the Science subject. Moreover, if the students have low Science process skills, they will perform poorly in their academic achievements in the subject. This result coincides with the results of Raj & Devi (2014), where they found a relationship between science process skills and achievement in science. As for Derilo (2019), science process skills correlate significantly with students' science performance. From a foreign study, Bayar (2019) also disclosed that as the academic achievement increased, so did the science process skills. Thus, all of the mentioned studies here, both foreign and local, point to the association between science process skills and students' academic achievement.

CONCLUSION

Based on the study's results, the researchers concluded that:

1. In general, students' acquisition of science process skills in terms of observing, measuring, classifying, inferencing, communicating, and hypothesizing has a general weighted mean of 3.19, which corresponds to

a descriptive interpretation of "sometimes used".

2. In terms of student academic achievement at the end of the school year, the students got a mean score of 26, corresponding to a "good" score.
3. Statistical inferences showed variations in the students' responses regarding gender (communicating and academic achievement) and family monthly income (measuring and classifying).
4. There was also a moderate positive relationship between the Science process skills and the students' academic achievement in the study.

From the conclusion mentioned above, the researchers validated its hypothesis that there is an existing relationship between the level of acquisition of science process skills and students' academic achievement in the subject. Furthermore, the study also found variations in the acquisition level of science process skills when grouped according to gender and family monthly income. These results can be the basis for some innovative techniques in delivering the science subject since the country is still in the state of "New Normal."

RECOMMENDATION

The researchers recommend the following actions referenced from the above finding and conclusions.

1. The Integration of Science Process Skills needed to be well emphasized in the science subjects in the pandemic setting needed to be enhanced.
2. The utilization of science experiment approaches in blended learning settings needs to be well defined. The experimentation should be addressed well in the modality of blended learning.
3. The Head Teachers/Supervisors can secure the learning facility to utilize available learning materials well-reviewed and assessed.

Table 9. Correlation Matrix between Level of Acquisition of Science Process Skills and Academic Achievement of the Students

Science Process Skills		Academic Achievement	Remarks
Observing	Pearson Correlation	.420*	Reject Null Hypothesis
	Sig. (2-tailed)	.000	
	N	105	
Measuring	Pearson Correlation	.391	Reject Null Hypothesis
	Sig. (2-tailed)	.000	
	N	105	
Classifying	Pearson Correlation	.400*	Reject Null Hypothesis
	Sig. (2-tailed)	.000	
	N	105	
Inferencing	Pearson Correlation	.449*	Reject Null Hypothesis
	Sig. (2-tailed)	.000	
	N	105	
Communicating	Pearson Correlation	.364*	Reject Null Hypothesis
	Sig. (2-tailed)	.000	
	N	105	
Hypothesizing	Pearson Correlation	.331*	Reject Null Hypothesis
	Sig. (2-tailed)	.000	
	N	105	

* $p < .05$

4. Collaborative /Coaching or sharing of knowledge in the faculty for the science teachers is essential in the private schools to improve strategies amidst the pandemic.
5. Faculty development in the integration of Science Process Skills must be addressed appropriately and prioritized to equip science faculty and initiatives/endeavours amidst the pandemic to ensure teaching quality.
6. The utilization of e-learning materials should be reviewed and aligned with the faculty and students' blended learning needs of science (biology subjects).

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Modeling the Performance of Senior High School Students' National Achievement Test Performance in Central Mindanao University

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ABSTRACT

The study is entitled Modeling the Performance of Senior High School Students' National Achievement Test Performance in Central Mindanao University. It aims to develop a predictive model of the National Achievement Test performance of Senior High School students. The study intends to extract predictive features of students' National Achievement Test performance, find the extent of the relationship between the students' academic performance in the previous and current year to their National Achievement Test performance, and recommend pedagogical interventions concerning National Achievement Test performance's predictive features. There were two types of datasets, National Achievement Test and Periodic grades of batch 2017 – 2018 when they were in Grade 11 and Grade 12 before taking the National Achievement Test. After the data is collected, the Feature selection and Logistic regression model is applied using the data mining process's rapid miner application. Out of 30 attributes, there are only 14 subjects selected by the feature selection technique. The feature selection selected those subjects which contributed to the prediction. We found out that Philosophy and Arts in the Last Quarter and Semester before the National Achievement Test exam has the most significant effect on the National Achievement Test Result. This study was based on a CMU-funded research entitled Leveraging Educational Data Mining and Machine Learning Techniques in Developing Strategic Interventions for Senior High School Students.

Keywords: EDM, Logistic Regression, Student Performance, Modeling

INTRODUCTION

Data Mining (DM) is a field in Computer Science that is concerned with finding patterns from large amounts of data or the discovery of properties of data through the use of various algorithms and computing tools for data exploration, visualization, and presentation in a simplified manner in order to support decisions through classification, prediction, finding clusters, relationships, and associations (Looi et al., 2005)

There are many approaches to learn patterns and properties from data, and one popular approach is using Machine Learning (ML) techniques (Witten et al., 2016). Using both DM and ML methodologies, scholars have started to investigate how these can improve educational research. Educational Data Mining (EDM) focuses on extracting new knowledge using data from educational software, online courseware, academic records, and databases, etc. By looking at the vast amount of education that is now available, it has become possible to predict student performance, behavior, affect, and other constructs that could be related or has an impact to both the students' and Teachers' educational experience (Romero et al., 2010). In the Philippines, the Department of Education (DepEd) has been giving the National Achievement Test (NAT) to students in the basic education level since 2006 in lieu to the National College Entrance Examination (NCEE), which started in 1973 for graduating high school students.

Under the K to 12 System, part of the DepEd Order No. 55, s. 2016 is the administration of an achievement examination for Grade 12 to determine if the students

meet the learning standards in senior high school, and this assessment will remain in force and effect until SY 2023-2024. In Ogena et al. (2018), showed that the prior performance of primary and secondary schools in the Philippines, both in national and international examinations, could be considered dismal. The new curriculum with the recent educational reform is adopted, but to ensure an improvement in the students' performance there must be a utilization of technology-driven research techniques.

The main objective of study is to develop a predictive model of the NAT performance of Senior High School students. In order to come up to that objectives this study needs to extract predictive features of students' NAT performance, find the extent of the relationship between the academic performance of the students in the previous and current year to their NAT performance and lastly to apply the result to reaching this must recommend pedagogical interventions in relation to the predictive features for NAT performance.

LITERATURE REVIEW

The Data Mining and Machine Learning Framework

Data Mining (DM) is an area of Computer Science which focuses on discovering novel and potentially useful information from large amounts of data (Baker, 2010).

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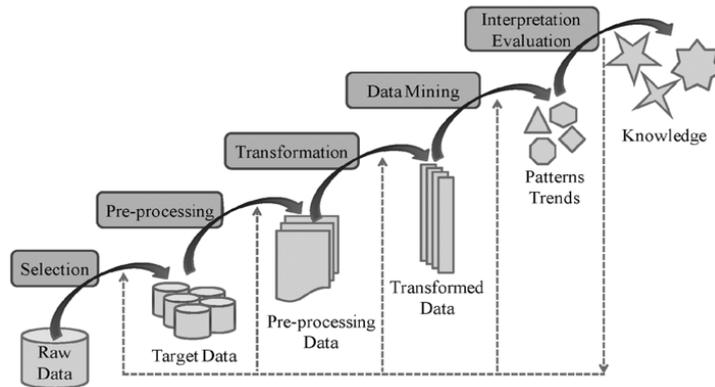


Figure 1. Data mining (DM) in knowledge discovery in databases (KDD)

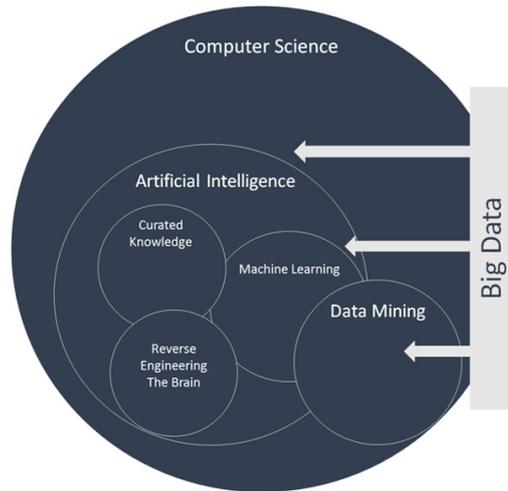


Figure 2. Data mining (DM) and Machine Learning (ML) as related sub-fields in Computer Science

DM has been applied in various fields, including business, bioinformatics, and security. Over the years, there have been an increasing interest in leveraging DM techniques in educational research. Thus, the term Educational Data Mining (EDM) has been defined as the area of scientific inquiry focused in the development of methods to make discoveries with data coming from educational settings towards a better understanding of the students, developing pedagogical practices, and creating models for computer-based learning environments or educational software. For example, data mining can be used to study student behavior in using an educational software by considering data at the keystroke level, solution level, session level, etc. It could also be used to develop predictive models of student performance and identify features which could help design pedagogical strategies as intervention.

DM is part of the process of knowledge extraction called Knowledge Discovery in Databases (KDD) also called Knowledge Discovery in Databases (KDD), which was formally adopted in 1989 and refers to a process that involves the identification and recognition of patterns in a database, in an automatic way, i.e., obtaining relevant, unknown information, that may be useful in a decision making process, without a previous formulation of hypothesis (Figueiredo et al., 2016). Figure 1 shows the essential parts of KDD which involves data selection, pre-processing, transformation, data mining, and interpretation.

In relation to DM, Machine Learning (ML) is also a sub-field of Computer Science that focuses on designing

algorithms that can learn from the data. ML is one of the many techniques used in DM to make predictions or classifications (Alpaydin, 2009). Figure 2 shows the relationship between DM and ML as sub-fields of Computer Science.

Machine Learning mainly divided into three categories: supervised, unsupervised, and semi-supervised (reinforcement). Supervised Learning, which will be used in this study, is the first type of machine learning, in which labeled data used to train the algorithms. In supervised learning, algorithms are trained using marked data, where the input and the output are known. We input the data in the learning algorithm as a set of inputs and the algorithm learns by comparing its actual production with correct outputs to find errors. It then modifies the model accordingly. The raw data is divided into two parts. The first part is for training the algorithm, and the other region used for test the trained algorithm. Supervised learning uses the data patterns to predict the values of additional data for the labels. This method is commonly used in applications where historical data predict likely upcoming events.

Prediction of Students' Performance using DM and ML

Over the years, the Philippines' basic education has shown below par performance in comparison to other countries specifically in the ASEAN region and one of the reasons cited for this was the 10-year curriculum structure. As a solution, the government ruled for the basic education

system to shift to the K-12 structure (Cruz, 2015). However, efforts for improvement seemed futile as the performance got worse based on the 2017 Global Innovation Index where the Philippines ranked poorly at the 113th place out of 127 countries (Lugtu, 2018). To alleviate this, the Department of Education (DepEd) has been conducting the National Achievement Test (NAT) (DepEd Memorandum 146 series, 2018) in order to assess the quality of education provided to the students. Students' performance is a significant part in educational institutions because one of the criteria of quality is based on the excellent record of academic achievement.

Data mining techniques and various machine learning algorithms have proven to be effective in creating predictive models of student performance. Decision Tree is one of a popular technique for prediction. Most researchers have used this technique because of its simplicity and comprehensibility to uncover small or large data structure and predict the value (Naika & Zwilling, 2014; Osmanbegovic & Suljic, 2012; Quadri & Kalyankar, 2010). Jishan et al. (2015) and Naika & Zwilling (2014) were able to get more than 90% accuracy in predicting performance using Decision Trees. Bunkar et al. (2012) has also shown that this method is effective for the prediction of performance improvement of graduate students using a larger data set.

Another option for researchers to make a prediction is Naive Bayes algorithm. Devasia et al. (2016) proposed a web based application which makes use of the Naive Bayesian mining technique for the extraction of useful information. The experiment is conducted on 700 students' with 19 attributes in Amrita Vishwa Vidyapeetham, Mysuru. Result proves that Naive Bayesian algorithm provides more accuracy over other methods like Regression, Decision Tree, Neural networks etc., for comparison and prediction. The same result was shown in another research (Saa, 2016) where three different data mining classification algorithms (Naive Bayes, Neural Network, and Decision Tree) were used on the dataset. The prediction performance of three classifiers are measured and compared and Naive Bayes

classifier outperforms other two classifiers by achieving overall prediction accuracy of 86%.

Moreover, the attribute that has been frequently used is cumulative grade point average (CGPA). Several researches have used CGPA as the main attribute to predict student performance (Abu Tair & El-Halees, 2012; Angeline, 2013; Osmanbegovic & Suljic, 2012; Quadri & Kalyankar, 2010). The main idea of why most of the researchers are using CGPA is because it has a tangible value for future educational and career mobility (Shahiri & Husain, 2015). It can also be considered as an indication of realized academic potential (Bin Mat et al., 2013).

For school heads and teachers, analyzing NAT results would be helpful not only to determine the quality of teaching and learning but also in finding specific factors that contribute to the students' performance. This study aims to leverage the use of educational data mining in order to find those factors and so teachers could design pedagogical strategies to help students and improve their academic experience.

Logistic Regression outperform the other five algorithms in the study entitled "Use Educational Data Mining to Predict Undergraduate Retention" (Lehr et al., 2016). Logistic Regression showed 80% of the precision in the study about Applying Educational Data Mining to Explore Students' Learning Patterns in the Flipped Learning Approach for Coding Education (Hung et al., 2020). Evaluating the performance of other algorithms; Logistic Regression, Naive Bayes, and SVM logistic regression showed a higher percentage in accuracy, precision, and F1 Score, the study identifies the Drop Out students using Educational Data Mining. (Tasnim et al., 2019)

Independent And Dependent Variables

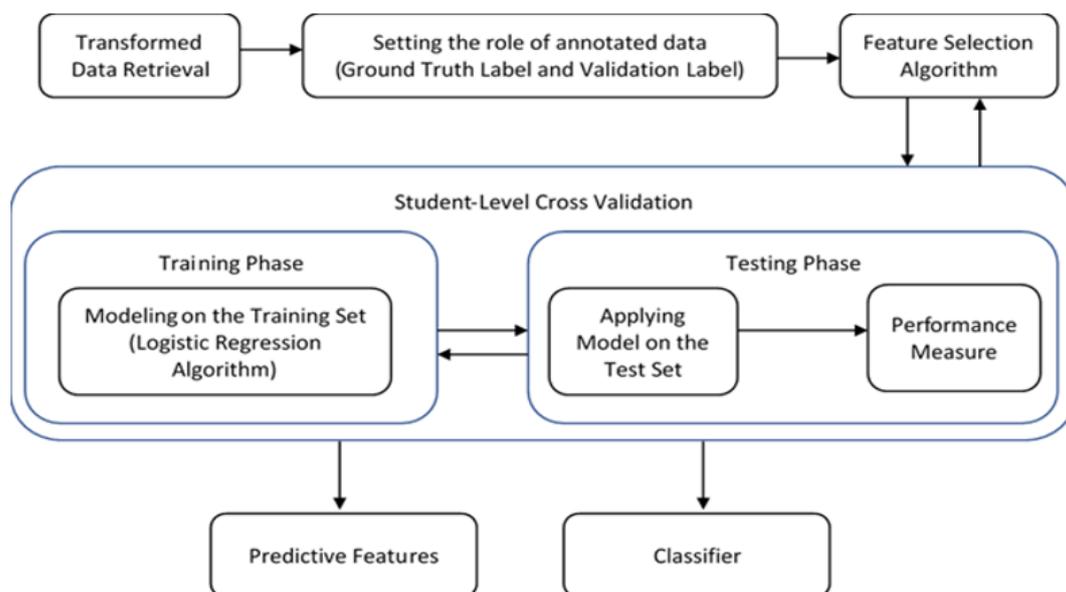


Figure 3. Logistic Regression with Feature Selection and Student-level Cross-Validation

In the diagram above, you can observe the independent and dependent variables. The dependent variable is the NAT Scores which the scores are categorized as Low Master and Very Low Mastery. The student grades retrieved from report cards with the following subjects are the dependent variables:

1. 21st Century Literature in the Philippines and the World
2. Pre-Calculus
3. Biology
4. Personal Development
5. Basic Calculus
6. Philosophy
7. Disciplines and Ideas in Social Science
8. Physical Science
9. English for Academic and Professional Purposes
10. Religion
11. Earth and Life Science
12. Reading and Writing Skills
13. Earth Science
14. Statistics
15. Filipino
16. Science
17. General Mathematics
18. Social Science
19. Information and Communication Technology
20. Understanding Culture Society and Politics
21. Mathematics
22. Creative Writing
23. Oral Communication
24. Physics

METHODOLOGY

This study implements the KDD (Knowledge Discovery in Database) methodology. Figure 3 shows the specific KDD (Knowledge Discovery in Database) methodology for this study using the Logistic Regression

Algorithm and Feature Selection Technique. Basically the KDD methodology focuses on the Selection, Pre-processing, Transformation, Data Mining and Interpret Evaluation these are also the steps in this study.

The coding of the Periodic Grades Dataset and the Union Operator in Rapidminer are both part of the selecting process. Pre-processing was the next step. Oversampling with Feature Selection Algorithm was used for the transformation. The Data Mining Process includes using logistic regression techniques throughout the training and testing phases. Finally, Designing the Strategic Intervention is under the category of interpret Evaluation.

Data

There are two data sources in this study: the Periodic grades dataset and the National Achievement Test dataset. All were collected from the college of Education of Central Mindanao University and in the form of hard copy.

The periodic grades data was about the student's subject performance grade when they were in grade 11 (The school Year 2017-2018) as well as their periodic grades in grade 12 (The school Year 2018-2019), before taking the National Achievement Test was collected from a total of 723 Senior High School students of Central Mindanao University.

The periodic grades of students are from the Four strands: 323 from STEM (Science Technology Engineering Mathematics), 159 from HUMSS (Humanities and Social Sciences), 94 from ABM (Accounting and Business Management), and 147 from TVL (Technical Vocational and Livelihood). The attributes are the students' subjects from their periodic grades in the 1st and 2nd Quarters in Grade 11 and 1st Quarter in Grade 12. There are a total of 23 subjects in the mentioned quarters of Grade Levels. There

EXAMINEE NUMBER 0257911	NAME ABALES, KEN ARCHIMEDES			SCHOOL ID 98127
NAME OF SCHOOL CENTRAL MINDANAO UNIVERSITY				
21st Century Skills		Problem Solving		
SUBJECT AREAS		AO	ESM	UTP
I. SCIENCE		33.33	55.56	50.00
II. PHILOSOPHY		100.00	66.67	50.00
III. HUMANITIES		33.33	33.33	66.67
IV. MEDIA AND INFORMATION LITERACY		66.67	66.67	66.67
V. MATHEMATICS		66.67	22.22	55.56
VI. LANGUAGE AND COMMUNICATION		50.00	75.00	56.33
VII. SOCIAL SCIENCE		66.67	83.33	33.33
Mean Percentage Score (MPS)		59.52	57.54	54.37
Summary	Problem Solving	Information Literacy	Critical Thinking	
MPS	57.14	51.19	49.87	
PR	97	94	94	
Total Test MPS		52.73		
Total Test PR (Percentile Rank)		96		

Figure 4. National Achievement Test Certificate Rating

are different, related, and the same subjects in different quarters. After collecting the dataset from periodic grades, the National Achievement Test dataset from the College of Education scores was sorted and digitized by the research assistants.

Figure 4 shows the National Achievement Test Certificate. The exam coverage is composed of 7 categories; Science Philosophy, Humanities, Media and Information Literacy, Mathematics, Language and Communication, and Social Science. These categories' scores are displayed using the three 21st Century Skills; Problem Solving ability, Information Literacy Ability, and Critical Thinking Ability.

It is presented in the lower-left side of the certificate, the table for the score's summary. Which consist of the Mean Percentage Score (MPS) and the Percentile Rank per category – Problem Solving, Information Literacy, and Critical Thinking. Figure 4 summarizes all scores, the Total Test Mean Percentage Score, and the Total Test Percentile Rank of the three categories below the summary of all scores.

Selection

The subjects' names are too long; it is recommendable to code these subjects per quarter and Grade level. To follow the proper computer file naming convention. The format is:

subject-name-acronym-grade-level-quarter name

For example, Oral Communication has an acronym of OC, followed by the year-level acronym: G11 for grade 11, next is the Quarter's acronym, Q1 for quarter 1. The coded subject looks like this: OC-G11-Q1. Shown in Table 1, the subject code for the Periodic Grades Dataset.

In preparing for the National Achievement Test dataset, the first thing that we did is convert the hard copy to digital. The Mean Percentage Score was then classified, and according to Albano (2019), the NAT score follows the following criteria, shown in Table 2.

The criteria are dependent on the Mean Percentage Score of the National Achievement Test. Table 2, the range 0 – 35, is classified as Very Low Mastery, 36 – 65 as Low Mastery, 66 – 85 is classified as Average Mastery, and 86 – 100 as Moving Towards Mastery. The criteria are renamed based on its acronym: VLM for Very Low Mastery, LM for Low Mastery, AM for Average Mastery, and MTM for Moving towards Mastery.

The Periodic grades dataset and the National Achievement Test dataset were combined and then was separated per strand. There are a total of 4 strands: Humss, Stem, ABM, and TVL. The four files were combined using a union operator to avoid redundancy to the attributes and data while combining the datasets, shown in Figure 5. The union operator creates a superset from multiple example sets. If there is a common attribute in both exampleset, the union operator only creates one single attribute that will hold the data for both data sets.

Table 1. Subject code in Periodic Grades Dataset

1. 2CLPW	21st Century Literature in the Philippines and the World	13. PC	Pre-Calculus
2. B	Biology	14. PD	Personal Development
3. BC	Basic Calculus	15. Ph	Philosophy
4. DISS	Disciplines and Ideas in Social Science	16. PSc	Physical Science
5. EAPP	English for Academic and Professional Purposes	17. R	Religion
6. ELS	Earth and Life Science	18. RWS	Reading and Writing Skills
7. ES	Earth Science	19. S	Statistics
8. F	Filipino	20. Sc	Science
9. GM	General Mathematics	21. SS	Social Science
10. ICT	Information and Communication Technology	22. UCSP	Understanding Culture Society and Politics
11. M	Mathematics	23. CW	Creative Writing
12. OC	Oral Communication	24. P	Physics

Table 2. National Achievement Test criteria

NAT Scores	Criteria
0 - 35	Very Low Mastery
36 – 65	Low Mastery
66 – 85	Average Mastery
86 – 100	Moving Towards Mastery

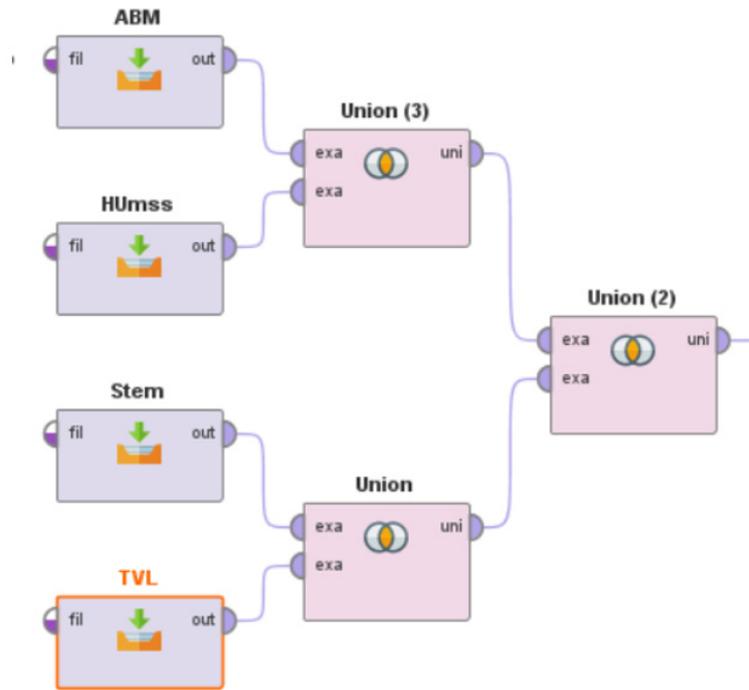


Figure 5. Union Operator in Rapidminer

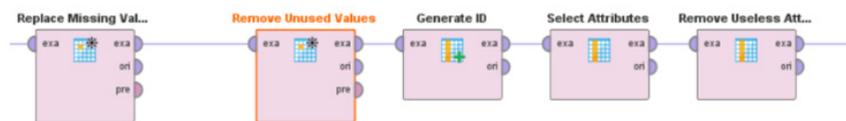


Figure 6. Preprocessing

Pre-processing

There are still inconsistent values in the dataset, like students without grades in some quarters, students that have not taken the National Achievement Test, and some other useless data. The Data Cleaning technique was done on this stage to replace the missing value, remove unused values, and remove useless attributes. Data Cleaning is part of the Preprocessing algorithm.

The preprocessing stage in rapidminer is in Figure 6. To uniquely identify the students; there is a need to generate the ID of all the students; the ID is necessary for the transformation phase. The select attributes operator is used to select only the attributes needed.

Transformation

The National Achievement Test Criteria is the output variable or the dependent variable assigned using the set role operator in this stage. The set role operator is used to set the dependent variable in rapidminer; the role should be the unique role label necessary in the Logistic regression algorithm.

The unique student ID is used as the batch label to ensure that a student's record will not be in the training set and the test set during the same iteration. An oversampling methodology was then applied because, upon the pre-assessment, there is an uneven/unbalanced amount of data. We found out that there are only two available NAT criteria in all the strand, VLM and LM. The

LM (Low Mastery) has the most significant ratio, while the VLM has only 3%; this means most of the students got Low Mastery in the National Achievement Test.

An oversampling technique is necessary in order to balance data. The distribution of the oversampling techniques is 50% VLM and 50% LM.

A feature selection algorithm is optimized to iteratively develop a parsimonious model as the data will be going through training and testing.

Feature selection has improved the comprehensibility of extracted knowledge; it is the process of identifying and removing as much irrelevant information as possible (Hall,1999). The operator used selects the most relevant attributes of the given exampleset; the performance measurement is inside the operator to indicate how well the feature subset performs.

Logistic Regression Algorithm

The cross-validation was connected after the feature selection technique to train and test the dataset; to apply the model to the dataset and, at the same time, estimates how accurately a model will perform in practice. This operator has two subprocesses: the training and the testing subprocess. In the training subprocess, the logistic regression learns good values for all the weights, and the bias from labeled examples iteratively called training. There is a need to test the Logistic regression model to check the accuracy and validate the model prediction; then place the

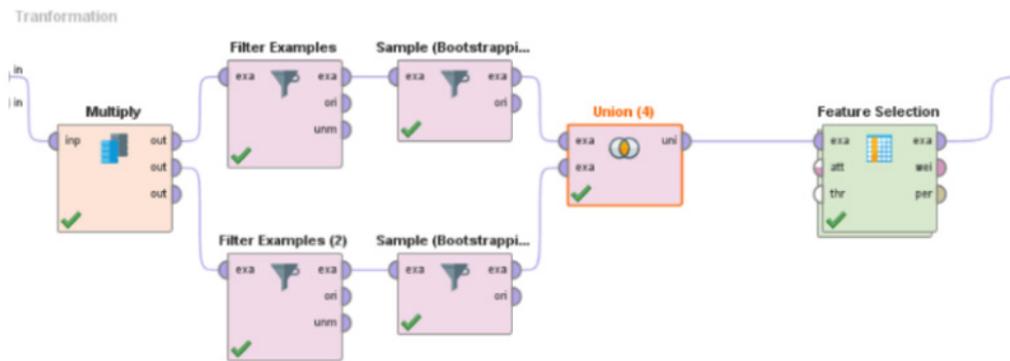


Figure 7. Oversampling with Feature Selection Algorithm

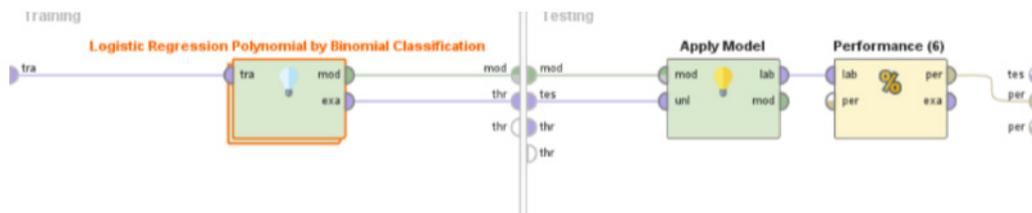


Figure 8. Logistic Regression Algorithm in Cross-Validation

applied model operator in the testing subprocess before the classification performance. Figure 8 shows the logistic regression in the training subprocess and performance classification in the testing subprocess.

There must be a partitioned subprocess to K subset then for testing the other subset must be retrained in cross-validation. Then the remaining K-1 will be applied to the training subprocess. This cross-validation will be iterated in K times, the usage of the partitioned K subsets will only be once.

Designing the Strategic Intervention

In order to design the strategic intervention it would be better to find out the pedagogical approach first thus, before finding out the pedagogical approach the interpretation of the data from the model must be considered. The process in interpreting in order to come up with the strategic intervention also known as the pedagogical approach will be expounded.

1. Identifying the Predictive Features - This part identifies the predictive features through the feature selection process. There are only 14 features being selected by feature selection, thus 2 subjects are repeated therefore there are only 12 subjects with significance to the National Achievement test based on the academic performance of students. These subjects are Earth and Life Science, Physical Science, Personal Development, Understanding Culture Society and Politics, 21st Century Literature in the Philippines and the World, Philosophy in quarters 1 and 2, Filipino, English for Academic and Professional Purposes, English for Academic and Professional Purposes, Filipino in Grade 11 quarters 3 and 4, Media and Information Literacy and lastly Arts.

2. Interpreting coefficients - in order to determine

relationship between the National Achievement Test and the Periodic grades this part is about interpreting the coefficients that is given by the model. Since the coefficients may interpret the likelihood of the student to pass or fail in the National Achievement test based from the student performance, we have used these negative and positive coefficient values to interpret the data.

a. Negative Coefficient - A negative coefficient suggests that as the independent variable increases, the dependent variable tends to decrease.

b. Positive Coefficient - A positive coefficient indicates that as the value of the independent variable increases, the mean of the dependent variable also tends to increase.

3. Finding out the strategic intervention - this is about researching and looking for references to be adopted in finding out what kind of pedagogical approach is recommended based from the result of the model.

RESULTS & DISCUSSIONS

The Predictive Model

The algorithm that was used for this study is the logistic regression model. Supposedly there will be 4 values being extracted from the National Achievement Test scores thus, upon observing the datasets and values of NAT student grades there are only 2 values: Very Low Mastery and Low Mastery

The developed Logistic regression predictive model of the NAT performance of Senior High School students shown in Tables 3, 4, 5 and 6.

Out of 30 attributes, there were only 14 that were selected by feature selection technique. 9 out of 14 are the subjects in Grade 11, and the remaining five subjects are from

Table 3. Predictive Model of the National Achievement Test Performance of Senior High School Students of Physical Science (Physical Scie), Personal Development(PerDev), Understanding Culture Society and Politics(UCSP).

Variables	Physical Scie	PerDev	UCSP
Grade	11	11	11
Quarter	4	2	1
Coefficient	-17.11	-4.1	-4.89
Std. Coefficient	-9.11	-15.61	-8.07
Standard Error	7.03	1.2	1.91
Wald	-2.43	-3.42	-2.56
p-value	0.01	0	0.01

Table 4. Predictive Model of the National Achievement Test Performance of Senior High School Students in 21st Century Literature in the Philippines and the World(CLPW), Philosophy, English in Academic and Professional Purposes(EAPP).

Variables	CLPW	Philosophy	EAPP
Grade	12	12	11
Quarter	1	2	2
Coefficient	-1.93	-1.36	-30.97
Std. Coefficient	-6.71	-13.67	-10.6
Standard Error	0.9	0.51	11.79
Wald	-2.14	-2.63	-2.63
p-value	0.03	0.01	0.01

Table 5. Predictive Model of the National Achievement Test Performance of Senior High School Students in Filipino, Media and Information Literacy(MIL), Earth and Life Sciences(ELS)

Variables	Filipino	MIL	ELS
Grade	11	12	11
Quarter	3	1	2
Coefficient	-0.65	-1.04	2.75
Std. Coefficient	-4.32	-6.06	3.76
Standard Error	0.75	0.58	3.3
Wald	-0.87	-1.78	0.84
p-value	0.38	0.08	0.4

Table 6. Predictive Model of the National Achievement Test Performance of Senior High School Students in Filipino for grade 11 in 2nd and 4th quarter, EAPP(English in Academic and Professional Purposes) and then Arts

Variables	Filipino	EAPP	Filipino
Grade	11	11	11
Quarter	2	1	4
Coefficient	0.46	18.32	0.15
Std. Coefficient	3.01	7.88	1.24
Standard Error	0.39	9.45	0.69
Wald	1.18	1.94	0.22
p-value	0.24	0.05	0.82

Grade 12. The model displayed five attributes; Coefficient, Standard Coefficient, Standard Error, Wald, and the P-Value. Each of the attributes is significant in the analysis and plays a vital role in prediction.

The academic performance of the students and NAT performance

National Achievement Test and Periodic Grades Relationship

The coefficient value signifies how much the dependent variable changes given a one-unit shift in the independent variable while holding other variables in the model constant. Table 3 shows the Coefficient of independent variables extracted by the feature selection algorithm.

The more the students got high grades in the subjects listed in Table 6, the less likely these students will get Low Mastery Grade. These subjects are Understanding Culture Society and Politics in Quarter 1, Personal Development and English for Academic and Professional Purposes in Quarter 2, Filipino in Quarter 3, and Physical Science in Quarter 4 from Grade 11. Then another two subjects from Grade 12 both in Quarter 1: Media and Information Literacy and 21st Century Literature in the Philippines and the World. Then one subject from Quarter 2 of Grade 12, Philosophy.

The positive Coefficient implies that the more the students get higher grades on these subjects listed in Table 7, the more likely they will get Low Mastery. It also implies that the more the student gets high grades, the less likely

they will get a Very Low Mastery criterion in the National Achievement Test. The subjects are English for Academic and Professional Purposes in Grade 11 Quarter 1. Earth and Life Science and Filipino in Grade 11 Quarter 2. Arts in Grade 12 Quarter 2 and Filipino in Grade 11 Quarter 4.

English for Academic Purposes from Grade 11 in Quarter 1 has a positive coefficient of 18.32. It implies that the more the student gets higher grades in this subject in the specific Quarter, the more likely the student will get Low Mastery. Then the negative Coefficient of -30.97 in Quarter 2 of the same subject implies that the more the student gets higher grade in this subject, the less likely these students will get Low Mastery Grade or the more likely these students could get a Very Low Mastery National Achievement Test Result Rating. English for Academic Purposes in Quarter 1 of Grade 11 showed the most substantial effect in the National Achievement Test performance rating.

Figure 9 shows the Result per Subject Category Coverage. 37.5% of all the subject implies, the higher the student's grade in Social Science and Personal Development, the less likely the student will get Low Mastery. 25% implies the higher the grade in Language and Communication, the less likely the student will get Low Mastery. 12.5% implies the higher the grade in Science, the less likely the student will get Low Mastery. 12.5% implies that the higher the grade in Media and Information Literacy, the less likely the student will get Low mastery. 12.5% implies the higher the grade in Philosophy, the less likely the student will get Low mastery.

Figure 10 shows the result per category coverages.

Table 6. Negative Coefficient:

Subject	Grade Level	Quarter	Negative Coefficient
Understanding Culture Society and Politics	Grade 11	Quarter 1	-4.89
Personal Development	Grade 11	Quarter 2	-4.10
English for Academic and Professional Purposes	Grade 11	Quarter 2	-30.97
Filipino	Grade 11	Quarter 3	-0.65
Physical Science	Grade 11	Quarter 4	-17.11
Media and Information Literacy	Grade 12	Quarter 1	-1.04
21st Century Literature in the Philippines and the World	Grade 12	Quarter 1	-1.93
Philosophy	Grade 12	Quarter 2	-1.36

Table 7. Positive Coefficient:

Subject	Grade Level	Quarter	Positive Coefficient
English for Academic and Professional Purposes	Grade 11	Quarter 1	18.32
Philosophy	Grade 12	Quarter 1	1.13
Earth and Life Science	Grade 11	Quarter 2	2.75
Filipino	Grade 11	Quarter 2	0.46
Arts	Grade 12	Quarter 2	2.70
Filipino	Grade 11	Quarter 4	0.15



Figure 9. The higher the periodic grades in these Subject Categories, the less likely the student will get Low Mastery.

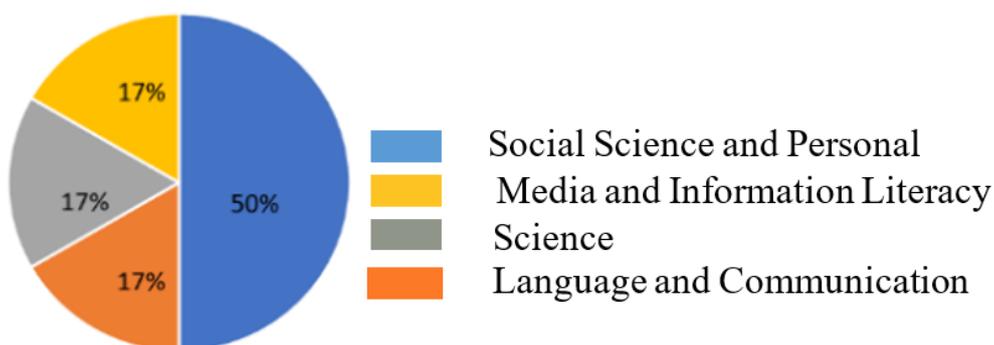


Figure 10. The higher the periodic grade in these Subject Categories, the more likely the student will get Low Mastery

50% of subjects belonging to the Language and Communication category coverage implies that the higher the periodic grade in this category, the more likely the student will get Low Mastery. Then, 17% from Philosophy, Science, and Humanities category implies, the higher the periodic grade in this category, the more likely the student will get Low Mastery.

The Relationship and Effect of the academic performance to National Achievement test

The Second highest absolute value coefficient is the Arts in the Second Quarter of Grade 12, shown in table 6. It means it has the second-highest effect on the Student's National Achievement Test performance among all the subjects. The Art's (Quarter 2, Grade 12) coefficient implies that the more the student gets the higher grade, the more likely they will get Low Mastery and other National Achievement Test Criteria except for Very Low Mastery. This attribute is accepted and statistically significant based on its P-value, as shown in Table 8.

There are two Filipino subjects from different Quarter and the same grade level; the positive Coefficient implies that the more the student got higher grades in quarters 2 and 4, the more likely they will get Low Mastery since Filipino is not on the list of Std. Coefficient's Highest Absolute Value table implies that this subject does not affect the National Achievement Test Student Performance. The P-Value is above .05, which means it is not statistically significant to the National Achievement Test.

Standardized regression coefficients are frequently used in quantitative social sciences and are very useful in many purposes: Selecting variables, determining the relative importance of explanatory variables, comparing the effect

of changing different variables, and so forth (Bring,1994). Menard(2011) cited the works of Agresti (1996); one of the reasons for using standardized coefficients is that when variables are measured in different units of measurement, standardized coefficients are useful for comparing the relative strength of different predictors or independent variables within a multiple regression or logistic regression model. The higher the absolute value of the standardized Coefficient, the stronger the effect (Glen, 2016).

There is sufficient evidence to conclude a significant linear relationship between the National Achievement Test and y because the correlation coefficient is significantly different from zero.

The results of the logistic regression model show that Filipino students in Grade 11 in Quarters 2, 3, and 4 had the greatest impact on the National Achievement Test; as a result, a path analysis was conducted solely for subjects with substantial impact. The subject Filipino in grade 11 in quarters 2, 3, and 4 has a significant impact on the National Achievement Test, according to the Model. As seen in the path analysis in Figure 11, Filipino in grade 11 in quarter 4 and quarter 2 has a positive and significant impact on the National Achievement Test. On the other hand Filipino in Grade 11 of Quarter 3 has a negative and significant impact on the National Achievement Test.

Filipino in Grade 11 of Quarter 2 and Quarter 4 has a direct effect in the National Achievement Test Score as seen in table 8. Filipino in Grade 11 of Quarter 3 indirect effect on the National Achievement Test as seen in Table 9..

Validation

The Confusion Matrix shows VLM's predicted

Table 8 Subject arrangement based on the P-Value

Variables	Grade	Quarter	Wald	P-Value
Physical Science	11	4	-2.43	0.01
Personal Development	11	2	-3.42	0.00
Understanding Culture Society and Politics	11	1	-2.56	0.01
21st Century Literature in the Philippines and the World	12	1	2.14	0.03
Philosophy	12	1	2.56	0.01
Philosophy	12	2	-2.63	0.01
English for Academic and Professional Purposes	11	2	-2.63	0.01
Arts	12	2	4.73	0.00

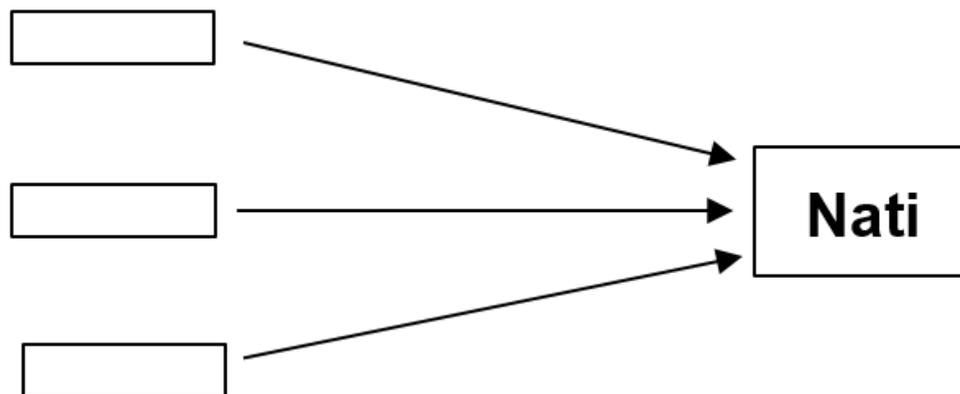


Figure 11. Path Analysis based on correlation coefficient with significant impact

Direct Effect	Predictive Value
Filipino G11, Q2	.46
Filipino G11, Q4	.15
Indirect Effect	Predictive Value
Filipino G11, Q3	-.65

Table 9. Subjects with Direct and Indirect Effect based from the Predictive Value

values (Very Low Mastery) and LM(Low Mastery). 42.85% of the population got a National Achievement Test Rating of Very Low Mastery with a yield sensitivity of 96.33% with a fair kappa rating of .852.

Model Fitting

R^2 is a metric that measures how well a model fits the data in regression (Leibler, 1995). This number can range between 0 and 1, with higher values suggesting greater model fit. In this analysis the R^2 resulted in 1. It would suggest that the model fits the data

CONCLUSION

Upon developing the predictive features, we found out that the feature selection technique selected only 14 subjects. It shows that the subjects in Grade 11 are more significant in the National Achievement Test Rating. As shown in the tables, the subjects in the 1st Semester of Grade 11 have the highest significant attributes.

This analysis shows that the higher the grade in Social Science and Personal Development, the less likely the student will get Low Mastery. The higher the periodic

grade in Language and Communication specifically English for Academic and Professional Purposes, the more likely the student will get Low Mastery.

We found out that the Philosophy in the 2nd Quarter of grade 12 shows the more significant effect in the National Achievement Test Score among all the subjects. This Quarter's subject also means that the more the students got a high periodic grade, the more likely these students will get Very Low Mastery Grade.

The student is putting so much attention and effort into the subject before the National Achievement Test could also be a factor. Arts in grade 12 of Quarter two, on the other hand, shows the 2nd subject with a more significant effect on the National Achievement Test. The more the students get higher grades in the mentioned subject and Quarter, the less likely they will get a Very Low Mastery criterion in National Achievement Test. It may also imply that those students enjoyed the Arts, the student will be more likely to get a higher criterion in the National Achievement Test.

There are two significant subjects in the 2016 – 2017 National Achievement Test Ratings: Philosophy and

Table 10. Confusion Matrix

Observed Y	Predicted Y		Accuracy
	VLM True	LM True	
VLM True	42.85	0.26%	96.33%
LM False	7.15	49.74	87.12
Overall Accuracy			92.59%

Arts, both from different categories. These are the only selected subjects of the feature selection from Grade 12 Quarter 2, a semester, and a quarter before the National Achievement Test Exam. The two subjects' results displayed that those students with a higher grade in philosophy are more likely to get a Very Low Mastery criterion.

On the other hand, those students who got higher grades in Arts are more likely to have higher results on the National Achievement Test. There are different factors of the student getting higher grades in their subject, looking at the result, the factor may affect the student performance in the National Achievement Test.

The pedagogical intervention depends upon a specific subject, and the pedagogical approach that is more recommended for Philosophy is reflective and constructivist. In constructivist theory, the learners have to construct their knowledge individually and collectively (Kumari, 2014). The study of Navaneethan (2011) resulted in a significant relationship between reflective teaching methodology and professional training. According to his study, the reason is that when an individual practices reflective teaching methodology by asking self-inquiry questions based on a set of learning objectives, it results in the refining of the individual's ability leading to professional training.

The effect of these subjects varies in the National Achievement test Result. Based on the result, if the student puts more effort and attention into a specific subject before the National Achievement Test, they will be more likely to get a lower National Achievement Test score.

RECOMMENDATIONS

It may be appropriate to try the study in other schools in Bukidnon or the whole Senior High School in Bukidnon to identify other factors why students usually get lower results on the National Achievement Test. It is also recommended to apply the pedagogical approach to these students' set and find out how effective the pedagogical approach. Finding the factors why Philosophy is statistically significant to the lower score in the National Achievement Test and finding the factors why Arts are statistically significant to a higher National Achievement Test may lead to another research study. Subjects that were not included to the selection might need further study. It may not mean that it has no impact or other factors might affect as to why these subjects were not selected.

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The Impact of Reading Positive Psychology-Themed Storybooks on Society during COVID-19 Pandemic

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ABSTRACT

This study aimed to gauge the impact and effectiveness of reading illustrated bilingual books on listeners' English language learning, creativity, and happiness during the COVID-19 pandemic. A public bilingual storybook reading was carried out with the support of two volunteer students, a professional ethnomusicologist, a Mogu-mogu project, a non-profit group, and Hon [Book] Café in Shinobuyama. Three self-published positive psychology intervention (PPI) - themed storybooks that dealt with elements of gratitude, kindness, and compassion using dialogic techniques, funded by the researcher's affiliated university were present at the reading. Post-reading, participants reported feeling grateful and almost as they had prior to the pandemic in response to the bilingual storybook. Through book reading, societal connectedness was strengthened, and organic flows of networking increased. This positive result draws attention to the significance of those factors originally motivating the project: the need to teach, learn, inspire and connect with others. It reinforced the idea that by being grateful, kind, and compassionate with others, we can be happy ourselves and spread happiness more widely.

Keywords: EDM, Logistic Regression, Student Performance, Modeling

INTRODUCTION

Time and time again, research has shown that people who read books are better informed, and aware of their environment, attitude, and the feelings of others. They are able to handle themselves in society better than non-readers, and through reading, they acquire a wide range of skills that makes them stand out in the workplace. In fact, reading books even make them healthier because people who read books are better informed about health risks and access to care, and because reading books has a positive effect on the brain. In addition: many consider reading books to be an exceptionally pleasant past-time that adds to individuals' happiness and sense of well-being (Boekwerk, 2019). Children's books are considered an important way to enhance emotions and feelings. Slogans such as 'Books build empathy' illustrate the enthusiasm for using children's literature to promote empathy and literacy.

The impact of reading books has been examined from perspectives such as psychology, neuropsychology, sociology, and teaching English as a second language. This research indicates that reading books helps both readers and listeners to develop the motivation and skills required for their intellectual, mental, psychological, and social improvement. Reading, in general, encourages reflection, the capacity to enhance imagination, self-reflection, and self-realization. Under the advent of recent societal conditions, in particular, the so-called 'new normal' brought about by COVID-19, reading books has become an even more important way to develop connections

between people, and mutual understanding. Reading enhances the ability to put oneself in the position of others, increases empathy, and enhances positive self-image, which in turn reduces the barriers to 'getting up and taking action.' Some readers read to 'lose themselves' and be carried away by the content of the book they are reading, developing a feeling of flow. This has a positive effect on their imaginative and empathic capabilities. It helps them find comfort, reflect, and be "drawn into another world," all of which can benefit their personal sense of well-being and happiness (Boekwerk, 2019).

Benefits of bilingual positive psychology-themed storybook reading

Based on the ideas mentioned above, we decided to develop bilingual positive psychology (PP) themed storybooks and present them at book readings. We intended that developing these storybooks, as described in this paper, could have a positive impact on society, especially during the difficult conditions at the time of writing. Books of this kind also bring other benefits. For example, they encourage and stimulate students' intellectual capacity to imagine the meaning of new vocabulary words they read and hear. They are a source of information for the reader and listener, assisting them to learn about a variety of related emotions. This, in turn, tends to support empathy-

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building (Kucirkova, 2019), and the maintenance of cultural values, both of which are commonly valued in society (Lamoreaux & Morling, 2012). In addition, they promote successful problem resolution and personal qualities and behaviors that are linked to successful goal achievement (Dyer, et al. 2000). In developing the storybooks, students were given the autonomy to write their own stories, and this both challenged them and intensified their curiosity about how to be more positive in life despite the pandemic situation. It was also anticipated that holding post-book reading discussions would not only enhance participants' communication skills but also their feeling of connectedness as they explored the meaning and messages of the storybooks more deeply together.

METHODOLOGY

Three original bilingual PP-themed storybooks (ST) were read in public to promote gratitude, kindness, and compassion and ameliorate happiness and wellbeing during the COVID-19 pandemic. The ST had specific target vocabularies, genres, and reading timespans. The illustrations and stories of two STs, Compassion and Kindness: Booster of Happiness (CKBH) and The solitary sad elephant (SSE), were created by six students in two months as part of the English conversation class activities

at Fukushima Gakuin College. Students gave voluntary consent to the use of their stories and illustrations for educational purposes before the completion of the school term. While, The Journey of Grateful Whitey Froggy (JGWF) storybook, which has a gratitude theme and was written and incorporated photographic pictures taken by the researcher, was completed in one month (Figure 1). The English text of the JGWF storybook was then translated into Japanese by the core members of the Happy Mogu-Mogu project (HMM), a Non-Profit Organization (NPO) group in Fukushima. Through the collaboration of the researcher and HMM, a community reading at Hon [Book] Café Shinobuyama Bunko (本カフェ信夫山文庫), Fukushima was held. During the community book reading, two students who attended the event helped to read the Japanese version of the ST. Moreover, the printing and reproduction of these three bilingual storybooks were funded by Fukushima Gakuin College, with which the researcher is currently affiliated. A self-produced questionnaire used a five-point Likert Scale : (1) Strongly disagree; (2) Disagree; (3) Neutral; (4) Agree; (5) Strongly agree. It is a psychometric scale that has multiple categories from which participants indicate their opinions, feelings, and attitude toward the impact of positive psychology-themed storybook reading. (Appendix 1).



Figure 1. Storybook covers showing examples of illustrations, titles and content details

Procedure

In FY 2019-2020, the students and the researcher produced PP-themed bilingual storybooks as an activity aiming to increase their vocabulary input, and improve their English writing and speaking ability. Students were first asked to write their stories in their first language (L1), Japanese, making it easier for them to create a story based on their basic ability and emotion. Then, the stories were translated into English by the researcher, taking into account the nuances and underlying messages in the Japanese text. Two bilingual storybooks and one English storybook were created. In early 2021, the three PP-themed storybooks were university-published as teaching materials with research fund support from Fukushima Gakuin College.

The researcher collaborated with HMM, a non-profit organization (NPO) in Fukushima City to share the importance of being grateful, kind, compassionate, and friendly to enhance happiness during the pandemic

among Fukushima citizens. Upon learning of the event's objectives: to enhance Fukushima citizens' happiness and improve English ability through bilingual PP-themed storybooks reading during the COVID-19 pandemic, the HMM core members freely volunteered to support the project. They agreed to translate the English storybook, JGWF, into Japanese and edited the Japanese version of CKBH and SSE. This helps to ensure the use of the correct and appropriate Japanese language. They also offered valuable assistance in promoting and carrying out the event.

HMM contacted the Hon [Book] Café Shinobuyama event's venue, which is located in Fukushima City. Initially, the event was declined due to the fear of spreading the virus, but after the deliberation to strictly avoid the 'Three Cs' (closed spaces, crowded places, and close-contact settings), the event was resumed in June 2021. Two Fukushima Gakuin University students also volunteered to participate in the event as Japanese version narrators. One of these volunteer students was also the illustrator of the

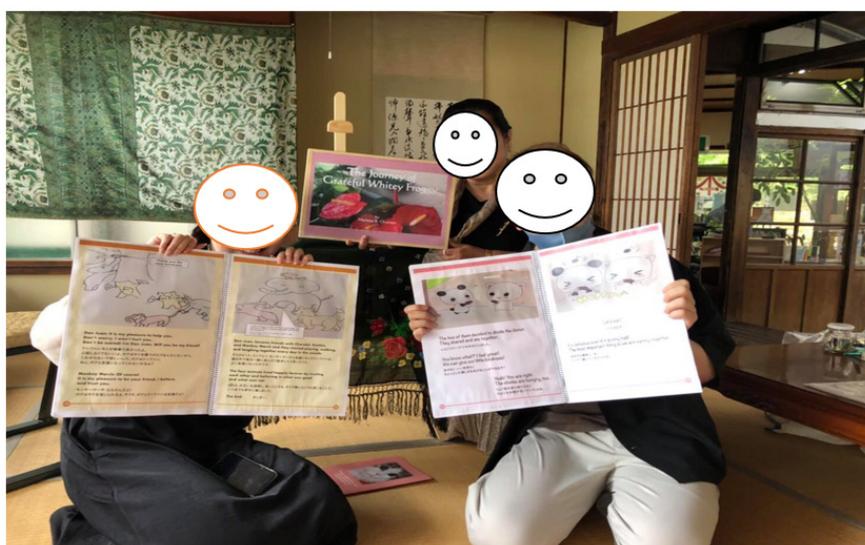


Figure 2. Ocampo (centre) displays bilingual storybooks during the reading at the Hon [Book] café in Shinobuyama (photo courtesy of J Graphic Factory)



Figure 3. Ocampo (centre) displays bilingual storybooks during the reading at the Hon [Book] café in Shinobuyama (photo courtesy of J Graphic Factory)



Figure 4. Tokyo-based ethnomusicologist and classical guitarist Kim Rockell performs during the storyreading at Hon [Book] café Shinobuyama (photo courtesy of J Graphic Factory)



Figure 5. Storybooks reading participants at the Hon [Book] café Shinobuyama (photo courtesy of J Graphic Factory)

CKBH storybook (Figure 2).

Music intervention

During an interval between the readings, a short acoustic guitar performance was included to augment listeners' happiness and relaxation. The researcher explained the event's objectives to a professional guitarist and music researcher. Based in Tokyo, the musician had spent several years living in Aizu Wakamatsu and was very sympathetic to the cause in Fukushima (Rockell, 2020). He then volunteered to perform three pieces, Natalie-Natalie by George Mustaki, Manha de Carnival by Luiz Bonfá, and the song Pokarekareana from New Zealand. As part of a story-telling event, music seems to have a narrative power of its own. This realization prompted the visiting musician to consider exploring music as a narrative in future research and community performances.

Participants

Due to strict rules in place to contain the COVID-19 virus, the Hon [Book] café Shinobuyama manager strictly limited the participants to a minimum of 13 adults and 2 children (Figure 5). The venue is a well-known, authentic book café in Fukushima so public event publication was restricted to avoid an uncontrollable increased number of listeners.

RESULT AND DISCUSSION

The impact of the bilingual storybook on the participants was found to be positive based on the results of their responses to a questionnaire. As already mentioned, there were three original PP-themed storybooks focusing on kindness and compassion,

friendship and connectedness, and gratitude. Participants' responses after listening to the storybook at the bilingual reading indicated that they strongly agreed to be kinder to others, and agreed with the notion that giving kindness to someone else enhances one's own happiness (Figure 6). They even agreed that they felt more grateful in life after listening to the stories (Appendix 2).

Positive psychology-themed storybook reading impact

Intellectual impact. Responses confirmed the idea that illustrated bilingual storybook reading can not only increase adults' and children's enjoyment but also help to increase their vocabularies. Japanese adult participants repeated some of the words they heard during the book reading session when they were answering the questionnaire. They were repeating these words to affirm what they learned on that day. Words and thoughts that are repeated often get stronger by repetition and sink into the subconscious mind (Sazzon, 2021). Easy words used in the questionnaire helped participants understand the questions, while on this occasion children appeared to learn fewer words than adults. However, these children participants repeated certain target vocabulary words along with their parents. Thus, joint book reading can be seen to develop children's language, literacy, and overall cognitive and intellectual abilities, confirming the findings of Saracho & Spodek, 2010. Children repeatedly uttered the following words: elephant, friend, help me, please, don't worry, run, cat, panda, kind, potato, wait, froggy, white, sad, kind, happy, and compassionate. Although two very young participants were not yet able to read, the illustrations and pictures in the storybook helped them understand the story. Moreover, providing supportive gestures, and repetition, a key feature of oral delivery (Ong, 2013), enhanced their enjoyment of the reading.

Psychological impact. Dialogic reading techniques were used partially to support the children's understanding of the message of the PP-themed bilingual storybooks. Based on the researcher's observation and followed up by an informal conversation with the parents,

children felt happy when the sad elephant found friends in the story. They also noted that the cat's name Potato was their favorite word of the day. Some of the adult listeners reported realizing the importance of friendship and learning to be happy through gratitude. Moreover, they also revealed that while listening to the intermission music, they felt the peace of mind, and became positive. One participant reported feeling as though she was by the sea. Bringing back memories of a younger time, a healing effect, and being relaxed and less tired were also reported in response to the music. The feedback of participants about the value of integrating music into small-group book reading activities is supported by scientific research. For example, it has been claimed to increase engagement (McCarthy, 2010), and improve connectedness with people's bodies and emotions (Lindblad, 2020). On this occasion, this was reflected in the disclosure of the listeners using imagery in their language such as 'I am by the sea'. Thus, the reading in Fukushima confirmed the idea that being in contact with one's emotion is important since it "lies at the heart of our capacity to experience meaning" (Johnson, 2007), and is a central ingredient of a sense of wellbeing. Emotions are at the heart of each foreign language learner and are necessary because without emotions, boredom would reign and very little learning would take place (Dewaele, 2015). Moreover, according to Macintyre & Gregersen, 2021, the imagination is powerful, in part, because the emotions that can be activated might broaden a person's perspective and opening the individual to absorb language.

During the pandemic, respondents agreed that they gave compassion and kindness to others, and were more empathetic. Though they also agreed to be compassionate with themselves, data revealed that this tendency was a bit lower. This discrepancy prompted the researcher to think more deeply about it in this study. A similar result revealed that the reason participants feared showing compassion was the perceived possibility that others would take advantage of their nature (Ocampo, 2021).

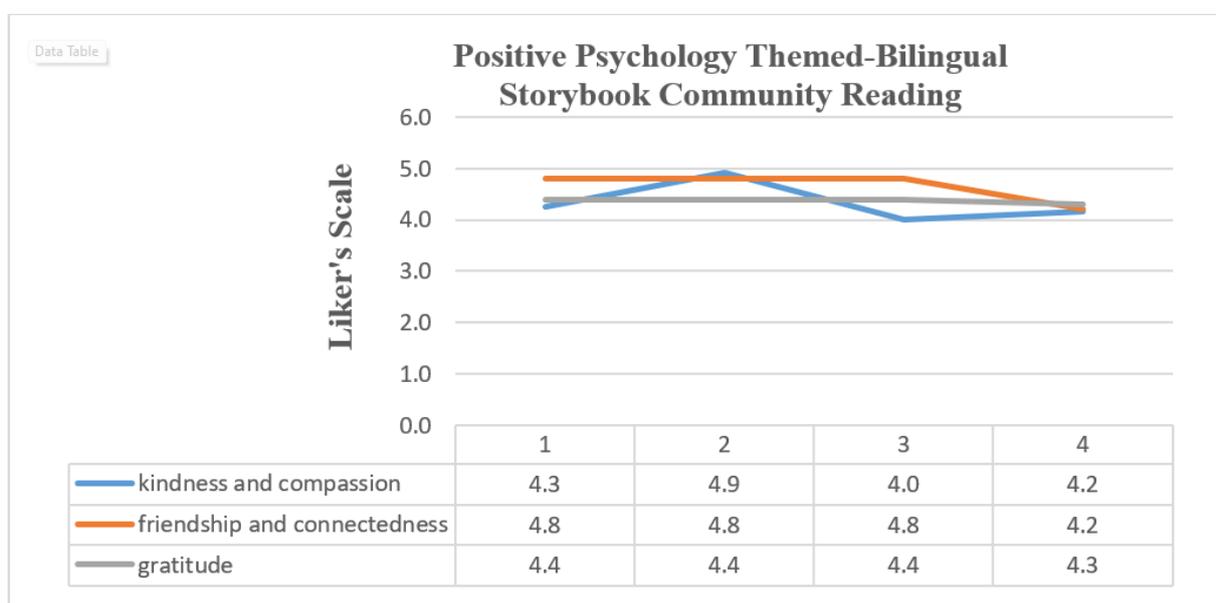


Figure 6. Impact of positive psychology-themed bilingual storybooks among participants.

Being compassionate to ourselves means that we give enough time to be with ourselves. A warm embrace of self-kindness makes our worries, problems, and even suffering bearable. It provides a soothing balm that softens the hard edges of someone's pain, which is no longer absorbed by playing the role of the one who is suffering (Neff, 2011, Neff & Germer, 2018). Participants felt a healing effect, relaxed and lessened tiredness, realized that they should be more grateful, and learned a bit about the nature of happiness. They also hoped that more children would be able to hear the stories.

The Vygotskian perspective illuminates how motivation "from within" can be fostered through the formulation of shared intentions and purposes rather than exclusively teacher-imposed goals (Uchioda, 2008; Karpov, 2003). Drawing on Vygotskian theory, learning occurs within a socio-cultural environment through the learner's dialogues with a more competent person, who might be a parent, a teacher, or a more advanced peer, and who 'mediates' the learning; models higher thought processes (Van et al., 2005). The effects of motivation, moreover, are conceptually distinct from those of pre-existing abilities and prior achievement. Even the most skilled students may not do well if they have no drive to understand, no willingness to work hard, no sense that they can be successful, or no enthusiasm for the material or skills they are faced with learning. (Wolters et al. 2011; Karpov, 2003). Supported by the perspective offered by these educational theories, the researcher, as the teacher in charge of this project, provided sufficient autonomy to the learners to finish their tasks. And, based on the assessment's result, 83% of learners' sense of self-determination increased while 17% answered no comment. This further supports that when teachers assisted learner autonomy, learners' self-determination increased (Benson, 2011). From an intercultural perspective, which the idea of bilingual delivery evokes, it is helpful to consider the observation of Pennycook (2014) who noted an attempt to push the individual, competitive, Western version of autonomy onto non-Western societies. Instead, Pennycook strongly encouraged awareness of cultural alternatives. The bilingual approach carried out during this project can be seen to offer such an alternative, and is highly recommended as a way to gather more ideas on how to relieve mental stress and anxiety.

CONCLUSION

Although the negative effects of the COVID-19 pandemic continue to be felt at a global level, this project operated at a local level, drawing on grass-roots support and increasing the agency of participants in Fukushima. Grateful to institutional support from Fukushima Gakuin College, NPO Happy Mogu-Mugu project, and community volunteers, an integrated, constructive intervention was successfully carried out, embedding research objectives within a wholesome, intergenerational framework and utilizing appropriate spaces in the Fukushima community. Although the promotion of happiness and wellbeing through this implementation was not easy, and the 'new normal' demanded that careful health protocols be strictly observed, the event was still able to go ahead.

Project research findings confirmed claims in the literature on the benefits of reading and also drew attention to the narrative power of music, which requires further investigation. The event's success highlighted the significance of those factors that originally motivated it: the need to teach, learn, inspire and connect with others. It reinforced the idea that by sharing something with others, we can be happy ourselves and spread happiness more widely. Through book reading, societal connectedness was strengthened, and organic flows of community networking increased. We were very grateful and touched that volunteers extended their care, abilities, and knowledge to promote gratitude, kindness, compassion, and friendship. All worked together to promote happiness and well-being during the unprecedented difficulties posed by the pandemic crisis.

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APPENDIX 1

バイリンガル絵本読み聞かせイベントのアンケート

Objective: The purpose of this study is to gather information about the general impression and impact that storybooks have on listeners' emotions and well-being in order to increase their well-being.

目的: この研究の目的は、幸福度を高めるために、ストーリーブックがリスナーの感情と幸福度に与える一般的な印象と影響についての情報を収集することです。

Procedure: Select one emoji sticker for each statement and paste it in the space that indicates your acceptance. 手順: 項目ごとに絵文字ステッカーを 1 つ選択し、承諾を示すスペースに貼り付けます。

Each statement is followed by five numbers 1, 2, 3, 4, and 5, and each number means: 各ステートメントの後には、1、2、3、4、5 の 5 つの数字が続き、各数字は次のことを意味します。



Geo-Spatial Dynamics of COVID-19 Pandemic Onset in Davao City

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ABSTRACT

Davao City, a major urban center in the Philippines with its various landforms and population distribution has been affected by COVID-19. This study aimed to identify and locate areas with COVID-19 cases in Davao City, create a location map of COVID-19 cases in Davao City and determine association between number of COVID-19 cases and population density. Data were obtained from the Philippines Statistics Authority, Davao City LGU and, the Department of Health Davao Region. QGIS application was used to generate location maps of COVID-19 cases and Pearson r correlation was the statistical method used. Most of the COVID-19 occurrence are in Poblacion, Talomo, Agdao and Buhangin. areas with high population densities record the high occurrence of COVID-19 cases There is a high correlation between number of COVID-19 infection and population densities for this study. This indicates that dense population may have contributed to the spread of the COVID-19 infection in the city. The occurrence of population densities in Davao City should be addressed to prevent public health threats brought about by infectious diseases such as COVID-19.

Keywords: COVID-19, Davao City, Urban Center, Correlation, Population Density

INTRODUCTION

There is a new public health crisis threatening the world with the emergence and spread of the 2019 novel coronavirus (COVID-19) or the severe acute respiratory syndrome coronavirus 2. The virus originated in bats and was transmitted to humans through yet unknown intermediary animals in Wuhan, Hubei province, China in December 2019 (Singhal, 2020).

In a global scenario, the World Health Organization officially declared the novel coronavirus (COVID-19) outbreak a Public Health Emergency of International Concern (PHEIC) last January 30, 2020, one month after the Wuhan Municipal Health Commission, China, first reported a cluster of pneumonia cases. This has been the 6th time WHO declared a PHEIC since the establishment of International Health Regulations (IHR) in 2005. The 30th also marked the rise of the ongoing outbreak in the Philippines which has 20,382 confirmed cases as of June 5, 2020. Out of these confirmed cases, 4,441 recoveries and 984 deaths were recorded (WHO, 2020). In the Philippines, on 30 January of 2020, the Department of Health reported the first case of COVID-19 in the country with a 38-year-old female Chinese national and on the 7th day of March with the same year, the first local transmission of COVID-19 was confirmed. World Health Organization (WHO) is working closely with the Department of Health in responding to the COVID-19 outbreak and in the case of the Davao region, the COVID-19 pandemic was confirmed to have spread to the Davao Region, Philippines on March 15, 2020, when the first case of COVID-19 was confirmed in Tagum City, Davao

del Norte. All provinces as well as Davao City has at least one confirmed COVID-19 case. The majority of the cases in the region are attributed to Davao City (Department of Health, 2020).

Since it is really necessary to identify the different areas with positive cases of COVID-19 which will help the community to assess in order to prevent more transmission of this disease thus, this study aims to identify districts with COVID-19 cases in Davao City, to create a location map of COVID-19 districts and to determine any correlation between the number of COVID-19 cases in the districts and the population densities.

A study on the early stages of COVID-19 was conducted in China by Kang (2020) to determine spatial association between adjacent places. The data considered in this study includes the number of COVID-19 cases in the different provinces of China, the populations and population densities. The study revealed that COVID-19 is highly likely to spread between geographically adjacent regions and that more people are likely to be infected with the virus in densely populated regions, which leads to the active spread of COVID-19 to other areas (Kang, 2020).

In another study about geographical dynamics of COVID-19 in Nigeria, Okafor (2020) discussed that one of

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its states has a high risk of infection because of its high population and it is considered the most densely populated state in that country. Olusola (2020) also focused his study on Nigeria and found out that a significant relationship between population density and COVID-19 cases in Nigeria which suggests that high population densities catalyze the spread of COVID-19. In a wider scope, Onafeso et al. (2021) considered the entire continent of Africa in the study about geographical trend analysis of COVID-19 pandemic onset in the region. The study highlighted the variables that show significant association with COVID-19 cases in the region to include both population and population densities as well as average annual air transport passengers carried. It stated that annual air transport passengers from each countries in Africa played a significant role on both the onset and spread of reported COVID-19 cases and this is aided by the corresponding population density condition of each country (Onafeso et al., 2021). A similar finding was determined by Yu (2021) that at country level, population density is a critical factor in the outbreaks and transmission which implies that countries with higher population density are more likely to be affected by COVID-19. Yu pointed out that this is due to the fact that faster spread within higher population density makes it difficult to control the transmission.

Cuadros et al, (2020), in another study, discussed the spatio-temporal transmission dynamics of the COVID-19 pandemic in Ohio state. The study reveal that a large number of confirmed COVID-19 cases are found in 5 counties that are characterized with high population densities. In contrast, the magnitude of infection is lower in the 31 counties which are located in rural and less connected areas in Ohio. A similar result was discussed by

Pequeno (2020) in his study concerning higher COVID-19 incidence in cities in Brazil with higher population densities as a significant predictor of infection.

Sahasranaman and Jensen (2020) discussed in their study the spread of COVID-19 in urban neighborhoods of the developing world such as Brazil, India, South Africa, Nigeria and the Philippines. Most commonly found in these countries are the high population densities in the urban slums which, according to the study, become the most vulnerable in the COVID-19 pandemic. Most of the COVID-19 cases are found in these high density areas making the people in these areas vulnerable and at a high risk in the pandemic. At the onset of COVID-19 infection in the Philippines, Villarama (2020) discussed the COVID-19 occurrence in high density area of Manila City which recorded higher cases compared to adjacent less dense areas. It is noted that people living in high density area will pose challenges to isolate infected individuals to avoid further transmission.

Population and population densities has been cited by the studies discussed above to have a significant factor in occurrence of COVID-19 cases in the context a continent, a country, and a state. However, there are only limited studies on the dynamics of COVID-19 infection and population density in the developing regions of the world including the Philippines. There is also few studies focusing on the different cities in the Philippines with regards to COVID-19 and its geo-spatial dynamics. This study will fill in this research gap by determining the association of COVID-19 cases and population densities in the context of a smaller spatial dimension which is the city and its sub-geographical units of administrative districts.



Figure 1. Map of the Philippines showing Davao City.



Figure 2. Geographic Boundaries of Davao City

METHODOLOGY

Study Area:

The study is focused on the eleven (11) administrative districts of Davao City where each district is comprised of different barangays. Davao city is situated in the southeastern part of the Philippines as can be seen in the map (Figure 1) below. Davao City serves as the regional center for Region XI. It is bounded in the north by Davao Del Norte Province, in the east by the Davao Gulf, in the south by Davao del Sur Province, and in the west by North Cotabato Province (see Figure 2). It was inaugurated as a chartered city on March 1, 1937, under President Manuel L. Quezon. The Davao City Comprehensive Land Use Plan 2013- 2022 described the land area as follows: "Davao City has an area of 244,000 hectares or 8 percent of the land area of Southern Mindanao Region or Region XI. It is divided into 3 congressional districts and divided into 11 administrative districts. Poblacion and Talomo District comprises District I, meanwhile District II is composed of the Agdao, Buhangin, Bunawan and Paquibato, District III includes Toril, Tugbok, Calinan, Baguio and Marilog.

Figure 3 shows the eleven (11) administrative districts of Davao City while Table 1 shows the corresponding population, land area, and the number of barangays for each district.

The districts of Bunawan, Buhangin, Poblacion, Talomo, and Toril commonly have a coastal section wherein these districts are considered the urbanized zone of Davao City where, commercial, industrial, residential and built-up land uses currently exist. Bunawan district is the industrialized center where numerous manufacturing establishments with port operations are located while

Buhangin, Agdao, and Poblacion are largely commercial areas with numerous residential structures are found at the coastal sections which are dense in proportion.

The coastal portion of Talomo District are also lined up with high to medium dense residential area which may be comparatively lower in density compared to Poblacion and Agdao Districts. Suburban residential areas are found about 5 to 15 kilometers away from the Poblacion District. These areas are lesser in density compared to the coastal shanties commonly in the districts as described above. Lesser population densities are found in the rest of the districts of Davao like Toril, Tugbok, Baguio, Calinan, Marilog, and Paquibato. The predominantly agricultural land use is found in the northern portion of Toril, Baguio, Tugbok, Calinan, Marilog, and Paquibato Districts. The hinterland portion of Davao City is found in the eastern portion of Toril and Baguio, Marilog, and Paquibato. About 8.6 percent of Davao City's land area is hinterland or part of the Mount Apo Natural Park with an area of 20,957.15 hectares which comes from Toril, Baguio, and Marilog Districts.

Figure 4 shows the map of Davao City indicating the different barangays from the different administrative and congressional districts. A total of 182 barangays comprise Davao City. The CLUP of Davao City indicates that the barangays in Davao City are classified as either urban or rural barangays. District 1 which covers Poblacion and Talomo districts consists of urban barangays. Districts 2 and 3 have a mix of both urban and rural barangays. Mostly the southern portion of these districts are urban and the northern portion is rural areas. All three districts, however, have a coastal portion in their respective areas. District 1 is the smallest in terms of land area compared to the other two and District 3 has the largest land area

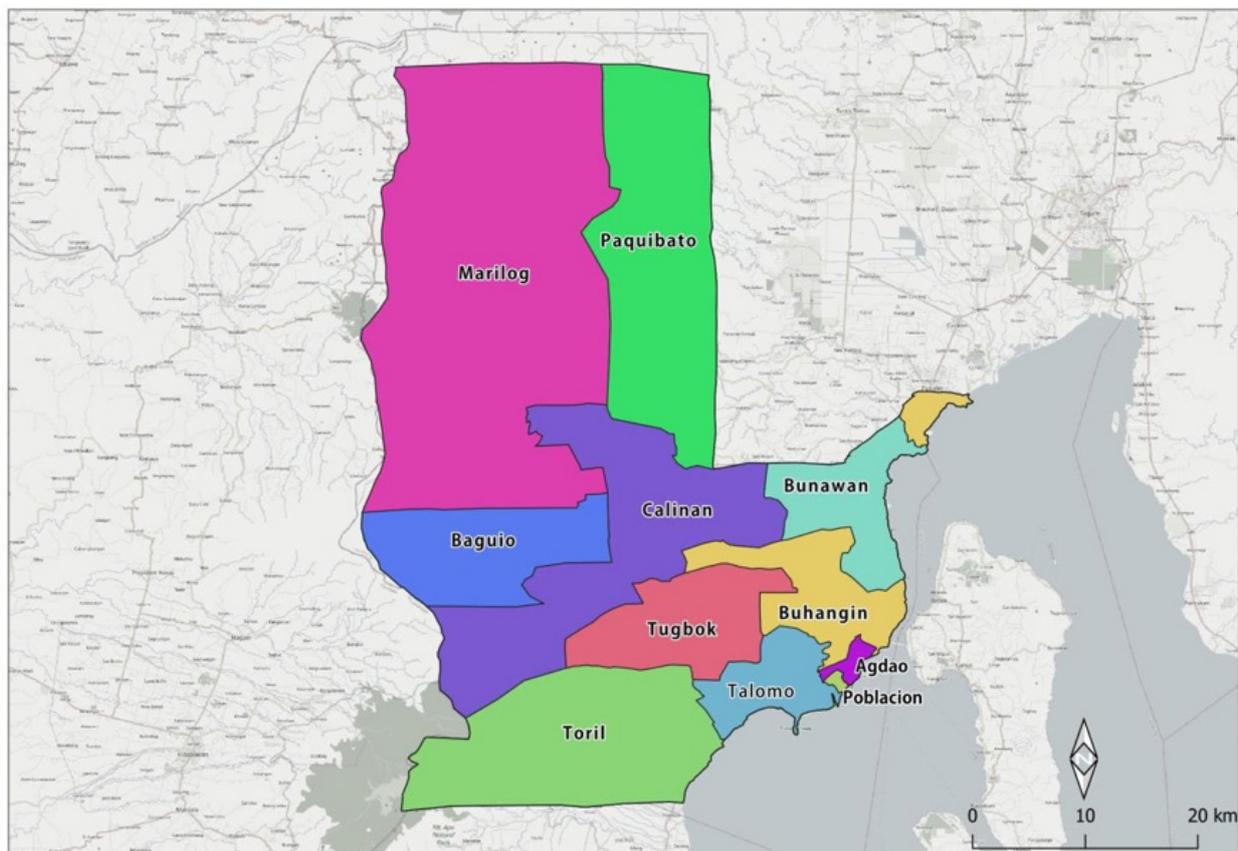


Figure 3. The eleven (11) administrative districts of Davao City

among the three.

Land Area and Population Distribution of Davao City

Table 1 shows the population for each administrative district of Davao City and their corresponding land areas. Shown also is the number of barangay covered by each district. Marilog and Paquibato have the largest land area among the districts while Talomo and Buhangin are the most populous.

Table 1. Administrative Districts in Davao City with corresponding land area, number of barangays, and actual population.

Sources of Data:

The population data of Davao City was obtained from the Census of Population for the Year 2015 by the Philippines Statistics Authority while the land area of the barangays of Davao City was gathered from the Comprehensive Land Use Plan of Davao City (2013-2022). The administrative district's data of Davao City was lifted from The Davao City Socio-Economic Indicators (2018).

The Department of Health Davao Region Facebook Page is the source for the data on COVID-19 Positive cases in Davao City. This case study included positive COVID-19 cases in Davao City as of June 7, 2020.

Spatial Analysis

For this study, QGIS application is used to generate maps of Davao City and to illustrate the location of COVID-19

cases in the city. The table for number of COVID-19 cases for each district are incorporated in the QGIS to generate a geographic illustration of where this COVID-19 cases are located in Davao City. The same geographic illustration are presented in the study of Onefaso (2021), Okafor (2021), Olusala (2020), Kang (2020) and Cuadros (2020).

Statistical Analysis

Empirical analysis employed in this study includes computation of population densities per administrative districts and barangays of Davao City. Given the land area per district and the population per district, population densities can be readily computed. Statistical analysis for this study involve simple distribution counts and correlation analysis which is the same method employed by Onafeso et al. (2021). Pearson r correlation analysis was used in this study to determine the association between the number of COVID-19 cases and the population densities of different districts in Davao City. This is the same method applied by Onafeso (2021) in his study to determine the relevance and significance of variables. Correlation analysis is also conducted in the study of Okafor (2021) to describe the geographical dynamics of COVID-19 cases in Nigeria.

RESULTS AND DISCUSSION

Table 2 shows the different administrative districts and the computed population density for each. Population density is the number of individuals that occupy a certain land area. It shows that Agdao District ranks No. 1 in terms of population density followed by Poblacion and Talomo Districts as No. 2 and No. 3 respectively. These districts have coastal portions which are where the dense

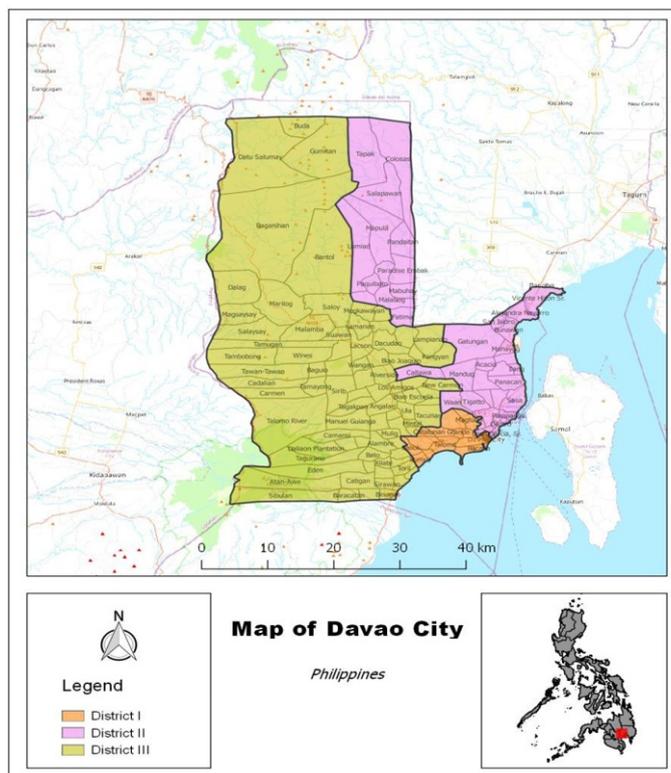


Figure 4. Barangay level map of Davao City.

Table 2. Population Density (Population Per Hectare) In The Different Districts of Davao City

Rank	District	Area (hectares)	No. of Barangays	Population (2015 Census)	Population Density (Population / Hectare)
1	Agdao	593	11	102,267	172
2	Poblacion	1,138	40	174,121	153
3	Talomo	8,916	14	418,615	47
4	Buhangin	9,508	13	293,118	31
5	Bunawan	6,694	9	152,102	23
6	Tugbok	15,391	18	121,334	8
7	Toril	29,459	25	148,522	5
8	Calinan	23,236	19	92,075	4
9	Baguio	19,023	8	33,873	2
10	Marilog	63,800	12	52,201	1
11	Paquibato	66,242	13	44,763	1

population normally occurs. Urban settlers encroaching in coastal areas is prevalent in most highly urbanized centers in the Philippines such as Davao City.

Davao City has not been spared from the COVID-19 pandemic. As of June 7, 2020, Davao City has recorded a total of 314 persons that are positive for COVID-19 infections. The breakdown or distributions of COVID-19 cases per district are shown in Table 3 below.

The table ranks the districts in terms of population density from the highest to the lowest. The four districts, Agdao, Poblacion, Talomo, and Buhangin show a significantly high number of COVID-19 positive cases among the districts. These districts are also considered as densely populated districts of Davao City. This goes to show that the prevalence of COVID-19 cases occurs in

densely populated areas of Davao City as can be seen in the table above. Fifty-seven (57) barangays in Davao City have confirmed positive cases of COVID-19 out of the total 182 barangays of the city. Figure 5 shows the location of the COVID-19 positive cases in Davao City per administrative district.

The areas with the highest incidence of COVID-19 positive cases have coastal areas where the over-densities can be found as shown in the map. The only district with the coastal area not having higher cases is Toril and Bunawan districts. Inland districts not having coastal sections have lower cases of COVID-19, wherein these areas are marked by lower population densities in the city. At this time of pandemic due to infectious diseases such as COVID-19, wherein the disease is transmitted from one infected person to another, dense communities are the ones highly

Table 3. COVID-19 Infectious Disease Positive Cases in Davao City according to Administrative District.

District	No. of Barangays With COVID-19 Positive Cases	Population Density (Person/Ha)	No. of COVID-19 Positive Cases
Agdao	9	172	72
Poblacion	13	153	80
Talomo	11	47	71
Buhangin	9	31	62
Bunawan	4	23	8
Tugbok	4	8	9
Toril	4	5	9
Calinan	1	4	1
Baguio	1	2	1
Marilog	0	1	0
Paquibato	1	1	1
Total	57		314

(Source: Department of Health Region XI and Davao City Comprehensive Land Use Plan)

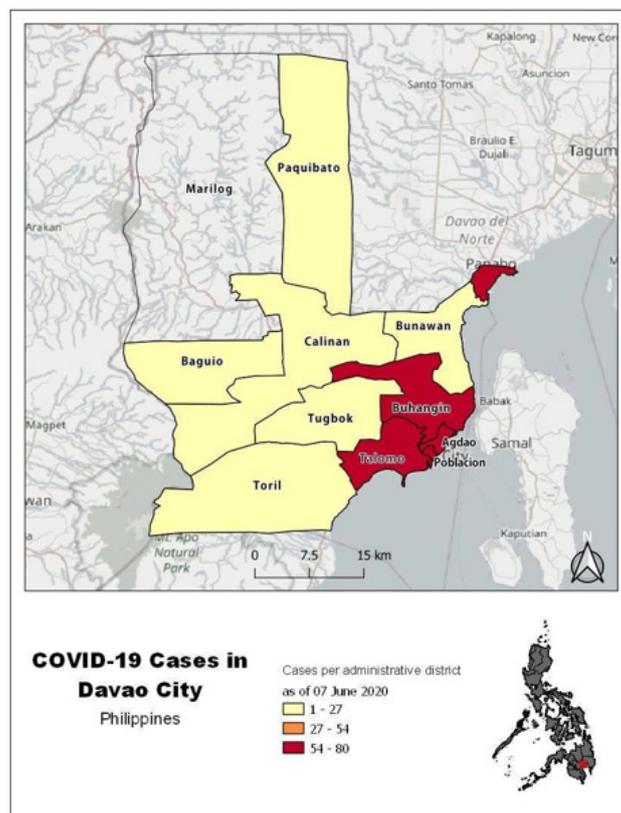


Figure 5. COVID-19 cases in Davao City per district

affected by the local transmission of the disease.

Figure 6 shows a graph of the COVID-19 cases in the different districts of Davao City and the population density of each district. The graph shows an increase in COVID-19 cases as the population density increases.

Result of statistical analysis showed a high correlation (correlation coefficient $r = 0.8186$) between number of COVID-19 infection and population densities. It shows that prevalence of infection are occurring in areas with high population concentrated in a smaller areas in Davao City. This means densely populated area contributed to prevalence of COVID-19 infection in the city context

such as Davao. This result is consistent with the findings of Kang (2020) wherein it is cited that more people are likely to be infected with the virus in densely populated regions. Similar pattern is true in the case of COVID-19 infection in the different states in the whole country of Nigeria (Okafor, 2020). Higher infections occurred in densely populated states in Nigeria. The findings of this study also confirm the result of Olusola et al. (2020) and Yu (2021) that an association exists between population densities and COVID-19 infection. In terms of the entire continent particularly in Africa, the study of Onifeso (2021) also cited a strong association between population densities and COVID-19 cases. The same finding was cited by Cuadros (2020) and Pequeno (2020) wherein areas that are densely

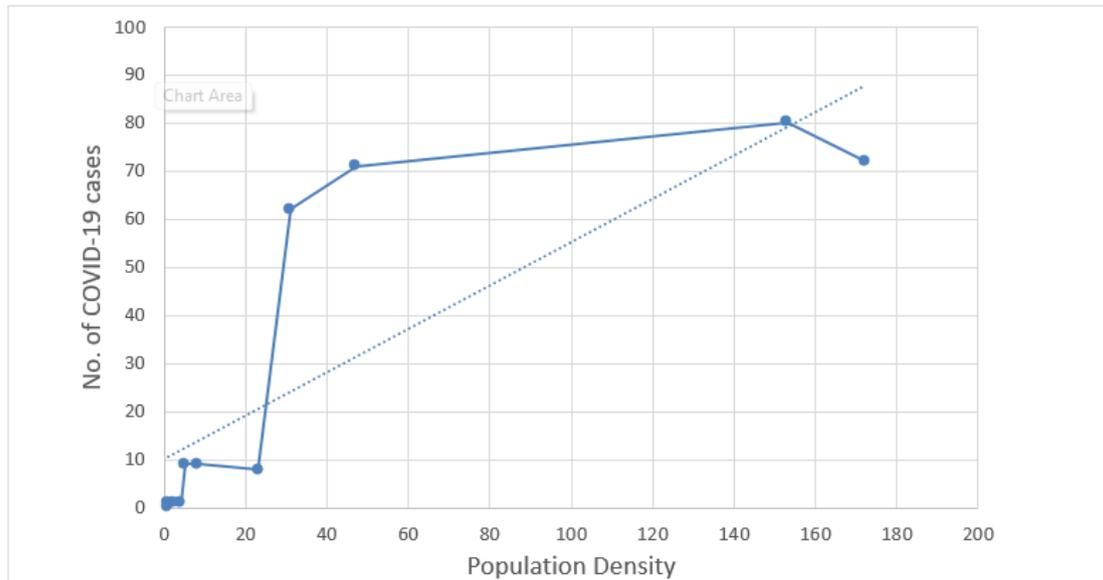


Figure 6. Number of COVID-19 cases and population density in Davao City

populated recorded large number of confirmed COVID-19 cases.

These studies reveal that at different geographic levels such as continent, country, state, province and city, the presence of densely populated areas record high prevalence of COVID-19 infections. Even in the developing world where the Philippines is situated, the result of this study is consistent with the study of Sahasranaman and Jensen (2020) and Villarama (2020) citing that the areas with higher population density are vulnerable to the rise of COVID-19 infection.

As one of the major cities in the Philippines, the presence of built-up areas and the densely populated areas in Davao City may have somewhat contributed to the rising cases of viral infection that are now affecting the country and the whole world. These densities may have contributed to the COVID-19 viral infection in urbanized cities like Davao.

For District 1 (covering Poblacion and Talomo administrative districts), Barangays 23-C, 19-B located in the Poblacion area posted the highest cases of positive COVID-19 infections while Barangays Catalunan Grande and Talomo Proper have the highest cases for Talomo area. The barangays in Talomo are less dense in population compared to Barangays 23-C and 19-B. The barangays with white color indicate zero cases of COVID-19 infections. Most cases are located in the coastal area of the barangays except for Catalunan Grande which is an upland barangay considered to be a suburban area with numerous subdivisions mostly occupied by middle-income class people, but patches of urban poor dwellers also exist within the barangay creating densities in clusters. The subdivisions in Catalunan Grande make the positions of houses more evenly and widely spaced from one another thereby reducing cluttering or densities of people. Subdivision houses are designed to be single detached from one another unlike in urban poor areas where houses are constructed side by side leaving only small gaps in between.

For District 2 (covering Agdao, Buhangin, Bunawan, and Paquibato administrative districts) Barangays Leon Garcia, Sr., and Agdao Proper have the highest number of COVID-19 positive cases. Most of the cases in this district are located within the coastal area of the city. This is where the population densities exist. The same case is true for District 1 where the coastal sections are the ones with a high number of cases except for Barangay Catalunan Grande. Inland Barangays of Tigatto, Cabantian and Indanagan also posted positive cases for COVID-19 and one hinterland barangay in Paquibato District has one case in the record.

District 3 (covering Toril, Tugbok, Bagiuo, Calinan and Marilog administrative districts) posted the least number of COVID-19 positive cases for Davao City. A minimum of three cases are tallied for barangays with infected cases and one barangay with a minimum of eight cases is recorded for District 3. Most of the land features in this district are residential, agricultural, grassland where less dense communities are present.

A typical land feature in coastal area in Davao City can be seen in Figure 7. It shows the densely populated residential area at the coastline of Poblacion District wherein the high incidence of COVID-19 infections is situated. Note that farther away from the coastline, the density becomes moderate where a mix of commercial and residential area can be seen at the bottom of the figure.

Figure 8 shows a portion of the Poblacion District of Davao City. At the top of the figure at the coastline, the dense urban residential area can be found, a portion of which is where most of the COVID-19 positive cases are recorded.

The middle portion of Figure 8 shows the commercial and institutional area of the Poblacion District. Commercial and business establishments are found in this section of the city where high-rise buildings exist. Several institutional buildings of schools, government offices, and churches also can be found in this section. The lockdown on



Figure 7. The densely populated coastal zone of Poblacion Davao City area



Figure 8. The Poblacion district of Davao City – commercial and residential area

mid-March 2020 may have prevented significant infections to COVID-19 in this area due to work stoppage thereby minimizing or eliminating possibilities of contamination of people due to close contact in the workplace.

The lower portion of Figure 8 shows a typical residential subdivision in the Poblacion area of Davao City wherein houses are built in a particular pattern most single-detached concrete house structures with the adequate easement and lot spaces between houses. These residential subdivisions are provided with adequate water, sanitation, and electrical facilities. More spaces in between houses can be seen in this area making it lesser dense in configuration compared to the shanties at the coastal areas. Lesser to no record of COVID-19 infections have been noted in this area.

CONCLUSION

Davao City has not been spared from the COVID-19 pandemic as infection has hit the city just like in other parts of the country as well as the entire world. The early stage of

COVID-19 pandemic in Davao City has recorded 314 cases as of June 7, 2020 and areas with high population densities have recorded high cases of COVID-19 infections.. Most of the high density areas in Davao City can be seen at the coastal section of Poblacion, Agdao, Buhangin, and Talomo districts where the cases occur. Inland districts have fewer COVID-19 positive cases because of lesser population densities. A high correlation exist between the number of COVID-19 cases and the population densities in the city which indicates that higher number of cases are located in densely populated areas. This indicates that dense population may have contributed to the spread of the COVID-19 infection in the city.

The land characteristics of Davao City are a mix of urban human settlements, commercial and institutional establishments, agricultural and recreational areas, and even forested areas. As a major city in Mindanao, Davao City is experiencing economic and population growth. The level of urbanization of the city is marked by influx of people that tend to cluster in a particular area creating urban densities specifically residential dense areas as can

be seen in Davao City itself.

Long-term solutions should be implemented in addressing high population density areas of Davao City marked by human settlements.

Further research can be done to include other urban attributes in the analysis such as transport system, road networks and building description. comparative analysis can also be done for two or more different cities to assess the geospatial dynamics of COVID-19 using population density and other urban attributes. It is important to exhaustively study and make comparison in order to come up with more scientific conclusions that will help in formulating policies to address the pandemic now and even in the future.

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Spatial Information on the Central Mindanao University's Academic Services in the Northern Mindanao Geographically Isolated and Disadvantaged Areas

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ABSTRACT

Central Mindanao University (CMU) is a premier university in Northern Mindanao with a mission to provide quality education. In response to Sustainable Development Goal #4 on Quality Education and the government's program on Geographically Isolated and Disadvantaged Areas (GIDAs), this study aims to assess the extent of CMU in providing academic services, particularly in GIDAs in Northern Mindanao, Philippines. This study employed an online survey among CMU students and alumni supplemented with secondary data. The study applied the Geographic Information System (GIS) to generate maps and spatially analyze the data. A total of 721 students and 641 alumni responded through the online survey, with 3,594 alumni sourced out from CMU graduation programs. The study's findings revealed that the distribution of students and alumni in CMU is mostly in Bukidnon, particularly in the central and southern parts. Most of the students and alumni in Northern Mindanao are spread in non-GIDAs, although a considerable percentage is in GIDAs. For CMU to respond to GIDAs and SDG Goal #4, the University should craft scholarship programs to attract students and extend its academic services in GIDAs to provide quality education in Northern Mindanao significantly.

Keywords: quality education; Geographically Isolated and Disadvantaged Areas (GIDAs), human capital; human resources; Northern Mindanao

INTRODUCTION

Universities play a critical role in producing human resources with relevant professional, technical and vocational skills to meet the labor market demands. Cortese (2003), Elton (2003), and Lozano (2006) argue the primary role of universities in creating and breaking paradigms for decision-makers, entrepreneurs, and leaders. Universities often offer courses in response to the nature and demands of the labor market in their respective localities, in the region, or at the national levels. Tertiary education in the context of social sciences and law enables students to possess the "capacity to analyze and understand complex socioeconomic and political problems" (Schweisfurth et al., 2018). The Philippines Commission on Higher Education (CHED) emphasized outcomes-based and critical thinking as curricular program outcomes.

According to Leftwich (2009), "thinking skills developed through high-quality higher education are key in higher tertiary enrolment rates and good governance." Policymakers evaluate the performance of universities as a basis for funding support to satisfy quality standards so that universities that can attract more students even outside of their territories become an indicator of the quality of the University (Columbo et al., 2021). Among universities, attracting students to enroll in offered degrees in tertiary education is a challenge. Choices and preferences in tertiary education are driven more by socioeconomic characteristics than the "services, variety and quantity of educational supply" based on the study of Columbo et al. (2021). The students anchor their decision to study on socioeconomic considerations such as social capital,

occupational opportunities, and rewards (Columbo et al., 2021). Similarly, some studies found out that aside from socioeconomic conditions, economic peculiarities in their respective geographical area of origin, and the location of the universities where they choose to study drive students' choices (Bratti et al. in 2019; Dotti et al. in 2013 and Giambona et al. in 2017). Columbo et al. (2021) further demonstrated that "the divergences in the socioeconomic and structural conditions of origin and destination play a critical role in determining students' mobility choices."

The study of Bailey & Dynarski (2011) and Carneiro & Heckman (2002) argued that students in low-income families are less likely to pursue tertiary education. If these students study in tertiary education, they are more likely to attend low-quality schools than those belonging to higher income categories (Hoxby & Avery, 2013). In the Philippines, state universities offer courses and specialized skills to cater to low income families. In addition, the Commission on Higher Education (CHED) implemented the RA 10687 known as the Unified Financial Assistance System for Tertiary Education (UniFAST) Act for students in both private and public schools.

Lozano et al. (2013) studied universities engaging in sustainable development and noted that several universities "tend to respond slowly to society's needs" and are lagged "behind corporations and governments

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in regards to contributing to making societies more sustainable." In the study of Andrews et al. (2020) on the Longhorn Opportunity Scholarship, they argued that raising the educational attainment and earnings of the high-achieving, low-income students addresses "multiple disadvantages faced by these students in the higher education system." Thus, Aleixo et al. (2018) highlighted "conceptual and organizational change in higher education institutions" through "new sources of financing, more flexible organizational forms, more comprehensive mission statements, more tailored educational offers, life-long learning and commitment to internationalization, and more strategic human resource management."

Article XIV, Section 1 of the Philippine Constitution mandates the protection and promotion of the rights of all Filipinos to quality education for all levels. Furthermore, it also calls on an education that is accessible to all. Under various Circulars and Memoranda, CHED formulates guidelines and programs in achieving these mandates. Education is a fundamental human right source of progress and social mobility. Education increases the value of a labor force, thus propelling the economic growth of an individual and the nation (Maiyo et al., 2009). In the report of Former CHED Chairperson Patricia Licuanan (2017), she highlighted that at the macro-level, education is an instrument for poverty alleviation as it builds human capital while at the micro-level, it expands and enhances career and life choices and chances of an individual. In this context, State Universities and Colleges (SUCs) face challenges as to their contribution in achieving this mandate, specifically in providing quality tertiary education. The number of CHED-declared Centers of Excellence and Development, accredited academic programs, board examination performance and ranking, and research and publication outputs are performance indicators in delivering quality education. But as producers of professionals and the labor force, SUCs are essential in improving the lives of low-income families and communities.

In a more focused approach, the government has identified Geographically Isolated and Disadvantaged Areas (GIDAs), which refer to communities with marginalized populations due to physical and socioeconomic separation from the mainstream society. The Department of Health (DOH, n.d.) defines GIDAs as a "marginalized population physically and socio-economically separated from the mainstream society and characterized by - 1. Physical Factors - isolated due to distance, weather conditions, and transportation difficulties (island, upland, lowland, landlocked, hard to reach, and unserved/underserved communities); and 2. Socioeconomic Factors (high poverty incidence, presence of vulnerable sector, communities in or recovering from a crisis or armed conflict). The categories of GIDAs are Focus Area A, i.e., both GIDAs and conflict-affected/vulnerable area with more than 30% poverty incidence; Focus Area B, i.e., conflict-affected/vulnerable area with more than 30% poverty incidence; and Focus Area C, i.e., GIDAs with more than 30% poverty incidence. Quality tertiary education should be able to cater to GIDAs. Interventions of universities in GIDAs contribute to the United Nation's Sustainable Development Goal #4 on Quality Education aims to "ensure inclusive and equitable quality education and promote lifelong learning

opportunities for all."

Providing quality education in GIDAs poses more challenges among SUCs. The question is the number of graduates and where the graduates came from, i.e., which University has impacted molding and building the human capital in the region. On the other hand, this will also be a constant challenge for the University to align its institutional priorities to the region's needs for human capacity development.

Central Mindanao University's (CMU) contribution to the development of Mindanao, if not to the country, is beyond doubt. Founded in 1910, CMU has produced professionals as pools of human resources in various fields and professions. Many of these graduates hold portfolios in key government and private agencies at local, national, and international levels.

The CMU University Annual Reports highlight the number of graduates produced. Similarly, colleges also keep track of the employability of their graduates. Now and then, University Administrators face the question of what have CMU contributed to poverty alleviation in the Province of Bukidnon, in particular, or in Mindanao, in general? Where do the student clients of CMU originate? Does the University reach out to the youths in the GIDAs? This study seeks to provide CMU the spatial information on the distribution of its students and graduates. Specifically, it evaluated whether CMU can spread its impacts and contribute to developing human resources within GIDAs. Using GIS as the primary tool, the outputs helped visually and critically assess the University's achievement in fulfilling its mandate. The output of this study may also aid in CMU interventions in GIDAs to address the Philippine and Northern Mindanao (Region X) Agenda on human capital development and the provision of economic opportunities.

One of the tools to show the extent of SUCs academic service areas is through mapping. GIS-based mapping can spatially show the scope of a university's reach in contributing to human resources development and addressing quality education, especially in GIDAs. Chandra et al. (2021) applied mapping to show the geographical distribution of foreign medical graduates.

The study's goal is to generate the spatial distribution of CMU students and alumni in Northern Mindanao. Specifically, the study aimed to:

1. map out the distribution of CMU students and alumni in Northern Mindanao;
2. classify the geographic distribution of CMU students and alumni in non-GIDAs and GIDAs Focus Areas in Northern Mindanao;
3. evaluate the geographical spread of CMU's academic services for the human resources development in Mindanao.

METHODOLOGY

The response to this study is purely voluntary. Questionnaire is structured to avoid discrimination in terms of age, gender and socio-economic status. Data collected were on year graduated and not specific age of

the respondent. A salary range or grade was used instead of directly asking for income. Respondent has also the option of not responding to this specific question and were classified as "No information" in the data analysis.

1. Protocols on Data Collection and Confidentiality

This study has approval from the Data Privacy Office of CMU in adherence to Republic Act 10173, otherwise known as the "Data Privacy Act." This study also secured clearance from the Institutional Ethics and Review Committee (IERC). With the current COVID-19 pandemic, this study reduced the risk of exposure to COVID-19 both on the researchers and on the respondents by using an online survey and limited printed forms for CMU alumni employees only with no email accounts.

The actual participation of student and alumni respondents was only in answering the online questionnaire via Google Form, which lasted on an average of five (5) minutes per respondent. The researchers disseminated the online survey links to various colleges and offices in CMU and personal contacts via social media. Participation in the online survey was purely voluntary. Respondents had the freedom to answer the questionnaire by not clicking or opening the link or to end it by clicking the exit button or not submitting the form. The questionnaire also contained statements on Informed Consent and Confidentiality of the data. The researchers verified the names of the respondents from the list of the University Registrar and the Human Resources Management Office. The online survey was opened in December 2020 and was closed in September 2021 to allow data analysis time. Data were supplemented from the list of graduates found in the CMU graduation programs from 1991 to 2016 that still show the names and addresses.

The online survey was pre-tested to non-CMU respondents primarily to check for any difficulties and technical issues in answering the online survey form. Since the data aimed to be inclusive for validity, the questionnaire was structured to avoid age, gender, and socioeconomic status discrimination.

The intent of this study is primarily in mapping out the extent of CMU's academic services, particularly in Northern Mindanao GIDAs. The generated maps provide the context for spatial analysis. The data analysis and presentation excluded the names and identities of respondents. Data on student names, courses, and year

graduated validate if respondents are CMU alumni or students. Data were coded in the analysis to protect the identity and confidentiality of the respondents. Researchers created a database for easy access and retrieval.

Data Processing and Analysis

The primary aim of this study is to map out the distribution of students and alumni by transforming data into spatial information using the Geographic Information System (GIS). The software used in the mapping is ArcMap ver. 10, a component of ArcGIS ver. 10 available at the Center for Geomatic Research and Development in Mindanao (GeoMin) in CMU. The mapping process started with acquiring necessary input data such as the location data of CMU students and alumni, GIDA focus areas, and GIS data on political boundaries. The data on GIDAs extracted from the National Economic and Development Authority (NEDA) list in the Northern Mindanao region was then appended to existing GIS data on political boundaries by attribution. The outputs of this process were the graduated symbol maps that provided better visualization as to where CMU students and alumni are across the Northern Mindanao region. These graduated symbol maps also showed the distribution pattern and concentration of CMU students and alumni relative to GIDAs in the region.

Researchers generated the following map overlays:

- Geographic distribution of CMU students
- Geographic distribution of CMU alumni
- Overlay of maps with GIDA Focus Areas.

In the absence of GIDAs data from other regions, the overlay of student and alumni distribution focused only on the Northern Mindanao region. Data analysis calculated the percentages of the distribution of students and alumni per province and in GIDAs in the region.

RESULTS AND DISCUSSION

1. Geographic Distribution of Students and Alumni of CMU
A total of 721 students and 4235 alumni responded thru the online survey. Most of the students who responded to the online survey come from Northern Mindanao, comprising 86% of the total student respondents. The geographical origin of these students comes from Bukidnon Province (78%), as depicted in Figure 1. The rest of the student respondents originated from other regions outside of

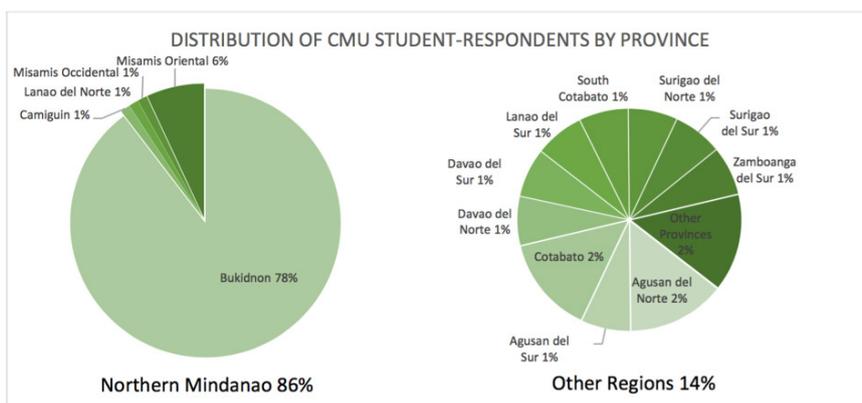


Figure 1. Distribution of CMU student-respondents by province, SY 2021-22. This figure illustrates the percentage distribution of CMU students in their respective provinces.

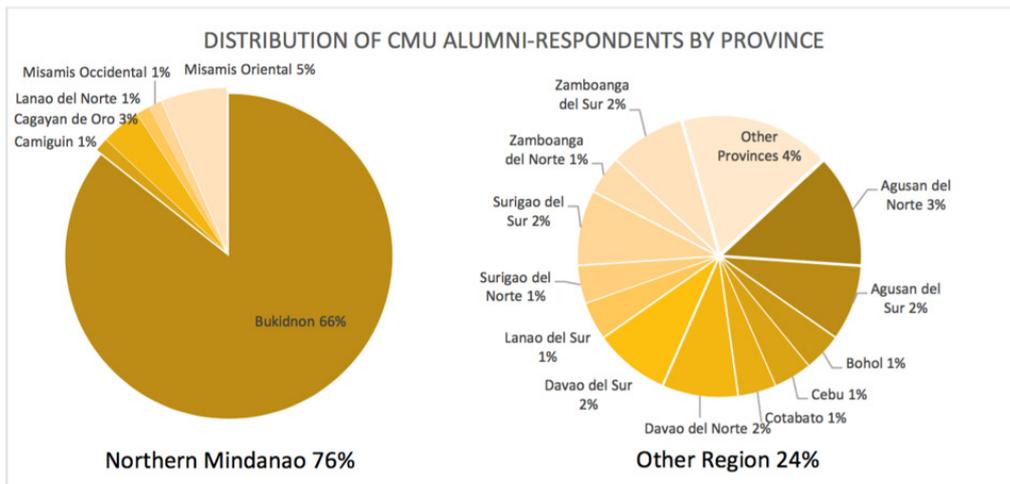


Figure 2. Distribution of CMU alumni by province. This figure illustrates the percentage distribution of CMU alumni in their respective provinces.

Northern Mindanao but are primarily from Mindanao Island.

The findings conformed to the studies of Bratti et al. (2019), Dotti et al. (2013), and Giambona et al. (2017), of which students are driven by "economic peculiarities in their respective geographical area of origin and the location of the universities." The peculiarity of the Bukidnon landscape is agricultural, and it is the agriculture sector that drives the province's economy. To match this economic peculiarity, CMU is a premier education and the Center of Excellence in Agriculture that caters to the labor demands of the agri-based economy of Bukidnon. CMU is the most convenient and accessible University for students who opt to enroll in agriculture and related courses. Another notable finding is the relatively few students in the northern part of Bukidnon because these places are near Cagayan de Oro City. The northern Bukidnon landscape is agricultural, but there are demands for non-agricultural jobs in adjacent Cagayan de Oro City. The choice of Cagayan de Oro is due to its "economic peculiarities," as described in Bratti et al., 2019; Dotti et al., 2013 and Giambona et al., 2017, such as the non-agricultural and urban economy. Thus, universities in Cagayan de Oro offer diverse tertiary courses, curricular programs, and, most importantly, diverse job opportunities for professional, technical, and vocational skills.

Of the total student respondents in Northern Mindanao, most are from Bukidnon (78% or 560 student respondents). The possible reason for the low number of students outside of Bukidnon is the availability and accessibility of equally high-quality education offered by universities in Cagayan de Oro and Iligan City – urban centers in Northern Mindanao. Cagayan de Oro City is in the midst of Misamis Oriental while Iligan City is in the midst of Lanao del Norte. These urban centers host several job opportunities, access to basic services, and higher and more diverse demand for the workforce. Other provinces with less than 1% include Siquijor Island in the Visayas, Pampanga in Luzon Island and Davao de Oro in Mindanao.

Alumni data generated from the online survey revealed that the oldest respondent graduated in 1970, while the recent ones were in 2020. Figure 2 presents a

similar distribution pattern with the students, most of whom now reside in Northern Mindanao (75% or 3443 alumni respondents) while the remaining 25% are outside of Northern Mindanao. Among the alumni in Northern Mindanao, 66% (3001) are in Bukidnon. In addition to the Mindanao regions, alumni respondents currently work in the Visayas region, i.e., Bohol and Cebu. Data also revealed that there are alumni who are now in Metro Manila, areas in the National Capital Region and Cebu, and in the countries of Thailand, Australia, New Zealand, Dubai, United Arab Emirates, USA, Canada, and the United Kingdom.

Data in Figures 1 and 2 imply that CMU attracted students mainly in Bukidnon and extended its service areas to nearby provinces in Northern Mindanao and the Mindanao region. This extent of CMU students and alumni distribution validates CMU's claim as a premier university and an "academic paradise in the South." According to Columbo et al. (2021), "universities who can attract more students even outside of its territories become an indicator of the quality of the university." This idea means that CMU has extended its reach to other Mindanao provinces to provide quality education. These students will soon become the human resources to fill in the workforce's needs in Mindanao.

CMU Students and Alumni in GIDAs in Northern Mindanao

One of the two characteristics of GIDAs is socioeconomic factors, particularly areas with high poverty incidence and the presence of vulnerable sectors. High poverty incidence translates to low-income households who are less likely to pursue tertiary education (Bailey & Dynarski, 2011 and Carneiro & Heckman, 2002) thus, the need to address "multiple disadvantages faced by these students in the higher education system" (Andrews et al., 2020).

Figures 3 and 4 show the distribution of students and alumni in Northern Mindanao GIDAs. Overall, most student and alumni respondents are in non-GIDAS.

Data in Table 1 show that only 28% of the student

respondents are in GIDAs, most of which are in Focus C (17%) and Focus A (9%). Figure 3 spatially show the distribution of student respondents in GIDAs in Northern Mindanao. Boundaries of GIDAs are at the barangay levels as per category of NEDA. It is interesting to know how many of these students will finish tertiary education and obtain the degree. The distribution of alumni in GIDAs is similar to students, of which 27% are in GIDAs of Northern Mindanao. Most of the alumni respondents in GIDAs are in Focus C (13%) and A (11%). Of the other five provinces in Northern Mindanao, only Misamis Oriental has students in GIDAs (9%).

On the other hand, most of the students in Northern Mindanao are in non-GIDAs. Figure 5 shows the distribution of CMU students in Bukidnon, the province where CMU is located. Among the student respondents in Bukidnon, 64% have geographical origin in non-GIDAs. The remaining 36% are in GIDAs, of which 12 % are from Focus Area A, 3% from GIDAS Focus Area B, and 22% from Focus Area C.

The majority of the students in GIDAs are from Maramag, understandably because CMU is under the political jurisdiction of this municipality in Bukidnon. However, CMU can provide quality education to nearby cities and municipalities, i.e., the GIDA Focus Area A in Impasugong, Malaybalay, Maramag, Quezon, and Kibawe. However, the significant coverage of GIDAs shows only a few students from CMU.

The fewer students in GIDAs may imply that those who want to pursue higher education may be constrained due to lack of financial resources due to high poverty incidence, lack of transportation facilities, or unstable peace and order situations. Bailey & Dynarski (2011) and Carneiro & Heckman (2002) argued that low-income families are less likely to pursue tertiary education. In this case, those in GIDAs opted to earn income or stay in their respective geographical origin rather than going out to pursue tertiary education and obtain a degree. Of the total alumni respondents, 60% are in non-GIDAs, while 11%, 3%, and 13% are in GIDAs Focus Area A, B, C,

Geographic al Location	Non-GIDAS (%)		GIDAS (%)						Other Region	
			A		B		C			
	Stud.	Alum.	Stud.	Alum.	Stud.	Alum.	Stud.	Alum.	Stud.	Alum.
Northern Mindanao	58	60	9	11	2	3	17	13	14	13
Bukidnon	64	66	12	14	3	4	22	16	N.A. (No available data on GIDAS)	
Camiguin	100	100								
Lanao del Norte	100	91	0	0	0	9	0	0		
Misamis Occidental	100	87	0	7	0	0	0	7		
Misamis Oriental	91	95	0	0	2	1	7	3		

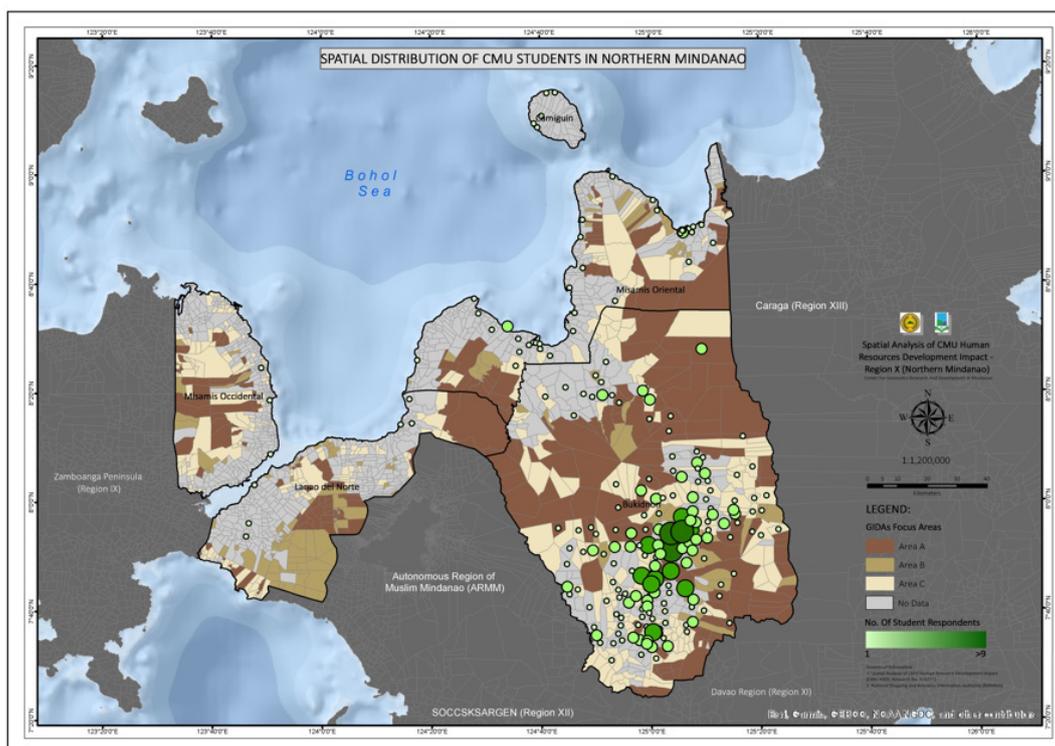


Figure 3. Spatial distribution of CMU students in Northern Mindanao. This figure illustrates the geographic location of CMU students in GIDAs and non-GIDAs in Northern Mindanao.

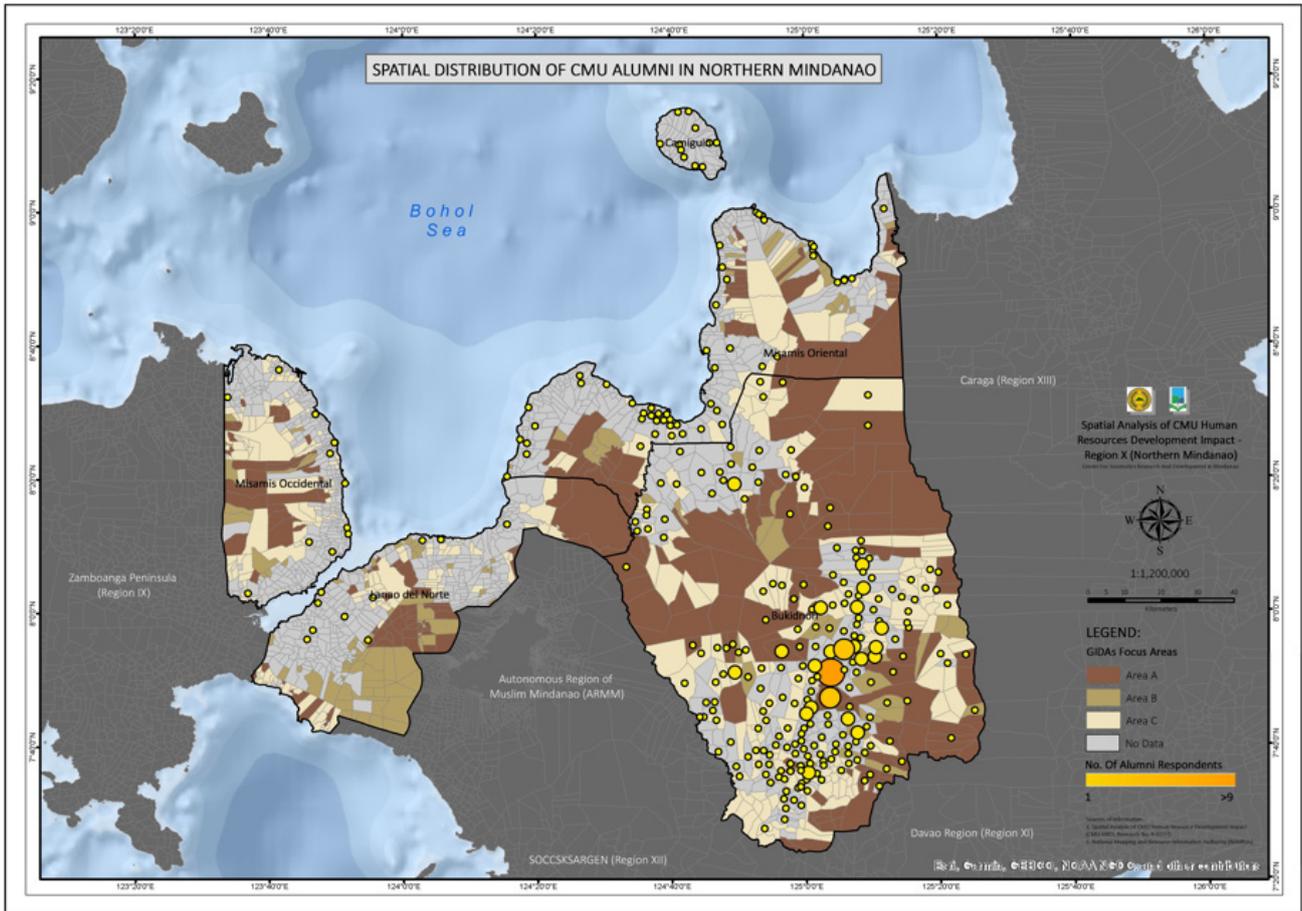


Figure 4. Spatial distribution of CMU alumni in Northern Mindanao. This figure illustrates the geographic location of CMU alumni in GIDAs and non-GIDAs in Northern Mindanao.

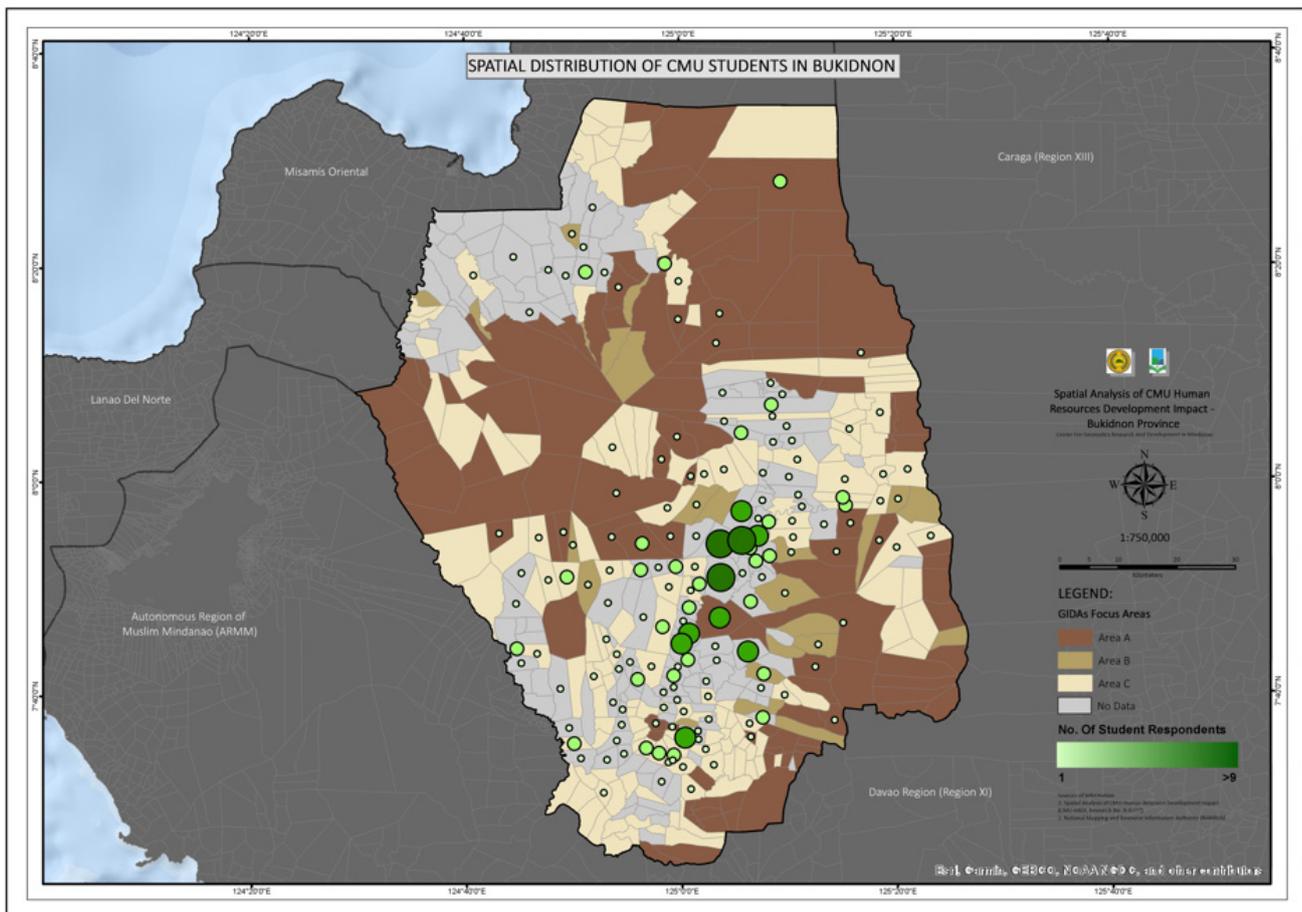


Figure 5. Spatial distribution of CMU students in Bukidnon. This figure illustrates the geographic location of CMU students in GIDAs and non-GIDAs in Bukidnon.

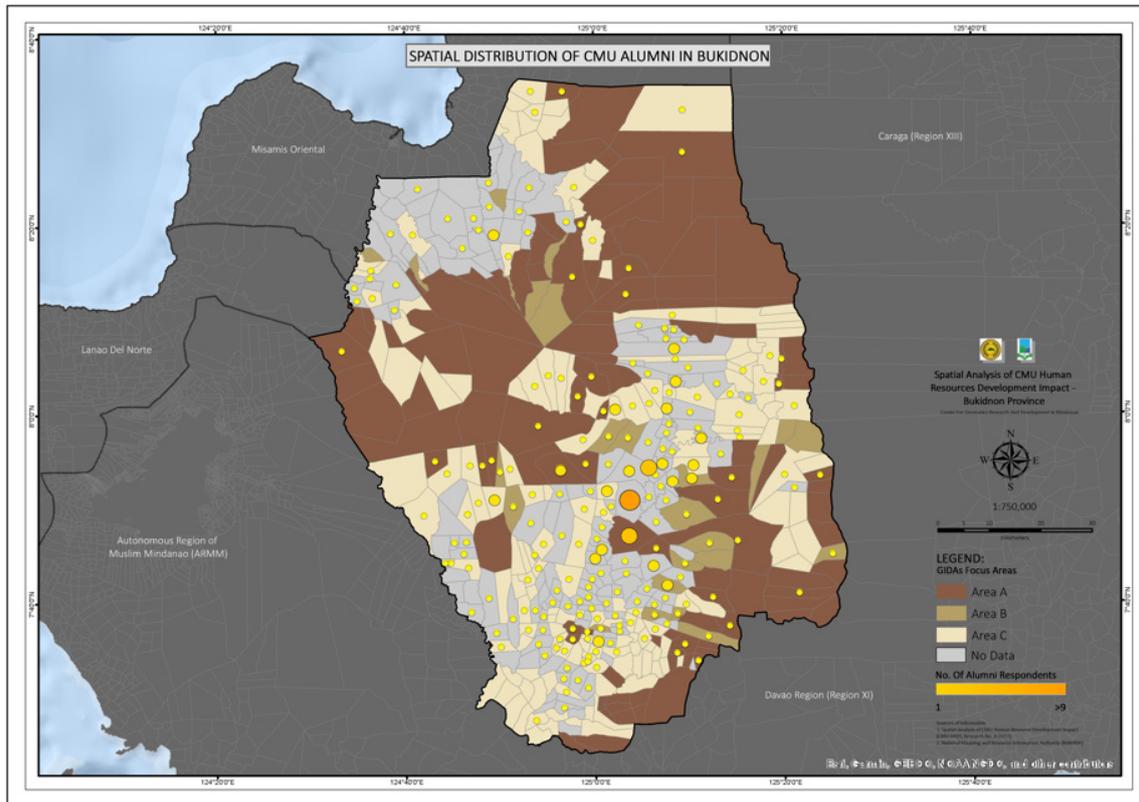


Figure 6. Spatial distribution of CMU alumni in Bukidnon. This figure illustrates the geographic location of CMU alumni in GIDAs and non-GIDAs in Bukidnon.

and C, respectively. Among the provinces in Northern Mindanao, Bukidnon has the highest percentage of alumni in GIDAs (34%) followed by Misamis Occidental (14%). The 95% of the alumni are in non-GIDAs probably because of the diverse employment sources, particularly in non-GIDAs urban and urbanizing places in Misamis Oriental such as Magsaysay, Tagoloan, Villanueva, El Salvador and Laguindingan.

In Bukidnon, CMU alumni are thinly spread but relatively high in the central and southern parts. The high number of CMU students in Bukidnon also coincides with the high number of CMU alumni mainly distributed in the south part of Bukidnon shown in Figure 6. Interestingly, these alumni are also spread in the GIDAs of the province, such as in the cities of Malaybalay and Valencia – urban centers with higher demand for employment with professional, technical, and vocational skills.

Geographical spread of CMU's academic services for the human resources development in Mindanao.

The generated data shows that CMU has a broad reach in Bukidnon, particularly in the central and southern parts. Outside of Bukidnon, the distribution is more focused in urban and urbanizing cities and municipalities. The majority of the students in CMU come from Bukidnon and Misamis Oriental, but the quality education service of CMU has also spread to other provinces even beyond Northern Mindanao. A similar pattern of CMU student and alumni distribution indicates that CMU concentration is within these two provinces, probably due to the proximity of CMU to these provinces. However, the limited number of students and alumni in other provinces in Mindanao is

due to other state-run colleges and universities that offer quality education at a cheaper cost. These findings indicate that CMU has impacted producing human resources for the regions in Mindanao, particularly in Bukidnon and Misamis Oriental Provinces, as shown in Figures 1 and 2. Bukidnon, an agriculture-based economy, needs human resources in agriculture and related fields such as Veterinary Medicine, Food Technology, Agricultural Engineering, Environmental Science, and others. However, the diverse curricular programs in CMU also cater to professional and technical skills demanded in urban cities and municipalities in the rest of the Mindanao regions. As such, CMU is the source of human resources for the development of the Mindanao region.

CMU's mission to provide quality education extends its academic service areas to the GIDAs. The academic services of CMU are an opportunity for students in GIDAs to exercise the right to be educated, pursue tertiary education, and enjoy the privilege to be educated in CMU that offers a quality education at a lower cost. Pursuing tertiary education in CMU is the gateway for low-income families and high poverty incidence communities to uplift their socioeconomic conditions. The presence of students in GIDAs indicates that CMU responds to the government interventions on basic services and peace and order initiatives in GIDAs and the SDG Goal 4 on Quality Education. This idea reiterates Andrews et al.'s (2020) point on "raising the educational attainment and earnings" among the high-achieving, low-income students by addressing "multiple disadvantages faced by these students in the higher education system."

CMU service areas in tertiary education have spread beyond Northern Mindanao, reaching other Mindanao regions and other parts of the country and abroad. Data generated

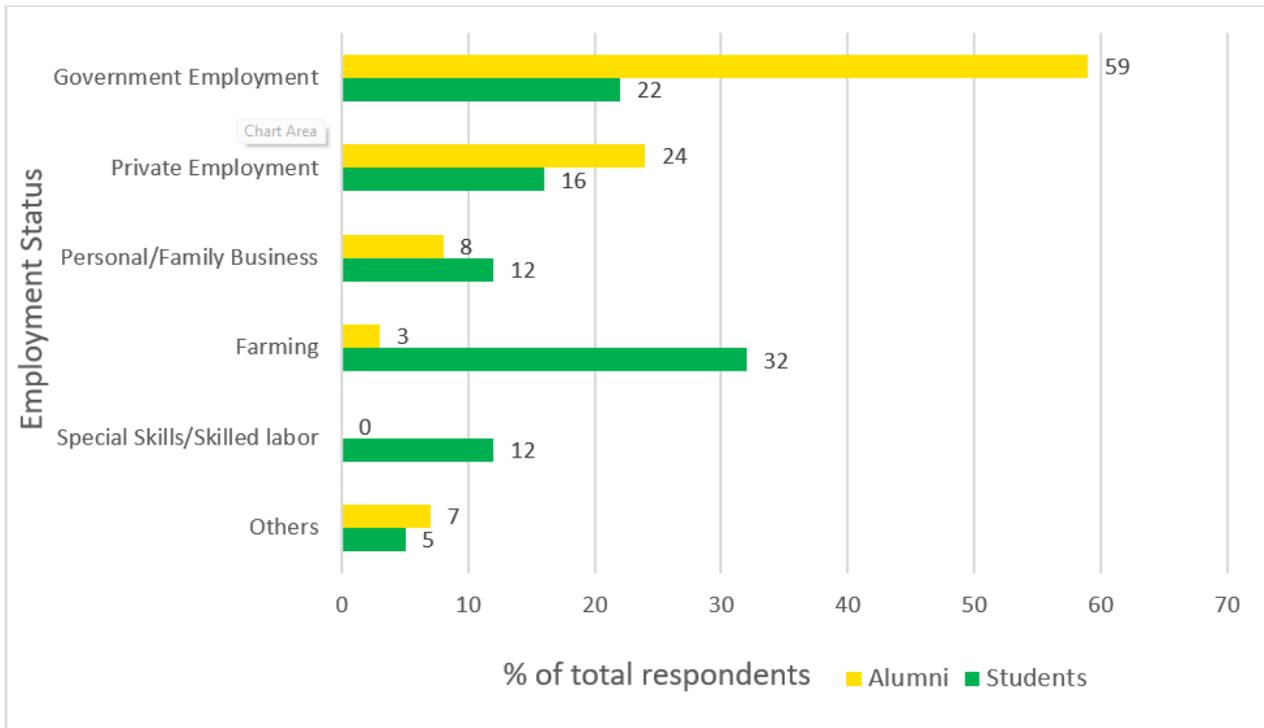


Figure 7. Comparison of the employment status of the households of CMU students and the alumni. This figure illustrates the percentage distribution of the sources of income of households of students and alumni.

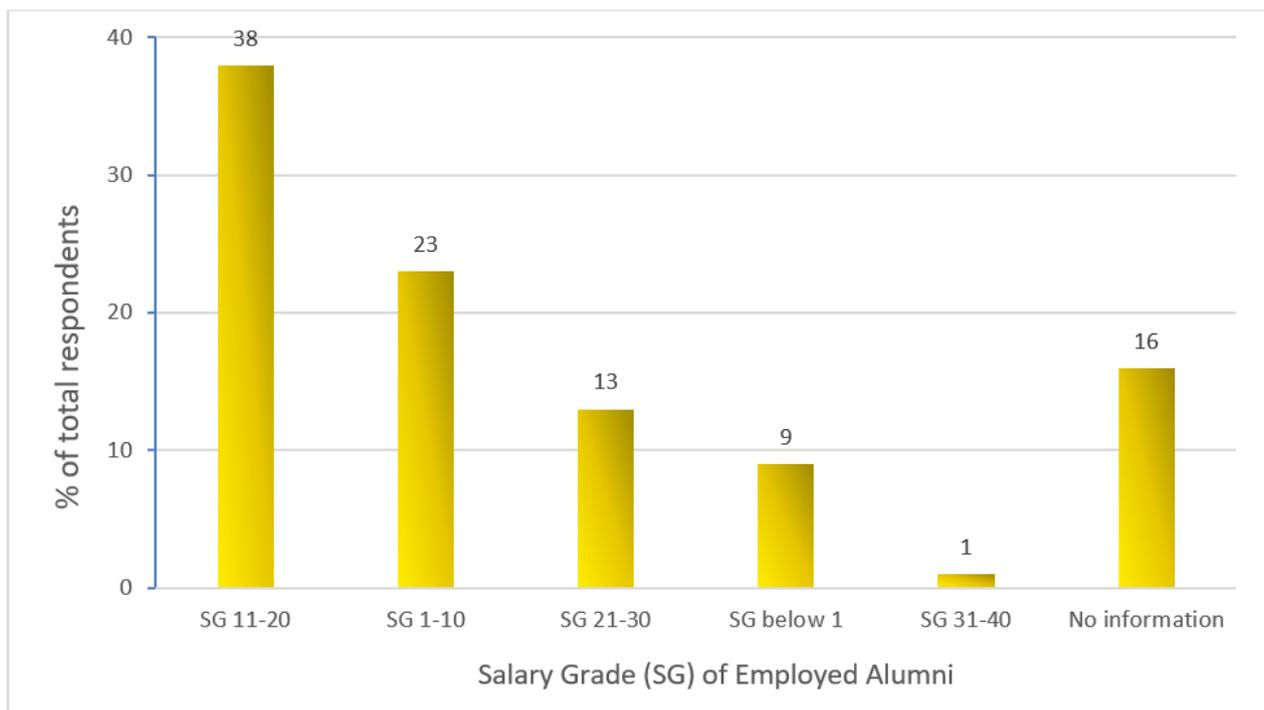


Figure 8. Salary grade of employed alumni. This figure illustrates the percentage distribution of alumni based on salary grade.

from this study also reveal that CMU has produced human resources for Mindanao. Figure 7 shows that farming (32%) is the source of household income for the majority of the students. On the other hand, alumni sources of income are government and private employment, while others venture into business. The alumni have an income ranging from 20,000 to 50,000 pesos per month, equivalent to Salary Grades 11-20 in government standard, as shown in Figure 8.

Figures 7 and 8 imply that CMU has produced graduates who contribute to the government and private sectors workforce. Their salary grade also means that these graduates are already occupying key positions. These data show that the academic services of CMU provide human resources for the workforce in Mindanao and the other regions. Thus, CMU has contributed to the region's human resources development through the employment of its graduates.

CONCLUSIONS AND RECOMMENDATION

From the generated data, the following conclusions are as follow:

1. The majority of the student respondents have geographical origin in Northern Mindanao (86%), of which 78% come from Bukidnon. Student respondents outside of Northern Mindanao comprise 14%.
2. The 76% of the alumni respondents are in Northern Mindanao, of which 66% come from Bukidnon. Alumni respondents outside of Northern Mindanao comprise 24%.
3. In Northern Mindanao, 28% of the student respondents are from GIDAs, while 27% of the alumni are in GIDAs. Bukidnon has the highest percentage of students and alumni in GIDAs, i.e., 36% and 34%, respectively.
4. CMU students and alumni are concentrated in central and southern Bukidnon. The relatively small number of students in other provinces of Northern Mindanao is due to the presence of state-run universities that offer quality education at a cheaper cost.
5. CMU has contributed to human resources development whose graduates have employment in government, private, and business sectors. The diverse curricular programs of CMU cater to the employment requiring professional and technical skills in the other regions of the country and abroad.

This study acknowledged its limitations regarding the number of responses, duration, and data sources. Methodologically speaking, the following recommendations are forwarded:

1. The Office of the Director of Instruction may extend the study using the same questionnaire to require all students to fill in the form. This filling up of the questionnaire may be a requirement for students to secure the final exam permit. Hence, CMU has a regular tracking and monitoring of the geographic location of their students per school year.
2. The Alumni Relations Office may continue to administer the survey for the alumni to increase the response rates and gather more data.
3. The Digital Transformation Office of CMU may create a database of the students and alumni with their corresponding addresses, i.e., city/municipal and province, but maintaining the confidentiality of the names. The database is helpful for easy access of the data for similar studies on the distribution of students and alumni.

The following suggested actions may provide more equitable access to quality instruction of CMU:

1. The CMU Administrative Council may strategize actions to encourage potential students from other provinces and regions, such as face-to-face or online campaigns through social media.
2. The Office of Admissions, Scholarships, and Placement (OASP) and the Office of Student Affairs may craft a scholarship program for students in the GIDAs. The program may encompass recruitment, accommodation, academic advising and coaching/mentoring, and monitoring activities. The program may also contain criteria for selecting and prioritizing potential students from the GIDAs.
3. CMU Administration may forge partnerships with other government agencies, legislators, and private companies

to generate funding for the said scholarship.

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Antibiofilm Activity of *Erigeron floribundus* (Kunth) against *Staphylococcus aureus* and *Pseudomonas aeruginosa*

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ABSTRACT

Antibiotic-resistant biofilm is a complex microbial community associated in the high risk of morbidity and mortality of hospitalized patients. The current study aims to determine the antibiofilm activity of invasive *Erigeron floribundus* plant extracts often known as "abas-abas" against *Staphylococcus aureus* and *Pseudomonas aeruginosa*. Bacterial strains were grown in M1 medium supplemented with fructose and cultivated for 24 and 48 hours at 30°C. Higher % biofilm inhibition was observed in gram-positive bacteria *Staphylococcus aureus* in most of the solvent use in extraction. Qualitative phytochemical screening was also evaluated and revealed the presence of tannins, flavonoid, saponins, steroid and the absence of alkaloid. The existences of these phytochemicals in the plant could be used to generate synthetic medications as a source of precursors. Moreover, this study also reveals that *E. floribundus* extract had antibiofilm action against the isolated nosocomial bacteria, implying that it could be used as an alternative to prevent microbial biofilm development.

Keywords: antibiofilm agent, invasive plants, *Pseudomonas aeruginosa*, *Staphylococcus aureus*

INTRODUCTION

Universities play a critical role in producing human HED) imOver 30% of cases were found to have bacterial coinfection during the 2009 H1N1 influenza pandemic, despite antibiotic therapy (Rice et al., 2012; Westblade et al., 2021). Viral lung infection weakened the immune system of the host, and altered the makeup and functions of the respiratory microbiota, predisposing hosts to bacterial coinfections (Feldman and Anderson, 2021). Several retrospective studies based on cases from various geographical regions have also shown bacteria coinfecting with SARS-CoV-2. The common co-infecting bacterial species include *Haemophilus influenzae*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Mycoplasma pneumonia*, *Streptococcus pneumoniae*, and *Pseudomonas aeruginosa* (Fattorini et al., 2020; Hughes et al., 2020; Chen et al., 2020; Bashir et al., 2021; de Buhr & von Köckritz-Blickwede, 2021). Bacterial coinfections worsen respiratory viral infections and are a common cause of death in influenza pandemics, but they're not well understood in individuals with coronavirus disease (COVID-19). One factor for coinfection is its ability to form a microbial biofilm. They are highly resistant to treatments and the immune systems of their hosts, making them a primary virulence factor that causes long-term infections (Muhammad et al., 2020). Biofilm formation composing of exopolysaccharide-protected bacteria up to 1,000 times more resistant to antibiotics than planktonic (free-floating) bacteria, posing substantial therapeutic challenges and complicating treatment alternatives (Sanchez et al., 2013). An estimated 75 percent of bacterial infections are estimated to be caused by biofilms, which are protected by an extracellular

matrix. Biofilm inhibition is a popular treatment target for a range of bacterial and fungal infections, and the pharmacological development of these medicines is now being studied extensively (Ramanathan et al., 2021). In several pathogens, this process results in the generation of virulence factors and/or a change in bacterial lifestyle, which is a crucial determinant of the infection's outcome and severity. Recent advancements in our understanding of the genetic and molecular foundation of bacterial community behavior indicate potential treatment targets for biofilm infection.

Pseudomonas aeruginosa is frequently isolated from the airways of patients with cystic fibrosis or with respiratory infections, it most often establishes chronic infections that usually persist for the rest of the lives of the patients (Davies, 2002). This bacterium is a leading cause of death and morbidity, and it has been extensively researched. On the other hand, the *Staphylococcus aureus* biofilm-associated burden is challenging to the field of medicine to eradicate or avoid. Even though several *S. aureus* biofilm mechanisms have been established, there is still a need to know more and require the development of new therapeutic strategies. In this viewpoint, we investigated the potential use of invasive *Erigeron floribundus*, locally known as abas-abas on how they affect the biofilm formation inhibition in nosocomial infections.

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One promising alternative is the search for naturally occurring plant-derived chemicals that can block biofilm formation (Rojita et al., 2020). Historically, plant extracts and their physiologically active compounds have long been a rich source of natural goods that have aided in illness prevention, treatment, and health maintenance. Furthermore, they are widely accepted due to the perception that they are safe and have a long history of use in folk medicine to cure diseases and illnesses since ancient times. This study evaluated the antibiofilm activity of an aqueous extract of *Erigeron floribundus* (Kunth) or (syn": *Conyza sumatrensis* (Retz) E.K. Walker) a terrestrial herbaceous plant of the family Asteraceae. Folkloric use of the plant shows multiple traditional benefits to treat several diseases, including rheumatism, gout, cystitis, nephritis, dysmenorrhoea, and dental pain. Since the plant is used traditionally in the treatment of painful illnesses, it is valuable to evaluate its antimicrobial biofilm activity. In vitro, the biological activities of *E. floribundus* essential oil displayed antioxidant, antimicrobial, and antiproliferative activities (Petrelli et al., 2016). Furthermore, it showed inhibitory effects on nicotinate mononucleotide adenylyltransferase (NadD), a promising new target for developing novel antibiotics. It also possesses interesting bioactivity in anti-inflammatory, immunomodulatory, antiplasmodial, antioxidant, antiproliferative, and antimicrobial activities (Tra Bi et al., 2008; Menan et al., 2006; Kuate et al., 2005). Given the plant's widespread usage in traditional medicine as well as its in vitro biological activities, it's worth investigating the causes for its bioactivity by evaluating its biofilm inhibitory activity against nosocomial pathogens in various extraction solvents.

METHODOLOGY

Bacterial Strains: *Pseudomonas aeruginosa* BIOTECH 1335 and *Staphylococcus aureus* BIOTECH 1582 strains were obtained from the National Institute of Molecular Biology and Biotechnology (BIOTECH), University of the Philippines Los Banos, Philippines.

Plant Materials: Fresh and healthy plants growing around the Bukangliwayway community, located at Kibawe, Bukidnon (7.4815 N, 125.0384 E), were collected between February to May 2020. Samples of vouchers were deposited at the herbarium of Central Mindanao University Herbarium (CMUH) while duplicates were sent to Philippine National Herbarium (PNH). Collected plants were rinsed severally with clean tap water to make them dust and debris free. Then, the leaves were spread evenly and dried in the shady condition for 3 to 4 days until they became crispy while still retaining the greenish coloration at room temperature (25±2°C). Finally, dried materials were ground in an electric chopper to get fine powder form for further analysis.

Medium: Nutrient-rich (NR) medium was used in seeding, maintenance, and storage of the bacteria and mineral salts (M1) medium of the same composition as that reported by Gutierrez et al., (2013 for biofilm formation analysis). The solvents used were purchased from were purchased from RCI Labscan.

Preparation of plant extracts: The dried and

powdered samples (each 50g were extracted successively with double distilled water, ethanol, and methanol (each 400ml) for 10 12 hrs. Then, the collected solutions were filtered through Whatman No-1 filter paper. The extracts were evaporated to dryness under reduced pressure at 50°C using a rotating vacuum evaporator, and then stored in a freeze condition at 180°C until used for further analysis.

Instrumentations: The samples were evaporated through the rotary vacuum evaporator from 60 - 100°C according to the B.P. of supplied solvents. Absorbance spectrophotometry was carried out using a UV-vis spectrophotometer (El, model-1371). Wavelength scans and absorbance measurements were in 1ml quartz cells of 1cm path length.

Biofilm formation assay: Biofilm formation was determined using a protocol modified by Gutierrez et al., (2013), cells were grown in 4 ml of M1 medium with 70 mM fructose in the presence or absence of crude extract at 30°C in glass tubes without agitation for 24 and 48 h. Static biofilm formation was measured by visual inspection of the air-liquid interface of the cultures. Coverage of the air-liquid interface of the culture by a layer of cells and matrix material was considered a biofilm. The tubes were washed with distilled water and stained with 0.1% crystal violet solution for 20 min. After the addition of 4.5 ml of 95% ethanol to each tube, the adsorbed dye was quantified from the OD readings at 600 nm.

$$(\%) \text{ inhibition} = \frac{OD \text{ control} - OD \text{ sample} \times 100}{OD \text{ control}}$$

Qualitative Phytochemical Screening. The *E. floribundus* ethanolic extracts were subjected to standard phytochemical tests to evaluate their chemical composition for different active constituents; for these extracts (3–5 mg/mL), they were separately suspended in 1 mL of absolute ethanol or distilled water using clean test tubes.

Statistical Analysis: All experimental results were expressed as mean ± standard deviation (SD) for analysis performed in duplicate at least three times. Using SPSS software version 17.0, statistical analysis of the data was performed using Analysis of Variance (ANOVA) and mean comparison using Student's -test.

RESULTS AND DISCUSSION

E. floribundus is widespread in Brgy. Bukangliwayway, Kibawe, Bukidnon, even along the barangay highway, and in all sampling sites (Figure 1). It prefers undisturbed sites and is a problem in low-tillage systems plantations and crops. Despite these concerns, *E. floribundus* can sometimes be viewed as having some economic values, e.g., improving soil fertility and controlling soil erosion. The antimicrobial activities of various parts of *E. floribundus* have not previously been thoroughly studied, and there is a lack of the essential information needed to commercialize its contribution.

Preliminary antimicrobial tests of *E. floribundus* against *S. aureus* and *P. aeruginosa* through monitoring



Figure 1. *Erigeron floribundus* (Kunth) or (syn": *Conyza sumatrensis* (Retz) E.K. Walker)

its growth inhibition was quite variable between different solvents. From the different extraction solvents, chloroform extract showed significant inhibitory activity against Gram-negative bacteria *P. aeruginosa* than in gram positive bacteria *S. aureus* (Figure 2). This suggests that the type of solvent used in the extraction technique has a significant impact on the success of determining physiologically active chemicals from plant material. The results of our cell density antimicrobial activity assay revealed no significant difference in the test organisms to the five different *E. floribundus* leaf solvents extracts (acetone, ethanol, chloroform, methanol, and water).

Interestingly, biofilm formation of *E. floribundus* extracts against *S. aureus* showed significantly higher % biofilm inhibition using different solvent extraction as shown in Figure 3. Aqueous extractions significantly inhibited biofilm formation for almost 80% inhibition in *S. aureus* (Figure 3a). In contrast, *E. floribundus* showed lower % inhibition in Gram-negative bacteria *P. aeruginosa* (Figure 3b). These results demonstrated that *E. floribundus* can be a potential antibiofilm agent for Gram-positive bacteria that are responsible for the majority of hospital-acquired infections, such as nosocomial infection. The active compounds of *E. floribundus* must be investigated to understand the underlying principles of its inhibition. The cell wall of Gram-positive bacteria has a thick

peptidoglycan layer that comprises linear polysaccharide chains connected by short peptides, providing a rigid structure that makes extract penetration difficult while Gram-negative bacteria have a thinner peptidoglycan layer. However, in this study, we have successfully found an interesting candidate against gram-positive bacteria.

Moreover, the photochemical analysis of *E. floribundus* also revealed the presence of tannins, flavonoids, saponins, steroids, and absences of alkaloids in ethanol extracts (Table 1). The existence of these phytochemicals suggests that the plant could be used to generate synthetic medications as a source of precursors. The absence of alkaloids indicates that the plant is not harmful or toxic. The plant provides a readily source for tea, with the caffeoylquinic derivatives being the most abundant constituents (Berto et al., 2014).

Thus, further identification and characterization of *E. floribundus* active compound responsible for its antibiofilm agent must be quantified to develop formulated products for herbal and medicinal tract.

CONCLUSION

E. floribundus endowed antibiofilm agent, and this invasive weedy plant species can be a potential candidate

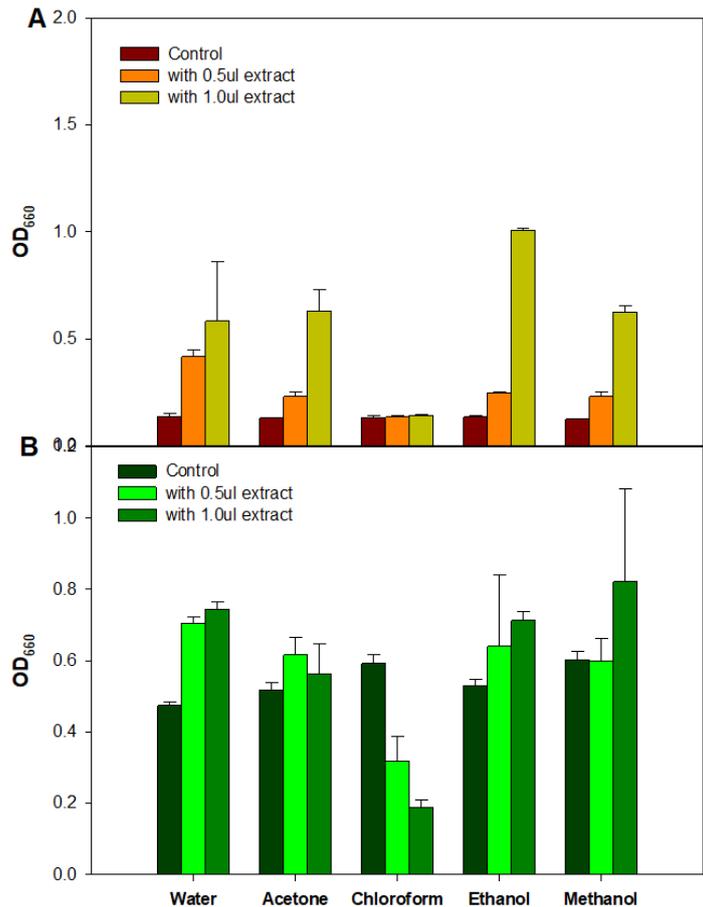


Figure 2: Growth of *S. aureus* and *P. aeruginosa* with *E. floribundus* plant extracts

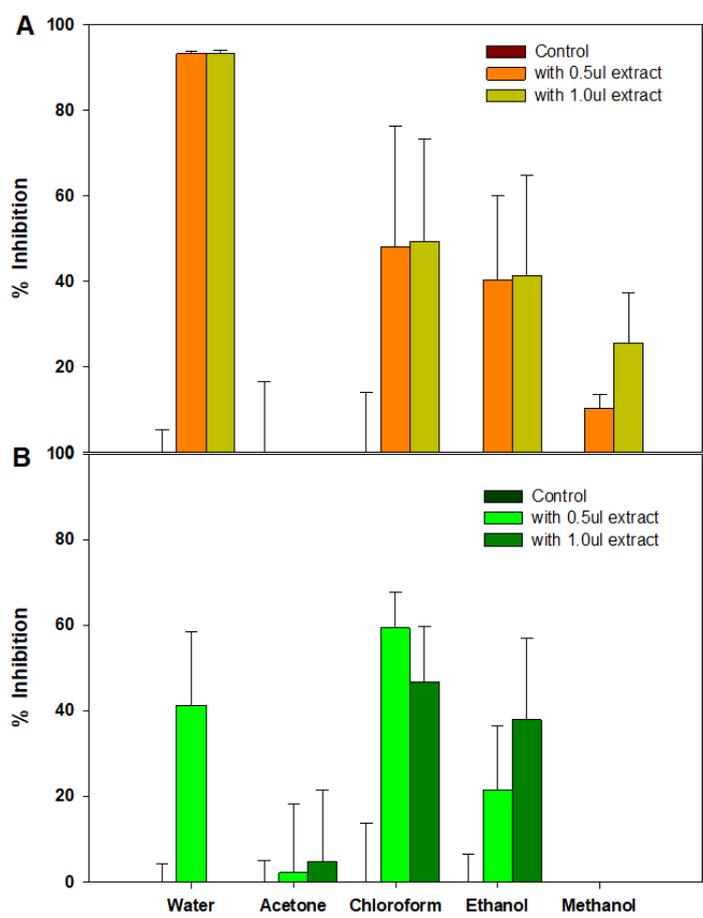


Figure 3: % biofilm inhibition of *E. floribundus* against (a) *S. aureus* and (b) *P. aeruginosa*

Table 1: Qualitative phytochemical analysis of *E. floribundus*

Active principle	Test	Ethanollic extract
Tannins	FeCl ₃	+
Saponins	Frothing test	+
Flavanoids	NaOH	+
Steroids	Salkowski	+
Alkaloids	Wagner's test	-

as readily available sources of antimicrobial agent, some of which may be useful as microbial biofilm inhibitor and antibiotic drugs. The search for naturally occurring compounds of more invasive plants and developing several green nonlethal strategies capable of blocking biofilm formation is further recommended.

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Effects of Multiple Game-based Strategies in Grade 10 Science Learning

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ABSTRACT

This study investigated the effects of multiple game-based strategies on learners' academic performance and engagement in Grade 10 Science. It was conducted at Esperanza National High School, Schools Division of Sultan Kudarat, during the school year 2019-2020. The study used one group pretest-posttest quasi-experimental research design. This was participated by Grade 10 learners. The development of lessons, validation of instruments, and try-out was made prior to the actual conduct of the study. The data gathered using the 30- item validated researcher-made academic performance test and engagement scale in Science were analyzed and interpreted using appropriate statistical techniques. Mean, standard deviation, and one-way analysis of covariance (ANCOVA) were also used. Findings revealed that the academic performance in Biology of Grade 10 learners taught with multiple game-based strategies was fairly satisfactory; while, the learners taught with the usual way of teaching method, "did not meet the expectation." There was a statistically significant difference in the academic performance between the learners' taught with multiple game-based strategies and those learners' who were taught with the usual way of teaching method. Moreover, the experimental group had high mean scores compared with that of the control group. The group of learners using multiple game-based strategies performed better.

Keywords: game-based strategies, instrument development, academic performance, ANCOVA

INTRODUCTION

Game-based learning has the capacity to capture learners' attention and ensure their full involvement and engagement. The motivating process of games turns lessons dynamic and thought-provoking, whose appeal is maintained as learners' progress to achieve learning objectives (Plass et al., 2015).

Multiple game-based strategies refer to the use of games to improve learners' learning experience, while content and gaming are balanced, and its application is maintained in real-life situations. In the same way, the term gamification is the use of game-based mechanics, aesthetics, and game thinking to engage people, motivate action, promote learning, and solve problems (Kapp, 2012). Vlachopoulos & Makri (2017) indicated that games or simulations have a positive impact on learning goals. They studied the influence of games and simulations in achieving specific learning objectives and identified three learning outcomes when integrating games into the learning process: cognitive, behavioral, and affective.

The Department of Education's K-12 Program envisions refining the 21st-century skills of the learners, which has three main frameworks according to Scott (2017): (1) career and life skills, (2) learning skills and innovation skills, and (3) information, media, and technology skills. Hence, to motivate the learners to learn and appreciate Science as relevant and useful, educators must organize the curricula around situations and problems that challenge and arouse their curiosity (DepEd K-12 Science Curriculum

Guide, 2016).

Biology is teeming with subject matter that obliges innovative and explorative style of pedagogical approach for better appreciation and understanding as an alternative to the usual classroom instruction using the traditional medium of packaged educational materials (Lao & Yuson, 2013).

Learners' learning engagement was increasingly observed as one of the keys to addressing difficulties such as low achievement, boredom, and alienation (Fredricks et al., 2004; Martin & Torres, 2017). Tyng et al. (2017) asserted that emotion has a substantial impact on attention, especially on modifying the selectivity of attention and motivating action and behavior. Emotion also facilitates encoding and helps the retrieval of information efficiently. This attentional and executive control is said to be intimately linked to learning processes.

One of the problems that Science teachers at Esperanza National High School are facing is enhancing the learners' academic performance. As observed in the result of their MPS (Mean Percentage Scores), the learners' academic performance in Science was low, especially the learners' under the Basic Education Curriculum. Another problem is the prominent use of gadgets by learners.

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In this study, the researcher introduces a teaching strategy for Biology lessons, which integrates the merits of active learning through multiple game-based strategies. Learning through games lets the learners experiment in non-threatening situations and obtain knowledge through practice and social interaction both with their peers and their environment. Hence, it is essential to integrate multiple game-based strategies to enhance learners' engagement and improve their academic performance in Science.

Framework of the Study

Multiple game-based strategies were also anchored by the theory of active learning, by which postulates that learners take increasing responsibility for their knowledge. Rather than lecturers or deliverers of ideas, teachers are enablers and activators of learning. Active learning describes a classroom approach that acknowledges that learners are dynamic in the learning process, which contrasts with the model of instruction where knowledge is imparted or transmitted from the teacher to students (Bonwell & Eison, 1991).

Furthermore, multiple game-based strategies were also built upon the theory of cognitivism, which focused on knowledge transfer from instructors to students. Different aspects of interactivity in the classroom, including questioning and answering, informative feedback, and explanations, are effective ways to improve knowledge transfer. Through cognitivism, the learner became the center of attention where they acquire knowledge through varied modalities such as text, pictures, and sounds. Thus,

it facilitates the learner to recognize and analyze problems and apply past learning (Protopsaltis, 2011).

The performance level in the pretest and posttest will be measured using the scale adapted from DepEd Order. No. 8 series of 2015: Outstanding, Very Satisfactory, Fairly Satisfactory, and Did Not Meet Expectations. The learner's level of engagement will be measured using an adapted and modified Attard's Learning Engagement Inventory Test (2012) in three categories: cognitive, behavioral, and affective.

Cognitive engagement includes investment, recognition of the value of learning, and willingness to go beyond the minimum requirements. Behavioral engagement comprises the awareness of active participation and connection in academic and social activities and is considered essential for achieving positive educational outcomes. Affective engagement covers students' reactions to school, teachers, peers, and academics, influencing their willingness to become involved in school activities (Attard, 2012).

Figure 1 presents the schematic diagram of the study and the visual representation of utilizing multiple game-based strategies. The boxes show the relationship between the variables in the study. The box on the left (Box A) shows the independent variable, which contains the two teaching strategies: teaching using multiple game-based strategies in the experimental group and using the usual teaching method in the control group. Both teaching strategies were used for the same topics for Grade 10 Learners in Biology. While the box on the right (Box B)

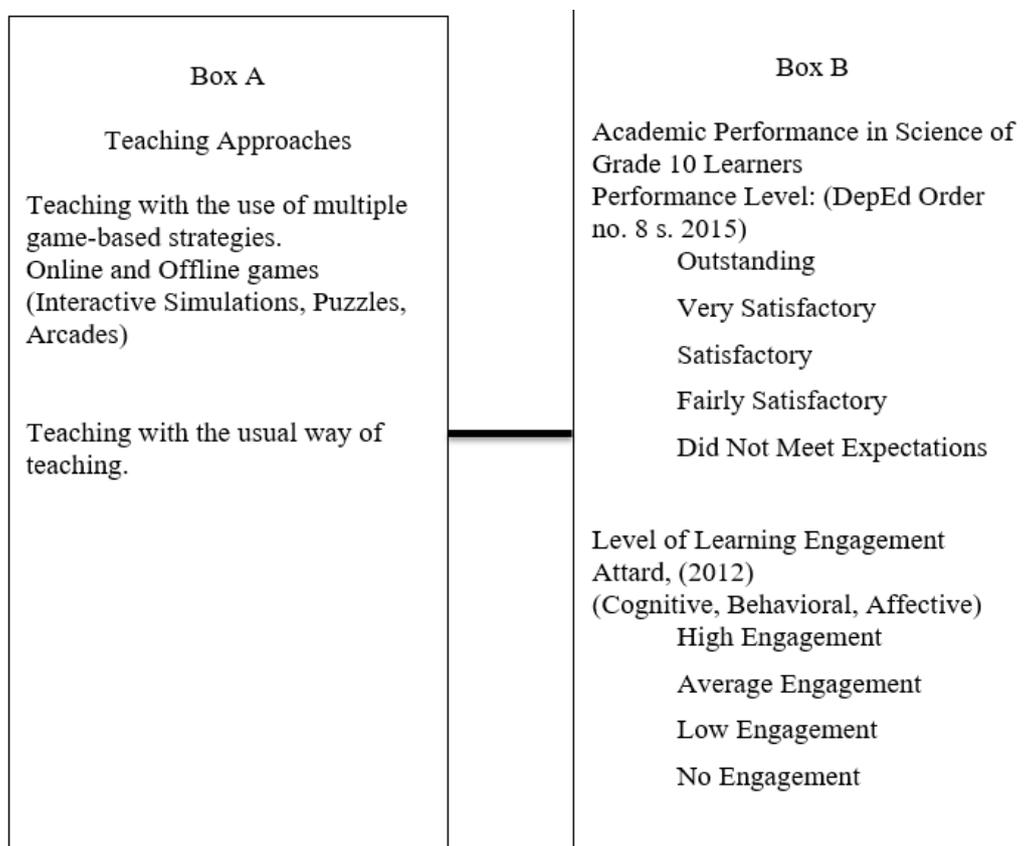


Figure 1: Schematic Diagram of the Study

shows the independent variables, which are the variables to be measured: academic performance and learners' engagement.

STATEMENT OF THE PROBLEM

This study aimed to investigate the effects of the utilization of multiple game-based strategies on learners' academic performance and learning engagement. This study was conducted to selected Grade 10 learners of Esperanza National High School in the Division of Sultan Kudarat during the Third Quarter of the School Year 2019-2020.

Specifically, it sought answers to the following questions:

1. What is the academic performance of Grade 10 Learners in Science taught with the use of multiple game-based strategies and those that were taught using the usual teaching strategy?
2. What is the level of engagement of the learners taught with multiple game-based strategies in Science?
3. Is there a significant difference in the academic performance in Science between Grade 10 Learners taught using multiple game-based strategies, and those taught with the usual way of teaching?

Null Hypothesis

There is no significant difference in the academic performance and learning engagement of Grade 10 learners taught with the use of multiple game-based strategies, and those learners taught using the usual teaching strategy in Science.

Significance of the Study

The researcher believes that the result of this study would benefit the following: the learners, science teachers, administrators, and other researchers.

The developed lessons in Science could serve as supplementary materials, which could further encourage them to create instructional materials on other topics. It could inspire them to be more innovative and explore more educational applications that would complement their lessons. It may support the teachers to modify their teaching strategies with the use of multiple game-based strategies.

Delimitation of the Study

This study was limited to the use of multiple game-based strategies that serve as a tool for high school science teachers to improve learners' academic performance and increase learner involvement. The study was conducted during the third quarter of the school year 2019-2020 among the Grade 10 learners of Esperanza, National High School, Division of Sultan Kudarat.

The participants of this study were junior high school learners from the two selected Grade-10 classes from the Basic Education Curriculum (BEC). Thirty (30) learners from each section were assigned to the experimental group and the control group.

The research instrument in this study was a 30-item researcher-made academic performance test, the lesson plans, and a learning engagement scale questionnaire. The researcher used a quasi-experimental group comparison pretest-posttest research design to analyze the effect of the developed lessons using multiple game-based strategies on the learners' academic performance.

Definition of Terms

Multiple game-based strategies. Multiple game-based strategies are combinations of online and offline games that are used in the teaching and learning process. Game-based strategies include elements of competition, engagement, and immediate reward.

Academic Performance. Academic performance represents performance outcomes that specify the extent to which a learner has accomplished specific learning goals that were the emphasis of activities in instructional environments, specifically in school. It also refers to the mastery of a particular skill or behavior as measured through performance test scores. The performance level in the academic performance test scores will be scaled following the DepEd Order No. 8, series of 2015 as Outstanding, Very Satisfactory, Satisfactory, Fairly Satisfactory, and Did Not Meet Expectation. In this study, the learners' level of academic performance is measured with the result of the pretest and posttest.

Level of Engagement. Learners' level of engagement refers to the amount of attention, curiosity, interest, optimism, and passion that the learners exhibit when being taught or when they are learning, which encompasses the level of motivation they have to learn and advance in their education (Abbott, 2014).

METHODOLOGY

Research Design

This study tested the effectiveness of multiple game-based strategies in the class to the academic performance and engagement of the learners. The quasi-experimental pretest-posttest research design was utilized. This study used two (2) intact classes, Grade 10 learners from Esperanza National High School. Sixty (60) learners from the Basic Education Curriculum (BEC) Grade 10 learners were the participants in the study selected through random sampling.

In this design, the experimental group was taught using multiple game-based strategies, while the control group was taught the usual way of teaching using K-12 learning materials. Both experimental and control groups were given a pretest that will assess their previous knowledge of Biology concepts, specifically in DNA and RNA structure and central dogma. The answer of the learners was checked and recorded. The post-test scores of each group were compared and treated as the dependent variable of the study. The pretest and post-test exam results of the two groups were compared using One-way ANCOVA (Analysis of Covariance).

This instructional development model involves three stages: pre-development, development, and post-



Figure 2 Geographical Map of the Research Locale

development stage. These three stages permit the researcher to plan, develop, and revise the developed lesson based on insinuated experts. The first stage (pre-development) includes needs analysis, identifying objectives of the lesson, planning for the content, and TAM (Task Analysis Matrix) preparation. The researcher developed and prepared the Task Analysis Matrix as a guide for organizing the lesson. TAM aided the researcher in identifying the skills to be improved, instructional objectives to attain, and allocation of the number of days in covering the lessons.

Research Locale

The study was conducted at the Esperanza National High School, Division of Sultan Kudarat, Municipality of Esperanza, Province of Sultan Kudarat Region XII (SOCCSKSARGEN) during the school year 2019-2020. Esperanza National High School is situated in the southeastern part of Mindanao, specifically in the Province of Sultan Kudarat. It is located at Mabolo Street, Barangay Poblacion, Esperanza, near the municipality's public market.

Figure 2 shows the geographical map of the locale of the study, where the study was conducted. The map was obtained from the online google map showing a detailed view of the site (Map of Sultan Kudarat with Esperanza highlighted, 2018).

Participants of the Study

The participants of this study were two (2) intact classes of the Grade-10 level of Esperanza National High School in Esperanza's Municipality, Division of Sultan

Kudarat. The participants are the selected Grade-10 learners out of fourteen (14) sections under the Basic Education Curriculum (BEC). The two intact classes involved in this study were made up of 48 learners in the experimental and 47 learners in the control group. The thirty learners from the control group are paired with the thirty learners in the experimental group based on their grades in Science from the second grading period.

Research Instrument

The 30-item validated researcher-made academic performance test was used in the paper-and-pencil test. The test was developed to measure and determine the academic performance of Grade 10 learners in the following Biology topics: DNA and RNA structure, Central dogma (Replication, Transcription, and Translation) Gene Mutations. The included topics in the academic performance test were based on the learning competencies from the third quarter K-12 learners' module in Science. The construction of the test was guided by a Table of Specification (TOS).

The researcher-made test was validated by three (3) panels of experts. Initially, the test consists of 50-item questions based on the competencies enumerated in the (TOS).

After the revision of the material, the test was tried out on Grade -11 learners from Bukidnon Laboratory School. The test results were used to test the internal consistency of the survey questionnaire. The result was analyzed and interpreted with the help of a statistician. The computed Cronbach alpha (α) = 0.801 indicated a highly acceptable performance test.

To measure the engagement level of the learners,

the researcher adapted and modified the learning engagement scale by Attard (2012). It was content validated by the three (3) panels of experts. The three evaluators agreed on the content accuracy of the items and strongly agreed on the clarity and appropriateness of the items in the learning engagement questionnaire.

Scoring Procedure for the Academic Performance Test

In the Academic Performance test, 30 points are the perfect score. A scoring scale for the academic performance was set based on DepEd Order #8 s. 2015 to assign the corresponding academic performance of the students from their scores on the test.

Engagement of the Learners

The researcher adopted and modified the Learning Engagement Scale of Attard (2012). The learners' engagement level was categorized into three: cognitive, behavioral, and affective. This scale was used to measure and evaluate the learners' opinions, actions, and participation in Science.

Data Gathering Procedure

The data gathering was held at Esperanza National High School, Esperanza, Sultan Kudarat, in the third quarter of the school year 2019-2020. The researcher explained the rationale and processes involved in the study to orient the participants concerned and obtain the data needed for the fulfillment of the study. Permission from the school principal was asked and secured in writing prior to the conduct of the study.

Treatment of the Data

After the gathering of the necessary data, it was treated with appropriate statistical tools. For both problems 1 and 2, the mean and standard deviation were used to treat the data to assess the academic performance in Science of Grade-10 learners taught with multiple game-based strategies and those who were taught with the usual way of teaching. Mobile applications (apps) were used in this study as learning and teaching tools which are not uncommon even in Higher Education (Pechenkina, 2017).

For problem 3, One-way Analysis of Covariance (ANCOVA) at 0.05 level of significance was used to compare the academic performance in Science of Grade-10 learners taught with multiple game-based strategies and those who were taught with the usual way of teaching.

RESULTS AND DISCUSSION

Academic Performance of the Control Group and Experimental Group

To determine the learners' academic performance in the control and experimental group, means and standard deviations of the pretest and posttest were compared and analyzed. The academic performance was measured following the DepEd order no. 8, s. 2015 and categorized as Outstanding, Very Satisfactory, Satisfactory, Fairly Satisfactory, and Did Not Meet Expectations. Table 1 presents the means and standard deviations of the pretest and posttest of Grade 10 learners taught with multiple game-based strategies, and those learners taught

Score Range	Equivalent Numerical Value	Level of proficiency	Qualifying Statements
28-30	90% and above	Outstanding	Exceeds the core requirements in terms of knowledge, skills and understanding in Science and can transfer them automatically and flexibly through authentic task
25-27	85%-89%	Very Satisfactory	Develop the fundamental knowledge, skills and understanding in Science and can transfer them automatically and flexibly through authentic task.
22-24	80%-84%	Satisfactory	Develop the fundamental knowledge, skills and understanding in Science with little guidance from the teacher and or with some assistance from peers, can transfer these understanding through authentic performance task.
19-21	75%-79%	Fairly Satisfactory	Possess the minimum knowledge, skills and core understanding in Science but needs help throughout the performance of authentic task
0-18	74% and below	Did not Meet expectation	Struggles with understanding; prerequisite and fundamental knowledge and or skills in Science have not been acquired or developed adequately to aid understanding.

Scale	Range	Response	Qualifying Statement
4	3.25 - 4.00	Always	Learners have high engagement in Science
3	2.50 - 3.24	Usually	Learners have an average engagement in Science
2	1.75 - 2.49	Sometimes	Learners have low engagement in Science
1	1.00 - 1.74	Never	Learners have no engagement in Science

Table 1. Pretest and Posttest of the Learners Academic Performance in Science

Groups	Pretest				Posttest		
	N	\bar{x}	SD	Performance Level	\bar{x}	3.451	Performance Level
Control	30	12.433	3.626	Did not meet expectations	17.867	3.451	Did not Meet expectations
Experimental	30	13.167	2.506	Did not Meet expectations	20.167	2.829	Fairly Satisfactory

using the usual teaching method.

Table 1 shows both pretest and posttest of the control and experimental group in Science, particularly topics in Biology, central dogma: replication, transcription, translation, and mutations. The control and experimental groups were in Did Not Meet Expectations level, based on the academic descriptions set by the Department of Education.

Pretest mean scores for both the control and experimental group showed that the learners' struggles with understanding the selected topics in Science. The pretest mean scores also indicate that the prerequisite and fundamental knowledge and or skills in Science have not been acquired or developed adequately to aid understanding.

Rogayan Jr. (2019) gauged the effect of the Biology Learning Station Strategy (BLISS) on junior high school student's academic achievement and attitude in Central Luzon. Similar to the present study, this action research utilized a within-group pretest-posttest experimental design involving 28 Grade 10 Science students. The results show that learners' Science achievement and their attitude towards learning Biology had improved. The researcher also found that there was a positive relationship between learners' achievement and attitude toward Biology.

Engagement in Science of Grade 10 Learners

This study examined the engagement of learners in Science when taught using Multiple Game-Based Strategies and when taught using the usual teaching strategies. To determine the engagement of the learners in Science, both the experimental and control groups, pretest and posttest mean, and standard deviations of the engagement scale were obtained, analyzed, and compared.

Table 2 presents the overall engagement in Science of Grade 10 Learners in the two groups before and after the conduct of the study. Results indicate that before the conduct of the study, the control group and experimental groups had an average engagement in Science based on the mean of the pretest scale. The standard deviation in the pretest in both groups show that the answers of the learners from the experimental group were more dispersed

compared with the control group.

The posttest mean results revealed that after the conduct of the study, the engagement of both groups was still on the average engagement level. However, the posttests mean of learners' responses was high in the experimental group compared to the control group. It could be inferred that with the use of multiple game-based strategies, there is an increase in the learners' engagement in Science better than the increase made in the control group.

The result of the study supports the findings of Liu and Chen (2013) that using games could increase students' motivation and interest to learn in a regular class. Nahmod (2017) emphasized that the use of technology in the classroom makes learning more easily accessible, creative, and fun. Zarzycka-Piskorz (2016) postulated that when learning incorporates any form of gamification, the learning process becomes more engaging as intrinsic motivation is induced.

Jones et al. (2015) conducted a study to contribute to the current theories of gamification and its ability to assist with the learning experience. Results indicate that the game was an excellent way to engage people with physics. The findings indicate that gamification is a valuable educational tool. The study conducted by Pesare et al. (2016) also supports the present study that games enhance student motivation, which means improvement and knowledge acquisition of the participants. Smart Learning Environment was utilized in this study.

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Table 2. Learners Over-all Engagement in Science

Engagement	Control Group						Experimental Group					
	Pretest			Posttest			Pretest			Posttest		
	X	SD	QD	X	SD	QD	X	SD	QD	X	SD	QD
Cognitive	2.37	.056	S	2.46	0.38	S	2.51	0.33	U	2.92	0.17	U
Behavioral	2.88	0.33	U	2.88	0.33	U	2.75	0.34	U	3.05	0.19	U
Affective	2.93	0.47	U	3.02	0.46	U	2.79	0.30	U	3.21	0.27	U
Overall Engagement	2.73	0.28	S	2.79	0.39	U	2.68	0.32	U	3.06	0.21	U

Table 3. Pretest and Posttest Scores of Cognitive Engagement of Learners

Items	Control Group						Experimental Group					
	Pretest			Posttest			Pretest			Posttest		
	X	SD	QD	X	SD	QD	X	SD	QD	X	SD	QD
1. I am looking forward to learn more in Science.	2.37	0.56	S	2.87	0.78	U	2.73	0.69	U	3.00	0.53	U
2. I read my Science book in advance to be ready in our class.	2.07	0.64	S	2.17	0.46	S	2.13	0.68	S	2.80	0.67	S
3. I devote my time to practice solving Science problems after school.	1.87	0.68	S	2.03	0.56	S	2.20	0.55	S	2.70	0.70	U
4. I am thinking a lot in Science class	2.33	0.76	S	2.33	0.61	S	2.50	0.51	U	2.90	0.61	U
5. In my free time, I spend time to look for more information on topics discussed in Science class.	1.93	0.58	S	2.00	0.53	S	2.30	0.75	S	2.77	0.68	U
6. Whenever I am absent in class, I am asking my classmates to help me understand my missed Science lesson.	2.23	1.01	S	2.70	0.88	U	2.77	0.97	U	3.10	0.71	U
7. I recognize the value of learning in our Science class.	2.40	0.56	S	2.87	0.68	U	2.77	0.73	U	3.00	0.64	U
8. I am investing time and efforts to learn a lot in our Science lessons.	2.37	0.62	S	2.67	0.55	U	2.63	0.72	U	2.80	0.61	U
9. I have to stay late at night to study our lessons in Science.	1.93	0.69	U	2.0	0.41	S	2.03	0.72	S	2.87	0.73	U
10. I am trying to learn as much as I could in our Science class.	2.53	0.73	S	2.90	0.76	U	3.03	0.77	U	3.32	0.68	U
Subtotal	2.37	.056	S	2.46	0.38	S	2.51	0.33	U	2.92	0.17	U

Legend: A= Always, U= Usually, S= Sometimes, N= Never

in the classroom makes learning more easily accessible, creative, and fun. Zarzycka-Piskorz (2016) postulated that when learning incorporates any form of gamification, the learning process becomes more engaging as intrinsic motivation is induced.

Jones et al. (2015) conducted a study to contribute to the current theories of gamification and its ability to assist with the learning experience. Results indicate that the game was an excellent way to engage people

with physics. The findings indicate that gamification is a valuable educational tool. The study conducted by Pesare et al. (2016) also supports the present study that games enhance student motivation, which means improvement and knowledge acquisition of the participants. Smart Learning Environment was utilized in this study.

Table 3 presents the learners' cognitive engagement in Biology between the control and experimental groups. Pretest responses indicate that the control group had low

cognitive engagement while the experimental group had an average engagement in Science before the conduct of the study.

In the cognitive dimension, more significant improvements were contributed by the use of multiple game-based strategies as compared to the use of the usual way of teaching. The relevant improvements were attributed to the teaching strategies employed. The utilization of online and offline games and downloadable mobile applications gave more notable results than the regular traditional lecture-based strategy.

Table 4 shows the behavioral engagement in the Science of the learners. The pretest and posttest mean responses of the experimental and the control groups were presented. Results revealed that before the conduct of the study, both groups had an average behavioral engagement. After the conduct of the study, the two groups remain at the average behavioral engagement level. However, the use of multiple game-based strategies had a higher increase compared to the use of the usual way of teaching. The standard deviations in the pretest and

posttest of the control group have very minimal changes.

Table 5 presents the affective engagement in the Science of the learners in the control and experimental groups. Both group's pretest and posttest results were on the average affective engagement level. The control group's responses were more widely dispersed compared to that of the experimental group. In the level of enjoyment in the activities in the class in item number nine (9), the experimental group posttest shows that the learners enjoyed the activities with the use of multiple game-based strategies. Moreover, the use of the said strategy had helped the learners to improve their affective engagement in Biology. The level was in average, but with the proper implementation, it would reach the highest level of affective engagement.

The results support the previous research conducted by Von Gillern & Alaswad (2016) that examines digital and non-digital games as useful mechanisms for promoting student engagement and learning. They argue that games can stimulate motivation, engagement, and learning.

Table 4. Pretest and Posttest Scores of Behavioral Engagement of Learners

Items	Control Group						Experimental Group					
	Pretest			Posttest			Pretest			Posttest		
	X	SD	QD	X	SD	QD	X	SD	QD	X	SD	QD
1. I am listening to the teacher's discussion during Science class.	3.23	0.77	U	3.33	0.71	A	3.47	0.63	A	3.37	0.56	A
2. I am doing the seat-works given by the Science teachers in class.	3.27	0.87	A	3.10	0.89	U	3.00	0.70	U	3.20	0.66	U
3. I am standing and answering my teacher's questions when called in Science class.	2.57	0.94	U	2.50	0.90	U	2.57	0.57	U	2.83	0.65	U
4. I am raising my hands whenever I know the answer.	2.70	0.88	U	2.80	0.89	U	2.67	0.84	U	3.10	0.66	U
5. I am doing my assignment in Science.	3.27	0.87	A	3.33	0.76	A	2.77	0.63	U	3.17	0.70	U
6. I am raising my hands and ask questions whenever I have queries about the lesson presented in our Science class.	2.30	0.60	S	2.30	0.65	S	2.17	0.70	S	2.83	0.54	U
7. I am actively participating in the different activities in our Science class.	2.60	0.68	U	2.90	0.80	U	2.57	0.77	U	2.87	0.63	U
8. I am studying my lesson at home whenever there are tests in Science.	2.87	0.90	U	2.80	0.76	U	2.63	0.62	U	2.90	0.71	U
9. I am writing down notes in my Science class.	3.03	0.85	U	2.90	0.92	U	2.80	0.89	U	3.03	0.72	U
10. I am doing my Science projects creatively and submit it on time.	2.97	0.77	U	2.87	0.82	U	2.83	0.79	U	3.23	0.73	U
Subtotal	2.88	0.33	U	2.88	0.33	U	2.75	0.34	U	3.05	0.19	U

Legend: A= Always, U= Usually, S= Sometimes, N= Never

Table 5. Pretest and Posttest Scores of Affective Engagement of Learners

Items	Control Group						Experimental Group					
	Pretest			Posttest			Pretest			Posttest		
	X	SD	QD	X	SD	QD	X	SD	QD	X	SD	QD
1. I like the feeling when I am solving problem.	2.33	0.66	S	2.50	0.73	U	2.53	0.63	U	3.03	0.56	U
2. I am helping my classmates in solving problems whenever they have difficulties	2.20	0.71	S	2.23	0.43	S	2.23	0.68	S	2.87	0.68	U
3. I am sharing my ideas and notes to my classmates in Science.	2.47	0.78	S	2.70	0.75	U	2.53	0.68	U	2.93	0.79	U
4. I am trying my best not to be absent in Science class	3.40	0.77	A	3.40	0.77	A	2.80	0.66	U	3.47	0.63	A
5. I am happy that my teacher in Science encourages me to be involved in class	3.33	0.84	A	3.40	0.86	A	3.10	0.55	U	3.30	0.54	A
6. I am glad that my classmates are willing to help me in answering Science problem.	3.07	0.83	U	3.17	0.75	U	2.80	0.61	U	3.00	0.74	U
7. I like the way my Science teacher delivers the lesson in class.	3.23	0.90	U	3.40	0.81	A	3.13	0.57	U	3.53	0.51	A
8. My Science teacher tries her best for me to learn.	3.50	0.78	A	3.57	0.73	A	3.13	0.51	U	3.63	0.49	A
9. I enjoyed the activities in our class.	3.03	0.96	U	3.17	0.75	U	2.93	0.69	U	3.30	0.54	A
10. I am not bored in our Science class.	2.70	0.99	U	2.67	0.80	U	2.67	0.61	U	3.03	0.81	U
Subtotal	2.93	0.47	U	3.02	0.46	U	2.79	0.30	U	3.21	0.27	U

Legend: A= Always, U= Usually, S= Sometimes, N= Never

Test of Significant Difference in the Academic performance Between the Experimental and Control Group.

The study examined the engagement of learners in Science when taught using multiple game-based strategies and when taught using the usual way of teaching. To determine the learners' engagement in Science of the control and experimental groups the pretest and posttest mean, and standard deviations of the engagement scale were obtained, compared, and analyzed.

The results show that there is a statistically significant difference in academic achievement between the control group and the experimental group in favor of the experimental group. The difference must have resulted from the use of multiple game-based strategies.

The study of Francisco-Catle (2018) pointed out the positive effects of computer-based educational games on students' achievement in science. Thus, the researcher investigated the effects of computer-based games in gauging learners in science. The study resulted that there is a significant difference in the learners' achievement in Science after the treatment. The researcher recommends integrating technology in the form of computer-based

educational games in teaching Science. It was also suggested to utilize other computer-based online games on other platforms such as mobile phones.

CONCLUSION

Based on the findings of the study, the following conclusions were formulated:

There was a significant difference between the academic performance pretest and posttest; therefore, the use of multiple game-based strategies in teaching improves the performance of learners on their Science subject. The use of multiple game-based strategies has enhanced the learners' engagement, especially the learners' cognitive engagement, to learn more about the subject. There is a significant relationship between the academic performance of the learners between the control and the experimental group; therefore, the use of multiple game-based strategies can enhance the learners' academic performance.

RECOMMENDATION

Based on the findings, the following are

Table 6. One - Way ANCOVA to compare the Learners Academic Performance between the Control Group and the Experimental Group

Source of variation	Sum of Squares	DF	Mean Square	F-ratio	p-value
Covariates	201.41	1	201.411	30.50	0.000
Main Effects	51.25	1	51.249	7.76	0.007
Error	376.22	57	6.600		
Lack-of-Fit	147.89	20	7.394	1.20	0.309
Pure Error	228.33	37	6.171		
Total	656.98	59			

recommended:

The lessons used in this study may also be replicated to other schools, districts, or divisions since it improves the learners' engagement and academic performance. Science teachers may use instructional strategies utilizing multiple game-based strategies. Given the results, the lowest items in the cognitive, behavioral, and affective engagement scale and academic performance test may be improved and recommended to give more emphasis on further research. Teachers may consider the use of multiple game-based strategies for remediation.

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