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## Contents

# NIETZSCHEAN MORALITY IN THE PHILIPPINES:
# FANATICISM AMONG FILIPINO CATHOLIC VOTERS IN THE 2022 ELECTIONS

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## ABSTRACT

Fanaticism occurs in activities like religion, mass media, and politics. Mass Media used during elections spread promises across voters providing them idealistic viewpoints that develops into Fanaticism through unity and uniformity. Filipino Catholics are among these voters who use their morality, participating in sociopolitical activities for the goal of social change. This study examines Fanaticism and its influences on the voting behavior and Catholic Social Teachings of Filipino Catholics living in NCR during the 2022 Elections. Literature review provided the perspectives, media influences and the Philippine context of Fanaticism. With Nietzschean Morality and Catholic Social Teachings, a narrative inquiry with discourse analysis was utilized to gain an in-depth understanding of Fanaticism among Filipino Catholic voters. Results presented Fanaticism existing among Filipino Catholics as illuminated by Nietzschean Morality of ressentiment, impacting their Catholic Social Teachings. Despite Fanaticism's effects, Catholic Social Teachings promoted democratic principles aiming for the universal common good.

*Keywords:* Friedrich Nietzsche, Master and Slave Morality, Fanaticism, Catholics Social Teachings, Mass Media

## INTRODUCTION

Fanaticism is a complex behavioral trait that manifests in activities ranging from moderate to violent forms (Marimaa, 2011). Appearing also in Mass Media activities, fanatics use the institution to manipulate information to achieve their goals and harm their victims. In Philippine elections, aspiring politicians utilize media platforms to present their advocacies and programs to voters (Kusaka, 2017; Sinpeng et al., 2020). Juliano (2017) states that these promises have instilled a sense of liberty, development, and egalitarianism among Filipinos as this assures them of a better life without concrete measures to address the country's pressing issues. This develops an "Us versus Them" mentality as political elites push their narratives while attacking opponents (Yusingco, 2021). Voters transform into fanatics as idealist promises and dualistic viewpoints influence their behavior into becoming prejudiced.

This partisan leadership of the Political elites enables them to exercise their Master morality to channel the Slave morality of their supporters toward their opponents (Ciulla, 2020). This parallels Nietzschean Morality as voters become biased toward their candidates and hostile to critics. Among these are Filipino Catholics living in the National Capital Region [NCR] who use their sociopolitical behaviors based on the morality and doctrines of the Roman Catholic Church (Kusaka, 2017). The Philippine Church community uses these in advocating their Catholic Social Teachings [CSTs] to tackle the sociopolitical challenges of the country (Burkhardt & Ferrer, 2011; Maboloc, 2018). Ballano (2019) states that these enable Filipino Catholics to participate in the country's issues to achieve its goal of building a peaceful and just humane society. With Fanaticism influencing the voting behavior and moralities of individuals (Dewi & Aminulloh, 2016; Marimaa, 2011), this study aims to examine the voting behavior and identify the impacts of Fanaticism on the CSTs of Filipino Catholics residing in NCR during the 2022 Elections. In achieving this, Nietzschean Morality would have to be illuminated by analyzing their voting behavior. Correspondingly, this study also aims to present the relevance of Fanaticism in the pursuit of building a peaceful and just humane society. With these objectives, this study seeks to present the goal of Filipinos that best reflects the 1987 Constitution. This idea of a peaceful and just humane society Filipino Catholics desire could be from their CSTs or fanatical attitudes; thus, developing the one united nation we wish to achieve.

### Literature Review

#### Perspectives of Fanaticism

Marimaa (2011) identifies three perspectives of Fanaticism: (1) it is a universal phenomenon found in all human activities, (2) despite the negativity, it can be beneficial or detrimental, depending on the reasons expressed, and (3) it is largely a behavioral characteristic that can manifest into action. Milgram (1977) states that a fanatic is someone who takes their views, feelings, and behaviors to extremes, but this emotional fervor does not have to be negative as it can be expressed positively through enthusiastic expressions such as passionate involvement, unwavering dedication, and profound religiosity. Despite these distinctions, it still presents the staunch problem of being devoted entirely to one's beliefs. Perkinson (2002) explains that its fundamental problem is that it rejects human progress, whereas instead of improving their qualities, fanatics dogmatically glorify it, disguise their shortcomings, and seek to force it on others resulting in universal unity but no development. This resonates with seeing the world under a Manichean dichotomy, with their beliefs residing in righteousness while others who exist beyond theirs are wicked (Calhoun, 2004; Marimaa, 2011).

#### Fanaticism in Mass Media

Mass Media is vulnerable to Fanaticism as it can be used as a destructive medium through misinformation, fake news, and propaganda. According to Dewi and Aminulloh (2016), Mass Media outlets that perpetually expose misleading or harmful ideas of religion or politics could strengthen the convictions of individuals which influences their behavior

to instigate fear and hate among others. Fanatical influences can set indifferences between groups in society especially if the information serves an agenda to disseminate conflict. Despite this concern, Mass Media still aligns with a positive impact as it promotes enlightening facts and information (Mehraj et al., 2014). The benefits outweigh its costs, but the vulnerability poses a problem for society because information can be qualified as education or disguised as propaganda.

**Philippine Elections and Fanaticism**

In the Philippines, elections are important for political elites as they legitimize their perpetual rule in the country; hence, Mass Media outlets are used to acquire constitutive votes (Teehankee, 2002). According to Kusaka (2017), political elites use moral politics to plead with the Filipino masses and elites; particularly, the usage of pro-poor or pro-reform narratives during elections. Thompson (2010) described these two competing narratives, where Reformists advocate good governance and Populists represent the masses; thus, political elites utilize these moral narratives in attracting voters through media-based appeals. Mass Media becomes a political tool during elections as aspiring politicians use it to manipulate information to serve their self-interests. Moral politics used during campaigns has split the electoral landscape, resulting in "Poor versus Elites" dichotomies resembling the Manichean dualism of "Good versus Evil". This creates unity and uniformity within the factional groups of candidates and their supporters as idealist campaigns by political elites forged the development of Fanaticism.

**Theoretical Framework**

This study would focus on Fanaticism illuminated by Nietzschean Morality–Master and Slave Morality, in analyzing the voting behavior of Filipino Catholics living in NCR during the 2022 Elections. From Warren (1985), Nietzsche relates the Masters' "good" moralities to Aristocratic values, while their "bad" moralities were associated with weakness and indigence describing the Slaves. Masters differed from the Slaves who perceived Aristocratic values as an "evil" morality while asserting their suffering as the "good" morality. Despite Master morality standing as a moral offense, Slave morality also equalizes as a danger as someone can organize and control the people based on their self-interests. Nietzsche describes this characteristic of Slave morality as Herd Mentality where a herd would need a "shepherd" who would lead its flock; thus, he fears that man would someday be the perfect "herd-animal" as they are organized, controlled, corrupted, and indoctrinated by their "shepherds" (Deleuze, 2005; Siemens, 2006).

An important characteristic of Slave morality is ressentiment, which is the emotional power of the oppressed against an oppressing power. Brought by frustration and hatred from the oppressing power where, because of their inferiority, this pushes their consciousness to pursue revenge (Deleuze, 2005; Kain, 1996). Nietzsche says that control and organization of ressentiment would encourage Fanaticism to propagate as this develops the idea of "grand politics" where the masses are united in a mighty tide of ressentiment (Ansell-Pearson, 2018). With the ressentiment of the herd, power unites people to overthrow the established order, creating a uniform thought to which Nietzsche saw this as a danger to society because they disallow any growth to emerge as people are satisfied to remain stagnated in their dogmatic worlds (Lemm, 2009).

Incorporated in this study are the Catholic Social Teachings [CSTs] of Filipino Catholics as it is inseparable from their sociopolitical behaviors. The Church developed CSTs around Catholic morality which aspires to contribute to the formation of a peaceful and just humane society by promoting concepts related to the universal common good (Ballano, 2019; Cahill, 2021). The Philippine Catholic community utilizes CSTs by analyzing and acting against the sociopolitical challenges of the country

(Tolosa, 2011). Through democratization, they practice Catholic Activism which empowers them to participate in sociopolitical issues to commit to its aim of promoting justice, good government, the rule of law, and solidarity in becoming the "Church of the Poor" (Cahill, 2021; Cornelio, 2014; Moreno, 2008).

Through this, a framework presented in the Paradigm below as Figure 1 illustrates how Nietzschean Morality occurs as a relationship between Political elites and Filipino Catholics. Supporters exposed to Mass Media outlets during elections become fanatical to their candidates and these political elites utilize their ressentiment in corrupting their supporters' morality influencing their voting behavior. Nietzschean Morality, between Political elites and Filipino Catholics, affects their morality and CSTs which influences their voting behavior.

With this, Filipino Catholics vote during elections in pursuit of social change through the idea of building a peaceful and just humane society. However, this does not entirely equate to positivity or negativity as this needs to be examined and analyzed to evaluate whether Fanaticism has relevance for Filipino Catholics in their pursuit of social change in the 2022 Elections. These contexts of Nietzschean Morality and its impact on the Catholic Social Teachings of Filipino Catholics are presented in the Paradigm below as represented by Figure 1.
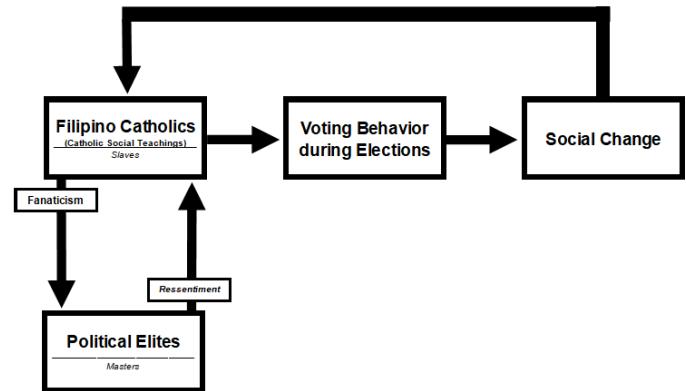


**Figure 1. The Paradigm of the Study**

## METHODOLOGY

This study employed a narrative inquiry research design as the experiences and stories of the participants are summarized in narrative chronological order (Creswell & Creswell, 2017). Data was collected through Focus Group Discussions [FGDs] and Key Informant Interviews [KIIs] to further strengthen this study. FGD was utilized as this allowed the researcher to compare and differentiate the perspectives of individuals chosen and gathered as a group (Wildemuth, 2009). In contrast, KII was used to enable the researcher to have in-depth discussions with experts in a specialized field related to the study (Taylor & Blake, 2015).

Filipino Catholic voters of the 2022 Elections living in NCR were chosen as the participants of this study as they exercise their Catholic morality in sociopolitical activities. According to the NCR Statistical Tables of the Philippine Statistical Authority's [PSA] 2015 Census (PSA, 2017), NCR is the second most Roman Catholic-associated region based on its latest religious affiliation data. Purposive sampling was employed as this incorporates specific criteria and common experiences met by the chosen participants (Padilla-Díaz, 2015); hence, a criterion was created where the participants of the study must be (1) a Catholic, (2) a registered voter during the 2022 Elections, and (3) a person living within NCR. With this, 17 individuals that met this criterion were purposively collected for the

FGDs and these were divided into two groups. Below are two tables of the informant profiles of both FGDs.

### Table 1. FGD 1 - Profile of Informants

| Participant Code | Profession/Educational Attainment |
| --- | --- |
| FGD1(I-1) | Businessman |
| FGD1(I-2) | Businessman |
| FGD1(I-3) | Government Employee |
| FGD1(I-4) | Urban Poor Member |
| FGD1(I-5) | Retired |
| FGD1(I-6) | Virtual Assistant |
| FGD1(I-7) | College Student |
| FGD1(I-8) | College Student |
| FGD1(I-9) | College Student |

### Table 2. FGD 2 - Profile of Informants

| Participant Code | Profession/Educational Attainment |
| --- | --- |
| FGD2(I-1) | Nun |
| FGD2(I-2) | Nun |
| FGD2(I-3) | Nun |
| FGD2(I-4) | Nun |
| FGD2(I-5) | Nun |
| FGD2(I-6) | Nun |
| FGD2(I-7) | Businessman |
| FGD2(I-8) | SHS teacher |

In Key Informant Interviews, 5 participants of the same criterion were interviewed, and they were purposively selected based on their expertise concerning the study. The Seminarian, Sociologist, and Social Psychologist were interviewed individually while both the Public Administration and Philosophy Professors were interviewed as a small group. Below is a table of the profile of the Key Informants.

### Table 3. Key Informant Profiles

| Participant Code | Profession/Educational Attainment |
| --- | --- |
| KII(I-1) | Seminarian |
| KII(I-2) | Sociologist |
| KII(I-3) | Social Psychologist |
| KII(I-4) | Public Administration Professor |
| KII(I-5) | Philosophy Professor |

Participants were interviewed with 12 questions about voting preferences, moral foundations, and fanatical behaviors. Interviews were done over Messenger, Google Meet, and Zoom wherein before the interview, the questionnaire included requirements from Republic Act 10173: Data Privacy Act of 2012. This included a consent agreement stating the purpose and explaining the goal of the study to which all information gathered was used only for this study. Data collected from both FGDs and KII participants were analyzed using discourse analysis to which examined their dialogue and its contexts. According to Dunmire (2012), this aims to understand how language was used in affecting people such as building trust, invoking emotions, and creating doubt. These results were then presented in a summarized narrative chronological order from the in-depth analysis and comprehension of the participants' experiences regarding Fanaticism and its effects on their Catholic Social Teachings supported by related literature reviewed.

## FINDINGS AND DISCUSSION

### Voting Behavior of Filipinos

Last May 9, 2022, Filipinos voted for leaders who would manage the future of the nation. Of the 22 interviewed, 20 informants answered they voted during the 2022 Elections. In elections, the vote of the people is also their representation of the society they want to have as they select leaders that would govern them through the sociopolitical issues of the country. Voting behavior originates from multiple factors where two informants described voting as being motivated by personal views and interpersonal influences.

KII(I-3): "Research says there is a link between religious values and sociopolitical values of a party or person. If your religious values are strong, then that could be a reference to your political beliefs meaning you would align with these teachings."

FGD1(I-4): "Voting behavior for me was as a family. We talked about who we will vote and who has integrity among fellow Catholics. Like the principles implemented and studied by the Church, that's where we rely on the candidate we chose."

Voters see suffrage as a chance to change the country with the act being based on what they believe is for the "common good" (Brennan, 2020; Wolff, 1994). Personal values and beliefs shape people during electoral periods as research shows that this influences individuals when the political dimensions of a political party are made clear (Barnea & Schwartz, 1998). Although, voting is not only an individual choice but is also an influential extent of their social network (Lee et al., 2016). Bello and Rolfe's (2014) study support this as social interactions and interpersonal relationships shape the voting behavior of individuals.

Despite, personal choices and social pressures affecting an individual's preferences during elections, external factors also contribute. An aspiring politician's popularity and political machinery also influence voters during elections. Two informants stated that voting behavior arises not from the individual's conscience but from the popularity and political machinery of aspiring politicians.

FGD1(I-7): "Filipinos vote for who is famous. Those always shown on TV, and whose name is heard. I noticed that when I ask people questions; why did they vote for them, they say that it's because they feel nationalistic.

KII(I-5): "I used to think that people vote according to their conscience. But it turns out that I was wrong because you see news of vote buying. The true reality of voting came out, and it's because of money and influence."

David and Legara (2017) discuss that in the Philippines, candidate winnability is more personality-driven rather than platform driven. Political machinery fuels these campaigns since election-related anomalies are still prevalent in the Philippines (Teehankee, 2017). From here, aside from personal choices and social influences, external forces also dictate voters and the outcome of an election because of the power and influence of an aspiring politician. This pronounces that the voting behavior of Filipinos in the recent elections originated from multiple influences ranging from the personal to the external level.

### The Power of Mass Media

During the 2022 Elections, Filipino Catholics supported candidates through various forms of work where many exhibited fanatical traits. Of the 22 interviewed, it was clear that Fanaticism influenced Filipino Catholics during the elections with 16 informants agreeing to Mass Media was the reason. Mass Media outlets, composed of traditional and social media forms, were influential in directing the people during the elections. Agenda-setting by Mass Media outlets influences the choices of voters (Ridout & Mellen, 2007), as most people do not experience the campaigns personally. Social media has become a favorable tool as this has helped aspiring politicians shape their narratives to garner support during campaign periods (Tapsell, 2021). Despite this, social media is plagued

with fake news, misinformation, and propaganda as two informants expressed their experiences.

> FGD1(I-7): "We know that fake news is widespread on social media. The masses get news from social media because it's accessible, they then encounter fake news. This influences their preferences becoming a way for them to fanaticize over a politician."

> KII(I-2): "Media is a propaganda machine. You have to control the media for your plans to succeed. You think you will run without a propaganda machine? Nothing will happen to you, you will not be recognized or understood."

Aspiring politicians utilize social media to ruin the opposing candidate while bringing positivity only to their camp. Alike the 2016 Elections, trolls became the political machinery as they employed propaganda techniques to shift voters toward their political camp while attacking other contenders (Tapsell, 2021). This strategy has asserted voters toward selected candidates while discrediting others, polarizing the electoral landscape. Two informants described this as leading voters to become dogmatic as this campaign tool strengthened their convictions over their candidates creating conflict with others.

> FGD1(I-8): "My best friend and I had different candidates, I tried talking and educating her since TikTok was her source. But she ignored me and didn't help herself even with resources available for her to research to know right from wrong."

> KII(I-3): "Social media was a double-edged sword because of fanaticism. Others were fanatical, not because they don't like your candidate but because they don't like you as a supporter. When informed, we call it education otherwise, we call it propaganda."

People continuously exposed to certain information strengthen their convictions, developing them to be fanatical (Dewi & Aminulloh, 2016). Yusingco (2021) states that this attitude of promotion and suppression has created an "Us versus Them" mentality where discourse becomes "toxic". Rather than seeing it as education, fanatics see discourses that discredit their beliefs as propaganda. Social media then has become a tool to polarize elections as healthy debates about national issues become propaganda in promoting or insulting candidates. With the power and influence of Mass Media, voters from various political camps became fanatical toward their candidates, affecting their voting behavior as this was encouraged by the prevalence of fake news, misinformation, and propaganda.

**Nietzschean Morality During the Elections**
The 2022 Elections showed a polarized context of two major political camps led by former Vice President Robredo and President Marcos Jr. These camps influenced Filipino Catholics during the elections as they seek change following the challenges of past administrations. With this, of the 22 informants, 15 answered that they were emotional during the 2022 Elections which influenced their voting. Emotional fervor translated into action as voters of both camps campaigned against their opposition. This developed a uniform thought among both camps as voters herded themselves into crowds based on their collective emotions and actions. The following informants described this phenomenon which parallels the unity and uniformity characteristics of Fanaticism and Nietzschean Morality.

> FGD1(I-1): "Example is "Tatay" here. Based on the emotions he experienced during martial law, he based his vote today there because he doesn't want a repeat of what Marcos did to him. He still carries that emotion."

> KII(I-4): "A protest vote explained what happened during the 2016 elections. The "Dilawans" in power thought that they would last forever but in 2016 that was broken. Duterte was voted, and he enjoyed broad political support."

> KII(I-2): "Filipinos were unstable during the elections and when you are within a crowd, people don't think anymore. Both parties maintained their crowds while supporters didn't want to think about what their leader said because they just want to follow."

During the 2022 Elections, Filipino Catholics were emotional based on the polarized electoral environment which translated these into votes. This reflects Nietzsche's ressentiment where the people were emotional for or against their selected political party. Termed a "Mass emotion" (Ciulla, 2020), because of the context of preventing another Marcos-Duterte administration or a Liberal Party "Puppet", Filipino Catholics translated their emotional fervor into protest votes. According to Altomonte et al. (2019), a protest vote is an emotional collective action to take revenge against a political "opponent" who they see as responsible for the current situation of a nation. Supportive and dissatisfied voters campaigned and voted against the opposition to satisfy the beliefs developed by their political camps.

These collective emotions and actions united voters and developed them into a uniform thought which reflects Herd Mentality. Lemm (2009) describes this as an individual being "made" to commit continuously himself to the herd they joined. The formation of crowds enabled political elites to push their narratives into voters who subconsciously become fanatical for their political camps. Marimaa (2011) explains that a fanatic is a uniform individual drawn united into their group who believes dogmatically in their narratives as the absolute solution to society. Fanaticism based on Nietzschean Morality existed among the voters of both political camps as they maintained their crowds and emotions. Nietzschean Slave morality through Herd Mentality and ressentiment prevailed in the recent elections as both major parties acted as "shepherds" controlling their united flock into achieving their goals.

**Impacting Catholic Social Teachings**
Catholics are urged in keeping the spirit of democracy alive to prevent the rise of fanatical authoritarian regimes that would endanger "the Way, the Truth, and the Life" (Heaney, 2007). Juxtaposed is Fanaticism which develops an alienated society that aims to advance the self-interests of authoritarian individuals and regimes (Marimaa, 2011). This indifference endangers Filipino Catholics as fanatics manipulate moral values to fit their narratives. As shared by one informant, one impact of Fanaticism on CSTs is that it twists Catholic moral values to satisfy their sentiments.

> FGD2(I-4): "It is sad because there are those who are religious like my best friend, who used to invite me to religious gatherings but because of her beliefs about a certain candidate, her moral values became twisted."

Perkinson (2002) illustrates that fanatics are dogmatic, twisting their moral values to self-satisfy their convictions while insisting their beliefs are correct. Differing are CSTs calling for the truth as necessary for

promoting democratic ideals (Bretherton, 2016). Diverging both concepts, Fanaticism endangers the truth in democracies following CSTs as fanatics insist that their morals and beliefs are valid. One informant exemplified another impact of Fanaticism as the idea itself desecrates these Catholic principles.

> KII(I-5): "Fanaticism is inconsistent with our concept of Catholic Social Teachings because it talks about human dignity and the community. Fanaticism destroys the concept of Catholic Social Teachings because human dignity, human rights, and everything are respected."

Fanaticism goes against Catholic teachings of human dignity and life as fanatics neglect others for their selfishness. Marimaa (2011) states that fanatics see the world under a Manichean dualism of "Good versus Evil" with their views as righteous whilst seeing others as the wicked of society. This threatens democracies as they reject progress by discarding criticism and ideas for their opinions (Perkinson, 2002). In relation, two informants described Fanaticism as encouraging authoritarianism as dogmatism towards a politician neglecting checks and balances.

> FGD1(I-4): "Fanaticism doesn't help our country because we believe too much in one politician. If we are fanatical, no matter what wrong things he does, we are blinded that we don't question anymore because we are fanatical about that politician."

> KII(I-1): "Fanaticism kills the true essence of democracy. Democracy becomes the voice of God if it is the word of an enlightened conscience. However, Fanaticism allows injustices because it oppresses those who are powerless in society."

Fanaticism affects the voting preferences of people in choosing rightful leaders to govern society as blind beliefs, twisted morals, and zealous support deceive fanatics; thus, allowing injustices and oppression to occur in a democracy. Perkinson (2002) states that this allows authoritarianism to prevail as obscurant beliefs disallow openness to change. This makes Fanaticism an antithetical ideology to democracy as it rejects truth and compromises while seeking to install one sociopolitical order (Goldsmith, 2022). Therefore, a democratic society that follows CSTs neglects Fanaticism as it calls for respect for one's human dignity, placing importance on checks and balances.

## A Peaceful and Just Humane Society
In the preamble of the 1987 Constitution, Filipinos aim to build a peaceful and just humane society reflective of CSTs principles. Contrasting is Fanaticism which undermines these principles as the dogmatic self-interests of fanatics threaten democracy (Goldsmith, 2022). Despite this negative connotation, the idea of bringing unity and uniformity into a society that shares the same beliefs, culture, and identity could still develop a nation. However, juxtaposed to the narrowed ideals of Fanaticism, CSTs promote principles related to the common good in pursuit of building a peaceful and just humane society. Two informants contrasted these ideas describing the relevance of Fanaticism and CSTs to the nation.

> KII(I-5): "Fanaticism has a contribution to a nation as it's a shared belief, culture, and identity. But what kind of nation because if it doesn't develop into a better, progressive, and one nation for the common good then it's a problem."

> FGD2(I-3): "Let us remember as a Catholic that our doctrines proclaim that human life is sacred, and everyone is well respected. Hence, the Catholic Church is always focused on the common good for everybody and what makes it affects our society."

Despite rejecting societal progress, creating unity and uniformity through a noble agenda could prove beneficial to society. Being fanatically united and uniform about a noble agenda such as good governance, democracy, or the promotion of human rights could be of great use to the development of a nation (Marimaa, 2011; Perkinson, 2002); however, this disallows societal progress as openness to change and criticism is neglected. Opposed to Fanaticism, CSTs enable the people to participate in nation-building by partaking in the country's sociopolitical issues. The Catholic Activism of Filipino Catholics applies the principles of CSTs to fight corruption, injustices, oppression, and poverty (Cornelio, 2014; Moreno, 2008). The democratic process of active participation enables Filipino Catholics to achieve their goal of bringing the social change it wants in society. In building a peaceful and just humane society, the Philippine Catholic community requires a spiritual leader to act as a moral compass and educator, which has been stated by two informants.

> FGD2(I-6): "The role of the Church in politics is to stand as a guide despite the separation of Church and State. I believe the Church needs to act when it comes to morality."

> KII(I-1): "The Church should educate on how to choose morally competent candidates because I believe the Church can enlighten those confused Filipinos on voting based on moral compass, political track record, and integrity of life."

The Philippine Catholic Church is influential among the Filipino Catholic community by giving moral guidance and education in choosing better leaders that desire the common good of society. The Catholic Church aspires in becoming the "Church of the Poor" (Cornelio, 2014; Moreno, 2008), by following the principles of CSTs in its active participation in addressing the socioeconomic inequalities and injustices, as well as the political oppression and human rights violations. Catholic Activism aims to call for societal changes within the government and society as the Catholic Church and its community remain vigilant in issues plaguing Philippine society. With these objectives, the Catholic Church acts as an important spiritual and moral leader among the Filipino Catholic community in its pursuit of building a peaceful and just humane society.

## CONCLUSION

This study was able to satisfy its objectives as it illuminated Fanaticism within the voting behavior of Filipino Catholics through the utilization of Nietzschean Morality. This was found among its participants during the 2022 Elections through their collective emotions and actions. Fanaticism has also impacted the Catholic Social Teachings of Filipino Catholics by twisting moral values, their specified characteristics, and allowing the rise of authoritarianism in a democratic society. Moreover, the relevance of Fanaticism comes as an answer that it does not provide the needed social change Filipino Catholics seek as the idea of the common good is absent among fanatical attitudes.

As Nietzschean Morality was central in the study, the characteristics of Slave morality such as the ressentiment and Herd Mentality was present among Filipino Catholic voters in the 2022 Elections. This Nietzschean philosophy illuminated Fanaticism among its participants, illustrating that

collective emotions and actions equate to attitudes of unity and uniformity vital in the formation of Fanaticism. With this, it exhibited that the democratic principles that the Catholic doctrines of Filipino Catholics promote are vital in our building of a peaceful and just humane society in the Philippines. Catholic Social Teachings are indispensable moral and educational doctrines in opposing authoritarian attitudes that Fanaticism pressures on society.

In a democratic nation such as the Philippines, the idea of building a peaceful and just humane society that reflects the preamble and principles of the 1987 Constitution relies on the kind of social change desired by Filipinos. This idea could draw itself from the democratic ideals and morals of Catholic Social Teachings to which the principles of openness, justice, peace, and freedom can be found. Alternatively, Philippine society could also adhere to Fanaticism and its authoritarian attitudes of unity and uniformity to create the one united nation that everyone also wishes to obtain. Regardless of the ideologies of democracy and authoritarianism, the goal of a peaceful and just humane society will be achieved when the Filipino people discern the fundamental aims of the nation.

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# OSHI (OREO-SUSHI)

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## ABSTRACT

The rise in health-conscious consumers post-pandemic highlights the demand for healthier food options, challenging the conventional perception of products, specifically Oreos, as unhealthy. Addressing this, the proposed business, "Oshi," aims to transform such products into healthier alternatives. Utilizing locally sourced ingredients such as fresh ground oats from Ifugao, Matcha from Catanduanes, and Milk from Nueva Ecija, Oshi seeks to offer a locally inspired, healthier dessert option. Research from the Department of Health (DOH) suggests blending sweets with nutritious ingredients to appeal to health-conscious individuals. Market research, including online surveys and direct interviews, was conducted to gauge demand and calculate market potential. Financial analysis indicates a promising 3-year business plan, projecting high returns on investment. Furthermore, Oshi aims to support the Philippine economy by sourcing from and supporting local farmers.

*Keywords*: Locally, Health-conscious, Business Plan, Market Research, Demand.

## INTRODUCTION

Health-conscious individuals have been developing and creating new product options that match their way of living (Food Industry Asia, 2021). In 2022, numerous businesses capitalized on the post-pandemic landscape to introduce new products. This trend was driven by shifts in consumer behavior and market demands, spurred by the global health crisis. Research shows that consumer-goods companies, including those in the food industry, paused many new product launches during the peak of the pandemic to focus on ensuring the availability of essential items (Bradley, Kohli et al., 2022). However, as the world began to recover, there was a significant uptick in new product launches to meet emerging consumer needs and preferences. For instance, McKinsey reported that new product introductions surged as companies sought to address untapped market demand and adapt to the evolving preferences of health-conscious consumers (McKinsey et al, 2022).

The firm has the opportunity to focus mainly on transforming the popular sweet brand Oreo into a healthy dessert product and integrating it with renowned Japanese gourmet food. Operating in the food market requires creating a strong and unique selling offer (Mutabazi, 2022). The intrinsic distinctiveness of these cuisines, originating from their diverse culture, makes them a perfect match for Oshi. These new products often emphasized health and wellness, reflecting a broader trend towards healthier lifestyles that gained momentum during the pandemic. This context provides an excellent opportunity for transforming popular brands, like Oreo, into healthier dessert options, aligning with consumer interests in nutritious and enjoyable foods. The emphasis on sustainability and supporting local communities further enhances the appeal of such innovative products in today's market (Hermundsdottir, 2020).

People are pleased when individuals from other countries bring innovation to their cultural items. Researchers see this as a good opportunity to provide a "healthy" confectionery item that is nutritional and appropriate for Filipino customers. This study intends to provide a variety of nutritious sweet dessert options that meet consumer preferences and criteria for enjoyment, nutritional content, and sweetness. The company's goal is to offer a varied range of Oreo sushi that can achieve significant recognition in various international markets.

The items will include a variety of flavors such as Coffee, Matcha, Strawberry, and Milk. The product will be enhanced by adding various toppings like Matcha powder, Cocoa Powder, and Strawberry powder, each providing unique flavors. All ingredients will be obtained from local sources to support the socio-economic growth of rural communities in the Philippines. The business will use a compact bento box that can be recycled, in addition to sustainable packaging techniques, to support environmental sustainability. The contribution of this study extends beyond mere product innovation; it highlights the positive impact on local communities by promoting sustainable agricultural practices and providing economic support to rural areas, thereby fostering a more inclusive and sustainable growth model for society.

### Name of the Company: "OSHI"

The proprietors of the business selected the name "Oshi" to align with their product name "Oreo-Sushi". The decision was made by the proprietors to incorporate and emphasize the letter "O" in the brand name as a representation of the primary ingredient, Oreo. Furthermore, the inclusion of the term "Shi" serves to communicate the concept that the product is created in the form of sushi. The chosen name also serves as a tribute to the proprietors' Filipino cultural background. "Oshi" is a colloquial term in the Filipino language denoting astonishment or admiration. Additionally, "Oshi" comes from the Japanese word "Oishi" which means delicious.



**Figure 1. Oshi Logo**

The tagline of the business is "MapapaOSHI ka sa sarap!". The company's tagline, "Mapapaoshi ka sa sarap," is written in Filipino and may be translated into English as "You'll be delighted with the taste," or "You'll experience delight due to the taste." The principal market of Oshi is located in the Philippines, where the official language is Filipino. Utilizing a Filipino tagline facilitates a profound connection between the company and its local audience, enhancing relatability and ensuring ease of comprehension for prospective buyers.

**Product Offering**
The Oshi product is intentionally designed to provide a nutritious and well-rounded assortment of innovative healthy dessert options. A sweet and healthful dessert is a delectable indulgence that satiates one's need for sweetness while simultaneously providing nourishment and promoting overall well-being. In contrast to conventional desserts, which can include high levels of sugar, harmful fats, and little nutritional value, healthy desserts are prepared utilizing nourishing components that provide substantial nutritional advantages (World Health Organization, 2023).



**Figure 2. Oshi Products**

Oshi's products are primarily composed of oats, coffee, matcha (green tea), strawberry, and milk. These ingredients are classified as "Halal" and can be consumed by any person. Based on research conducted by Future Market Insights, it has been projected that the market for healthy low-fat desserts is anticipated to see a compound annual growth rate (CAGR) of 6.1% over the forecast period spanning from 2021 to 2031 (Choudhury, 2023). The increased consumer interest in nutritious low-fat sweets, spanning many age groups including children and adults, has contributed to their widespread popularity in the market.

**Marketing Plan Highlights**
Oshi targets 18–35-year-old students, self-employed, and employed people. The first and subsequent administrative divisions of San Juan City in Metro Manila are of interest. Within its 4Ps, the company will use local SEO, social media advertising, influencer marketing, and others. The business is in San Juan City's Barangay San Perfecto. This location was chosen as the central hub for operations by unanimous agreement due to its proximity to the target market in San Juan City.

**Management Highlights**
The OSHI enterprise is managed by a group of four aspiring marketing experts, each of whom will contribute to the development of the "Oshi Oreo-Sushi" concept. They will assume complete accountability and ownership for optimizing corporate operations. The team is composed of individuals holding certain roles and responsibilities. These include a General Manager, Marketing Officer, Operations Officer, and Finance Officer. The company employs a "flat" organizational framework that is specifically tailored to suit startup enterprises, representing a contemporary strategy for mitigating communication barriers.

**Operations Highlights**
Oshi will conduct its business in Barangay San Perfecto, San Juan City, Metro Manila, Philippines. The Head Pastry Staff and Assistant Pastry Staff are the laborers. The company will operate 16 days per month, a total of 192 days in a year. The physical store and online store will operate from 8:00 AM to 5:00 PM.

**Financial Highlights**
The business is funded by four partners. The Capital investment will be 200,000.00 Pesos. The company will buy equipment, supplies, and other necessities with the allocated funds. The funds will also be used for marketing, promotions, employee salaries, and other purposes.

**Socio-Economic Contributions**
The proposed company venture is expected to make a significant contribution to economic development by generating new employment opportunities and fulfilling its financial obligations. These include tax payments and other government dues, at both the local and national levels.
1. **Customers.** The firm demonstrates its dedication to transparency by providing clients with information regarding the nutritional composition of the dessert.
2. **Public.** The business will engage in the recruitment of personnel from the local community, thereby providing the public with an opportunity to enhance their standard of living.
3. **Government.** The firm largely contributes to the government by fulfilling its tax obligations and paying different fees to regulatory organizations. Such are the Department of Trade and Industry (DTI), Bureau of Internal Revenue (BIR), Security Exchange Commission (SEC), local government entities including mayors and community representatives, as well as other relevant agencies.
4. **Researchers.** Oshi will persist in refining its business plan and enhance the quality of its content and underlying data points.

**Literature Review**
The Gross Domestic Product (GDP) is a metric used to quantify the total value of goods and services produced within a country's economy. It serves as an indicator of national income and output. The GDP represents the aggregate sum of expenditures on all ultimate goods and services generated domestically within a specified timeframe. The GDP of the Philippines amounted to 404.28 billion US dollars in the year 2022 (World Bank, 2022). The GDP of the Philippines accounts for approximately 0.18 percent of the global economy.

The increase in popularity can be ascribed to the incorporation of vegan, low-sugar, and gluten-free alternatives into conventional Asian cuisine by restaurants. This is in response to the growing interest in dietary choices that promote nutrition, particularly in the aftermath of the pandemic (Fanzo, 2023). In 2022, Asian cuisine dominated the market within the full-service restaurant (FSR) segment, capturing the largest market share of 42.92%. The demand for Japanese cuisine is substantial within the country (Mordini Intelligence, 2023).

Following Oshi, this study aims to analyze the dietary composition of the population, as well as the prevalent food items found in households, to establish a foundational understanding. The aforementioned cuisines are subsequently with Japanese cuisine to ascertain the commonalities and disparities between them. The perspectives of Filipinos regarding healthy desserts have transformed over time. It is driven by an increasing awareness and consciousness towards personal health and the significance of maintaining a well-rounded dietary regimen.

The Filipino population has exhibited a notable inclination towards indulging in sugary treats during the COVID-19 pandemic. It is evidenced by recent data indicating a persistent increase in their interest in chocolates, candies, and other confectioneries since the onset of the viral outbreak (Philstar, 2022). Many Filipinos, except for particular products, have global tastes and are quite receptive to foreign brands. As long as it is affordable, we tend to accept these labels because we think they are more fashionable and of greater quality.

Doing market research and determining your target market are the most important steps in starting a small dessert business. Consider variables such as age, gender, way of life, and location. Starting business must also comprehend the needs and behaviors of customers. It is important to identify your target market by researching the area, potential foot traffic areas, and places where dessert businesses currently operate (OVVI, 2023). Oshi has established its business in committing to providing high quality services to its desired location.

A significant number of individuals in the Philippines exhibit a strong affinity for fusion cuisine and innovative confections, rendering them

highly receptive to the concept of healthy dessert as an enjoyable and distinctive culinary indulgence (Pysk, 2018). Although Oreo-Sushi may fall under the category of traditional Japanese cuisine, the concept of transforming food into visually captivating and artistic presentations resonates with the principles of Japanese gastronomy (Zi, 2022).

## METHODOLOGY

### Research Design
A firm must possess a comprehensive understanding of its clients and consumers, as they are the fundamental lifelines of the company. Consumers' presence is crucial for generating revenue, making it essential to implement appropriate identification measures. These measures facilitate effective outreach efforts, enhance sales performance, and develop a strong brand presence.

Market surveys play a crucial role in enabling businesses, particularly startups, to gain a comprehensive understanding of their intended geographic target market, improve sales performance, and drive prospective company expansion (Netigate, 2021). According to a market survey conducted by entrepreneurs in San Juan City, the age group demonstrating the highest degree of involvement with the surveys falls within the range of 18 to 35 years old.

It is important to note that the Generation Z population spends a sizable percentage of their disposable income on food and beverages, as highlighted by Emily Moquin in her 2022 analysis of the food and beverage industry. Additionally, Generation Z shows a special enthusiasm for discovering new and interesting products. Oreo Sushi from Oshi Company may therefore be a perfect fit for this target market's tastes and spending patterns.

### Target Market

Table 1. Target Market of Oshi

| Oshi's Consumer/Customer Target Market | |
| --- | --- |
| **Target Market Indicators** | **Specified Target Market of OSHI (Oreo-Sushi)** |
| **Target Population** | Residents of San Juan City, Metro Manila, Republic of the Philippines. (1st district and 2nd District) |
| **Age** | The target age of OSHI is in the range of the ages 18-35 years old. |
| **Financial Capacity** | OSHI caters to a target market consisting of middle-class individuals, specifically those with a monthly income or allowance of at least 5,000 pesos or less. |
| **Buying Characteristics** | The primary target market consists of individuals who fall within the **Average Spenders** category and frequently make purchases of sweet, health-conscious desserts. |
| **Lifestyle** | The target market comprises individuals who prioritize their health and well-being, accounting for about (100%) of the total consumer base. |

Table 1 depicts the market segmentation of Oshi. The target market is the residents of San Juan City, aged 18-35 years old, male and female, allowance of 5,000 pesos or less, average spenders, and people who prioritize their health.

### Procedure
The researchers conducted a marketing survey to identify the target market and evaluate the acceptance of the product. The survey involved 100 respondents, who were selected from the population residing in San Juan City. To establish the target market and identify segmentation characteristics, the researchers used Slovin's formula to determine the appropriate sample size for the study. The estimated population of the target market in San Juan City, as of 2023, is 60,670 individuals aged 18-35 years. The survey was conducted with a margin of error of 10%.

### Instrument of the Study
The process involves asking a series of questions to understand consumer preferences, opinions, and behaviors regarding a product or service. The goal is to gather valuable data that can inform marketing strategies, product development, and overall business decision-making. Marketing surveys can be conducted using various methods, including online surveys, phone interviews, focus groups, or face-to-face interactions. These surveys are typically carried out to collect data that aids in making informed decisions about marketing, expansion, and product development (UpReports, 2022). For its survey, Oshi utilized both online platforms and physical locations

### Data Processing
The first stage of sales prediction involves conducting a market survey and analyzing demographic statistics. Additionally, sales data from competitors offering similar or identical products to those provided by Oshi are reviewed. This analysis helps identify demand, a crucial component of demand and supply analysis. According to Dayton (2020), the economic theory of "Supply and Demand" explains the dynamic interaction between resource suppliers and consumers.

As previously mentioned, Oshi has targeted San Juan City, specifically Districts 1 and 2, as the intended market. As of 2020, this area has a population of 126,347 individuals. The data used by the researchers was sourced from the official city population website, which draws from the databases of the Philippine Statistics Authority (PSA), the National Statistical Coordination Board (NSCB), and the San Juan City Mayor's office. According to census data from the PSA, this location has an annual growth rate of 0.71%.

## RESULTS AND DISCUSSIONS

### Demand and Supply Analysis
Demand and supply analysis is crucial for any business as it helps in understanding market dynamics, predicting future trends, and making informed decisions (Hall, 2020). By analyzing historical demand data from 2020 to 2022 and projecting demand for 2024 to 2026, businesses can identify patterns and fluctuations in consumer behavior. This allows companies to adjust their production, inventory, and pricing strategies accordingly. For instance, if demand is projected to increase, businesses can ramp up production to meet the anticipated need, ensuring they capitalize on potential sales opportunities (Kelwig, 2022). Reciprocally, if a decline in demand is expected, companies can reduce output to avoid excess inventory and associated costs.

Moreover, demand and supply analysis aids in resource allocation, budgeting, and financial planning. By accurately forecasting demand, businesses can allocate resources more efficiently, plan for future investments, and manage cash flow better. This forward-looking approach enables companies to remain competitive, respond to market changes, and better position themselves to meet customer needs (Boyles, 2022).

The population statistics for San Juan City in the years 2015 and 2020 were obtained from the Philippines Statistics Authority (PSA). According to the most recent population statistics, San Juan City has a growth rate of 0.71% in the year 2020. To ascertain the present population of San Juan City, the previous population was multiplied by the growth rate of 0.70%. This is as per the PSA National Census for the years 2015 and 2020. The following table presents the historical demand from 2020 to 2022 and a comprehensive projected demand for the period spanning 2024 to 2026.

Table 2 shows the total Potential demand of Oshi for the years 2024-2026. According to the Philippine Statistics Authority (2020), the population growth rate is projected to be 0.71 percent each year from 2020 to 2025. The targeted segmented population was gathered from the Philippine Statistics Authority (2020), the age bracket of 18-35 was

provided, and the segment was 47%. It shows the detailed computational breakdown of the total potential demand for 2022- 2024.

**Table 2. Potential Demand Schedule for the next 3 years (2024-2026)**

| Year | Total population | Segmented population | Acceptance rate (100%) | Total demand |
|------|------------------|----------------------|------------------------|--------------|
| 2024 | 129,973 | 61,087 | 100% | 61,087 |
| 2025 | 130,896 | 61,521 | 100% | 61,521 |
| 2026 | 131,825 | 61,958 | 100% | 61,958 |

Table 3 presents the anticipated supply projections of the competitors for the years 2024 to 2026, indicating growth rates of 0.38% for Big Scoop, 0.21% for Park n' Go, and 0.12% for Maxi Mango. To get the projected data for the years 2024 to 2026, the data from the year 2023 was multiplied by the growth rates corresponding to the aforementioned rivals. The total supply is determined by aggregating the annual competitor data spanning from 2022 to 2024.

**Table 3. Three Years Projected Supply**

| Year | Big Scoop | Park n' Go | Max Mango | TOTAL |
|------|-----------|------------|-----------|-------|
| Growth Rate | 0.38% | 0.21% | 0.12% | |
| 2024 | 1,831,301 | 1,309,504 | 691,337 | 3,832,142 |
| 2025 | 1,838, 260 | 1,312,254 | 692,166 | 3,842,680 |
| 2026 | 1,845,245 | 1,315,010 | 692,997 | 3,853,252 |

### Demand-Supply Gap Analysis

A projected demand-supply gap for the years 2024–2026 is displayed in Table 4, with corresponding values of 302,226 units, 321,061 units, and 340,006 units. With a steady 2% annual growth rate, the market share is predicted to increase from 10% in 2024 to 14% in 2026. An analysis of industry growth, market conditions, and marketing effectiveness determines a projected market share. The gap is multiplied by the projected market shares for each year to determine the cumulative predicted sales volume.

**Table 4. Three Years Projected Supply**

| Year | Potential Demand | Potential Supply | Demand and Supply Gap | Assumed Market Share | Total Projected Volume of Sales |
|------|------------------|------------------|-----------------------|----------------------|---------------------------------|
| 2024 | 4,134,368 | 3,832,142 | 302,226 | 10% | 30,223 |
| 2025 | 4,163,741 | 3,842,680 | 321,061 | 12% | 38,527 |
| 2026 | 4,193,318 | 3,853,252 | 340,066 | 14% | 47,609 |

Forecasting sales volume and revenue accurately requires a thorough understanding of supply and demand. Revenue forecasts show the state of the company by approximating expected earnings over a given period. Monthly sales volume predictions show seasonal trends. Small businesses first assess production or acquisition costs. Batch pricing and supply-demand analysis determine the total expected sales for each commodity every year. This subsection provides a more thorough explanation. Forecasted sales show either good or negative tendencies, giving information about overall financial health (Capital US, 2021).

### Projected Financial Statements

The sales projections for the years 2024 to 2026 are shown in Table 5. The predicted market share for the years 2024, 2025, and 2026 is expected to be 10%, 12%, and 14% respectively. These take into account the prevailing market circumstances. The total projected sales volume for the next three-year period amounts to 116,359 units. The predicted sales figures for the years 2024, 2025, and 2026 are 30,223 units, 38,527 units, and 47,609 units, respectively. The predicted sales figures for the years 2024, 2025, and 2026 are ₱2,266,727.00, ₱3,149,580.00, and 4,242,350.00 Pesos, respectively.

**Table 5. Projected Sales in Volume and in Pesos**

| Year | Demand & Supply gap | Market Share | Total Projected Sales in Volume (Yearly) | Total Projected Sales in Pesos (Yearly) | Total Projected Sales in Pesos (Daily) |
|------|---------------------|--------------|------------------------------------------|-----------------------------------------|----------------------------------------|
| 2024 | 302,226 | 10% | 30,223 | ₱2,266,727 | ₱11,806.00 |
| 2025 | 321,061 | 12% | 38,527 | ₱3,149,580 | ₱16,404.00 |
| 2026 | 340,066 | 14% | 47,609 | ₱4,242,326 | ₱22,096.00 |

### Projected Income Statement

Oshi "Oreo-sushi" projected income statements for 2024–2026 with a 25% income tax rate are shown in Table 6. The estimated after-tax net income for 2024, 2025, and 2026 is 61,152.00 pesos, 82,292.00 pesos, and 299,006.00 pesos. Given the restricted financial resources, ROI has an impact on the initial modest net income. Increased capital reinvestment for product development and market expansion is a result of operational advancement. In 2025 and 2026, sales over three million pesos will result in a 12% value-added tax. Up to 2026, the corporation intends to raise prices by 9% a year and make wage adjustments in line with them.

**Table 6. Projected Income Statement of Oshi**

| OSHI (Oreo-Sushi) Income Statement For the years ending 2024, 2025, and 2026 | | | |
|---|---|---|---|
| | **2024** | **2025** | **2026** |
| Sales | 2,266,727 | 3,149,580 | 4,242,326 |
| Less: Spoilage allowance | (22,667) | (31,496) | (42,423) |
| Less: Cost of sales/services/goods sold | (1,341,617) | (1,864,157) | (2,510,921) |
| Gross profit | 902,443 | 1,253,927 | 1,688,982 |
| Less: Operating expenses | | | |
| Rent Expense | (12,000) | (12,240) | (12,485) |
| Utilities Expense | (18,000) | (18,360) | (18,727) |
| Supplies Expense | (17,638) | (17,991) | (18,351) |
| Salaries Expense | (538,720) | (549,494) | (560,484) |
| Selling Expense | (149,012) | (150,634) | (153,646) |
| Taxes and Licenses Expense | (72,678) | (382,626) | (513,755) |
| Depreciation Expense | (12,859) | (12,859) | (12,859) |
| Net income before tax | 81,536 | 109,723 | 398,675 |
| Income Tax (25%) | (20,384) | (27,431) | (99,669) |
| **Net income after tax** | **61,152** | **82,292** | **299,006** |

## CONCLUSION

The healthier dessert served by Oshi Company is regarded as the ideal option because it appeals to sweet-tooth, health-conscious, and casual eaters alike. As the world adapted to the **"new normal"** there has been an evident rise in search interest for chocolate and other sweets, with a notable 20% increase (iPrice, 2020). Additionally, 81% of Filipinos think it is their responsibility to maintain a healthy and balanced diet. However, they also state that they would like additional assistance from the industry (Food Industry Asia, 2021).

By creating healthier desserts that find a balance between enjoyment and health, OSHI Company responds to this need with a unique yet well-known solution. These desserts include reduced serving sizes, a variety of flavors, and creation to answer concerns about nutrition and sugar intake. The business model of Oshi revolves around offering a distinctive, nutritious, and delectable dessert alternative. It harmoniously blends the taste of Oreos with the craftsmanship associated with sushi preparation. Oreo-sushi presents a unique confectionary delight that has yet to be conceived or produced by any other enterprise.

Oshi has emerged as a distinctly inventive dessert operation showing profitability, sustainability, and repeat custom. For instance, it's profits have been steady, which indicates its dominance in the market and ability to appeal to consumers. What sets Oshi apart is its innovative blending of flavors that is sweet but healthy for the increasing number of health-conscious individuals. As a starting business, this accolade shows that they are committed to providing tasty options that are nutritious.

The researchers' approach was visionary and led them towards coming up with new products that speak to different types of Filipinos. The payback period for the venture is proceeding well, implying that financial returns would soon recover the initial capital outlay. In-depth

examination of operational costs vis-à-vis projected income has shown some positive results; therefore, guaranteeing future profitability for Oshi.

Additionally, Oshi has innovative desserts that take care of people's health while considering environmental conservation and it commands a significant market share. Moreover, through constant researches on local flavors to increase their offerings as well as maximize the emerging operating business. This dedication to innovation entails a thorough investigation of a broad diversity of local ingredients and customary Filipino flavors.

The integration of traditional Japanese culinary elements into a dessert offers a sense of novelty and uniqueness. Thus, it enhances its appeal to prospective consumers. The Oshi enterprise provides a diverse selection of distinctive and delectable Oreo sushi rolls crafted from a combination of oatmeal and Oreo cookies. Thus, this tactic improves the business's relationships with the community by encouraging cooperation and a sense of shared success. The emphasis on regional vendors and ingredients is consistent with Oshi's larger environmental responsibility and sustainability pledge.

The Oshi enterprise prides itself on the craftsmanship exhibited by its culinary professional, who adeptly combines various components to create sushi rolls that surpass conventional limitations. This functions as a roadmap to the harmonious composition of ingredients within each sushi roll.

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# UNDERSTANDING STEM LEARNERS:
# ENGAGEMENT AND SUCCESS IN MATHEMATICS

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## ABSTRACT

The purpose of this paper was to describe the level of students' behavioral, emotional, and cognitive indicators of engagement, and to explore their relationship to the math performance of Grade 11 STEM learners. The study employed descriptive correlational research, utilized stratified random sampling (n=200), and surveyed students enrolled in general mathematics during the first and second quarters of the school year 2023-2024. Weighted means were used to analyze student engagement indicators, descriptive statistics for test scores, and Spearman-Rho Correlation to show relationship between two variables. Results showed that there was a weak positive relationship between students' engagement and their performance in mathematics. In addition, students were 'highly engaged' in terms of cognitive engagement and 'engaged' in behavioral engagement, while 'neutral' based on their emotional engagement. This result suggested that students' emotions greatly affect behavior and self-regulated learning.

***Keywords:*** mathematics, student engagement, behavioral engagement, emotional engagement, cognitive engagement

## INTRODUCTION

In the Philippines, mathematics from K to 10 is a skills subject and provides a solid foundation for STEM (Science, Technology, Engineering, and Mathematics) learning areas in senior high school. The importance of learning mathematics extends beyond academic pursuits, equipping learners with essential problem-solving skills applicable throughout life (Li & Schoenfeld, 2019). Additionally, one of the objectives of STEM education is to foster engagement, which may inspire learners to pursue STEM majors in college (Idin, 2020; Sauder, 2023).

Student engagement has emerged as a key factor in understanding student success in mathematics. One common definition of student engagement is, learners attending classes and possessing active participation in learning tasks and activities (Liang et al, 2018; Cents-Boonstra et al., 2020). There must be a cyclical, two-way approach between a supportive, caring, and encouraging teacher and an enthusiastic, motivated, and 'hands-on' learner to have positive behavioral, cognitive, and emotional engagement. Thus, positive student engagement leads to better performance in class.

However, many students grappled with math, experiencing disengagement, and ultimately, lower academic performance. The Programme for International Student Assessment (PISA), a global benchmark for educational performance, has painted a concerning picture of mathematics learning in the Philippines. In the latest PISA 2022 results, only 16% of Filipino learners were at least able to understand and identify how a straightforward situation can be represented mathematically without explicit instruction, and almost no learners can choose, assess, and compare suitable approaches to problem-solving for complex situations as well as represent them numerically. (Education GPS, 2024). A concerning trend coincided with research highlighting low levels of student engagement which threaten performance in secondary mathematics classrooms (Schuetz et al., 2018). Students were passive recipients of information; lacking opportunities for active participation and inquiry-based learning (Tesfaye & Berhanu,

2015). Moreover, students relied on rote memorization and failed to see the relevance of mathematics in real-life situations, leading to a lack of interest and motivation and resulting in anxiety, and discouragement in exploring new concepts in Mathematics.

Previous research on the developmental paths of engagement were not entirely consistent. There were other factors affecting student engagement, and each region, country, or even community may have different experiences regarding student engagement. For instance, one study has shown that there is no correlation between learner engagement and their grades, even if the most participative and active learners show higher scores in tests (Floris et al., 2022). More recent longitudinal research (Hong et al., 2020) has reported that student engagement in mathematics learning has been generally stable

In a classroom devoid of engagement, the students passively absorb information while their minds are wandering elsewhere. In such an environment, learning becomes a chore, and achieving true understanding remains elusive. Understanding the engagement-performance link empowers educators to develop effective teaching strategies by creating a supportive and engaging learning environment, fostering deeper student involvement, promoting positive attitudes towards mathematics, and enhancing learning outcomes. The field of mathematics education has been constantly evolving, with researchers and educators exploring innovative approaches to address the challenges of student engagement. However, existing research often focuses on younger student populations. Learners taking STEM strand, for instance, faced educational factors crucial for their classroom performance. (Rogayan et al., 2021). Understanding the specific relationship between student engagement in math and the academic performance of STEM learners is therefore particularly relevant.

By examining the distinct contributions of behavioral, cognitive, and emotional engagement, this study sought to provide a nuanced understanding of the complex interplay between these factors and how they influence math performance of STEM learners. Moreover, this study can potentially develop a deeper understanding of how to nurture a love

for learning and equip senior high school students with the necessary mathematical skills to thrive in the 21st century.

## Theoretical Background

### Theoretical Framework

The multidimensional model of student engagement by Frederick, Blumenfeld, and Paris (2004), which stressed behavioral, emotional, and cognitive aspects of school participation in addition to overall engagement, served as the foundation for student engagement. According to Fredricks and McColskey (2012), there are distinctions and relationships between the three engagement domains, and the association holds true for various facets of engagement, including cognitive engagement (deep processing of information, critical thinking, and problem-solving), behavioral engagement (active participation in learning activities), and emotional engagement (positive feelings towards the subject) (Skinner, Furrer, Marchand, & Kindermann, 2008).

The model posits that student engagement is not a singular construct, but rather a combination of cognitive, emotional, and behavioral dimensions. Cognitive engagement refers to the mental investment and effort students put into learning, which directly influences their ability to understand and solve mathematical problems. Emotional engagement reflects students' feelings of interest and enthusiasm, which can foster a positive attitude that enhances learning outcomes. Behavioral engagement, encompassing active participation and persistence in tasks, is connected to greater effort and better performance. Hence, the model suggests that when all three dimensions of engagement are high, students are more likely to perform better in mathematics due to increased motivation, focus, and persistence in their studies.

### Literature Review

### Student Engagement

Student engagement is the lifeblood of the teaching and learning process—a spark that ignites curiosity, drives motivation, and propels students towards deeper understanding and academic achievement. Often intertwined with motivation (Grootenboer & Marshman, 2016), a little involvement coming from a student can transform a learning landscape and can become an interactive journey. Learners become active participants rather than passive observers. Just like a fire that needs fuel to burn brightly, the learning process needs student engagement to flourish. Student engagement is a term on how interested and immersed the students and the degree of curiosity, motivation, optimism, willingness, and enthusiasm they employ inside the classroom setting (Bond & Bedenlier, 2019). Moreover, this is about how students devote themselves to academic and extracurricular activities, and how they utilize what the school or institution offers.

Student engagement is a complex connection between the learner and the learning environment, such as the curriculum, teachers, peers, and the school. Learners can be influenced by societal and cultural factors that play relevant roles in shaping student engagement, such as teacher's behavior in class and parents' expectations (Li & Lajoie, 2021; Wang et al, 2019). Hence, the more the students are inspired, empowered, and engaged in class, the more they will bring back the energy and in the learning process, leading to a more participative class.

According to Lee (2018), engagement is significantly related to student performance. Positive student engagement leads to higher rates of positive academic performance. However, lack of interest and motivation in learning has extremely grave implications that need to be addressed. A study by Vijayakumaran et al. (2023), said that when learners are well-

engaged in their academic activities, it lowers the possibility of student dropout.

### Student Engagement Indicators

Student engagement is a multifaceted concept that includes various unique but connected aspects, including behavioral, emotional, and cognitive engagement. Student's behavioral engagement is perceived as the level of students' attention, active participation in learning, adherence to rules, and task completion (Fredricks et al., 2004; Sinatra, Heddy, and Lombardi, 2015). Students' attitudes, the extent to which students believe they are capable of doing a task, and on how learners perceive social pressure all have an effect on their behavioral engagement (Gjicali and Lipnevich, 2021).

Student's emotional engagement is centered on assessing learning outcomes and responding positively or negatively to peers, instructors, and institutions. It includes interest, happiness, fear, and a sense of belonging and involves both positive and negative attitudes (Flores et al., 2021). Moreover, emotional engagement takes into account student's willingness to take on challenges and their sense of belonging (Zorn et al., 2022). Positive or negative emotions can affect student's cognitive processes and greatly influence memory, reasoning, and problem solving (Tyng et al., 2017; Fredericks et al., 2004).

Student cognitive engagement is centered on self-regulated learning (Zorn et al., 2022), and entails the notion of investment, an appreciation of the importance of learning, and a readiness to go above and beyond what is required of responsibilities. Among the three indicators, cognitive engagement is considered the stimulus or the driving force to learn (Hong et al, 2020). Students who engage in high levels of cognitive engagement tend to acquire more knowledge and skills, characterized by critical thinking, problem-solving, and deep processing of information, leading to better performance in mathematics (Dong et al., 2020).

### Student Engagement and Math Performance

In recent years, the study of student engagement gathered great attention, as it is accepted as a sign of mathematics achievement (Petričević et al., 2022; Skilling et al., 2020). Studies have shown a significant relationship between student engagement and math performance. For instance, a study by Maamin et al (2021) revealed that emotional engagement, cognitive engagement, and behavioral engagement pose a significant relationship in the success of students' performance in mathematics. Moreover, emotional engagement has become a largest predictor of math performance.

Guinocor et al (2020) supported other findings, which revealed that Filipino learners with high student engagement through personal study orientation possessed high performance in mathematics tests. However, according to Mazumder et al (2020), results revealed a weak correlation between student engagement and math performance among mechanical engineering students. It is shown that classroom engagement is not a good indicator in assessing students' performance in mathematics, but students preferred grouped or independent study outside the classroom.
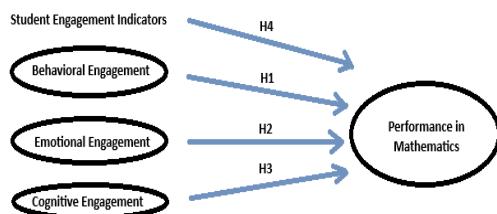
A study by Karademir (2019), revealed that there were variations on how students' performance in mathematics related to student engagement. Moreover, Grade 5 learners prefer reading their notebook and mathematics book, copying their notebook one by one, and learning by heart as a sign of their engagement which helped them to perform well in class. However, it has been shown that they were also aware of the trauma brought by group activity that pose positive and negative emotions towards the subject.

Based on a recent study, behavioral engagement and Filipino students' performance in mathematics appear to be somewhat positively correlated (Flores et al., 2021). A moderate, positive relationship between cognitive engagement and academic performance was shown, but academic performance poses no correlation with emotional engagement. Numerous studies have focused on cognitive engagement (Cevikbas & Kaiser, 2021), yet few studies have been conducted that concern the behavioral and emotional aspects of engagement in relation to performance in mathematics.

Based on these research gaps, the following hypotheses were set for the study:

H1: There is a significant relationship between students' behavioral engagement and their performance in mathematics.
H2: There is a significant relationship between student's emotional engagement and their performance in mathematics.
H3: There is a significant relationship between students' cognitive engagement and their performance in mathematics.
H4: There is a significant relationship between students' engagement and their performance in Mathematics.

### Conceptual Framework



**Figure 1.** The Conceptual Framework

The framework sought to answer the research questions pertinent to the importance of the three student engagement indicators and their relationship to student performance in mathematics. Moreover, it highlights the interplay between students' engagement in general and their performance in mathematics, in terms of behavioral, emotional, and cognitive engagement.

## METHODOLOGY

### Research Design
This study employed a descriptive correlational method research design to explore the relationship between student's math engagement indicators and mathematics performance among Grade 11 senior high school students enrolled in General Mathematics subject. According to Devi et al (2023), a descriptive correlational design is utilized when the researcher seeks to describe a relationship among variables, without attempting to infer causal relationship.

### Subjects
This study focused on 270 Grade 11 STEM students from Colegio de San Juan de Letran, 96 Grade 11 STEM students from City of Mandaluyong Science High School, and 34 Grade 11 STEM students from San Juan City Academic Senior High School (N=400) who took the General Mathematics subject and who are enrolled for the second quarter of school year 2023 – 2024. General Mathematics is the math subject that is offered during the first and second quarters. This study utilized a stratified random sampling technique using Slovin's Formula (n=200) to ensure the right number of respondents in every school.
### Study site

This study was conducted at three different schools in three different cities in Metro Manila, namely: San Juan City Academic Senior High School in San Juan City, City of Mandaluyong Science High School in Mandaluyong City, and Colegio de San Juan de Letran in Manila. Permission to conduct research was granted by the principals of all participating schools. This selection provides a geographically diverse sample, encompassing public and private institutions, and catering to a range of socioeconomic backgrounds, thus, ensuring a well-rounded perspective for the study.

### Instrumentation
A survey questionnaire by Flores et al. (2021), was adopted to assess student engagement and performance in mathematics. A 32-item, Likert-type scoring format is used for each of the subscales: behavioral (10 items), emotional (10 items), and cognitive engagement (12 items). On a five-point rating system, ranging from highly engaged (strongly agree) to highly not engaged (strongly disagree), students were asked to indicate how much they agreed with each statement.

It is to note that the instruments used to measure engagement and performance may not fully capture the complex nature of these constructs. The study focuses solely on the subject of mathematics, limiting the applicability of the findings to other academic domains.

### Data Collection Procedure and Ethical Consideration
The study gathered data from a sample of Grade 11 STEM students enrolled in General Mathematics classes during the first and second quarter, school year 2023 – 2024. Quantitative data collection methods were employed, including surveys and second quarter examination scores of the respondents. Informed consent was sought from the respondents, and the consent holds assurance that individual results will be treated with confidentiality. It also guaranteed that no cost was incurred from them. Lastly, proper citations and references to the authors throughout the study were highly observed and recognized.

### Data Analysis
Descriptive statistics were calculated to assess test scores. Weighted means were used to describe the student's engagement indicators. Inferential statistics were used to show statistically significant relationships between the variables. To examine the relationship between student engagement indicators and math performance, test the normality then a bivariate analysis was constructed through Spearman Rho with alpha level set at $p < .05$, which was used to determine the relationship between two variables, and the data gathered are ordinal and had outliers.

## RESULTS

### Student Engagement Indicators
Table 1 presents the weighted means of pupils' participation in General Mathematics class. It is revealed that the respondents are highly engaged in terms of their level of cognitive engagement in mathematics (Mean=4.263), based on their level of preparation for the mathematics subject, their level of attention to their teacher's lectures, and their desire to get good grades. Students' engagement based on their behavior (Mean=3.703) were rated "engaged" in terms of their perceived level of attention, active participation in class discussion, following teacher's directions, and eagerness to complete a task behavioral engagement. However, respondents were "neutral" with their emotional engagement (Mean=3.239). This implies that respondents were 'in between' emotionally engaged or not engaged, based on their interest, attitude, and feeling towards math, and their willingness to take all challenges during math discussions.

**Table 1.** Student Engagement Indicators

| Student Engagement Indicators | Mean | Interpretation |
|---|---|---|
| Behavioral Engagement | 3.703 | Engaged |
| Emotional Engagement | 3.239 | Neutral |
| Cognitive Engagement | 4.263 | Highly Engaged |

Legend: 1.00 – 1.80 - Highly not engaged; 1.81 – 2.60 – Not engaged; 2.61 – 3.40 – Neutral; 3.41 – 4.20 – Engaged; 4.21 – 5.00 – Highly engaged

**Students' performance in General Mathematics**

Table 2 revealed the mean performance of STEM students in Grade 11 under General Mathematics. The mean score of students was high with an average of 35.34, median of 37, and standard deviation of 8.65. The standard deviation implied an average dispersion of students' scores around the mean. The skewness of the level of students is -0.449. A distribution with a negative skewness has a longer left tail and a majority of values that are concentrated on the right side of the mean. The kurtosis of -0.883 implies that there is less extreme data in the distribution.

**Table 2.** Mean Performance of STEM Students

| Statistics | Value | Interpretation |
|---|---|---|
| Mean | 35.34 | High |
| Median | 37 | |
| Standard Deviation | 8.65137 | |
| Skewness | -.449 | |
| Kurtosis | -.883 | |

**Relationship between Student Engagement and Performance in Mathematics**

Table 3 shows Spearman-Rho correlation to evaluate the significant relationship between students' engagement (behavioral, emotional, cognitive) and the mathematics performance of Grade 11 STEM learners. Findings showed that there is a weak positive correlation between the two variables ($\rho$=.230). It also revealed that the p-values are less than the significant level, thus rejecting the null hypothesis.

**Table 3.** Correlation between Student Engagement and Test Scores

| Variables | | Spearman-Rho | P-Value | Decision | Conclusion |
|---|---|---|---|---|---|
| **Student Engagement** | **Test Scores** | .230 | .001 | Reject HO | Significant |
| Behavioral | | .242 | | | |
| Emotional | | .115 | | | |
| Cognitive | | .279 | | | |

## DISCUSSION

**Student Engagement Indicators**

The study discussed three student engagement indicators, namely: behavioral engagement, emotional engagement, and cognitive engagement. Gjicali and Lipnevich (2021) described behavioral engagement as the extent to which students believe they are capable of doing and completing a certain task, and on how learners perceive social stress. Tyng et al (2017) posited positive or negative emotions that can affect student's driving force to learn (Hong et al., 2020) and greatly affects critical thinking, problem solving, information processing, and eventually their performance in class (Dong et al., 2020).

The respondents were united in their decision on their level of interest and behavior in mathematics. The item, "I follow my teacher's directions in math class" ranked first with the interpretation 'highly engaged'. This resolves to the willingness of the learners to follow the teacher's instructions in solving math problems. Moreover, the item "Sometimes, I skip difficult math questions" ranked last and can be interpreted as 'not engaged'. This implies that several students are resolving to proceed to another problem, without asking for help from friends or teachers to solve a difficult math problem. This holds true to students who liked independent studying habits or having the tendency to disengage.

The overall weighted mean of emotional engagement was in between emotionally engaged or not engaged in this subject. This implied that their performance in mathematics depends on their positive or negative feelings before and during the class discussion. Among questionnaire items, the "I am interested in learning new things in math" received the highest engagement. This means that the students have the drive to learn new lessons. On the contrary, the item "I like to study other subjects rather than math", and "I am excited about solving difficult math problems" received the lowest engagement among respondents. This implies that there are other factors affecting students' learning, making them feel bored and uninterested in class discussions.

The overall weighted mean for cognitive engagement is labeled as "highly engaged". Moreover, the item "I want to get a good grade in math class" ranked first. This means that the respondents were desiring for good grades by memorizing important facts, thinking of different ways to solve math problems, developing their own strategy, and asking themselves math questions ensuring that they truly understand the lesson.

**Students' Performance in General Mathematics**

Based on the results of the study, the mean score of the students (Mean=35.34) implied that they performed high in their second quarter examination in general mathematics, with few students getting low scores. Moreover, the median score (Median=37) is higher than the mean, indicating that the distribution of the test scores is skewed to the left, with few extremely low scores pulling the mean down. Therefore, the skewness of data indicates that median is better in describing the center of distribution than the mean. In addition, the standard deviation of 8.65137 suggested that the scores are varied. However, the kurtosis of -.883 implied that there are more scores above the mean.

The test results reflect how well students performed in their quarter examination in General Mathematics and revealed that several respondents attained the mastery of the competencies in General Mathematics. These findings are contrary to the recent PISA 2022 results, where almost none of the learners can solve problems for complex situations.

**Relationship Between Student Engagement and Performance in Mathematics**

The results show that student engagement posed a significant relationship with their performance in mathematics. This supported the fact that learners with high student engagement possess high performance in mathematics (Maamin et al., 2021; Guinocor, 2020). The learners exhibited a positive attitude and attention towards learning mathematics. However, high levels of behavioral and cognitive engagements were greatly affected by their emotional engagement. External factors, such as classroom environment, teacher and teacher's strategy, peers, trauma from group activities may pose positive and negative emotions towards the subject.

## CONCLUSION

**Theoretical Contributions**

Since dearth studies have been conducted showing the relationship between student engagement and mathematics performance, the results of the study will be a great contribution to the field of mathematics education, as the findings can provide valuable insights into effective strategies for promoting student engagement in mathematics classrooms. Research results have shown that emotional engagement greatly affects student performance in mathematics, as it affects cognitive and behavioral engagements. This will help teachers fully understand that in

taking the full grasp of students' interest can help entice their attention, and to acquire knowledge and skills in mathematics in the long run. Findings of this study will contribute to further exploration of the body of knowledge in the area of student engagement in relation to mathematics performance. Lastly, this will aid possible researchers for further studies involving student engagement and math performance.

## Practical Implications

This study gives a more sound understanding of the role of teachers in fostering student engagement in a mathematics class. The study could help identify students who are disengaged or struggling with mathematics. This early identification allows teachers to provide timely support and interventions to ensure these students are not left behind. Moreover, this will help teachers develop more interactive, stimulating, and student-centered learning environments that cater to diverse learner needs. The study can encourage dialogue and collaboration among teachers, enabling them to share best practices for promoting student engagement and learn from each other's experiences.

By fostering a culture of engagement among students, schools can witness significant improvements in academic performance, particularly in mathematics. This can lead to higher graduation rates and better preparedness for future education and careers. The study can guide schools in allocating resources effectively, focusing on initiatives that demonstrably enhance student engagement and promote a positive learning environment. The study can facilitate collaboration between schools and parents, fostering a shared understanding of the importance of student engagement and encouraging joint efforts to support students' learning.

## Limitations

This study solely focuses on exploring students' behavioral, emotional, and cognitive indicators of engagement and its relationship with performance in mathematics specifically among Grade 11 STEM learners. Student engagement indicators other than those included in the literature review and instrument may also be covered, especially for future studies in the senior high school, collegiate, and graduate levels. Future research could benefit from employing a larger, more diverse sample, or by utilizing a mixed methods approach to gain a more understanding of the complex relationship between student engagement and mathematics performance.

Finally, the study confirmed the significant relationship between three engagement indicators affecting performance of students in mathematics. Little can be concluded about the correlation between student engagement and math performance. Therefore, it is essential to recommend the study of student engagement alongside other variables such as math attitude, math self-efficacy, and math burnout, and determine the relationships between and among the variables.

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# COMPRESSIVE AND FLEXURAL STRENGTH ANALYSIS OF BAMBUSA BLUMEANA FIBER REINFORCED COPPER SLAG GEOPOLYMER CONCRETE

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## ABSTRACT

Concrete is a widely used material in the construction industry known for its excellent compressive strength. Despite this, conventional concrete mixtures made with Portland Cement have several limitations, including sustainability, sturdiness, and unfavorable environmental effects. Thus, researchers are exploring alternative materials that can improve sustainable building practices, specifically in the Philippines. This study focuses on the performance of bamboo fiber-reinforced copper slag-based geopolymer concrete composites in terms of their compressive and flexural strength compared to Ordinary Portland Cement concrete. Bamboo fiber improves concrete flexural strength, and copper slag geopolymer acts as partial replacement for cement. Bamboo is an abundant and renewable resource that is cultivated sustainably. Copper slag is a byproduct of copper smelting. Both materials are considered sustainable, yet there is insufficient research and implementation of such in the Philippine construction industry.

*Keywords:* Bamboo fiber, Copper slag, Geopolymer, Sustainability, Concrete

## INTRODUCTION

Concrete is a widely used construction material for many infrastructure projects due to its ability to resist high compressive loads while having the flexibility to receive additional reinforcement. However, traditional concrete mixtures manufactured using Ordinary Portland Cement concrete (OPC) have concerns with sustainability. Cement production is responsible for 5% to 8% of global $CO_2$ emissions (Walach, 2020; Banstola et al., 2021). In the past few years, there was growing interest in exploring alternative materials and technologies to address these concerns including the incorporation of other natural and/or sustainable materials into concrete such as fibers in order to minimize the volume of cement production.

Natural fiber is a feasible alternative to synthetic fiber in the construction due to increased environmental awareness of biomaterials usage. Considering bamboo fiber as a natural fiber, it is a suitable material that can be used in concrete composites due to its higher fracture toughness and quick renewability (Ahmad et al., 2023). *Bambusa blumeana* is a species of bamboo abundant in Southeast Asia, notably in the Philippines. Despite local abundance, literature on application of *Bambusa blumeana* fibers in concrete is limited (Libre Jr. et al., 2022).

Portland Cement manufacturing consumes vast amounts of energy and raw materials, consequently emitting tons of $CO_2$ responsible for global warming. Studies identified that partial replacement of Portland Cement in concrete significantly decreased the amount of $CO_2$ emissions in the atmosphere (Walach, 2020; Banstola et al., 2021). Innovative cementitious materials called geopolymers provide several advantages including less carbon emission, high durability, and increased mechanical properties compared to traditional Portland Cement-based concrete (Singh & Middendorf, 2020).

Studies were conducted to investigate the mechanical properties of copper slag as a fine aggregate replacement in concrete and cement replacement in cementitious materials. These studies found that copper slag can increase the mechanical properties of such composites at optimal percentages, particularly in compressive strength. Despite this, there is

limited research into using copper slag geopolymer as cement replacement in concrete.

### Theoretical Background

The construction industry is one of the main producers of $CO_2$ and other gasses that are potent in destroying the environment. Although previous and ongoing studies and investigations on more sustainable alternatives to cement and concrete exist to tackle such a problem, the construction industry is reluctant to replace an existing product that is a reliable material for decades in their line of work. There is still room to provide more insight on alternatives to cement in concrete mixes. This study investigates the mechanical properties of bamboo fiber reinforcement and copper slag geopolymer in concrete composites.

Bamboo fiber is studied to improve the flexural performance of concrete, yet *Bambusa blumeana* bamboo species has limited studies into the properties of its fiber as flexural reinforcement in concrete. Copper slag is a byproduct studied to be an appropriate partial replacement for both concrete fine aggregates and mortar cement but has limited research into partial cement replacement for concrete composites.

This study evaluates the effectiveness of bamboo fiber as reinforcing material and copper slag as partial replacement for cement. It assesses copper slag geopolymer and bamboo fiber mixture's flexural and compressive strength in concrete. The study relies on the data obtained from testing procedures to evaluate effectiveness of copper slag geopolymer and bamboo fiber as an additive material reinforcement in concrete using specific testing standards (ASTM C39M for testing concrete compressive strength and ASTM C293 for concrete flexural strength testing) to determine its performance. The study only considers the effect of bamboo fiber and copper slag on concrete performance and mechanical composition. It does not investigate other properties of bamboo fiber and copper slag that can influence the stability and workability of concrete nor the resistance to decay of *Bambusa blumeana* fiber.

## Literature Review

### Tensile and Flexural Properties of Bamboo Fiber
Bamboo has similar tensile strength to steel (28,000 N/m²). Only a small number of modern structures have utilized bamboo due to the advancing technology and the creation of concrete and steel. Compared to steel being a manufactured construction material, bamboo can only be acquired through plantation. This results in inconsistent mechanical properties of bamboo. Its properties heavily depend on its age, species, diameter, wall thickness, position of load, radial position from outside to inside, and levels of water (Manandhar et al., 2019).

Study found that there was a noticeable increase of up to 355.82% in flexural strength for bamboo fiber-reinforced fly ash-based geopolymer concrete (Libre Jr. et al., 2023). Study on the thermal and mechanical properties of bamboo fiber presented that bamboo fiber reinforced concrete with fibers treated with 10% sodium hydroxide (NaOH) concentrated solution increased the fiber's tensile strength to 319.52 MPa (Chin et al., 2019).

### Compressive Properties of Bamboo Fiber as Composite Additive
Addition of bamboo fibers beyond 1% of composite weight decreases compressive strength by a minimal drop of 3.8% to 9.6%. Samples including 0.75% fiber showed more positive results. At this additive percent, fibers worked as crack arrestors, helping slow the spread of cracks, further increasing the final strength (Ahmad et al., 2023).

Incorporating bamboo fiber and fly-ash geopolymer in cementitious material with the addition of short bamboo fiber extracted from *Bambusa blumeana* enhanced mortar compressive strength. The length and loading of bamboo fiber influenced the strength of fly ash-based geopolymers. Using Unconfined Compressive Strength, there was an increase of 292.41% compressive strength when bamboo fiber was added at fiber loading of 1.4% by weight and 20 mm fiber length.

### Copper Slag as Cement Replacement for Cementitious Materials
Investigation of mechanical properties of geopolymer replacement in concrete showed that the compressive strength of geopolymer cement paste was higher than OPC. Found stable at hot temperatures, making it a viable material for fire resistive composites. The replacement of copper slag in cement reports that 5% is recommended for increasing concrete flexural strength. High percent replacement of cement in cementitious materials can decrease its mechanical properties. The highest percentage of replacement allowable for copper slag geopolymer in cementitious materials was 20% to avoid reduction in compressive and flexural properties (Chaitanya & Kumar, 2021; Jin & Chen, 2022).

### Slag as Cement Replacement in Concrete
Mechanical properties of concrete were analyzed when cement is replaced with ladle furnace slag and blast furnace slag at percentages of 30%, 40%, and 50%. At 30% cement replacement, blast furnace slag increased concrete compressive strength by 10%, whilst 40% replacement yielded a 7% increase, and 50% replacement yielded a 5% increase. Flexural strength for 50% cement replacement with blast furnace slag yielded the highest increase of 4%, with 40% replacement having a 3% increase, and 30% replacement having a 1% increase in flexural strength.

Compressive strength increases when cement replacement with slag is smaller, whilst flexural strength increases when the percent replacement is higher (Parron-Rubio et al., 2019). In an investigation of compressive and flexural strength of steel slag as cement replacement in M40 concrete, the most optimum percent replacement to increase mechanical properties was 10% for both compressive and flexural strength. Higher percent replacement presented a decrease in compressive and flexural strength (Pushpa & Sharma, 2021).

## Theoretical Framework
Using ASTM guidelines for concrete compressive and flexural strength, the study establishes the objective of the BFRCS-GPC (Bamboo Fiber-Reinforced Copper Slag Geopolymer Concrete) composite meets said standards to be deduced as a feasible alternative to traditional concrete mixes (American Society for Testing Standards, 2017). Preparation and extraction of the bamboo fibers is through soaking in 10% NaOH concentrated solution (Aziz et al., 2023). Copper slag is prepared through alkali solution treatment.

Bamboo fiber and copper slag geopolymer are incorporated into a concrete mix of various mix ratios before being left to cure. ASTM testing methods are utilized to evaluate composite compressive and flexural strengths. Three separate test specimens for flexural and compressive testing include the OPC control variable, copper slag geopolymer composite of varying partial replacement for cement, and BFRCS-GPC of varying percent addition of bamboo fiber and geopolymer partial replacement for cement.

To measure compressive strength of concrete, cylindrical test specimens of 100 mm diameter by 200 mm length are cast per ASTM C39M and ASTM C293 procedures (American Society for Testing Standards, 2017; American Society for Testing Standards, 2010). To determine concrete flexural strength, a beam test specimen with dimensions of 500 mm length and 150 mm width by 150 mm depth is cast per ASTM C293 procedure. Specimens were subjected to a curing time of 28 days. Results were recorded with evaluation of collected data.

## METHODOLOGY

### Bambusa Blumeana Fiber Extraction
Preparation of the bamboo fiber starts with the chemical treatment of the *Bambusa blumeana* splints soaked in a 10% NaOH solution for 48 hours (Chin et al., 2019). The length of each extracted bamboo fiber is approximately 20 mm.

### Design of Concrete Mix Ratios
There are two groups of composite designs used in the study: the control group consisting of OPC and design samples of BFRCS-GPC. Each percent bamboo fiber added has a percent copper slag-based geopolymer cement replacement of 20% and 40%.

Mix ratio design of 1 cement: 2 sands: 4 aggregates for OPC was used. M15 grade concrete has a nominal maximum diameter of 20 mm for coarse aggregates and a minimum water-cement ratio of 0.40. For this study, 0.50 was used (Verma et al., 2022). The composites assessed for compressive load are cast into 100 mm x 200 mm cylinder molds at room temperature subjected to 28 days of curing time, while composites assessed for flexural load are cast into a 500 mm x 150 mm surface area by 150 mm height rectangular molds.

Table 1 Mix proportions for the control group.

| | Samples | Cement (kg) | Sand (kg) | Gravel (kg) | Total weight per sample (kg) |
|---|---|---|---|---|---|
| OPC-C | 3 | 0.522 | 1.052 | 2.176 | 3.750 |
| OPC-F | 3 | 3.742 | 7.536 | 15.593 | 26.871 |

Table 2 Mix design for BFRCS-GPC.

| Group | No. of samples | Bamboo Fiber (% added) | Copper Slag Geopolymer (% cement replacement) |
|---|---|---|---|
| BF1.00CS20 | 3 | 1.00 | 20 |
| BF0.75CS20 | 3 | 0.75 | 20 |
| BF1.00CS40 | 3 | 1.00 | 40 |
| BF0.75CS40 | 3 | 0.75 | 40 |

**Table 3 Mix Proportions for Design Samples.**

| Label | Sample | Cement (kg) | Sand (kg) | Gravel (kg) | Copper slag cement wt% replacement | Total weight per sample |
|---|---|---|---|---|---|---|
| BF1.00CS 20-C | 3 | 0.418 | 1.052 | 2.176 | 0.104 | 3.750 |
| BF0.75CS 20-C | 3 | 0.418 | 1.052 | 2.176 | 0.104 | 3.750 |
| BF1.00CS 40-C | 3 | 0.313 | 1.052 | 2.176 | 0.209 | 3.750 |
| BF0.75CS 40-C | 3 | 0.313 | 1.052 | 2.176 | 0.209 | 3.750 |
| BF1.00CS 20-F | 3 | 2.994 | 7.536 | 15.593 | 0.748 | 26.871 |
| BF0.75CS 20-F | 3 | 2.994 | 7.536 | 15.593 | 0.748 | 26.871 |
| BF1.00CS 40-F | 3 | 2.245 | 7.536 | 15.593 | 1.497 | 26.871 |
| BF0.75CS 40-F | 3 | 2.245 | 7.537 | 15.593 | 1.497 | 26.871 |

The table 1-3 represent the mix proportions and design specifications for different concrete samples used in an experimental study. Specifically, they provide details on the materials and their quantities used in both the control group and the experimental group incorporating bamboo fiber and copper slag in geopolymer concrete (BFRCS-GPC).

## Copper Slag Activation
Copper slag geopolymer is used as the binding agent in BFRCS-GPC. Copper slag underwent alkaline activation using sodium silicate, an industrial-grade water glass solution. In obtaining a homogenous mixture, activator was dissolved in water before mixing.

## Concrete Curing
After cylinder and beam molding, samples were stored in a moisture controlled environment. Water immersion of specimens was employed to maintain moisture temperature. Concrete mixtures maintained initial curing temperatures between 16 and 27 °C for up to 48 hours. After initial curing and 30 minutes after removing the molds, specimens were cured with free water maintained on their surfaces at all times at a temperature of 23° C. Drying of surfaces of the beam was prevented between removal from water storage and testing (American Society for Testing Standards, 2019).

## Control Group Testing
Perform compressive test for control groups in cylinder molds, and flexural test for beam molds. Applied forces and corresponding deformation were recorded at regular intervals during testing.

## Compressive and Flexural Strength Test
Perform compressive strength tests for cylinder mold design specimens by placing the lower bearing side and centered on the upper bearing side of the test. Applied forces and corresponding deformations were recorded during the test.

Perform flexural strength test for beam mold design samples by placing it in at center of the UTM, ensuring that loading devices contact the midpoint of the specimen. Gradually apply load at the center of the specimen with a specified range until failure. Record the maximum applied load and the corresponding deflection or deformation.

## Data Analysis
Application of Test of Homogeneity of Variances to investigate the variability of data sets. If the significant difference is more than 0.05, then data is tested using ANOVA. Otherwise, Welch Robust test is used (University of Southern Queensland, 2022). One-way ANOVA was used due to the presence of a single independent variable. The independent variable is the control group consisting of OPC with no added bamboo fiber and copper slag.

Tukey's Honest Significant Difference (HSD) test is used as a post-hoc test (Kenton, 2024; BioSTATS, 2020). Dunnett's Test was also used as a post-hoc test in case the variances from the data are not equal (Statistics How To, 2020). Correlational analysis is applied to determine if there is a relationship between the variables (QuestionPro, 2020).

# RESULTS AND DISCUSSION

## Compressive Strength
**Table 4 Compressive Strength of Control and Design Samples**

| Label | Sample # | Maximum Load (kN) | Compressive Strength (MPa) | Average Compressive Strength (MPa) |
|---|---|---|---|---|
| OPC-C | 1 | 142.50 | 18.10 | |
| | 2 | 109.35 | 13.90 | **16.00** |
| | 3 | 125.85 | 16.00 | |
| BF1.00C S20-C | 1 | 40.65 | 5.20 | |
| | 2 | 39.35 | 5.00 | **5.33** |
| | 3 | 45.40 | 5.80 | |
| BF0.75C S20-C | 1 | 46.70 | 5.90 | |
| | 2 | 50.56 | 6.40 | **6.23** |
| | 3 | 50.10 | 6.40 | |
| BF1.00C S40-C | 1 | 19.30 | 2.50 | |
| | 2 | 22.55 | 2.90 | **2.73** |
| | 3 | 21.65 | 2.80 | |
| BF0.75C S40-C | 1 | 22.20 | 2.80 | |
| | 2 | 26.00 | 3.30 | **3.03** |
| | 3 | 23.85 | 3.00 | |
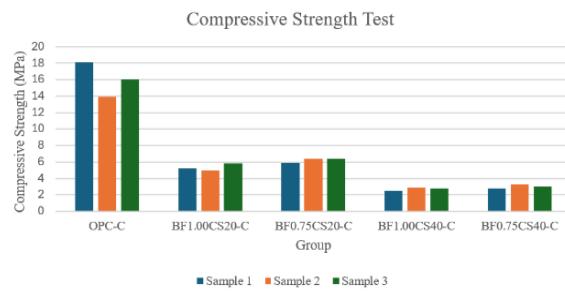


Figure 1. Compressive strength of control and design samples

Table 4 and Figure 1 present and visualize the data for the compressive strength of each control and design sample, considering the average compressive strength achieved by all three samples in each batch. Results of the control sample compressive strength test yielded an average of 16 MPa, indicating that the control sample was able to achieve the expected 15 MPa standard compressive strength for the M15 concrete mix.

BF1.00CS20-C achieved an average compressive strength of 5.33 MPa, showing an estimated 70% reduction in concrete compressive strength. BF0.75CS20-C samples achieved an average compressive strength of 6.23 MPa, showing an estimated 60% reduction in concrete compressive strength. BF1.00CS40-C samples achieved an average compressive strength of 2.73 MPa, showing an estimated 80% reduction in concrete compressive strength. BF0.75CS40-C samples achieved an average compressive strength of 3.03 MPa, showing an estimated 80% reduction in concrete compressive strength.

Design sample of 0.75% bamboo fiber added reinforcement and 20% copper slag cement replacement exhibited the smallest reduction in concrete compressive strength of 60% whilst both samples of 1% and 0.75% bamboo fiber added reinforcement with 40% copper slag cement replacement exhibited the highest reduction of concrete compressive strength of 80%.

**Table 5 ANOVA Test on compressive strength**

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Compressive Strength (MPa) | Between Groups | 353.247 | 4 | 88.312 | 92.505 | <.001 |
| | Within Groups | 9.547 | 10 | .955 | | |
| | Total | 362.793 | 14 | | | |

Table 5 Presents the results of the ANOVA test on the concrete samples' compressive strength. Significance level is shown to be less than 0.05, indicating a significant difference among the five groups.

**Table 6 Post Hoc Tukey's HSD test on compressive strengths of design groups against a control group**

| Control Concrete Group | Design Concrete Group | Mean Difference | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1 | 2 | 10.666666 666666668 | .7977 7468 2754 752 | <.00 1 | 8.04112 460747 68 | 13.2922 086772 588 |
| | 3 | 9.7666666 66666666 | .7977 7468 2754 752 | <.00 1 | 7.14112 460747 66 | 12.3922 086772 586 |
| | 4 | 13.266666 666666667 | .7977 7468 2754 752 | <.00 1 | 10.6411 246074 767 | 15.8922 086772 588 |
| | 5 | 12.966666 666666667 | .7977 7468 2754 752 | <.00 1 | 10.3411 246074 767 | 15.5922 086772 587 |

Table 6 presents Tukey's Honest Significant Difference test on the mean compressive strength of design groups against the control group. Results show a significant difference with design samples to the control sample.

Addition of bamboo fiber and cement replacement of copper slag in the design groups had a significant effect on concrete compressive strength in terms of strength reduction. The high partial replacement of cement, 0.5 cement ratio, and addition of bamboo fiber affected the composition of the concrete sample, making it rough and brittle in appearance after the curing stage. Bamboo fiber has a high absorption rate of water and past studies found that water absorption rises linearly with the addition of bamboo fiber. This is because the inclusion of bamboo fiber in the matrix increases the material's space and cavity.

The added bamboo fiber also contributed to the decrease in compressive strength due to potential voids created when the fibers were incorporated, lowering the binding tension between cement and aggregate (Ahmad et al., 2023). Therefore, incorporating bamboo fiber and copper slag in concrete has no significant performance as a replacement for OPC in terms of compressive strength.

Data from the compressive strength tests show that the experimental group failed to match or surpass the compressive strength of the control group. By analyzing each group individually, different mix ratios of bamboo fiber and copper slag geopolymer affected the percentage of decrease in the sample's compressive strength. At 40% copper slag geopolymer cement replacement, the samples achieved an 80% strength reduction, regardless of the amount of bamboo fibers added.

**Table 7 Correlational Analysis of Compressive Strength Variables**

| Variables | Pearson's R | Qualitative | P-Value (N=12) | Significance ($\alpha$=0.05) |
|---|---|---|---|---|
| Bamboo Fiber – Compressive Strength | -0.1989 | Very Weak Negative Correlation | 0.53523 | **Not Significant Correlation** |
| Copper Slag – Compressive Strength | -0.9612 | Very Strong Negative Correlation | 0.00001 | **Significant Correlation** |

Result of Pearson's correlation coefficient in Table 7 for bamboo fiber-compressive strength shows a negative correlation (-0.1989). As the addition of bamboo fibers increases, the compressive strength decreases. Implying that compressive strength of concrete will lessen if more bamboo fiber is added. This correlation between bamboo fiber and compressive strength was very weak, implying that addition of bamboo fiber to the mixture will not affect the concrete compressive strength at a significant value. Pearson's correlation coefficient suggests that no amount of bamboo fiber reinforcement replacing cement will exhibit a statistically significant correlation with the concrete's compressive strength. There is no clear linear relationship between bamboo fiber addition and reduction of concrete strength.

Results of Pearson's correlation coefficient for copper slag and compressive strength yielded a negative correlation (-0.9612), which in hand means that the more copper slag is added to the mixture, the compressive strength of the concrete will decrease. In this relationship, a very strong negative correlation was also observed with a P-value of 0.00001 which means that when the copper slag is added to the mixture, the compressive strength of the concrete decreases. Therefore, what can be inferred from this observation is that the addition of copper slags into the mixture is correlated to the decrease in the compressive strength of the concrete.

Previous studies stated that 1% bamboo fiber additive was the maximum %wt addition to concrete before a noticeable reduction in compressive strength. A 0.75% bamboo fiber addition to concrete was favorable in increasing compressive strength (Ahmad et al., 2023; Chin et al., 2019). Bamboo fiber has properties that contribute to increasing the strength of concrete such as low density, high impact resistance, high flexibility, low specific gravity, and less abrasiveness. Though it should be worth noting that bamboo has high water absorption that could affect the concrete's mechanical strength, this can be mitigated through chemical and physical treatment as was done through soaking in 10% NaOH solution and performing compression extraction (Aziz et al., 2023).

Previous studies have concluded that a high copper slag percentage lowers the compressive strength significantly, and lower percentages yield a much better result (Jin & Chen, 2022; Edwin et al., 2019). Using more than 20% slag replacement can negatively impact early-age strength development, confirming that 20% copper slag cement replacement is the maximum amount before a noticeable decrease in compressive strength occurs. Replacing a significant proportion with inert material like slag dilutes the amount of cement available to react and form the strong binding phases responsible for early strength. Despite other types of slag geopolymer having observed an increase in compressive strength beyond the 20% replacement level (Chaitanya & Kumar, 2021; Parron-Rubio et al., 2019; Shoaib et al., 2023), this is not the case for copper slag-based geopolymers.

## Flexural Strength

**Table 8 Flexural strength of control and design samples**

| Label | Sample # | Maximum Load (kN) | Flexural Strength (MPa) | Average Flexural Strength (MPa) |
|---|---|---|---|---|
| OPC-F | 1 | 18.55 | 2.70 | **2.97** |
| | 2 | 20.55 | 3.00 | |
| | 3 | 21.30 | 3.20 | |
| BF1.00 CS20-F | 1 | 18.70 | 2.80 | **2.80** |
| | 2 | 19.75 | 2.90 | |
| | 3 | 18.15 | 2.70 | |
| BF0.75 CS20-F | 1 | 15.00 | 2.20 | **2.57** |
| | 2 | 15.80 | 2.30 | |
| | 3 | 21.90 | 3.20 | |
| BF1.00 CS40-F | 1 | 14.55 | 2.20 | **2.27** |
| | 2 | 15.85 | 2.30 | |
| | 3 | 15.65 | 2.30 | |
| BF0.75 CS40-F | 1 | 18.10 | 2.70 | **2.57** |
| | 2 | 15.75 | 2.30 | |
| | 3 | 18.55 | 2.70 | |
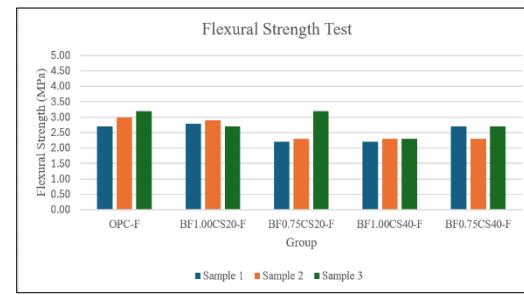


Figure 2. Flexural strength of control and design samples

Table 8 and Figure 2 present and visualize the data for the flexural strength of each control and design sample, considering the average flexural strength achieved by all three samples in each batch.

Results of the flexural strength test for the control sample yielded an average flexural strength of 2.97 MPa as seen in Table 4.4. This indicates that the control sample nearly achieved the expected strength of 3 MPa, the standard flexural strength of M15 grade concrete mix after 28 days.

BF1.00CS20-F achieved an average flexural strength of 2.80 MPa, showing minimal reduction in concrete flexural strength. Both BF0.75CS20-F and BF0.75CS40-F samples achieved an average flexural strength of 2.57 MPa, showing an estimated 15% reduction in concrete flexural strength. BF1.00CS40-F samples achieved an average flexural strength of 2.27 MPa, showing an estimated 25% reduction in concrete flexural strength.

**Table 9 Welch Robust test on flexural strength**

| | | Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| Flexural Strength (MPa) | Welch | 13.875 | 4 | 4.539 | **.009** |

Table 9 shows the results from the Welch Robust test on flexural strength among the five groups, indicating that there is a significant difference among all groups.

**Table 10 Post Hoc Dunnett's test on mean flexural strength of design groups against the control group**

| Control Concrete Group | Design Concrete Group | Mean Difference | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1 | 2 | .16666666666666667 | .1347191994114 | .914 | -.850027032337857 | 1.1833603671192 |
| | 3 | .40000000000000000 | .349602949390051 | .890 | -1.7408291661613 | 2.5408291661612 |
| | 4 | .70000000000000000 | .149071198499986 | .136 | .441998105557905 | 1.841998105557905 |
| | 5 | .40000000000000000 | .197202659436654 | .496 | -.5537891431040 | 1.3537891431040 |

Table 10 presents the results of Dunnett's test on the mean flexural strength of design groups against the control group. The mean difference is significant at 0.05 level. Upon individual analysis of each group, results from the Post Hoc test suggest that none of the experimental groups surpassed the flexural strength of the control group. Lack of significant difference implies that, on average, experimental samples performed similarly to control samples. This suggests that despite cement reduction in the beam, the presence of bamboo fiber was able to compensate for the reduced binding material by acting as additional flexural reinforcement in the concrete. When bamboo fibers are added to concrete, it helps avoid brittle failure (Abdalla et al., 2023).

Previous studies suggest that when bamboo fiber is added to concrete mix, there is an increase in flexural strength at additions of 0.5%, 1%, and 1.5%, enhancing concrete resistance to bending. However, at a bamboo fiber addition of 2.5%, there is a decrease in flexural strength compared to other bamboo fiber ratios (Kumarasamy et al., 2020). Therefore, incorporating bamboo fiber and copper slag in concrete has significant performance in terms of flexural strength.

Design mix containing 1% bamboo fiber reinforcement and 20% copper slag replacing cement achieved the best balance of flexural strength among the tested groups. This mix performed closer to the control samples than the other experimental groups.

Previous studies supported the idea that bamboo fibers possess high tensile strength due to their unique cellulose structure (J. S. V. &

Wongkean, 2021). This strength helps to restrain cracks in the concrete mix, enhancing its overall flexural strength. In addition, bamboo fibers act as links that stretch across cracks, stopping them from spreading further (Ahmad et al., 2023).

**Table 11 Correlational Analysis of Flexural Strength Variables**

| Variables | Pearson's R | Qualitative | P-Value (N=12) | Significance (α=0.05) |
|---|---|---|---|---|
| Bamboo Fiber – Flexural Strength | -0.0534 | Very Weak Negative Correlation | 0.87006 | Not Significant Correlation |
| Copper Slag – Flexural Strength | -0.4270 | Moderate Negative Correlation | 0.16623 | Not Significant Correlation |

Table 11 shows that the negative values in Pearson's correlation coefficient indicate a negative correlation (-0.0534), in which the values of one variable increase, and the value of the other variable tends to decrease. There is a very weak negative correlation between the bamboo fiber content and flexural strength. This indicates a slight tendency for flexural strength to decrease as the amount of bamboo fiber increases. This correlation is so weak that the reduction is negligible. The high significance level suggests this correlation is not statistically significant. On the other hand, there is a moderate negative correlation (-0.4270) between the copper slag content and flexural strength. This is a stronger association compared to bamboo fiber, suggesting a more noticeable decrease in flexural strength as copper slag content increases. However, the significance level for this correlation is also not significant.

Therefore, Pearson's correlation coefficient suggests that neither the amount of bamboo fiber additive nor the level of copper slag replacing cement exhibits a statistically significant correlation with the final concrete's flexural strength. This means that there is no clear linear relationship between these factors and the reduction of concrete strength.

Copper slag as cement replacement in cementitious materials was observed to have a decrease in flexural strength at higher levels of cement replacement similarly to compressive strength. A study on different slag geopolymers showed an increase in flexural strength at lower replacement levels, unlike its compressive strength (Chaitanya & Kumar, 2021; Parron-Rubio et al., 2019). This may not be the case for BFRCS-GPC showing influence in decreasing concrete flexural strength. Yet it is worth noting that this decrease did not significantly reduce the flexural strength of the concrete composite.

Copper slag with high calcium oxide content can be a beneficial additive for concrete. This is because calcium oxide reacts with water to form additional cementitious hydrates. These hydrates fill the gaps within the concrete, making it denser and stronger. This strongly suggests that despite flexural strength reduction, copper slag-based geopolymer has such chemical properties that improve the mechanical strength of concrete, reducing its effect on flexural strength reduction.

## CONCLUSION

Studies highlighted the unique cellulose structure of bamboo fibers as a key factor in its strong tensile strength (Aziz et al., 2023). This property allows bamboo fibers to effectively restrain cracks within the concrete mix. By mitigating crack formation, bamboo fibers can significantly enhance the overall flexural and compressive strength of concrete (Ahmad et al., 2023). The design samples experienced a slow decline in the maximum load it can carry after failure due to the crack restraining properties of bamboo fiber, whilst OPC experienced an immediate drop once it reached its maximum load. This translates to improved performance in structures subjected to bending forces, leading to greater durability and potentially longer lifespans.

Among the four design mix ratios, incorporating 0.75% and 1% bamboo fiber addition, and 20% and 40% copper slag geopolymer cement replacement in concrete decreases its compressive strength by 60% to 80% compared to OPC. High absorption rate of bamboo fiber and the high percent reduction of cement with copper slag geopolymer contributed to this outcome. The combined effect of bamboo fiber and copper slag on flexural strength nearly achieved the flexural strength of OPC samples. Addition of 1% bamboo fiber and 20% copper slag cement replacement presented the highest value of flexural strength amongst the design group. In comparison among the four design setups, adding bamboo fiber at an optimal percentage of 0.75% and 1% can help the concrete composites perform similarly to OPC in terms of flexural strength among the four design groups. Influence of copper slag on flexural strength can vary. There is a decrease in higher replacements of copper slag, potentially due to weaker interfacial bond between copper slag particles and cement paste, compromising the concrete's overall integrity under bending stress.

Performance of BFRCS-GPC was investigated through correlational analysis. Results show that bamboo fiber has a very weak negative correlation between compressive and flexural strength. Statistical analysis show that the correlation is not significant as there is no linear relationship between bamboo fiber addition and reduction of compressive and flexural strength. On the other hand, copper slag geopolymer attained a very strong and moderate negative correlation in terms of compressive and flexural strength, respectively. The moderate negative correlation was insignificant as there is no linear relationship between the addition of copper slag and the decrease in flexural strength. The very strong negative correlation is significant as it displays that adding more copper slag to the concrete mix will decrease composite compressive strength.

Copper slag geopolymer showed mixed results in strength development when used among the four design mix ratios. Incorporating both bamboo fiber and copper slag geopolymer in the design mix decreases compressive strength by 60% to 80% compared to OPC. While these alternatives offer environmental benefits, they can negatively impact compressive strength, especially when combined. Data assessment and statistical analysis of the flexural strength of design samples indicate that all the samples in the experimental samples have similar values to OPC. The 1% bamboo fiber and 20% copper slag replacement exhibit the highest value of flexural strength among the four design mix ratios. Beyond optimal levels of bamboo fiber addition, there's a negative effect on flexural strength due to air voids created by excess fibers. Higher levels of copper slag replacement weaken the interfacial bond with cement paste, reducing concrete integrity under bending stress. Therefore, incorporating bamboo fiber and copper slag in concrete has no significant performance as a replacement for OPC for compressive strength., but has significant performance as a replacement for OPC for flexural strength.

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