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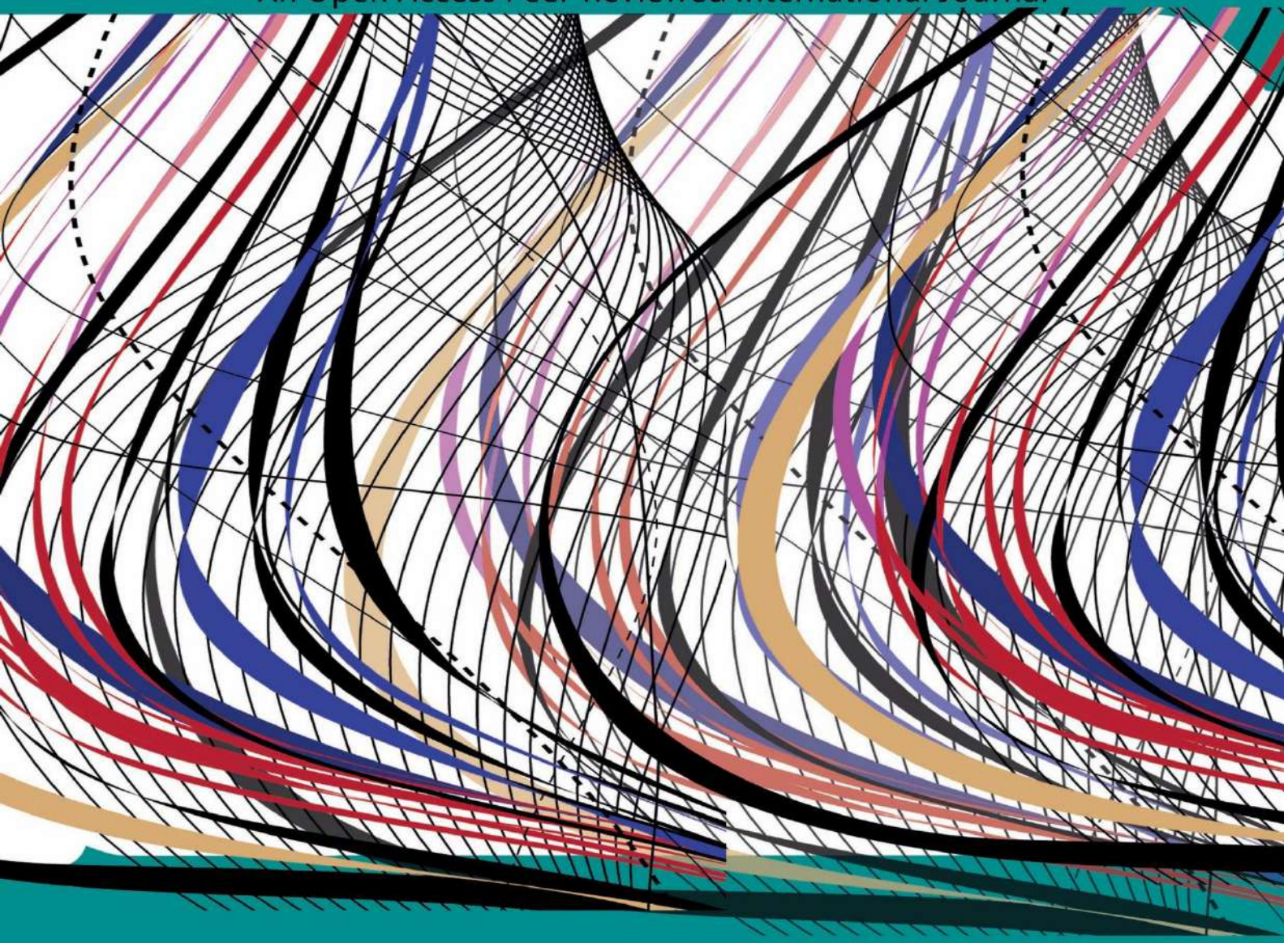

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Financial Literacy Among the Senior High School Students: Basis for Financial Stewardship Plan

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Abstract**—***This study investigated the financial literacy of senior high school students, exploring their ability to make informed financial decisions and navigate money management challenges. The researchers also assessed the financial knowledge, behaviors, and the most common difficulties that the students encountered. The study aimed to identify potential areas in which future financial education initiatives could offer significant assistance in preparing young individuals for financial security. The data from this study were gathered from selected senior high school students using a self-administered questionnaire featuring a Likert-scale checklist, inspired by National Center for Education Statistics (NCES) questionnaires and all other subsequent analyses using descriptive statistics. The findings revealed that parents were the primary source of financial knowledge.Also, students faced challenges in money management and showed limited familiarity with financial terms, particularly budgeting. Therefore, the findings suggested a moderate to high level of financial literacy among senior high school students, emphasizing the need for a financial stewardship plan.*

Keywords**—** ***Budgeting, Financial Literacy, Financial Stewardship, Money, National Center for Education Statistics, Senior High School, Students***

I. INTRODUCTION

Over the past few years, concerns surfaced by various governmental bodies, school administrations, community interest groups, and other organizations about the lack of clarity and specificity in financial literacy policies. It is essential to have adequate knowledge of finances to make sound financial decisions (Contreras, 2021). Therefore, promoting financial literacy has gained more attention lately. Felipe et al. (2017) emphasized the importance of financial literacy in assisting individuals in making informed financial decisions to achieve financial well-being.

Swiecka's (2020) research indicates that financial literacy is critical to the long-term growth of both individuals and society. Despite increased financial literacy research over the past decade, experts still define it differently, indicating the need for further research. A significant demand for more research on financial literacy was present, as evidenced by scientists worldwide who continue to study it. Understanding finance is crucial in making informed financial decisions and exhibiting sound financial behavior, as stated by Lusardi (2019). Therefore, an individual's financial decision-making abilities depend on their knowledge and understanding of personal finance, according to Lusardi (2017).

A study conducted in eight European countries found that students who receive financial advice from friends or parents with high income levels possess more knowledge about personal finance. Although parents play a crucial role in shaping their children's financial literacy, recent studies suggest that environmental factors and technology also significantly influence (Ergün, 2018). However, it is unclear whether senior high school students possess adequate financial knowledge and if they are aware of their level of financial literacy. A financial stewardship plan can serve as a roadmap for better financial decisions.

The main goal of this study was to evaluate the financial literacy levels of senior high school students as a foundation for financial stewardship plans. The researchers aimed to address the following questions: (1) What is the level of financial literacy among senior high school students? (2) What financial challenges are they encountering as senior high school students? (3) What are the possible financial stewardship plans yet to be proposed for them?

II. METHODOLOGY

The researchers employed a descriptive-quantitative research design to analyze financial literacy among Senior High School students in the Philippines. Through random selection, 90 senior high school students became respondents to the study. The survey instrument was created with due care and attention to detail and validated, taking inspiration from National Center for Education Statistics (NCES) questionnaires to ensure the reliability and validity of the questions (National Center for Education Statistics, 2018). The structured questionnaires, featuring a Likert-scale checklist, facilitated participants in expressing their opinions and experiences on various financial topics. Subsequent analysis involved the utilization of descriptive statistics. The results were computed using Google Sheets because of its accessibility and collaborative capabilities. Moreover, participant consent was obtained in pursuing ethical research, confidentiality was assured, and rights protection was emphasized. This comprehensive approach upholds credibility and prioritizes participant well-being and data integrity. This research presents valuable insights into students' financial literacy challenges in the Philippines. The researchers also employed the following criteria to assess the level of financial literacy among senior high school students:

Criteria for a Likert scale with three (3) choices:

Mean Score	Interpretation of the Mean
1.00-1.66	High (H)
1.67-2.34	Moderate (M)
2.35-3.00	Low (L)

Criteria for a Likert Scale with four (4) choices:

Mean Score	Interpretation of the Mean
1.00-1.75	Very High (VH)
1.76-2.50	High (H)
2.51-3.25	Low (L)
3.26-4.00	Very Low (L)

III. RESULTS AND DISCUSSION

This section shows the results and discussion of the study

1. Level of financial literacy

Like others, senior high school students also suffer from some financial challenges. Most students need help to buy school supplies and save money, especially if they live in a family with a low income, have low financial literacy, or have much debt.

Table 1: Exposure of Senior High School Students to Financial Education

Responses	Frequency (f)	Percentage (%)
In a subject specifically about managing your money		
Yes	78	86.67
No	12	13.33
TOTAL	90	100
At school, as part of another subject or class		
Yes	69	76.67
No	21	23.33
TOTAL	90	100
In a subject specifically about managing your money		
Yes	68	75.56
No	22	24.44
TOTAL	90	100

Table 1 demonstrates whether or not the senior high school has learned money management skills in class. Based on the results, 86.67% of the students said they had learned money management in school, either in a class or

subject dedicated to the topic. While 76.67% said they learned it in another subject or class, and 75.56% said they learned it outside school. This implies that most respondents have had some exposure to financial education during their time at school, whether the information was from their teachers or books related to the financing they are using. In addition, learning how to manage personal finances can have long-term benefits for them. This connects with the study of Bernheim et al. (2001), which indicates that those who completed a high school course on personal finance had lower debt levels and better savings rates.

Table 2: Exposure of Students to School Textbooks about Money Matters

Have You used a specific textbook on money matters?	**Frequency (*f*)**	**Percentage (%)**
Yes	35	38.89
No	55	61.11
TOTAL	**90**	**100**
Have you used a textbook on some other subject that discusses money matters?		
Yes,	38	42.22
No	52	57.78
TOTAL	**90**	**100**

Table 2 offers valuable insights regarding the prevalence of textbook usage as a source of information for individuals seeking to learn about financial management or money-related topics. The data reveals that within the past year, most respondents (59.45%) have not utilized any school textbooks to acquire knowledge in this area. Based on Table 1, it means that the students have learned about financing either from their teachers or their classmates. This also concludes that the students might not be familiar with some terms connected to financing.

Table 3: Knowledge of Senior High School Students About Financing Terms

Items	Responses(%)	
	Weighted Mean	Verbal Description
Call Option	2.34	Low
Dividend	2.22	Moderate
Diversification	2.21	Moderate
Credit Default Swap	2.2	Moderate
Depreciation	2.17	Moderate
Exchange Rate	2.07	Moderate
Compound Interest	1.94	Moderate
Return On Investment	1.8	Moderate
Interest Payment	1.79	Moderate
Wage	1.74	Moderate
Entrepreneur	1.71	Moderate
Central bank	1.7	Moderate
Shares/stocks	1.68	Moderate
Debit Card	1.66	High
Pension Plan	1.61	High
Incometax	1.6	High
Bank Loan	1.52	High
Budget	1.43	High
TOTAL	1.86	Moderate

Table 3 presents the results regarding the familiarity of students with commonly used financial terms. According to the study, the majority of students are familiar with concepts such as "debit card," "bank loan," "pension plan," "budget," and "income tax. " In contrast, they are less familiar with the "call option." According to the data, high school students understand frequently used financial terms at a moderate to high level. This is consistent with Table 1, which shows that students have had financial education and know the most basic financial terminology. As Holden et al. (2010) stated, pupils with financial education typically comprehend financial terminology more fully than those without it. The data can help researchers and marketers make informed decisions regarding which concepts require more explanation or education to facilitate better understanding among individuals who lack financial knowledge. The results also suggest that students may need more exposure to financial activities in school.

Table 4: Exposure of Students to Activities Involving Financing in Class

Items	Responses(%)	
	Weighted Mean	Verbal Description
Discussing the ways in which money invested in the stock market changes value over time	2.02	Moderate
Discussing the rights of consumers when dealing with financial institutions	1.96	Moderate
Exploring ways of planning to pay an expense	1.82	Moderate
Analyzing advertisements to understand how they encourage people to buy things	1.79	Moderate
Describing the purpose and uses of money	1.76	Moderate
Exploring the difference between spending money on needs and wants	1.72	Moderate
TOTAL	1.86	Moderate

Table 4 represents how often the respondents encountered different things related to financing and saving. The majority of the students had only sporadically experienced these things, according to the statistics in the table. Nevertheless, it also suggests that the most common activity they encounter is examining the difference between spending money on necessities and desires ($\bar{x}$=1.72). The majority of students who report this. On the other hand, they have encountered least frequently examining how the value of money invested in the stock market changes over time ($\bar{x}$=2.02). These findings suggest that while students have some exposure to financial concepts, there is still room for improvement in their understanding and application. Moreover, they may acquire those improvements from sources other than their classes. This also applies to the study of Bernheim et al. (2001), which found that having financial knowledge may fade over time without further practice and learning.

Table 5: Source of the Respondents in Financial Information

Parents/guardians or other adult relatives	Frequency (f)	Percentage (%)
Yes	78	86.67
No	12	13.33
TOTAL	90	100
Friends		
Yes	69	76.67
No	21	23.33
TOTAL	90	100
Television Or Radio		
Yes	68	75.56
No	22	24.44
TOTAL	90	100
The Internet		

Yes	79	87.78
No	11	12.22
TOTAL	90	100
Magazines		
Yes	25	27.78
No	65	72.22
TOTAL	90	100
Teachers		
Yes	69	76.67
No	21	23.33
TOTAL	90	100

Table 5 provides information on the sources from which students learn knowledge about financial matters. The table indicates that 86.67% of the students obtain this information from their parents, while only 27.78% rely on magazines for financial information, the least preferred source. Moreover, a study conducted by Xu and Feng in 2018 demonstrated that parents who communicate openly and positively about finances usually have children with higher levels of financial literacy. This highlights the significant role of parents in developing their children's financial literacy and emphasizes the need for effective communication and education within families.

Table 6: Frequency of Financial Communication among Students

Items	Responses (%)	
	Weighted Mean	Verbal Description
News related to economics or finance	2.5	High
Your spending decisions	2.47	High
Your savings decisions	2.33	High
The Family Budget	2.27	High
Cash to purchase items you wish to buy	2.14	High
TOTAL	2.34	High

Table 6 presents how students converse with their parents and relatives about money-related discussions. The table shows that most students talk about money once or twice a week, or nearly every day regarding savings decisions, family budgets, and money for items they wish to buy. However, It's interesting to observe that an average of 2.5 of the respondents, which is nearly too low based on the criteria, engage in conversations about news related to economics and finance, indicating that these topics may not be as prevalent in their daily lives. Nevertheless, it is essential to emphasize the importance of discussing ways for students to earn their income instead of relying solely on the support of others.

Table 7: Money Sources of Senior High School Students

An allowance or spending money for regularly doing chores at home	Frequency (f)	Percentage (%)
Yes	57	63.33
No	33	36.67
TOTAL	90	100
An allowance for spending money, without having to do any chores		
Yes	53	58.89
No	37	41.11
TOTAL	90	100

Working Outside of School Hours (e.g., summer job, part-time work)		
Yes	20	22.22
No	70	77.78
TOTAL	90	100
Working in a Family Business		
Yes	29	32.22
No	61	67.7
TOTAL	90	100
Occasional Informal Jobs(e.g., babysitting or mowing lawns)		
Yes	25	27.78
No	65	72.22
TOTAL	90	100
Gifts from friends or relatives		
Yes	71	78.89
No	19	21.11
TOTAL	90	100
Selling Things(e.g., at local markets or one bay)		
Yes	36	40
No	54	60
TOTAL	90	100

Table 7 describes where the students get their money. The data reveals that most students, specifically 78.89%, obtain their funds from friends or relatives who kindly give them money. On the other hand, a smaller proportion of students, comprising only 22.22% of responses, earn their money by working outside school hours. These findings shed light on the diverse financial backgrounds of the students and the circumstances regarding how they obtain money to support themselves. Once they have this money, it is up to each student to decide how to use it wisely and responsibly; this will show how well they manage their finances.

Table 8: Practice of Students on Managing Their Cash

Items	Responses (%)	
	Weighted Mean	Verbal Description
I need to ask my parents or guardians for permission before I spend any money on my own.	2.44	High
I can decide independently what to spend my money on.	2.07	High
I can spend small amounts of my money independently, but I need to ask my parents or guardians for permission for larger amounts.	1.92	High
I am responsible for my Money Matters(e.g., for preventing theft)	1.91	High
Average Weighted Mean	2.09	High

Table 8 study focuses on how self-sufficient students manage their finances. It reveals that a majority of students, approximately 1.91, handle their financial matters responsibly. On the other hand, an average of 2.44 students still rely on the permission of their parents or guardians before spending money. This highlights the significance of financial education and literacy in enabling young people to make informed choices when buying goods, managing their finances, and gaining financial independence.

Table 9: Frequency of Comparing Products among Senior High School Students

Items	Responses (%)	
	Weighted Mean	Verbal Description
Buy The Product Without Comparing Prices	2.56	Low
Wait until the price of the products gets cheaper before buying it	2.04	High
Compare Prices in Different Stores	1.74	Very High
Compare Prices Between a store and an online store	1.69	Very High
Average Weighted Mean	2.01	High

Table 9 It is intriguing to observe the level of enthusiasm exhibited by the students when it comes to utilizing their allowance for the purchase of new items. Most students ($\bar{x}$=1.69) have indicated that they always conduct a thorough cost evaluation between in-person and online retailers before purchasing. This demonstrates their sense of responsibility and informed decision-making regarding spending their money. This indicates that students are savvy shoppers conscious about getting the best value for their money. The findings also highlight the importance of competitive pricing and convenience in attracting student consumers. Aside from understanding how students consume their money, it is also important to link smart shopping habits with convenient saving options.

Table 10: Saving Money Preferences of Senior High School Students

Items	Responses(%)	
	Weighted Mean	Verbal Description
A debit card	2.68	Low
An account with a bank or credit union	2.42	Low
A mobile app to access your account	1.69	Moderate
Average Weighted Mean	2.26	Moderate

Table 10 tells if the students have an account where they can save their money. The data shows that around ($\bar{x}$=1.69) of the students have a mobile to access their account, highlighting the growing prevalence and convenience of digital banking solutions. It is pertinent to highlight that an average of some students ($\bar{x}$=2.68) favor utilizing traditional debit card usage to save money. Financial organizations and instructors who want to learn more about the financial needs and preferences of the student body today may find this material invaluable. They can effectively meet the demands of the students and give them the resources they need to make wise financial decisions by acknowledging and accommodating their preferences.

Table 11: Confidence of Senior High School Students in Different Financial Situations

Items	Responses (%)	
	Weighted Mean	Verbal Description
Making a money transfer (e.g., paying a bill)	2.72	Low
Filling in forms at the bank	2.71	Low
Understanding a sales contract	2.66	Low
Keeping track of my account balance	2.63	Low
Understanding bank statements	2.56	Low
Planning my spending with consideration of my current financial situation	2.43	High
Average Weighted Mean	2.62	Low

Table 11 describes the level of confidence the students feel when doing something connected to money matters. The findings reveal that the students exhibit relatively lower confidence when transferring money. However, they have more confidence in monitoring their account balance.This implies that there might be some areas where the students need further guidance and support, especially in making money transfers. In today's digital age,

maybe electronic transactions feel more familiar to students.

Table 12: Confidence of Students on Different Financial Situations Electronic Devices

Items	Responses(%)	
	Weight Mean	Verbal Description
Paying With A Debit Card Instead Of Using cash	2.82	Low
Paying With Mobile Device(e.g., cell phone or tablet) instead of using cash	2.54	Low
Keeping Track of balance	2.5	High
Transferring Money	2.48	High
Ensuring the safety of sensitive information when making an electronic payment or using online banking	2.42	High
Average Weighted Mean	2.55	Low

Table 12 indicates the level of confidence displayed by the students when using digital or electronic devices outside of the bank. The results have shown that most students are not entirely comfortable performing transactions using digital devices, particularly when using a debit card instead of cash, as reported by $\bar{x}$=2.82 individuals. However, most students exhibit a high degree of confidence in keeping track of their balance, making payments via mobile devices, and ensuring the security of their private data while using online banking or electronic payment methods. These findings suggest that while certain reservations exist among students regarding specific aspects of digital transactions, they generally feel at ease using technology for financial purposes. Nonetheless, it remains crucial that they handle their finances responsibly overall.

Table 13: Financial Practices of the Respondents Within 12 months

Checked that you were given the right change when you bought something	Frequency (f)	Percentage (%)
Yes	83	92.22
No	7	7.78
TOTAL	90	100
Talked to someone about the job you would like to do when you finish your education		
Yes	77	85.56
No	13	14.44
TOTAL	90	100
Complained that did not have enough money for something wanted to buy		
Yes	68	75.56
No	22	24.44
TOTAL	90	100
Bought something online (alone or with a family member)		
Yes	79	87.78
No	11	12.22
TOTAL	90	100
Did voluntary work		
Yes	50	55.56
No	40	44.44
TOTAL	90	100

Made a payment using a cellphone		
Yes	68	75.56
No	22	24.44
TOTAL	90	100
Bought something that cost more money than you intended to spend		
Yes	62	68.89
No	28	31.11
TOTAL	90	100
Checked how much money you have		
Yes	83	92.22
No	7	7.78
TOTAL	90	100

Table 13 depicts whether the students have experienced something connected to money matters. Based on the findings, 92.22% of the students checked if they were given the right change when they bought something and checked how much money they had. While few (55.56%) of the students said they did voluntary work, These results imply that most students prioritize financial responsibility and awareness; however, it is equally critical to establish clear objectives regarding how they intend to utilize their funds.

Table 14: Perspective of Senior High School Students When Talking About Money Matters

Items	Responses (%)	
	Weighted Mean	Verbal Description
Money matters are not relevant to me right now.	2.69	Low
I enjoy talking about money matters.	2.19	High
Young people should make their own decisions about how to spend their money.	1.89	High
I would like to run my own business in the future.	1.72	Very High
Average Weighted Mean	2.12	High

Table 14 The data indicates the level of agreement among students on financial issues. An average score of 1.72 shows that most students aspire to start their own company. Moreover, 2.69 of the respondents disagreed that financial problems are unimportant to them presently, proving that they understand the significance of money even at this early stage. This could be attributed to various factors such as financial independence, career aspirations, or simply a desire to be financially stable.

In general, data indicates that students in senior high school showed financial literacy. However, there is still room for improvement in understanding and application. The findings suggest several areas for future action, such as developing engaging and accessible financial education programs tailored to various learning styles and needs, encouraging family conversations about money matters and utilizing relevant resources to support parents in this role, and promoting responsible digital financial practices while ensuring security and awareness of risks, considering incorporating student preferences like mobile banking options into financial education resources and encouraging students to explore their financial goals and develop plans for achieving them. Nonetheless, students may still face specific challenges regarding saving, like unexpected expenses or limited income.

2. Financial Challenges Senior High School Students Face

According to the study's findings, 82.22% of students who responded to the survey indicated that they still had some financial difficulties, despite having a high degree of financial literacy. It agrees with the study of Adepoju (2020), which says that budgeting and saving were major areas of difficulty for students.

Table 15: Financial Challenges

Items	Frequency (f)	Percentage (%)
Too much Expenses	32	43.24
Lack of Allowance	17	22.97
Budgeting	12	16.22
No Challenges	7	9.46
Family Financial Problems	5	6.76
Can't Save enough	1	1.35
TOTALl	74	100

Table 15 describes the common financial challenges most senior high school students face. Among students, 43.24% said handling high expenses was their primary concern. They described difficulty balancing school supplies, transportation costs, and other bills with their available resources. Additionally, some students acknowledged challenges with controlling impulse spending. This finding connects with the observation of Chapman and Huston (2010) that many students struggle with similar expenses, highlighting the widespread nature of this challenge.

Another significant concern involved, according to 22.97% of the students, is the availability of personal funds. Some students reported limited allowances, while others indicated having none at all. It supports research by McCarthey and Ormond (2015) that indicates the capacity of students to attend to basic needs, engage in classroom activities, and interact with classmates may be hampered by unreliable access to personal cash. These findings highlight the importance of addressing expense management and accessible funds for senior high school students. Supporting them with financial literacy tools and strategies and ensuring equitable access to resources can help them navigate financial challenges, promote academic success, and foster broader social participation.

3. Financial Stewardship Plan for Students

Based on the findings of the study, School and personal expenses garnered the highest percentage in Table 2.1, which pertains to financial challenges encountered by students. A lack of allowances, Budgeting, and Insufficient savings followed this. Despite some students claiming that they do not face any financial difficulties, it is still imperative to implement a Financial Stewardship Plan for their present and future circumstances. Implementing such a plan can assist students in effectively managing their finances while cultivating good financial habits. Brahmana and Memarista's (2017) research further revealed that financially literate individuals who exhibit motivation towards saving money are more likely to have better financial expenditure planning skills. As such, the researchers recommended implementing a Financial Stewardship Plan among senior high school students to equip them with the necessary tools needed to overcome existing and potential monetary obstacles both now and in the future. Financial Stewardship is the responsible management and monitoring of financial resources (Gatawa, 2022), learning about financial stewardship can help students learn about saving, budgeting, and managing their debts which are essential for their financial future. The proposed plan items are outlined below:

1. Integration of money management skills in subjects and classes with related financial literacy areas such as Fundamentals of Accounting 1 & 2, Business Finance, and Entrepreneurship among others.
2. Explore related e-books or educational apps on financial literacy to engage students in a pleasant and dynamic learning experience.
3. Strengthen financial literacy lessons to address varying levels of familiarity with financial terminologies.
4. Invite financial advisors to lecture students about proper financial management.
5. Facilitate parental engagement in financial literacy through focused group discussions about finances within families and options for schools to offer resources to empower parents to effectively communicate financial concepts, thereby augmenting students' overall financial literacy.
6. Promote regular financial discourse within family settings to enrich students' understanding of economic fundamentals and nurture their capacity for financial independence.
7. Introduce the concept of saving for future purposes and responsible debt management to students in financial literacy education, to help them for their long-term financial welfare.

8. Expand financial education initiatives to instill responsible financial habits in students, ensuring they possess the knowledge and confidence to manage their finances autonomously and thrive in an increasingly complex financial landscape.
9. Support students by offering guidance on adopting cost-conscious shopping behaviors and providing accessible saving options, thus enabling them to build strong financial skills and make informed financial decisions.
10. Personalize financial services to align with student preferences, integrating digital banking solutions and acknowledging the enduring popularity of traditional debit card usage for savings. This guarantees effective assistance for students in making well-informed financial decisions.
11. Expose students to different financial scenarios in which parental guidance and support are still involved. This would enable students to become more self-assured in a variety of financial situations and, eventually, independent in carrying out such transactions.
12. Address varying levels of confidence in using digital devices for financial transactions by implementing targeted digital financial literacy programs to equip students with the necessary skills to handle digital financial activities confidently and responsibly.
13. Encourage students to apply financial principles to real-life circumstances by providing activities such as financial goal-setting and budgeting as a stepping stone for them to deepen their understanding and enhance financial awareness.
14. Develop personalized financial literacy programs, promote family discussions on money matters, and support responsible digital financial practices and planning for financial goals, while addressing saving challenges like unexpected expenses or limited money.
15. Assist students in creating and developing accurate budgets that outline all income and expenses, categorizing expenses as fixed or variable to discover areas for possible savings.

IV. CONCLUSION

In summary, the financial literacy assessment among Senior High students revealed a generally high level of financial literacy, with room for improvement in certain areas. While students encountered financial concepts, textbooks proved to be less impactful, highlighting the need for alternative resources. Parental guidance played a crucial role, alongside formal education, in shaping financial literacy. Despite proficiency in basic financial tasks, students faced challenges such as high expenses and limited personal funds. The researchers recommend that students create a financial stewardship plan that presents financial stewardship plan items mentioned above to enhance their financial literacy thereby increasing chances for long-term financial success.

V. RECOMMENDATIONS

The researchers suggest the following actions based on the results of their study about the financial literacy of senior high school students:

1. Develop and implement comprehensive financial education programs in schools to address specific knowledge gaps among students through a Financial Stewardship plan. Focus on debt management, investing, saving, and budgeting. According to research, children and young people need financial education, and the demand is strong and evident. For this reason, a plan of action is needed for curriculum implementation, teacher training, and incorporating financial education into state standards (McCormick, 2009).
2. Promote and assist parental participation in financial literacy. The study emphasizes how important adult relatives and parents are in helping students develop their financial literacy, and according to Cude et al. (2006), parents play a key role in shaping the early financial habits of kids. Create courses or programs to encourage parents to help their kids learn about money management. Parents and peers, who serve as the primary source of financial information, greatly enhance the financial literacy of students (Kovarova-Simecek & Aubram, 2018).
3. To improve financial literacy, use various resources, including the Internet, specifically the use of e-books. It provides interesting and developmentally appropriate content to stimulate the curiosity of students and support learning outside the conventional classroom. It is fascinating to notice that higher levels of financial literacy can arise from using the Internet to handle finances. The beneficial effects of the Internet appear to exceed the bad, despite its reputation for information flow that may lead to false information (Sabri and Aw 2019).
4. Navigate finances, set clear goals, and practice

self-control as it can be powerful tools for senior high school students. Studies by Stolper and Walter (2017) highlight the importance of sticking to financial plans and avoiding impulse purchases to achieve financial goals. While resisting tempting buys can be challenging, saying no to unnecessary expenses allows students to save money and reach their objectives faster.

5. Lastly, encourage students to make independent financial decisions. Based on the results, the confidence of students in their ability to manage money on their own varies, so efforts should be made to give them more control over this area. Also, young adults are in the process of transitioning from financial dependence on their parents to financial independence (Xiao & Kim, 2014).

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Creative Authenticity: A Framework for Supporting the Student Self in Craft Education

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Abstract— *This article introduces a pedagogical approach in design education referenced as creative authenticity. Creative authenticity is defined as an ongoing process of learning to create through intrinsically motivated, self-aware and self-affirming actions and rationales. The concept is grounded in Constructivist learning theory, Postmodernist views of pluralism and cultural position, Anthony Giddens' theory of reflexive identities, and scholarship on intrinsic motivation in learning. This ideology seeks to personalize the learning experience for each student in ways that are meaningful to their person, not just useful to the design industry, at large. This conversation proposes four samples of methodology by which to infuse creative authenticity into curriculum as a starting point for shaking off implicit biases; focusing on student learning and growth; initiating meaningful and empowering discussions; and redefining success through collaborative and participatory educational design. This work promotes teaching with creative authenticity as a foundation to help students realize their strengths through their ever-evolving identities. In a broader context, authenticity in education supports marginalized groups to see themselves, their histories and their experiences authentically reflected in their education and work.*

Keywords— ***creative authenticity, identity, design education, dialogue, collaboration, introspection***

I. INTRODUCTION

Providing an authentic learning experience in the design classroom is often viewed through the lens of practicality and applicability to the professional field. 'Authenticity' is thus seen as recreating an experience in the classroom that is analogous to how it is in the 'real world' (e.g., design studios and agencies or in-house departments). Martha C. Nussbaum warns us that leaning into the corporatization of higher education emphasizing usefulness and timeliness over thoughtfulness and criticality—could lead to the production of 'generations of useful machines, rather than complete citizens who can think for themselves, criticize tradition, and under- stand the significance of another person's sufferings and achievements' (Nussbaum, 2010, 2). In opposition to the over-commodification and corporatization of the university classroom, which foregrounds learning as largely pre-vocational instead of scholarly (Cote´ & Allahar, 2011), we suggest a different view of authenticity—one rooted in creativity and identity—as a means of creating more meaningful, empowering and engaging learning experiences for our students.

A study by Reid & Solomonids (2007) showed that students' experience of design and design learning is 'strongly related to sense of self' (Reid & Solomonids, 2007, 37). According to their findings, students can achieve a 'Sense of Being' through higher engagement and creativity, which enables them to consider the personal effects of their work and their emotional commitment towards specific design problems (Ibid., 28). This personal engagement with course content leads to students gaining intrinsic motivation for learning and growth, identified by educational scholars as a key factor for high performance and critical thinking. The aim of our perspective—what we are calling creative authenticity—is to personalize the learning experience for each student in ways that are meaningful to them, not just useful to the design industry. This new view does not negate the applicability to professional work as an integral part of learning, but enhances it by providing internalized understandings of,

and progressive challenges to, the future of inclusion in the profession.

Issues Surrounding Authenticity in Education

As with any progressive suggestion of this sort, it should be noted that there are arguments against the case of authenticity in relationship with education. First and foremost, defining authenticity—what Dutton calls a 'dimension word' whose meaning shifts depending on the dimensions being discussed (Dutton, 2003)—is a challenge in and of itself. Jongman-Sereno & Leary (2019) argue that behavioral researchers often disagree with the best way to conceptualize and measure authenticity. Further, they discuss the implications of authenticity for psychological well-being thus arguing whether or not, in the grand scheme of things, behaving authentically is always desired. For example, they explain, 'Contemporary perspectives implicitly assume that authenticity is uniformly beneficial, without recognizing that behaving congruently with one's undesirable attitudes, beliefs, values, motives, and other characteristics can be highly problematic' (Jongman-Sereno & Leary, 2019, 137). In addition, they raise the argument of inevitable authenticity; that all intentional behaviors, regardless of external pressures, are shaped by people's personal characteristics, attitudes, beliefs, values and motives—calling into question if anything we do can ever be considered 'inauthentic'. Tracy and Trethewey (2005) add to this discussion by highlighting a perceived dichotomy between the 'real self' and the 'fake self,' arguing that this dichotomy encourages '(a) strategized self-subordination; (b) perpetually deferred identities; (c) auto dressage; and (d) the production of organizationally preferred "good little copers"' (Tracy & Trethewey 2005, 170). As will be seen later in this paper, a poststructuralist approach to identity is applied when discussing authenticity as a crystallized, intersectional and reflexive construction.

Additionally, the issue of evaluating authenticity in creative works brings its own challenges. In a study of two undergraduate arts programmers, Belluigi (2020)

found that while authenticity—which she defines as intentionality and authorship was discussed by faculty throughout the process of the students' creation of work and writing of artist statements, that content was rarely 'referenced, discussed nor given weight during grading processes' (Belluigi, 2020, 10). Studies in education (Meyers, Rowell, et al. 2019) show that designing policies that uphold academic standards while allowing for flexibility communicates empathy, understanding and inclusion of authenticity. The current design of higher education classrooms does not enthusiastically support this kind of flexibility. In actuality, it often presents itself as a rigid classroom structure where we experience imbalanced student to teacher ratios, a fixation on timely completion of degree plans, strict attendance policies, hard grading, etc. These terms make it difficult for students or educators to validate flexibility or access opportunities to discuss authenticity in the classroom.

Authenticity through the Lens of Creativity

Creative authenticity, as we define it, is an ongoing process of learning to create through intrinsically motivated, self-aware and self-affirming actions and rationales. It is grounded in Constructivist learning theory (Chuang, 2021), Postmodernist views of pluralism and cultural position (Davis, 2012), Anthony Giddens' theory of reflexive identities (Bontempo e Silva & del Carmen Flores Mac´ıas 2017), and scholarship on intrinsic motivation in learning. By using a definition of authenticity that incorporates aspects of what Newman & Smith (2016) classify as 'value authenticity' and 'self-authenticity,' we provide opportunities for the student to determine their own authentic creative identity through the act of making and reflecting on their work. Who they are as 'creatives', or who they see themselves as, is constructed through critical analysis of what they create (output/execution/ style), how they create (both the physical and mental processes of creation), and why they choose both the what and how of their creative endeavors. It is important to note that this is a process—which, by its very nature, is not finalised. Creative authenticity is not about creating a fixed, unchanging identity, but continually adding layers of understanding to one's sense of self through making, reflection and discussion—akin to Tracy and Trethewey's concept of the 'crystallized self' (2005, 186).

Creative authenticity is not to be confused with Auteur Theory (Sarris, 1973, 50–51) in that the process of identifying one's own creative authenticity is not a means to generate sole ownership or auteur ship over one's work. We do find it important, though, for the designer (and design student) to have a personal connection to and perspective on their work, regardless of perceived level of control or agency. This connection and understanding of personal contributions to work—a degree of authorship—allows the designer/student to, in the words of Michael Rock (2009, 114), 'rethink process, expand design methods, and elaborate our historical frame to incorporate all forms of graphic discourse.' By opening the design student's eyes to the inherent agency, they have in any kind of creative endeavors, we help them to challenge their preconceptions and assumptions about client work, collaborative work and their role in the creative process.

When a student takes their responsibility of the design practice beyond the realm of production, they are invited to recognize the obligation they have over their design

research and practice. Schiffer (2020, 419) states, 'closely linked to reflexivity are considerations of positionality'. Positionality describes people's social standing or representation as influenced by personal characteristics such as gender, marital status, age, level of education, ethnicity and even personality. Thus, positionality is entwined with issues of intersectionality, implicit bias, and of power and representation. Schiffer affirms, 'designers ought to reflect on the values, attitudes and assumptions they have carefully to negotiate power relations and methods during the design process', (Ibid., 419). This ideology recognizes that in order to more fully practice creative authenticity and student agency in our design classrooms, it includes a call for renouncing outdated power models between student and educator as they claim their own education and style of learning.

II. APPLYING CREATIVE AUTHENTICITY IN DESIGN CLASSROOMS

There are different means of including creative authenticity into curricula, each with its own strengths and purposes. From our collective experience, we have found the easiest application in project-based learning, though we believe that the concepts and methods presented in this essay are applicable (with some adaptation) to any type of creative coursework. Just as we seek to inspire creative authenticity in our students, we recognize that we, too, must bring ourselves and our identities to our classrooms in order to lead by example and create a safe space open to vulnerability, experimentation and discovery. Even between the two of us, our application of the methods varies as we bring our own approaches, experiences, knowledges, skills and identities to our pedagogy. We encourage educators to take our work and shape it to fit their own personal pedagogy and teaching styles.

Method 1: Leading with Why

In our classrooms, we often see students hyper fixate on the what of their work: the output, style, execution, materiality and form of their work. In critique, especially in foundational classes, students focus on the colors, shapes and other formal elements of design when evaluating others' work without much thought or question to purpose or intent. On the surface, this makes sense; our students, especially in today's world, are already well-accustomed to visual language when they step into their first design classroom and are being trained in the fundamentals of visual language. Many are entering our programmers with pre-established knowledge of creative software, arts backgrounds and even their own design practice (e.g., making logos for friends, e-motes and frames for their personal Twitch streams and TikTok videos), not to mention the over-abundance of visual stimuli in their daily lives. Leading with Why reframes critique and evaluation of the what through a preliminary discussion of why.

To begin, students describe the purpose of their work without yet showing the outcome. They lay the foundation for comprehension and evaluation by providing the objective of the work and any relevant context. This introduction helps create a framework by which the other students (and the faculty) can offer constructive criticism based less on aesthetic value and visceral reactions, and more on the success of the work in reaching its desired outcome(s) or objective(s). From an educator's viewpoint, Leading with Why also provides a glimpse into the nuances of how a student approaches their work, creating opportunities to highlight individual strengths, areas of interest, as well as areas of improvement.

Method 2: Reflections on Work and Process

It is a common gesture to use ice breaker exercises at the beginning of a semester or at the start of a student gathering to better understand group working dynamics, build rapport and community, and help foster a productive learning environment. This practice, while helpful, is often offered with a short timeframe and is relatively superficial.

We advocate for practicing deeper, more mindful activities that cultivate the foundation for transformative learning experiences. According to Taylor and Cranston (2012, 76), transformative learning is a process by which we 'transform our taken-for-granted frames of reference (meaning perspectives, habits of mind, mindsets) to make them more inclusive, discriminating, open, emotionally capable of change'. This, in turn makes our perspectives reflective so that they may provoke new beliefs justified to guide our actions. To do this, we experiment and formulate a series of reflective questions for students which invite them to investigate their processes of making and thinking. The questions allow students not only to answer directly, but to consider the process by which they have answered, and why they have answered that way in the first place. It is in this practice that students practice active reflection. Rothstein and Santana (2011, 120) support reflection as it 'gives students the opportunity to name for themselves what they are learning, and when they do that, they own the skills more strongly and deepen their understanding of how they can use what they learned in other situations'. The questions, while simple on the surface, intend to provoke thoughtful contemplation, and an opportunity for students to notice the uniqueness of their own and their peers' creative identity.

For instance, we might ask each student to creatively respond to prompts such as: 'What is your superpower?', or 'What brings you joy?'. Then, we propose they analyses

their responses based on questions of personal and creative authenticity (see Table I).

Giving the students agency over how they respond and having them reflect on

that choice invites them to explore the authenticity of their creative identity and encourages interest in their work and processes.

Table I Personal and Creative Authenticity questions for student reflections

Personal authenticity	Creative authenticity
What was the subject of your response?	**What** was your process for creating your response?
How did you choose that subject?	**How** did you choose that method/process?
Why do you think you chose that subject?	**Why** do you think you chose that method/process?

This teaching is formed from an asset-based mindset, or strength-based teaching, where curriculum deciphers students' potential by focusing on their innate talents and interest in contrast with a deficit-based framework which focuses on what the student lacks. Asset-based concepts stem from a capacity-focused community development process by Kretzmann and McKnight (1996), which pushed for mapping and recognizing the skills and experience of community-based organizations. This type of approach adapts for educational encounters where educators meet students where they are, authentically. According to Paris and Halim (2014), it is an infusion into culturally sustaining pedagogy that displaces the deficit model of teaching approach that spans years and years in the history of education in the United States.

The concepts of these exercises reappear in the form of statements in the more substantial projects to come later in the semester. In these statements, students are asked to submit their creative work alongside a Statement of Intent, a Statement of Process and a Personal Statement. Again, they are asked to understand their own creative authenticity and share not only what they made, but how they made it, and why they made it.

Method 3: Collaborative Assessment

As mentioned above, evaluating authenticity in creative work offers its own challenges. As educators, we bring our implicit biases into our classrooms, especially when critiquing and assessing work; this includes our subjective opinions about what constitutes 'good' work, or 'good' design, as well as what we deem important for our students to learn. According to Taylor & Cranston (2012, 81), education involves a 'transfer of authority from the educator to the learners,' adding that the 'successful educator works herself out of her job as educator and becomes a collaborative learner.' We can apply this philosophy by applying a participatory design strategy of working with our students to identify and implement core objectives and criteria for work. Likewise, through the lens of Human-Centered Design (Wheelock et al., 2020), design education requires not just the understanding of our students as the recipients and beneficiaries of learning, but as collaborative and equal partners in the act of learning.

One application of this method is through the philosophy of 'upgrading', which focuses on metacognition and understanding over compliance and execution. Alfie Kohn (2020, xvi) sums up the argument for upgrading as such: 'The more [students'] attention is directed to how well they're doing, the less engaged they tend to be with what they're doing' (original emphasis). Similarly, Rohrbach (2010) shows us that, in most design classes, assessment focuses solely on the artefacts created by students, not the learning process, 'which encourages students to work passively with the intent to please their instructors instead of striving to solve complex problems independently'. By shifting focus away from grades, the student is free to explore, practice, and learn through experimentation and failure, feed- back, and reflection rather than a numeric ranking from an esoteric and arbitrary rubric. This structure creates opportunities for more authentic engagement and intrinsic motivation for learning and success.

Upgrading can take many forms: through rubrics made collaboratively with student input, reflection essays/presentations done by students throughout their coursework, or 'grade contracts'—in which students and educators work together to identify the quality and deliverables necessary for different grade levels—to name just a few (Blum, 2020). These methods allow us, as educators, to differentiate our own goals for our students from their personal objectives for their education; to create a shared vision of what a course can and should be; and to help encourage and emphasize individually authentic understandings and applications of course content.

Method 4: Discussion and Dialogue

Throughout the application of our methods, we continue to find that uncovering a creative authentic identity requires as much extrospection as it does introspection. After practicing active reflection, the students are led to share their responses with classmates, creating awareness of differences and similarities between their and others' personal and creative authenticity. While the self-reflection exercises help unravel personal identity, it is the conversations and access to different perspectives which allow students to gain a deeper understanding of the

complexities of self. Transformative learning, mentioned earlier, requires constructive discourse to 'use the experience of others to assess reasons justifying these assumptions, and making an action decision based on the resulting insight' (Taylor & Cranston, 2012, 76).

Similarly, discussion around personal interpretations and perspectives situates

each student as an expert on their own lived experiences. As educator Josh Halstead (AIGA Eye on Design 2020) says, 'when we guide students through the process of honoring lived experience as expertise and questioning the role and function of design through non-design discourses, we invite them into this critical work,' with the 'work' being the deconstruction of perceived realities and challenging of dominant narratives. These discussions also allow us to better get to know our students on a more personal level, allowing us to craft individual learning plans, address personal barriers to learning and encourage areas of excellence and differentiation.

As educators, facilitating a space for intentional opportunities for students and educators to get to know one another through discourse at the beginning of (and throughout) a course helps build trust and foster a sense of community (Conrad & Donaldson, 2011). Building community cultivates inclusion as the birthplace for authenticity, empowerment and creativity. A research laboratory at the University of Ottawa led by Dr. Jude Mary C´enat invited people suffering from anxiety, stress and sleep deregulation during the COVID-19 pandemic to participate in sharing their experiences with others (Ce´nat et al., 2020). They discovered that inviting members to experience community in a collective, empathic and humanistic setting helped them recover effectiveness and motivation that will likely outlive the pandemic. Ce´nat shares, "Often resilience must be supported, and keeping research groups impersonal can result in losing bright students along the way." Facilitating a space of open discussion and dialogue gives all students not only permission to be themselves, but encouragement, release and actualization for the long run.

Situating Creative Authenticity

In a broader context, authenticity in education supports marginalized groups to see themselves, their histories and their experiences authentically reflected in their classes. In alignment with Diversity, Equity and Inclusion (DEI) efforts, creative authenticity follows the philosophy of culturally sustaining pedagogy, which 'positions dynamic cultural dexterity as a necessary good, and sees the outcome of 13

learning as additive rather than subtractive, as remaining whole rather than framed as broken, as critically enriching strengths rather than replacing deficits'. (Paris & Alim, 2017, 1).

Creative authenticity sits within the larger practice of decolonizing design education by centering the students' identities and embodiments within their process to, in the words of Josh Halstead, 'cultivate critical consciousness and emancipatory world building' (AIGA Eye on Design 2020). Creative authenticity is not just about our students, though; we, as educators, also bring our identities into our classrooms, along with our experiences, biases and perceptions. Educator Kim L. Morrison (2017, 180–181) relates, 'I am attempting to decolonize my mind. .so that I can participate as a scholar while describing the conditions of being a colonized scholar. while describing the conditions of being a decolonizing educator, while describing the conditions of being someone who was colonized through education, shifting constantly'. The critical reflection and investigation of our processes and understanding relate to our teaching and pedagogy as much as it relates to our students' learning. In essence, design educators need to design better learning experiences.

III. CONCLUSION

Elizabeth White (White, 2019) offers this statement on a more holistic idea of teaching: 'Teaching to the whole student requires taking layered complexities into account and shaping a definition of success that incorporates students' capacity to find personal fulfilment and make meaningful contributions to their communities; developing their skills to both navigate the world as it is and to make it as they want it to be'. We believe that teaching with creative authenticity in mind helps students realize their whole selves as a means to identify their own strengths and goals in an ever-shifting, ever-changing, ever-developing world of complexity. The methods introduced in this paper are a starting point for shaking off implicit biases; focusing on student learning and growth; initiating meaningful and empowering discussions; and redefining success through collaborative and participatory educational design. While we have already begun to implement these strategies in our classrooms through the methods mentioned above, we also see the potential for these strategies to build into workshops that promote creative authenticity in various communities seeking to understand and take ownership of their place in the world: immigrant populations, LGBTQ+ youth, even new parents. One such workshop was held at SXSW EDU 2022 in Austin, Texas with other educators as a way to introduce the framework and help other educators realize their own authentic identities within their classrooms. We believe that understanding one's ever-evolving identity is

an integral part of more fully and positively participating in society.

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Solar Based Garbage Cleaning Boat

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Abstract— *The aim of this project is to focuses on the working model of the river waste cleaning boat powered by solar. As we know the population of India increasing day by day and due to this the pollution also gets increase. The garbage with are produce by the peoples are the main cause of pollution. The most of the garbage are dumped or just thrown in the lake, river of other water resources. The garbage which are thrown in the water such as lakes, rivers and other water resources due to which the water get polluted because of which the water will harm the humans as well as aquatic life. In many of cities of India this is the major problem. To overcome this water pollution our project "Solar Based Garbage Cleaning Boat" is very helpful by collecting the garbage which are floating on the surface of water by a conveyor belt mechanism and put down in the trash collector. This project is very efficient and work on the solar energy no external power supply is required. We have battery to store the energy and used this energy for cleaning water surface. The main aim of this project is to minimize the manpower and time taken for cleaning the water bodies.*

Keywords— ***Solar, Motor, Conveyor Belt, Trash collector, Garbage, Pollution.***

I. INTRODUCTION

Cleanliness is the basic need of human society. We need to keep our environment and surroundings clean, but we limit ourselves to the areas in our own surroundings or our society. Maximum of the waste is thrown in the water bodies like seas, rivers, lakes, ponds etc. Hence it causes a high amount of water pollution.

Our project aims to get rid of this waste and clean the water surfaces. The whole world is currently facing a lot of problems regarding the poor condition of the environment we live in. Floating bottles, plastic bags and even toys have become a part of the marine environment in these recent times. Pitiful photos of such plastic debris washed ashore on the remote shorelines have frequently made headlines in news. Most of this plastic pollution is attributed to an increase in tourism, shipping, and fishing activities, etc. India also has drastically affected by this degradation and which has cause increase in water pollution. In India very common problem is water pollution.

Fig. 1: Waste garbage in the water.

To combat this challenge, we present an innovative project aimed at developing a solar power-based water trash collecting boat. This project combines renewable energy technology, waste collection mechanisms, and sustainable

practices to provide an efficient and eco-friendly solution for cleaning up our water bodies. The primary objective of this project is to design, develop, and deploy a solar power-based water trash collecting boat capable of efficiently removing floating debris from water surfaces.

The boat is totally works on solar power, which is free of cost. This boat will not require any external supply of energy so it saves the money. In day time the boat will stored the energy with the help of sun rays which are falling on the solar panel and at night time boat will start working and collect the garbage. The Main advantage of working at night time is the fewer crowds. In this way we support to "The Swatchha Bharat Abhiyan".

II. MOTIVATION

As India is developing in terms of technology very rapidly, it is quite important that the devices which are introduced need to be updated on a regular basis. Nowadays, all the devices are more dependent on digital technology rather than analog technology. So, people in the government cleaning sector can start using this boat in their Cleaning activities.

III. PROBLEM STATEMENT

In the absence of garbage disposal facilities, the practice of dumping garbage into nearby water bodies has become quite common in recent years and has posed long-term negative impacts both on biodiversity of the area and as well as on the local environment.

IV. SYSTEM DESCRIPTION

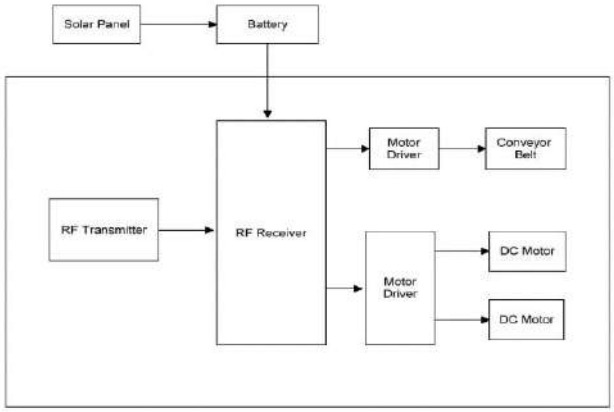

Fig. 2 Block diagram.

Our Main aim in this project is to lift waste from the water surface and collect them within a tray. We know that solar panels convert light energy into electrical energy which is DC in nature. Solar panel output energy is given to the charge controller that controls DC output of solar which is pulsating in nature and fed pure DC to charge the battery. As we know that battery is used to store the energy. This stored energy is given to all this circuitry for overall operation.

It consists arrangement of conveyor which is place on shaft of motor. Due rotation of motor conveyor rotated. As the conveyor is move, it collect water debris, waste garbage and plastics from water bodies. As the machine is placed within the water the waste debris in water will get lifted and it moves in upward direction. As the waste debris reaches the upper extreme position it'll get dropped within the tray. Hence this may end in cleaning of water surfaces and safe collection of waste debris from water.

V. COMPONENTS

- **RF Module**: The RF module comprises of an RF Transmitter and an RF Receiver. The transmitter/receiver (Tx/Rx) pair operates at a frequency of 434 MHz. RF transceiver module will always work in a pair that is it needs a Transmitter and Receiver to send and receive the data. A transmitter can only send information and a Receiver and can only receive it, so data can send from one end to another.
- **L293D Motor Driver Board**: The 293D is used to provide bidirectional drive current up to 600mA and voltage from 5V to 36V. L293D consist of the output clamping diodes for protection.
- **Motor**: The motor which is placed in the boat it can help to move the conveyor belt in any direction and collect the garbage. It can also help for moving the wheels of the boat in left or right side as well gives the direction to the wheels for moving in forward or backward direction.
- **Battery**: This boat is fully operated by battery. The battery which can run the conveyor belt and wheels so man can easily operate the boat and it requires very less effort.
- **Solar Panel**: A solar panel consists of photovoltaic cells, which can be used to generate electricity through photovoltaic effect. This energy used to charge the batteries. Solar output is given to the DC Regulators.
- **Propeller (Wheel)**: Propeller is used for giving the motion to the boat. The flopped Propeller is motorized in the boat so it can easily give the direction to the boat for moving in forwarding or backward direction.
- **Conveyor Belt**: In this machine we used the polyvinyl Conveyor Belt. This is controlled by the RF Module system using a motor driver circuit. This collects all

floating waste from the water surface and discharges it into the dustbin (Garbage collector).

- **Relay Module**: This module provides the protection to the microcontroller from the higher load current.
- **Pipes**: Polyvinyl chloride (PVC) is synthetic plastic polymer. These pipes are air enclosed. Pipes are used as a base of model (boat).
- **Garbage collector**: The garbage collector is made up of fiber material and it is connected with the conveyor belt so it can store the garbage which is collected by the conveyor belt and the water which is left in the dust material garbage collector can also remove that water.

VI. WORKING

In this project the foremost aim of this machine is to lift waste garbage from the water surface and dispose of it within the tray (garbage collector). It consists of an arrangement of conveyor which is placed on the shaft of the motor. Due rotation of motor conveyor rotated. Because the conveyor is moved, it collects water debris, waste garbage and plastics from water bodies because the machine is placed within the water the waste garbage in water will get lifted and it moves in an upward direction. Because the waste debris reaches the upper extreme position it'll get dropped within the tray. Hence this will end in cleaning of water surfaces and safe collection of waste debris from water. Propeller (Wheel) is used to drive the machine on the river and run with the help of a PMDC motor. The total electrical devices are controlled by an RF transmitter and receiver which are used to manage the machine remotely.

Collecting Mechanism is employed in our project to beat real time issues as thanks to water tension garbage is difficult to collect. By using this four bar mechanism, it rotated at a particular angle intended to gather the rubbish for the model. it's two windows open and shut as the user wishes using remote to ON and OFF the mechanism. Water wheel is bolted on a shaft which is placed aboard the frame. The aim of a water wheel (propeller) is to maneuver the machine forward or backward on water. Motor is used to rotate the water wheel with the assistance of a chain drive mechanism.

VII. APPLICATIONS

- It is applicable to reduce water pollution in rivers and ponds.
- It is useful to remove the sediments present in the water bodies to keep it clean.
- Can be easily installed for domestic sewage treatment.
- •It is useful to remove eichhornia (Water plants) from the top of the river.
- •It is also useful in fisher collect plant to collect solid impurities and dead fishes from river.

VIII. ADVANTAGES

- Use of renewable energy Sources.
- Easy to use and flexible.
- Need less manpower.
- Maintenance cost is low.
- Cost effective.
- Eco-friendly.
- This is efficient method.

IX. CONCLUSION

This boat can prove to be a helping hand in controlling the increasing problem of water pollution. This is simple and cost-effective water cleaning Mechanism. And is generally intended to support water trash cleaning and eliminating water contaminations like plastics, wastes, water trash which is coasting on stream and lake surface. This project is for keeping up human wellbeing and for expanding the existence of sea-going creatures.

Solar based trash removal systems will successfully replace manual drainage cleaning ways. So, it is economical and efficient using solar energy. This type of system is designed and fabricated successfully it works satisfactorily.

The water trash Collector concept can prove to be a helping hand in controlling the increasing problem of water pollution. It will also greatly reduce the problems caused by floating waste.

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An Overview of Supervised Machine Learning Paradigms and their Classifiers

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Abstract**—** *Artificial Intelligence (AI) is the theory and development of computer systems capable of performing complex tasks that historically requires human intelligence such as recognizing speech, making decisions and identifying patterns. These tasks cannot be accomplished without the ability of the systems to learn. Machine learning is the ability of machines to learn from their past experiences. Just like humans, when machines learn under supervision, it is termed supervised learning. In this work, an in-depth knowledge on machine learning was expounded. Relevant literatures were reviewed with the aim of presenting the different types of supervised machine learning paradigms, their categories and classifiers.*

Keywords**— *Artificial intelligence, Machine learning, supervised learning paradigms***

I. INTRODUCTION

For intelligent system to perform complex tasks that historically requires human intelligence such as recognizing speech, making decisions and identifying patterns (Staff, 2023), it requires the ability to learn from past experiences. Learning is a process that leads to change and it is an attribute that is possessed by humans. It occurs as a result of experience and increases the potential for improved performance and future learning (Ambrose *et al*., 2010). As the intelligence demonstrated by machines are said to be artificial, their learning ability is referred to as machine learning (ML). ML is a type of Artificial Intelligence (AI) focused on building computer systems that learn from data. It has applications in all types of sectors including manufacturing, retail, cyber-security, real-time chatbot agents, humanities disciplines, Agriculture, Social media, healthcare and life sciences, Email, Image processing, travel and hospitality, financial services and energy, feedstock and utilities (Bansal *et al*., 2019).

In the light of its applications, it is undoubtedly more valuable than other branches of AI because for a system to be intelligent, it must possess the ability to learn in order to improve the performance of their AI software applications over time and as well as possess the ability to adapt to changes. This in turn fuels the advancements in AI and progressively blurs the boundaries between machine intelligence and human intellect (Tucci, 2023).

II. MACHINE LEARNING

ML are computational techniques (scientific algorithms and statistical models) that enable computers to learn from data without being explicitly programmed. If programming is automation, then ML is automating the process of automation. It provides machines with the ability to learn independently (Ghahremani-Nahr *et al*., 2021) and makes programming scalable.

According to NetApp (2023), ML is made up of three parts. They are:

a) Computational Algorithm: A formal procedure describing an ordered sequence of operations to be performed a finite number of times (Falade, 2021). This is at the core of considering determinations.
b) Variables and features that make up the decisions.
c) Knowledge Base: The known facts which the system trains to learn from.

In a typical simple model of machine learning (Fig. 1), the environment supplies the information to the learning element which uses the information to make improvements in the knowledge base in order for the performance element to perform its task accurately. The kind of information

supplied to the machine by the environment is usually imperfect, with the result that the learning element does not know in advance how to fill in missing details or ignore details that are unimportant. The machine therefore, operates by guessing and then receives feedback from the performance element. The feedback mechanism enables the machine to evaluate its hypotheses and revise them if necessary.

Two different kinds of information processing are involved in machine learning. They are the inductive and deductive information processing. General pattern and rules are determined from raw data and experience in the inductive information processing and it is used in similarity-based learning where as in deductive, general rules are used to determine the specific facts and is used in proof of a theorem where deductions are made from known axioms to other existing axioms (Haykin, 1994).

In comparison with the traditional programming, ML uses data and output to run on the computer to generate a program which can then be used in traditional programming while traditional programming uses data and program on the computer to produce output (Brownlee, 2020).

(a) Traditional Programming (b) Machine Learning

Fig. 1: Typical simple model of machine learning

Machine Learning Classifiers

The technique for determining which class a dependent belongs to base on one or more independent variables is termed as Classification. The type of machine learning algorithm that assigns a label to a data input is known as Classifier.

Supervised Machine Learning Paradigm and their Classifiers

As the name implies, it is when a machine learns under supervision. This is the learning paradigm for acquiring the input-output relationship information of a system based on a given set of paired input-output training samples. The model is provided with a correct answer (output) for every input pattern (Samarasinghe, 2006) and as such referred to as "learning with a teacher" (Jain, 1996), that is, available data comprises feature vectors together with the target values. The learner (computer program) is provided with two sets of data, training set and test set. The training set has labelled dataset examples (solution to each problem dataset) which the learner can use to identify unlabeled examples in the test set with the highest possible accuracy as depicted in Fig. 2. The data is analyzed in order to tune the parameters of the model that were not in the training set to predict the target value for the new set of data (test data).

The major tasks of supervised learning paradigms are:

i. Classification: Labeled data and classifiers are used to produce predictions about data input classifications. The function is discrete and it is a categorical type.
ii. Regression: The function is continuous. The target variable is numeric.
iii. Forecasting (Probability Estimation): The function is a probability.
iv. The supervised learning paradigm classifiers are Decision trees, Naïve Bayes, Regression, Logistic Regression, Support Vector Machine (SVM), K-Nearest Neighbor (K-NN), Discriminant Analysis, Ensemble Methods and Neural Networks.

Decision Trees

This is a statistical classifier used for both classification and regression problems. It incorporates nominal and numerical values that are expressed as a recursive partition of the instance space. Decision tree is a graphical representation of a well-defined decision problem (Fig. 3). It consists of nodes that are concerned with decision making and arcs which connects the nodes (decision rules). The decision tree forms the rooted (directed) tree that has basically three types of nodes: the root nodes, the internal nodes and the terminal nodes. The root node originates from the tree and in turn is called the parent node. It has no incoming edges and zero or more outgoing edges. Every other nodes have one incoming node and are called child node. A node with outgoing edges is termed an internal node. It is also referred to as the test node. It represents the features of the dataset. Each internal node has exactly one incoming edge, two or more outgoing edges and splits the instance space into two or more sub-spaces based on the discrete function of the input attribute values (attribute test condition) to separate records that have different characteristics. This latter process is called Splitting.

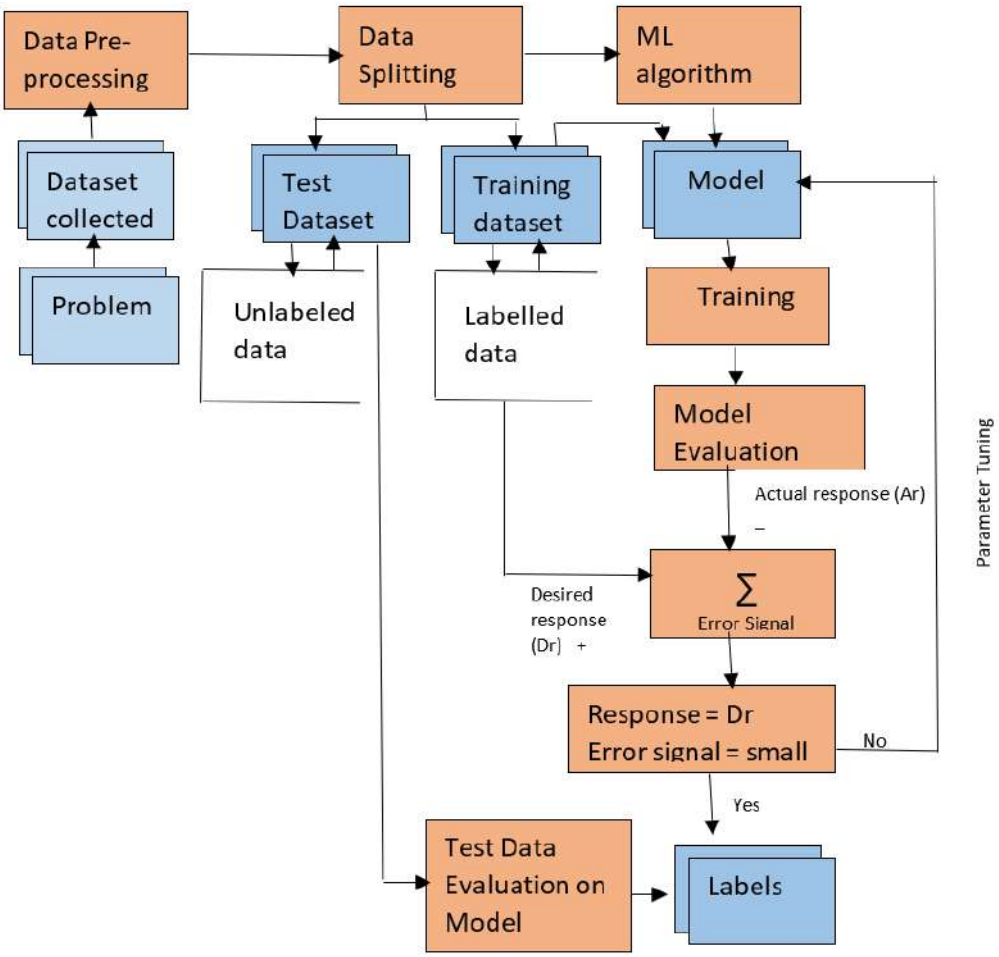

Fig. 2: Data Flow Diagram of Supervised Learning Paradigm

This is the process of dividing a node into two or more nodes and decision branches off into variables. For numeric attributes, the range is considered as the partition criteria where the decision tree can be geometrically interpreted as a collection of hyperplanes, each orthogonal to one of the axes. For classification problem, the entropy, Gini index and information gain (IG) are the splitting metrics used while for regression, residual sum of squares is applied. All other nodes apart from the root and internal nodes are termed as the leaves/terminal/decision nodes. Each of the leaf has exactly one incoming edge and no outgoing edges because it represents the outcome. The leaf node is assigned to the class label describing the most appropriate target value. Instances are classified by navigating them from the root down through the arcs to the leaf (Figure 4). Pruning in decision tree classifier is the opposite of splitting. It is the process of going through and reducing the tree to only the most important nodes or outcomes.

Decision Tree Pseudocode:

1. Start the decision tree with a root node, P that contains the complete dataset.
2. Using the Attribute Selection Measure (ASM), determine the best attribute in the dataset P to split it.
3. Divide P into subsets containing possible values for the best attributes.
4. Generate a tree node that contains the best attribute.
5. Make new decision trees recursively by using the subsets of the dataset P created in Step 3. Continue the process until a point is reached that the nodes cannot be further classified.

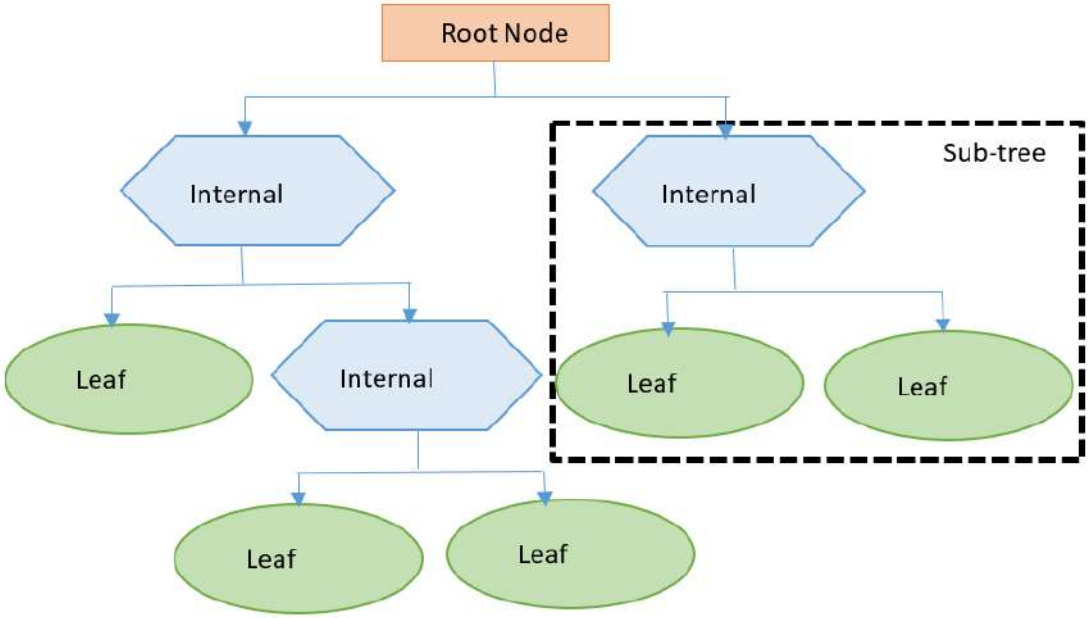

Fig. 3: Decision tree showing the root, internal and leaf nodes

Naive Bayes

This is a probabilistic classifier and a generative learning algorithm that is based on Bayes' theorem. It is used for text classification task. Given the data and some prior knowledge, the theorem is based on the probability of a hypothesis. The classifier assumes that all features in the input data are conditionally independent of each other, given the class label (note: this assumption is not true for all real world cases) thereby, permitting the algorithm to make predictions quickly. The dataset is divided into two: the feature matrix and the response vector. The feature matrix contains all the vector of the dataset in which each vector consist of the value of the dependent features. The response vector contains the value of class variable (prediction) for each row of the feature matrix.

Assumptions of Naive Bayes

i. Feature independence: The features of the data are conditionally independent of each other, given the class label.
ii. Continuous features are normally distributed: If a feature is continuous then it is assumed to be normally distributed within each class.
iii. Discrete features have multinomial distributions: If a feature is discrete then it is assumed to have a multinomial distribution within each class.
iv. Features are equally important: All features are assumed to contribute equally to the prediction of the class label.
v. No missing data: The data should not contain any missing values.

For the mathematical analysis from Bayes theorem, if A and B are events and P(B) ≠ 0, to find the probability of event A:

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)} \quad \ldots(1)$$

where Event B is an evidence (true), P(A) is the priori of A, P(B) is the marginal probability, $P(A|B)$ is the posteriori probability of B and $P(B|A)$ is the Likelihood probability that a hypothesis will come true based on the evidence.

Applying Bayes theorem:

$$P(y|X) = \frac{P(X|y)P(y)}{P(X)} \quad \ldots(2)$$

y is the class variable and X is the dependent feature vector (of size n), where

$$X = x_1, x_2, x_3, \ldots, x_n \quad \ldots(3)$$

Putting the naïve assumption into the Bayes' theorem (independence among the features), we split the evidence into independent parts.

If A and B are independent, then:

$$P(A,B) = P(A)P(B) \quad \ldots(4)$$

Hence,

$$P(y|x_1, x_2, x_3, \ldots, x_n) = \frac{P(x_1|y)P(x_2|y)\ldots P(x_n|y)P(y)}{P(x_1)P(x_2)\ldots P(x_n)} \quad \ldots(5)$$

which can be expressed as:

$$P(y|x_1, x_2, x_3, \ldots, x_n) = \frac{P(y)\prod_{i=1}^{n} P(x_i|y)}{P(x_1)P(x_2)\ldots P(x_n)} \quad \ldots(6)$$

As the denominator remains constant for any given input, we remove $P(y|x_1, x_2, x_3, \dots, x_n) \propto P(y) \prod_{i=1}^{n} P(x_i|y)$

In order to create the classifier model, we find the probability of the given set of inputs for all possible values of the class variable y, and with maximum probability.

$$y = argmax_y P(y) \prod_{i=1}^{n} P(x_i|y) \quad ..(7)$$

Regression

The goal of this statistical classifier is to plot the best-fit line or curve between the data (Kurama, 2023). A continuous outcome (y) is predicted based on the value of the predictor variables (x). Linear regression is the most common regression model due to ease (Fig. 4). It finds the linear relationship between the dependent variables (continuous) and one or more independent variables (continuous or discrete).

Steps in determining the best-fit line:

1. Considering the linear problem $y = mx + c$ where y is the dependent data, x is the independent data within the dataset, m is the coefficient (contribution of the input value in determining the best fit line) and c is the bias or intercept (deviations added to the line equation for the predictions made).
2. Adjust the line by varying m and c.
3. Randomly determine values initially for m and c and plot the line.
4. If the line does not fit best, adjust m and c using gradient descent algorithm or least square method.

$$y = mx + c \quad \dots(8)$$

y = the dependent variable and it is plotted along the y-axis

x = the independent variable and plotted along the x-axis

m = Slope of the line

c = the intercept (the value of y when x = 0)

Line of regression = Best fit line for a model

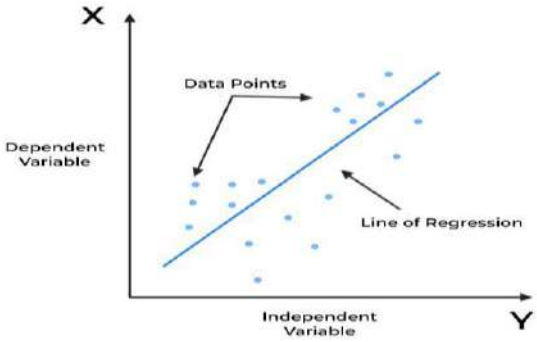

Fig. 4: Linear Regression Model showing the Best Fit Line

Logistic Regression

This does binary classification tasks by predicting the probability of an outcome, event, or observation. Based on the independent variables, it predicts the probability of an event occurring by fitting the data to a logistic function (Fig. 5). The coefficients of the independent variables in the logistic function are optimized by maximizing the likelihood function. A decision boundary is determined such that the cost function is minimal using Gradient Descent. The model delivers a binary or dichotomous outcome limited to two possible outcomes: yes/no, 0/1, or true/false. This is mathematically defined as:

$$y = \frac{e^{(b_0 + b_1 X)}}{1 + e^{(b_0 + b_1 X)}} \quad \dots(9)$$

where x = input value, y = predicted output, b_0 = bias or intercept term and b_1 = coefficient for input (x)

Logistic regression is similar to linear regression where the input values are combined linearly to predict an output value using weights or coefficient values but differs in the output value model. Logistic regression returns a binary value (0 or 1) as output rather than a numeric value as with the linear regression.

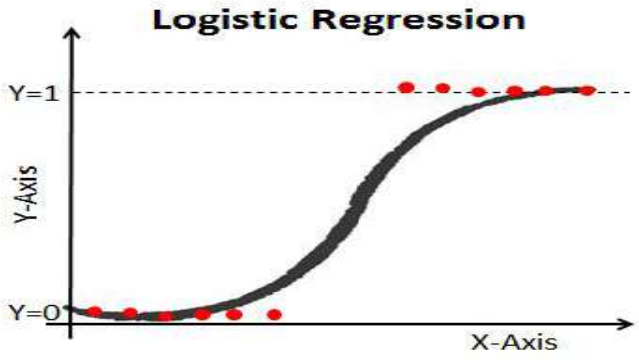

Fig. 5: Logistic Regression with predicted y between 0 and 1

Support Vector Machine (SVM)

This is used for classification (pattern recognition) and regression (function approximation) problems. It is based on statistical learning theory that can transform the input data into an N-dimensional (where N is the number of features that is high) by the use of kernel function to clearly create a linear model in the feature space. The kernel functions used in SVM include linear, polynomial, radial basis function and sigmoid function.

It constructs an optimal hyperplane (decision boundary) in a multidimensional space that separates cases of different class labels by using the objects (samples) on the edges of the margin (support vectors) to separate objects rather than using the differences in class means. It is based on the separation mechanism of the algorithm to obtain a hyperplane by supporting (defining) using the vectors (data points) nearest to the margin that it was called the Support Vector Machine.

Sahu and Sharma (2023) noted that SVM uses the Hinge Loss function to maximize the margin distance between the observations of the classes (training) as in Equ. 10.

$$l(y) = \max(0,1 + \max_{y \neq t} w_y x - w_t x) \qquad \ldots(10)$$

where w is the model parameter, x is the input variable and t is the target variable.

SVM can efficiently be used in high dimensional space where the number of spaces is higher than the number of samples, though it can result to poor outcome. The fame of SVM rests on two key properties: it finds solutions to classification tasks that have generalization and it solves non-linear problems using the kernel trick, thus, referred to as kernel machine. It uses Gaussian

distribution, thereby, making the induction paradigm for parameter estimation the maximum likelihood method which is then reduced to the minimization of sum-of-errors-square cost function.

K-Nearest Neighbour (K-NN)

This is a non-parametric instance base learning classifier that uses proximity (distance) to make predictions about the grouping of individual data. Due to the fact that it is unlikely for an object to exactly match another, the classifier finds a group of *k* objects in the training set that are closest to the test object by measuring the distance between the data (similarity measure) and assigns a label based on the predominance of a particular class in their neighbor (Steinbach and Tan, 2009). K-NN is a lazy learning technique because it delays until the query occurs to generalize beyond the training data.

K-NN Pseudocode

1. Determine parameter k = number of nearest neighbor.
2. Calculate the distance between the query-instance and all the training examples.
3. Sort the distance and determine the nearest neighbour based on the k-t minimum distance.
4. Gather the category Y of the nearest neighbor.
5. Use simple majority of the category of the nearest neighbor as the prediction value of the query instance.

Linear Discriminant Analysis (LDA)

This is also known as normal discriminant analysis (NDA) or discriminant function analysis (DFA). This technique aids in optimizing machine learning models in data science. It has generative model frame work because the data distribution for each class is modeled and uses Bayes theorem to classify new data points by calculating the probability of whether an input data set will belong to a particular output. Also, this is used to solve multi-class classification problems by separating multiple classes with multiple features through data dimensionality reduction.

Assumptions of LDA

1. Every feature such as variable, dimension, or attribute in the dataset has Gaussian distribution.
2. Each feature holds the same variance and has varying values around the mean with the same amount on average.
3. Each feature is assumed to be sampled randomly.
4. Lack of multicollinearity in independent features and there is an increment in correlations between independent features and the power of prediction decreases.

In reducing the features from higher dimension space to lower dimensional space, the following steps should be considered:

1. Compute the separate ability amid the various classes. This is to determine the between-class variance of the different classes (the distance between the mean of the different classes).
2. Compute the distance among the mean and the sample of each class (within class variance).
3. Determine the lower dimensional space that maximizes the between class variance and minimizes the within class variance.

Ensemble Methods

This classifier encapsulates multiple learning algorithms for better predictive results. It aims to mitigate errors or biases that may exist in individual models by leveraging the collective intelligence of the ensemble (Singh, 2023). The outputs of many models are combined thereby utilizing the strengths of these models to improve accuracy and handle uncertainties in data in its learning system. The various ensemble techniques are Max Voting, Averaging, Weighted Average, Stacking, Blending, Bagging and Boosting.

Artificial Neural Network (ANN)

It is designed to mimic the function and structure of the human brain. ANN is an intricate network of interconnected nodes or neurons that collaborates to tackle complicated tasks. The main characteristics of ANN is the ability to learn in classification task. It learns by example and through experience. In high dimensionality data, learning is needful in modeling non-linear relationships or recognizing not well established relationship amongst the input variables. The learning process is achieved by adjusting the weights of the interconnections according to the applied learning algorithm. The basic attributes of ANNs can be classified into Architectural attributes and Neuro-dynamic attributes (Kartalopoulos, 1996). The architectural attributes define the number and topology of neurons and interconnectivity while the neuro-dynamic attributes define the functionality of the ANN. Based on this, ANN is also referred to as Deep Learning (DL) when it has more than three layers (the depth of the layers are considered) to handle complex non-linear tasks. The Feed forward neural network comprises of the single layer (Hopfield net architecture) and Multiple layer perceptron (MLP) uses back propagation learning (Levenberg Marquardt) and Radial basis neural network are supervised learning.

Feed Forward Neural Networks (FFNN): This is a layered neural network in which an input layer of source nodes projects on to an input layer of neurons but not vice versa.

a. **Single-layer Feed Forward Network:** This is the simplest kind of neural network that is flat and consists of a single layer of output nodes (Fig. 6). It is also called single perceptron. The inputs are fed directly to the outputs through a series of weights. The sum of the products of the weights and the inputs are calculated in each node, and if the value is above some threshold (typically 0), the neuron fires and takes the activated value (typically 1); otherwise it takes the deactivated value (-1). Single perceptron is only capable of learning linearly separable patterns.

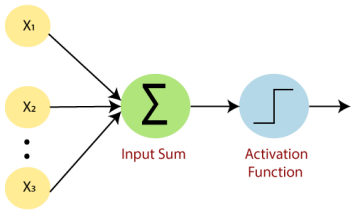

Fig. 6: A Single layer Feed Forward Network

The mapping of single unit perceptron is expressed as:

$$y = f(\sum_{i=1}^{n} w_i x_i + b) \quad \ldots(11)$$

where w_i are the individual weights, x_i are the inputs and b is the bias

b. **Multilayer Feed Forward Network (MLP):** This distinguishes itself by the presence of one or more hidden layers called hidden neurons between the input units and the output units (Fig. 7). This aids the network in dealing with more complex non-linear problems. MLP is structured in a feed forward topology whereby each unit gets its input from the previous one (back propagation).

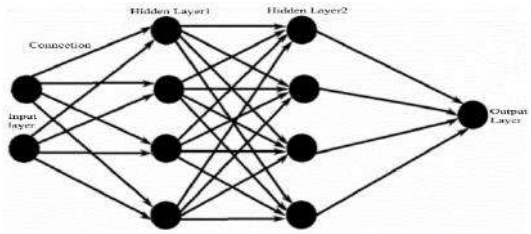

Fig. 7: Multiple Layer Perceptron

The mapping of the inputs to the outputs using an MLP neural network can be expressed as:

$$y_k = f\left(\sum_{j=1}^{m} w_{kj}^{(2)} \left(\sum_{i=1}^{n} w_{ji}^{(1)} + w_{j0}^{(1)}\right) + w_{k0}^{(2)}\right) \quad \ldots(12)$$

Where $w_{ji}^{(1)}$ and $w_{kj}^{(2)}$ indicate the weights in the first and second layers respectively, going from input i to hidden unit j (hidden layer 1), m is the number of the hidden units, y_k is the output unit, $w_{j0}^{(1)}$ and $w_{k0}^{(2)}$ are the biases for the hidden units j and k respectively. For simplicity, the biases have been omitted from the diagram.

c. **Radial Basis Neural Network (RBNN):** This is also called Radial Basis Feed Forward (RBF) network. It is a two layer feed forward type network in which the input is transformed by the basis function at the hidden layer (Fig. 8). At the output layer, linear combinations of the hidden layer node responses are added to form the output. The name RBF comes from the fact that the Basis function in the hidden layer nodes are radially symmetric, that is, the neurons in the hidden layer contain Gaussian transfer functions whose outputs are inversely proportional to the distance from the center of the neuron.

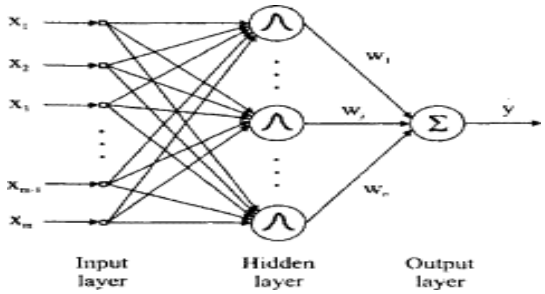

Fig. 8: Radial Basis Neural Network

Mathematically, it can be expressed as:

$$y(x) = \sum_{i=1}^{N} w_i \emptyset(\|x - c_i\|) \quad \ldots(13)$$

where x is the input vector, N is the number of neurons in the hidden layer, w_i are weights of the connections from the hidden layer to the output layer, c_i are the centers of the radial basis functions, $\|x - c_i\|$ is the Euclidean distance between the input vector and the center of the radial basis function and $\emptyset$ is the radial basis function usually chosen to be a Gaussian Function.

III. CONCLUSION

As the present world revolts round AI for its benefits, machine learning has been of immense importance to the building body of such intelligent systems to improve their performances. Learning under supervision to predict the output of a system when given new inputs has been more accurate and of ease when the decision boundary is not overstrained. The overview of supervised machine learning paradigms gave a detailed insight to the various statistical and scientific classifiers used in building functions that map new data onto the expected output values in tasks that requires either or both classification and regression issues.

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Guardians of E-Commerce: Harnessing NLP and Machine Learning Approaches for Analyzing Product Sentiments in Online Business in Nigeria

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Abstract**—** *In today's e-commerce in Nigeria, customers access online stores to browse through and place orders for products or services via the internet on their devices while some are skeptical due to the experiences from what I ordered versus what I got syndrome. Though this method of business has flourished to an extent, it greatly faces a crucial challenge in unravelling consumer's sentiments particularly in the realm of product reviews. This deficiency inhibits most e-commerce platforms in Nigeria from gaining effective sensitivity into users' preferences, thus, limiting their ability to boost their product recommendations and, understand and improve customers' experiences. This research aims to bridge this gap by developing a sentiment analyzer of product in the e-commerce domain using Natural language processing and machine learning approach. The model will analyze the customers' reviews based on positive or negative. The experimental data was collected from kaggle.com. Stemming and lemmatization were approaches used for cleaning the collected data. Features were extracted and transformed using CountVectorizer. Gaussian Naïve Bayes classifier was used as the machine learning technique. The model's performance was evaluated and it returned 90% of accuracy, hence, an efficient and reliable model for product review sentiment analysis is developed.*

Keywords**— *E-commerce, Natural language processing, Sentiment analysis, Machine learning***

I. INTRODUCTION

Commerce as the engine that drives the economy of societies by promoting business inventions has brought about advanced growth in the nation. It has developed from the trade-off systems to a more global network of businesses from the inception of the internet over the years. This act of encompassing commerce by the internet gave birth to electronic commerce. Electronic commerce (e-commerce) is the buying and selling of goods and services, or the transmitting of funds or data over an electronic network, primarily the internet (Lutkevich *et al*., 2023) via devices. This transaction occurs either as business-to-business (B2B), business-to-consumer (B2C), consumer-to-consumer (C2C), consumer-to-business (C2B), business-to-administration (B2A), consumer-to-administration (C2A) or mobile e-commerce (m-commerce).

No matter the type of e-commerce a consumer delves into, the benefits are easy and fast accessibility, wide visibility of goods and services, and 24/7 hours market service availability. Despite these advantages, it is still greatly challenged in the areas of cybersecurity, competition, order fulfillment, customer's experience, quality website traffic and visitor conversion, visibility, return and refund policies, finding the right market, making and increasing sales, borderless e-commerce and augmented reality (Post, 2023). Amongst these challenges, the most troubling issue is customer's experience. Presently, customers that would like to order products online are skeptical in doing such because of the experiences many encountered with ordering products online. One of such is receiving an item not in the form of what was initially shown to the buyer and not having the opportunity to lay compliant in that regards. This syndrome was tagged with a slogan termed "what I ordered versus what I got".

In order to find the product-market fit, the reviews of the customers are very much needed. It is the first step of any

business, and e-commerce is not different. It is an important metric that helps a business manager address customer's issue, prevent churn and build a base of loyal customers (Needle, 2023). One will learn what the customers like about their offers and areas where they can improve, thereby, providing a method of facilitating development. This development involves personal growth, motivation, creativity, morale, job satisfaction, clarity, professional relationships, meaningful discussion and goal alignment. It is important to note that in absence of a product-market fit, some of the challenges such as competition and poor sales of products are as a result of the shortcomings of customer review.

In the light of this grave challenge, there is a need to create the so much needed avenue that can handle the review of customers in order to boost productivity in business.

II. LITERATURE REVIEW

Artificial Intelligence (AI) which is sometimes called machine intelligence is the intelligence demonstrated by machines in contrast to the natural intelligence displayed by humans and other animals (Ziyad, 2019). It handles the important question of what knowledge is needed in any mode of thinking and how should that knowledge be applied. The basic components of AI are learning, reasoning and decision making, problem solving and perception. There are six main branches of AI. They are machine learning, deep learning, expert systems, Natural Language Processing (NLP), Robotics and Fuzzy logic (Tyagi, 2020). Amongst these branches, the one that addresses interpretation, comprehension and manipulation from human language in order to resolve the issue of customers' review is the NLP.

Natural Language Processing

Natural Language Processing is a subset of Artificial Intelligence that facilitates seamless communication between humans and computers by granting machines the capacity to interpret, comprehend, generate, manipulate and extract significance from human languages (Oracle, 2022). It has become a crucial area of research and development that merges interdisciplinary fields in computer science, linguistics, and cognitive psychology. Due to the available large volume of text and voice data in various forms, such as posts from online or social media and news articles, NLP covers different tasks such as text analysis, speech recognition, language translation, text summarization, and sentiment analysis.

Sentiment Analysis

Sentiment analysis is literally known as opinion mining. It is the process of determining the emotional tone behind a piece of text, whether it is positive, negative, or neutral (Biyani 2023). Naturally, companies receive feedbacks from countless sources, including customer messages, call center and social media posts. These sources are the different views of people about the companies' products. Based on the analysis of such sources, the companies gain valuable insights in their businesses as they identify areas for improvement in terms of products and rendered services, thereby, creating and promoting the overall satisfaction for their customers.

In situations where very large volume of textual data are collected, the act of manually analyzing these textual data is not feasible. In order to effectively analyze such, statistical, natural language processing and machine learning techniques are applied to determine the emotional meaning of communications (Korolov, 2021). Statistical methods are used to estimate and evaluate the occurrences of positive, negative, or neutral sentiments in a given dataset, machine learning algorithms (supervised) train the labeled datasets to recognize the available patterns and make predictions while NLP techniques enables the system to have an extensive acumen of the emotional context within the text of the human language by identifying words, phrases and linguistic constructs that are sentiment based. Sentiment analysis automates the process of analyzing large volumes of text data and extracting feelings, emotions and attitudes about a product or services generated by depending on NLP, thereby, saving time and effort when compared to manual analysis.

Review of Related Works

Numerous studies have explored the use of sentiment analysis for product in e-commerce. Some of them are:

Alharbi *et al*. (2021) conducted a research aimed at accurately forecasting customer feedback based on smartphone reviews gathered from Amazon.com. Deep Learning (DL) methods were employed in this study, focusing on the analysis and categorization of reviews into three classes: positive, neutral, and negative. The authors explored various DL approaches including Recurrent Neural Networks (RNN) and its four variants—Gated Recurrent Unit (GRU), Long Short Term Memory (LSTM), Update Recurrent Neural Netwok (UGRNN), and Group Long Recurrent Neural Network (GLRNN). These algorithms were complemented by word embedding techniques, utilizing Glove, word2vec, and FastText as feature extraction approaches.

Norrega *et al*. (2023) delved into a comprehensive investigation into Amazon reviews, employing advanced deep learning techniques. Alongside the primary aim of the research, a randomly relatable objective was to explore the impact of sentiment analysis on customer satisfaction in e-

commerce. The models utilized in this study encompassed Bidirectional Encoder Representations from Transformers. (BERT), Robustly optimized BERT approach (RoBERTa), ULMFiT and Extra-Long Network (XLNet), representing a diverse set of deep learning frameworks. The research unfolded through four distinct stages. The initial stage, Data Validation, involved the authors dividing the Amazon dataset, sourced from GitHub, into training and testing subsets, labeled as 0 or 1 to denote negative or positive reviews. Following this, the Statistical Analysis stage ensured the avoidance of overfitting, a critical consideration to prevent misleading results. Moving forward, the third stage involved Exploratory Data Analysis (EDA), where the authors employed TF-IDF and K-means clustering to sift through the data and eliminate irrelevant words, enhancing the precision of the analysis. The culmination of these stages led to the Approach stage, where the authors applied the proposed models to discern their respective performances. Notably, the RoBERTa model emerged as a standout performer, achieving an impressive overall classification accuracy of 82%.

Prakash and Aloysius (2021) introduced a noteworthy contribution to sentiment analysis on tweets by proposing a lexicon-based approach. Their endeavor aimed at tackling the pivotal challenges in sentiment analysis, particularly focusing on optimizing the performance of lexicon-based methodologies.

Tang *et al.* (2016). proposed a deep learning-based sentiment analysis model for product reviews that incorporates attention mechanisms to focus on sentiment-bearing words and phrases, improving the accuracy of sentiment classification. The authors developed a sentiment analysis model based on convolutional neural networks (CNNs) with attention mechanisms. CNNs are effective at extracting local patterns from text, while attention mechanisms allow the model to focus on the most important parts of a sentence for sentiment classification. The model first extracts local features from product reviews using CNNs. Then, an attention mechanism is applied to assign weights to these features based on their importance for sentiment classification. The final sentiment polarity of the review is determined based on the weighted combination of the extracted features.

Vangheese and Nellasivan (2023) proposed a sentiment analysis of tweets concerning food delivery services employing lexicon-based approaches. The primary objective was to discern consumer perceptions towards two prominent food delivery brands, namely Swiggy and Zomato. Utilizing the R programming language, the authors collected data directly from the two brands' Twitter feeds for analysis. The collected data underwent thorough cleaning and pre-processing using various R language techniques to ensure data integrity. Subsequently, the authors employed a lexicon-based method for emotion classification, identifying terms such as "positive," "anger," and "joy" to categorize the sentiments expressed in the tweets. Post-analysis, it was revealed that the Swiggy brand outperformed Zomato, garnering a higher number of positive tweets. This outcome underscores the effectiveness of the lexicon-based approach in gauging and comparing consumer sentiments in the context of food delivery services.

III. MATERIALS AND METHODS

Data Collection

Two separate datasets were collected: the first dataset being a labeled dataset from yelp.com that was obtained from Kaggle.com a reputable website and an excerpt from reviews attained from amazon.com served as the second dataset. The two datasets were merged into one dataset called “training_dataset.csv” for the purpose of this research (Fig.1).

Objectives of the Design

In order to achieve the development of a product review sentiment analyzer, the following objectives were carried out:

a) design a sentiment analyzer using Gaussian Naïve bayes model.
b) to preprocess the dataset using lemmatization and tokenization methods of NLP.
c) to extract and transform features using CountVectorizer.
d) design a user-friendly interface that can capture both individual and batch sentiments using Streamlit.
e) evaluate the performance of the model using accuracy, precision, recall and F1-score.

Fig. 2 shows the model of the product review sentiment analyzer.

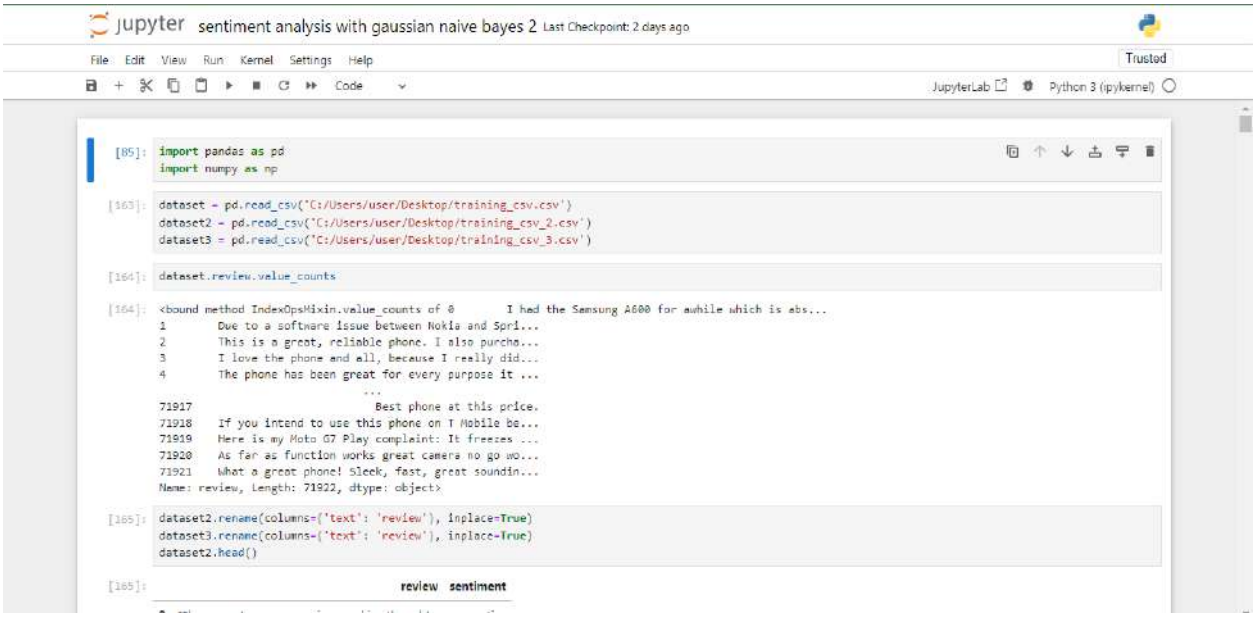

Fig. 1: Merging of the two datasets obtained from kaggle.com

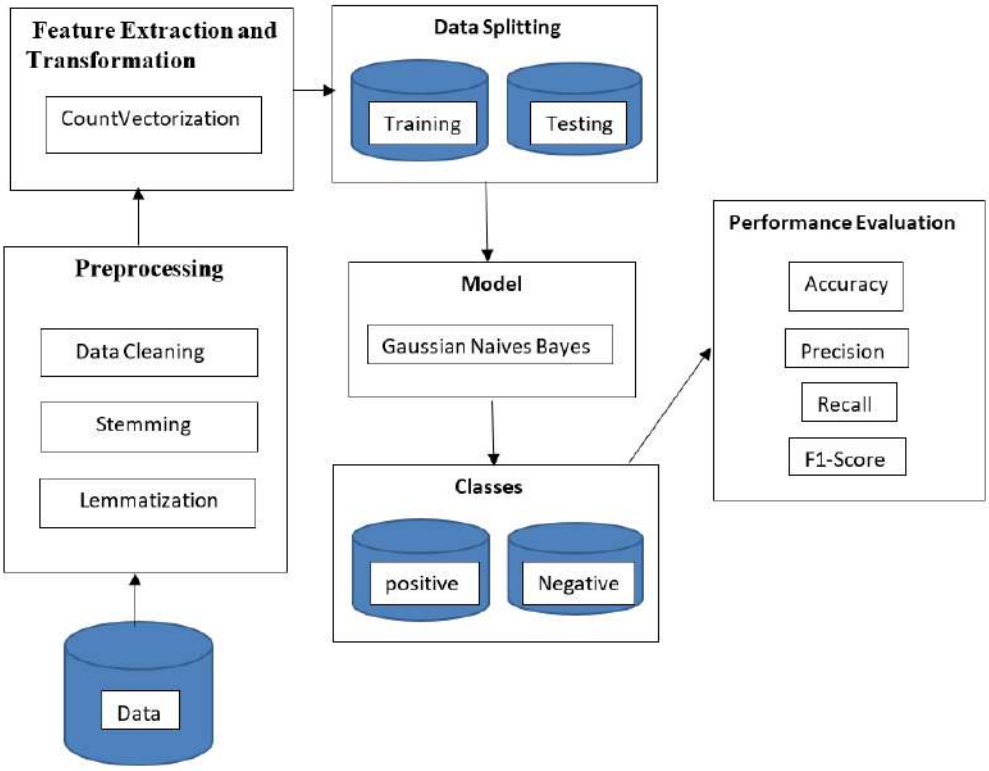

Fig. 2: Product Review Sentiment Analyzer

Preprocessing

Data in its unprocessed form might contain some features which are not relevant to the research. The first stage of preprocessing was cleaning of the dataset whereby the columns of the data were renamed for easy interpretation as seen in Fig. 3 and removing duplicate data, handling null values, and cleaning non-alphabetic characters, as well as converting text to lowercase were implemented to reduce bias and inconsistencies which may affect the performance of the model.

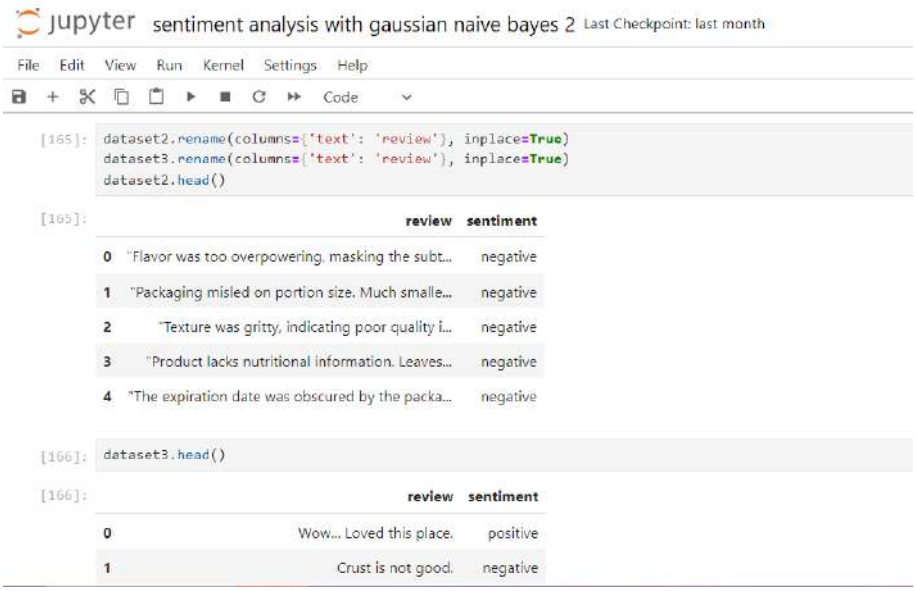

Fig.3: Code block of cleaning of the dataset

The preprocessing techniques such Lemmatization and Tokenization were applied to reduce words to its base or root form and convert a sentence into a list of words respectively as shown in Fig. 4.

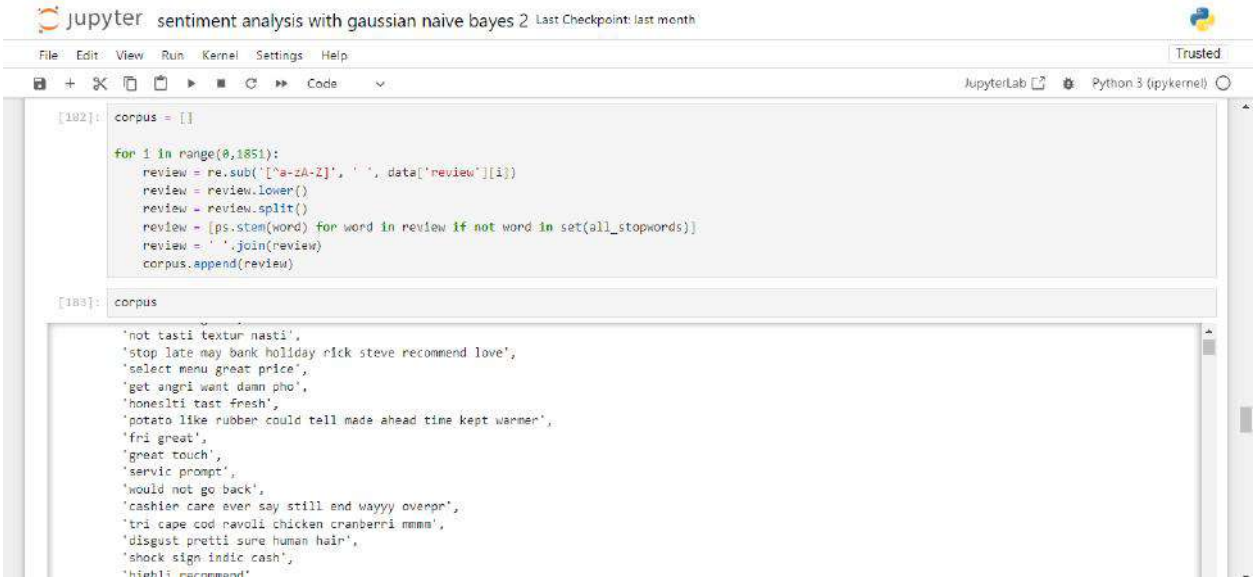

Fig. 4: Code Block for Data Preprocessing

Data Splitting

For effective model evaluation, a randomized split with a fixed random state was used to split the dataset into training and testing sets in the ratio of 80%:20% of data for each respectively (Fig. 5). This approach ensures reproducibility.

Fig. 5: Data Splitting Code Block

Feature Extraction

CountVectorizer was employed to convert raw text into a numerical format suitable for model's training. This technique created a matrix of token counts, where each row represented a document and each column a unique word (Fig. 6). This transformation facilitated machine learning model comprehension of textual data. It allowed extraction of meaningful patterns from text, aligning with the numerical nature of machine learning models and captured word frequencies for sentiment determination. Figs. 7a and b show word cloud for positive and negative reviews.

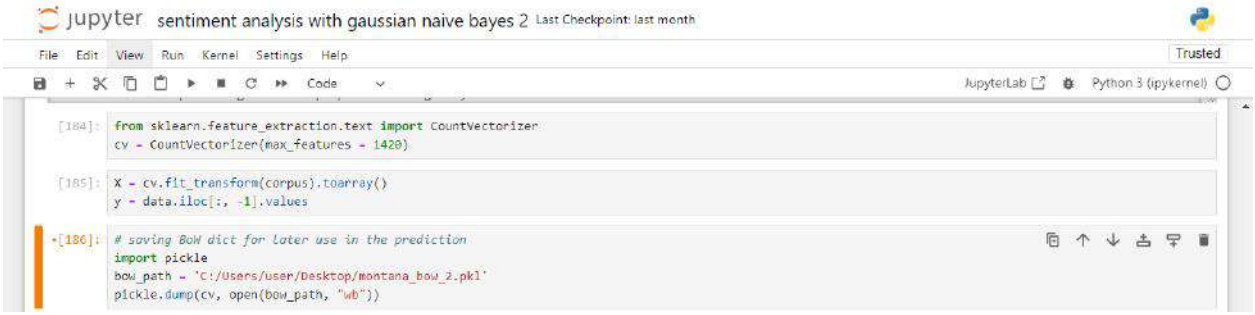

Fig.6: Feature Extraction using CountVectorizer

Fig. 7a: WorldCloud for Positive Reviews

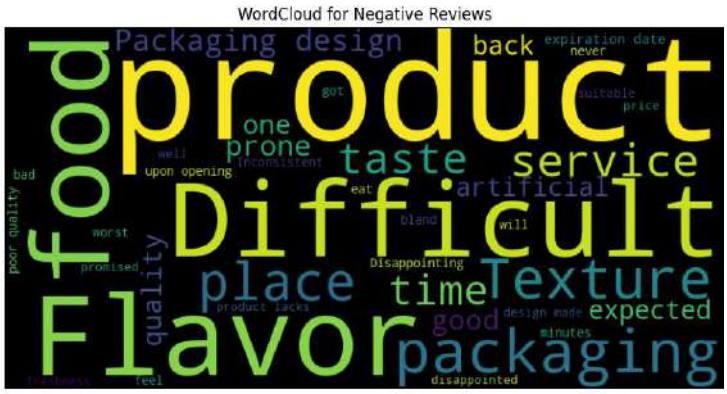

Fig. 7b: WorldCloud for Negative Reviews

Model Selection

The Gaussian Naive Bayes (GNB) was adopted. The choice was motivated by its suitability for handling numerical features which aligns with the transformed data obtained from features extractions using techniques like CountVectorizer and particularly effective in scenarios where features follow a Gaussian distribution.

Training

The model was trained using the training dataset. The process involved exposing the model to the labeled dataset, thereby, allowing it to learn patterns and relationships between the numerical features and sentiment labels (positive and negative). For the testing, the testing dataset was used to test the model.

Performance Evaluation

The model was evaluated using accuracy, precision, recall, and F1-score as the evaluation metrics to gauge the model's effectiveness in classifying sentiments.

Precision: This is used to determine the exactness of the measurement. It measures the accuracy of the positive predictions. It is calculated as:

$$Precision = \frac{True\ Positives}{(True\ Positives + False\ Positives)} \quad (1)$$

Recall: This measures the completeness of positive predictions, that is, measure of how well a model correctly identifies True Positives.

$$Recall = \frac{True\ Positives}{True\ Positives + False\ Positives} \quad (2)$$

F1-Score: A measure of a model's accuracy on a dataset. It is a harmonic means of both precision and recall of the model. It is determined as:

$$F1_{Score} = 2\ X\ \frac{(precision\ x\ recall)}{(precision + recall)} \quad (3)$$

IV. RESULTS AND DISCUSSION

For the user interface, Fig. 8 shows the user interface featuring the analysis of a customer's review. The user interface accepts both individual and batch sentiments depending on the input at hand.

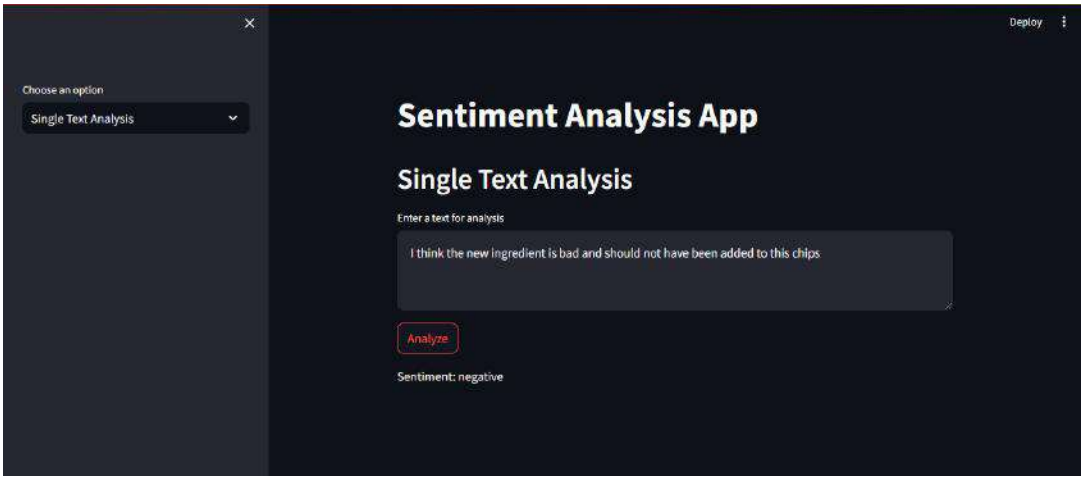

Fig. 8: A User-friendly interface that captures both individual and batch sentiments

For batch analysis, Fig. 9 shows the sample of customers' analyzed sentiments.

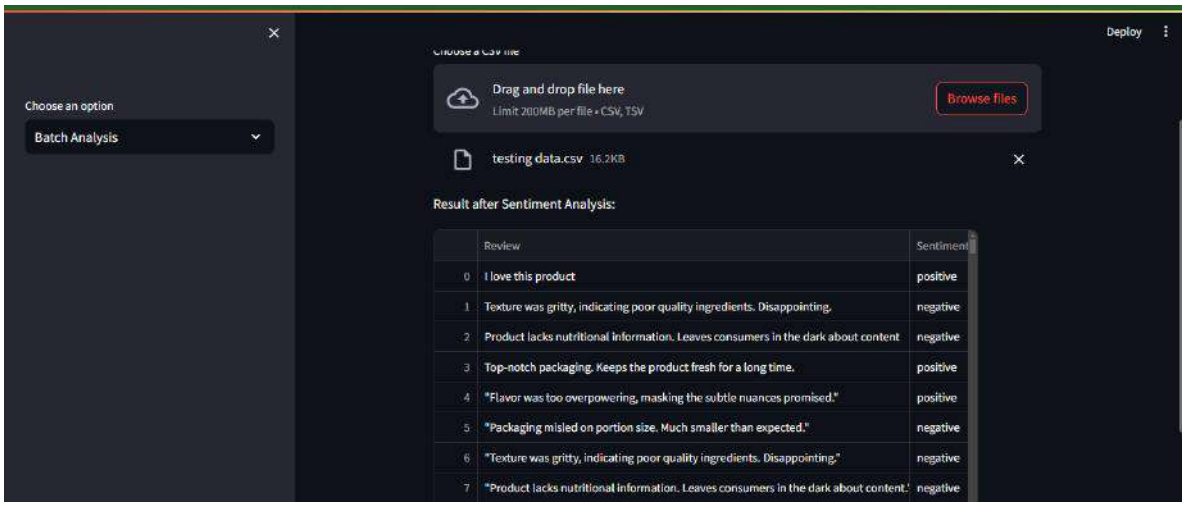

Fig. 9: Sample of analyzed sentiments

The evaluation of the performance of the model returned 90% as accuracy (Fig. 10). This shows the effectiveness and reliability of the model in analyzing sentiments of customers for the products received. The results of the distribution and proportion of the positive and negative reviews are presented on Figs. 11 and 12 respectively. The accuracy of the model returned 90% to show its efficiency.

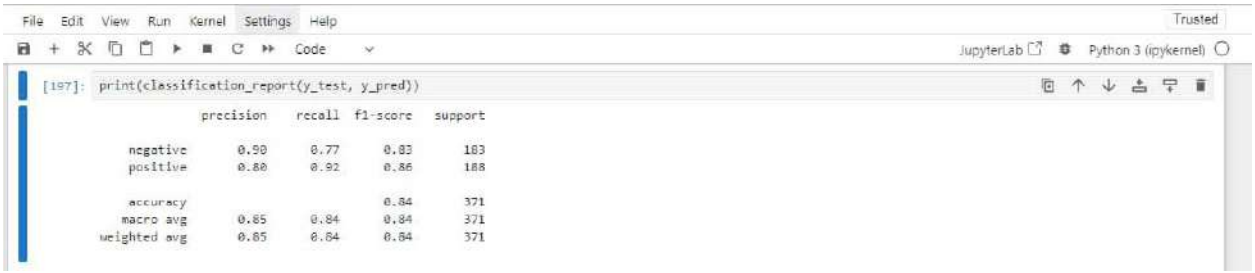

Fig. 10: Performance Evaluation of the model

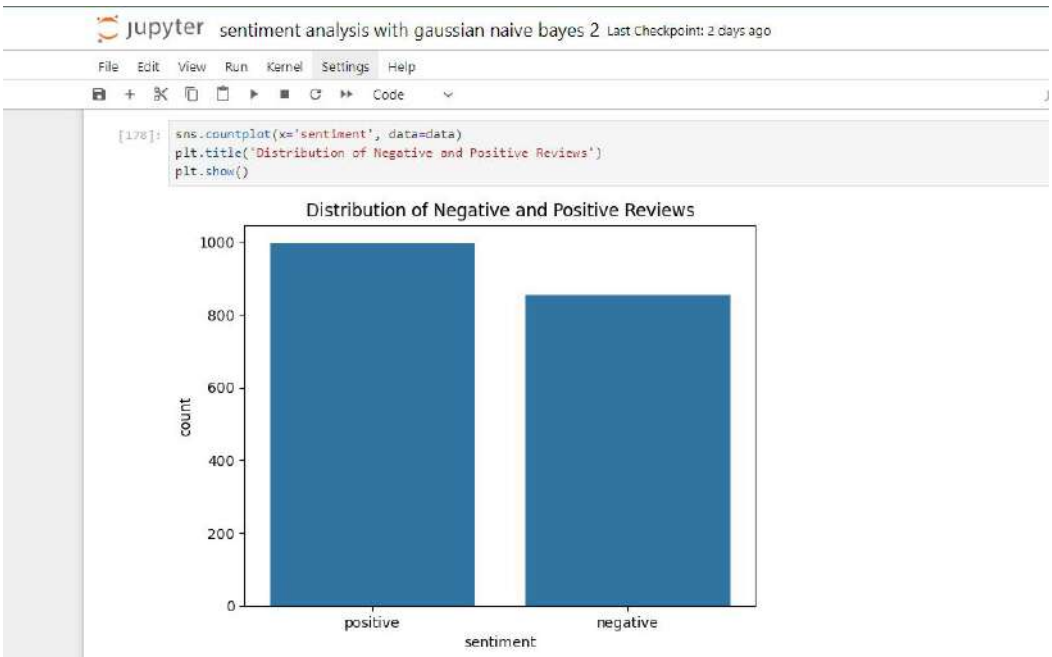

Fig. 11: Bar Chart showing the Distribution of Negative and Positive Reviews

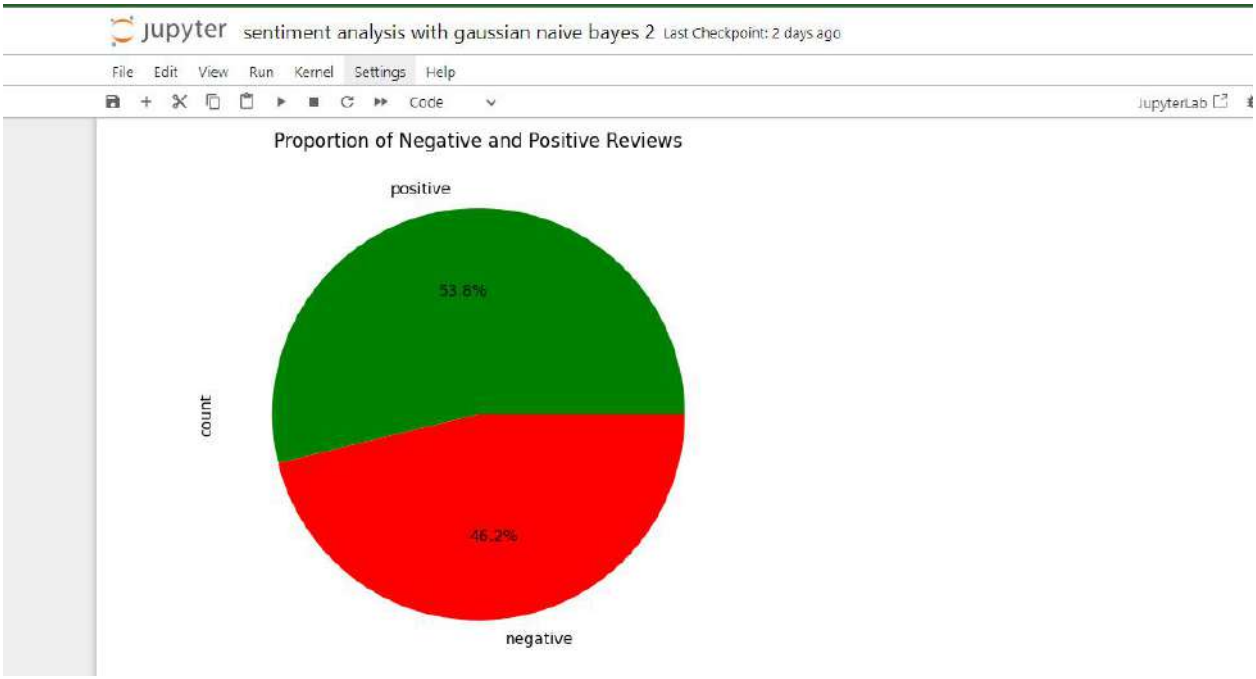

Fig. 12: Pie Chart of the Proportion of Negative and Positive Reviews

V. CONCLUSION

The research shows the feasibility and effectiveness of utilizing Gaussian Naive Bayes in sentiment analysis for e-commerce product review. The user interface enhances accessibility, enabling users to analyze sentiments for both individual and across large datasets. The outcomes of this research contributed to the advancement of sentiment analysis techniques in the context of e-commerce, thereby, providing valuable insights into customer preferences and sentiments.

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Automatic Water Level Controller for Overhead and Underground Water Tank

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Abstract— *This is an Arduino-based automatic water level controller. Here, we are going to measure the water level with the help of Float switch fluid level controller sensors. The Float switch fluid level controller sensors use the principle of a "2-way switch". The motor pump automatically turns ON when the water level is low. There is a lot of drinking water crisis in India and also in other countries. Today we need to preserve water at any cost. In India, we can see many houses as overhead tanks and they keep on overflowing water. It wastes a lot of water as well as electricity. If we do not do anything on this matter, then we can face a huge scarcity of water. In this project, implement an automatic water level controller so that we no longer have to manually switch ON and switch OFF the motor. The device automatically detects the water level, when it is low, hence triggering the relay which turns on the motor. This helps in reducing wastage of water as well as electricity. This also reduces manpower as we no longer need to operate it manually.*

Keywords— ***Water Level Detector, water crisis, overhead tanks, water level controller, Float switch.***

I. INTRODUCTION

An automatic water level controller for overhead and underground water tanks is a smart device designed to efficiently manage water levels in both types of tanks. This innovative system utilizes sensors to detect water levels and activates pumps to fill or empty the tanks as needed, ensuring a consistent supply of water. By automatically regulating the water flow, it prevents overflow or dry running, optimizing water usage and reducing wastage. With its user-friendly interface and reliable operation, this controller offers convenience and peace of mind to users, making it an indispensable solution for maintaining optimal water levels in residential, commercial, and industrial settings [1].

In modern water management systems, ensuring efficient utilization and conservation of water resources. The effective control of water levels in both overhead and underground tanks. To address this need, automatic water level controllers have emerged as invaluable tools. These controllers employ technology to monitor and regulate water levels, offering convenience, reliability, and conservation benefits.

An automatic water level controller for both overhead and underground water tanks is a comprehensive solution designed to streamline the process of managing water supply. It comprises a network of sensors, valves, and a control unit that work seamlessly to maintain optimal water levels in the tanks [2].

The automatic water level controller for overhead and underground water tanks offers numerous benefits, including improved efficiency, reduced water wastage, and enhanced convenience for users. By leveraging cutting-edge technology, it addresses the challenges associated with water management, contributing to sustainable usage and conservation efforts [3].

II. RESEARCH MOTIVATION

The research aims to develop an automatic water level controller for both overhead and underground tanks to address inefficiencies in manual monitoring, reduce water wastage, and ensure consistent supply. By integrating advanced sensors and control systems, the solution offers convenience and efficiency in water management, crucial for regions facing water scarcity. This technology

promotes sustainability by optimizing water usage and minimizing human error. Additionally, it caters to diverse user needs by accommodating different types of storage systems. Overall, the research is motivated by the pressing need for improved water management solutions to meet the challenges of the modern world**.**

III. OBJECTIVES

The objectives of developing an Automatic Water Level Controller for both overhead and underground water tanks are multifaceted, addressing key concerns in water management and conservation.

The primary aim is to enhance efficiency in water usage. By automating the process of maintaining desired water levels in tanks, the system ensures that water resources are utilized optimally without unnecessary wastage. This is particularly crucial in regions facing water scarcity or where water is a precious commodity [4].

Secondly, the objective is to reduce manual intervention in water level management. Traditional methods of monitoring and adjusting water levels in tanks require constant human oversight, which can be time-consuming and prone to errors. The automatic controller eliminates the need for such manual intervention, providing convenience to users and freeing up time for other tasks.

Thirdly, safety is a key objective of the Automatic Water Level Controller. Overflow from tanks can lead to property damage and pose safety hazards. By preventing overflow through automated monitoring and adjustment of water levels, the system helps to mitigate these risks, ensuring the safety of both property and individuals [5].

Moreover, the versatility of the controller is an important objective. It should be adaptable to different settings and applications, including residential, commercial, and agricultural contexts. This ensures that the benefits of efficient water management can be realized across various sectors, contributing to overall water conservation efforts. Reliability and durability are also crucial objectives. The controller should be designed to withstand environmental factors and operate consistently over the long term. This ensures that users can depend on the system for uninterrupted water level management, thereby promoting sustained water conservation practices [6].

Overall, the objectives of developing an Automatic Water Level Controller for overhead and underground water tanks encompass efficiency, convenience, safety, versatility, reliability, and durability. By addressing these objectives, the system aims to contribute to sustainable water usage practices and environmental conservation efforts [7].

IV. COMPONENT USED

1. **Water pump:** A water pump is used to move, compress, or transfer water from a lower level to a higher one. The main purpose of a water pump is to transfer water between two points and to get rid of excess water. It is often used in construction sites, tunnels, riverbeds, residential buildings, etc [8]. water pump is physically shown in Fig.1.

Fig.1: Water Pump

2. **Float switch sensor:** A float switch is a type of 2-way switch which operates the float of the sensor as shown in Fig.2. If the water level is low then 1 switch is ON but the water is filled then the sensor floats and then the 2 switches are operated then the water motor is OFF [8].

Fig.2: Float Switch Sensor

3. **LED 3V:** LED, or light-emitting diodes, are semiconductor devices that emit light when an electric current passes through them. LEDs are physically shown in Fig.3. Commonly operated at 3 volts, LEDs offer energy-efficient illumination in various applications such as lighting [9].

Fig.3: LED 3V

4. **Relay 12V:** A relay is an electrically operated switch that controls the flow of electricity in circuits. Rated at 12 volts, relays are commonly used to control high-power devices with low-power signals [9]. 12 V Relay is physically shown in Fig. 4.

Fig. 4: 12 V Relay

5. **Resistance:** Resistance is a fundamental property of materials that opposes the flow of electric current. Measured in ohms (Ω), it determines how much a material impedes the flow of electricity [10]. It is physically shown in Fig. 8.

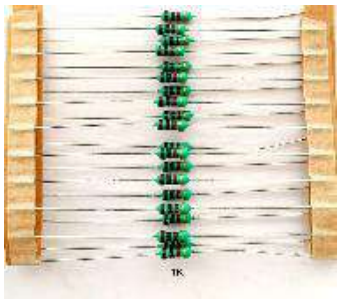

Fig. 5: Resistance

6. **Arduino Nano:** The Arduino Nano is a compact, versatile microcontroller board based on the ATmega328P chip as shown in Fig.6. It offers a wide range of features including digital and analog input/output pins, USB connectivity, and compatibility with the Arduino IDE [2].

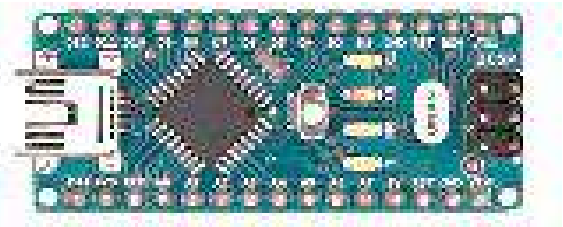

Fig.6: Arduino Nano

7. **Transistor:** Transistors are semiconductor devices crucial in electronic circuits for amplification, switching, and signal modulation. They control the flow of current between two terminals based on the voltage applied to a third terminal [9]. It is physically shown in Fig. 7.

Fig.7: Transistor

8. **Diode:** A diode is a semiconductor device that allows current flow in one direction while blocking it in the opposite direction. It is physically shown in Fig. 8.

Fig. 8: diodes

9. **Buzzer:** The buzzer is an electromechanical device that produces a buzzing sound when an electrical current passes through it. Commonly used in alarms, timers, and signalling systems, it consists of a coil of wire and a vibrating armature that creates the buzzing noise, alerting users to a particular event or condition [9]. A buzzer is shown in Fig. 9.

Fig.9: Buzzer

10. **Switch:** A control is defined as an on-off switch when its function is to open or close an electrical circuit in a stable manner as shown in Fig.10.

Fig. 10: Switch

11. **Breadboard PCB:** A breadboard is a reusable solderless prototyping tool used to build and test electronic circuits as shown in Fig. 11. It consists of a

grid of holes for inserting components and metal strips for connectivity.

Fig.11: Breadboard PCB

12. **Wire:** A wire is a flexible metallic conductor as shown in Fig. 12, especially one made of copper, usually insulated, and used to carry electric current in a circuit.

Fig. 12: Wire

13. **Storage tank:** A storage water tank is a container designed to hold water for domestic, industrial, or agricultural use, providing a reserve for when water demand exceeds supply or during emergencies.

V. WORKING

The automatic water level controller for overhead and underground tanks operates through a simple yet effective mechanism to ensure consistent water levels and prevent overflow or dry-running situations. It typically comprises sensors placed at different levels within the tanks. For the overhead tank, sensors are installed at the desired high and low water levels, while for the underground tank, sensors are positioned at the upper and lower thresholds.

When the water level in the overhead tank drops below the set low level, the controller activates the water pump to refill the tank from the underground reservoir. Conversely, when the water level in the overhead tank reaches a high level, the controller stops the pump to prevent overflow. Simultaneously, the controller monitors the water level in the underground tank. If the level falls below the lower threshold, indicating insufficient water, it triggers an alarm or notification to alert the user. This ensures timely refilling of the underground tank to maintain a continuous water supply. The controller relies on microcontroller-based circuitry to process sensor inputs and control the pump operation accordingly. It may incorporate additional features such as LCD displays for real-time monitoring, manual override switches, and battery backups for uninterrupted operation during power outages. Overall, the working principle of the automatic water level controller involves intelligent monitoring of water levels in both overhead and underground tanks, coupled with automated pump control to maintain desired levels and prevent wastage or shortage of water. The picture of the completed system is shown in Fig. 13.

(a)

(b)

Fig.13: Pictures of the Project

VI. CONCLUSION

The automatic water level controller for both overhead and underground tanks present a pragmatic solution for effective water management. By automating the maintenance of desired water levels, it promotes the

optimal use of water resources while reducing waste and the need for manual intervention. This system brings convenience and reassurance to users by eliminating the necessity for constant monitoring and manual adjustments of water levels in tanks. Furthermore, it improves safety by preventing overflow and potential property damage due to water overflow. Its adaptability makes it suitable for various settings, including residential, commercial, and agricultural applications. With its proven reliability and durability, it ensures prolonged functionality, thus fostering sustainable water usage practices. Overall, investing in the automatic water level controller for overhead and underground tanks is a worthwhile endeavor, delivering tangible benefits to users and contributing to environmental sustainability efforts.

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Review on Optimization of Microgrid Using Various Optimization Techniques

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Abstract**—** *The development of a smart grid includes the microgrid. Microgrids are essential to the development of the present and future electricity networks, as they can provide many advantages to the expanding and complex power systems, such as better power quality, increased integration of clean and renewable energy sources, increased efficiency, and increased network stability and reliability., etc. It is basically a small power system which has distributed energy resources (like renewable energy etc.). This paper conducts a literature review on Optimization Algorithms of Microgrid. We provide a summary of the typical system structure, which consists of energy end users, energy distribution systems, energy storage systems, and energy generation systems. Finally, we identify areas for future microgrid research challenges.*

Keywords**— microgrid; microgrid control; renewable energy; photo voltaic; optimization.**

I. INTRODUCTION

India has produced much more renewable energy in the last few years. The Ministry of New and Renewable Energy (MNRE), the business sector, and the Regional Energy Development Agency all play a part in the expansion of this renewable energy plant. Policies for government assistance are also encouraging the adoption of renewable energy. In order to attain sustainable energy supplies, the Indian Planning Commission has released the Integrated Energy Policy Report (IEPR), which emphasizes the necessity of maximizing domestic supply programs and diversifying energy sources [1].

By 2032, renewable energy may make up 11–13% of India's energy mix, according to the IEPR. The reference [1] presents a number of issues and workable answers pertaining to the widespread use of renewable energy technology in India. India has developed solar, wind, small hydro, and biofuels as grid-interactive energy sources. Based on India's plentiful supply of biofuels in a variety of forms, it is predicted that biofuels would become increasingly important in the ensuing decades. In the area of distributed energy, the nation has erected 33 grid-interactive solar photovoltaic power plants and synchronized them with a negligible amount of bioenergy with the financial assistance of MNRE. These facilities have a max installed capacity of 2.125 MW, which is expected to produce. The nation has a large number of remote places that could use concerted action development. The MicroGrid located on Sagar Island is among the most well-known. MNRE, the Indian government, the West Bengal Renewable Energy Development Agency (WBREDA), and the India and Canada Environment Fund (ICEF) are co-financiers of the project. Currently, 400-kilowatt diesel generators and 250 kilowatts of solar energy are used to provide Sagar Island's electricity needs. On the other hand, a lot of prospective customers are waiting on power. WBREDA has made the decision to construct a 500-kW wind-diesel hybrid power plant in order to meet these criteria. In general, WBREDA has carried out renewable energy program activities in the Sundarban region. Based on the real electricity usage of residential, commercial, and industrial users, a three-tiered pricing structure for electricity has been established. Residential customers pay Rs 5 per kWh, business users pay Rs 5.5 per kWh, and industrial users pay Rs 6 per kWh for electricity. [2; 3]

A bibliometric review of the literature relevant to earlier studies on microgrid optimization strategies is presented in this paper.

II. SYSTEM STRUCTURE OF MICROGRID

Power supply systems in particular have grown more complex in recent times [4–9] [10]. All forms of Energy Information Systems (EIS) have a common physical structure and equipment set, which encompasses integrated power supply, gas supply, heating, hydrogen supply, cooling, and other energy systems together with associated communication and information infrastructure. A schematic representation of a microgrid system is shown in Figure 1. The following is an overview of each microgrid structure:

(1) *Energy generating system:* It is capable of direct energy transmission through pipelines, cables, overhead lines, and other means without the need for energy conversion.

(2) *Energy distribution system:* It is capable of achieving a change in energy grade or energy form transformation. Electric energy is transformed into hydrogen using electric hydrogen generating equipment. Gas is converted into electrical energy using fuel cells. A shift in energy grade can be achieved by using specialized equipment, such as heat pumps, which can absorb heat from a low-temperature heat source and release it to a high-temperature heat source through electric energy. Modern energy power production devices, such as photovoltaic (PV) and wind turbines, transform solar and wind energy, respectively, into electrical energy.

(3) *Energy storage system:* By reducing peaks and filling troughs, energy storage devices can decrease the mismatch between cooling/heating demands and gas turbines. These devices include power storage, heat storage, and cold storage equipment.

(4) *End users of energy:* People who utilize energy for refrigeration, power, heating, and other applications; this group includes industrial, residential, commercial, and other users.

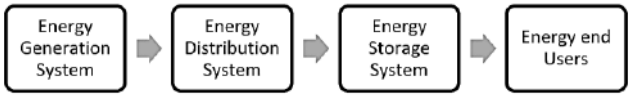

Fig.1. Structure of a MG.

III. IMPORTANT EQUATIONS AND CONSTRAINTS

Systems for generating power include diesel generators, batteries, photovoltaic power, and wind power. The incentive demand response direct control approach transfers the load and provides compensation throughout the dispatch time.

PV Power Generation: The following connection describes how a PV power generation system's output power is influenced by the external temperature T_{amb} and illumination R [11],

$$P_{PV} = P_{PV,STC} \times \frac{R}{R_{STC}} \times (1 - \lambda(T_a - T_r)) \quad (1)$$

$$T_a = T_{amb} + \frac{R}{R_{STC}} \times (T_{NOC} - 20) \quad (2)$$

In equations (1) and (2), R_{STC} is the illumination value under standard test conditions; $P_{PV,STC}$ is the maximum power under standard test conditions; λ is a coefficient; T_r is the reference temperature of the PV unit; T_a is the actual temperature of the PV unit and T_{NOC} is normal operating conditions temperature of the PV unit, respectively.

Wind Power Generation: The following equation can be used to convert wind energy into fan power output for wind turbines [12–14].

$$P_W = \frac{1}{2}\rho\pi R^2 V^3 C_P \quad (3)$$

Where, V is the wind speed from the blade tip; R is the radius of the fan blade; ρ is the air density and C_p is the wind energy conversion efficiency. C_p is determined by the blade pitch angle θ and the blade tip speed ratio λ. C_p is defined as,

$$C_P = f(\theta, \lambda) \quad (4)$$

The blade tip speed ratio λ is defined in equation (4) as,

$$\lambda = \frac{W_W R}{V} \quad (5)$$

Where, W_w represents the fan's mechanical angular velocity in rad/s.

Diesel Generator: A diesel generator's fuel consumption rate (F) is a direct function of its generated output power.

$$F = F_0 . Y_{gen} + F_1 . P_{gen} \quad (6)$$

Where, F_0 is the intercept coefficient; Y_{gen} is the rated power of diesel generator; F_1 is the slope and P_{gen} is the actual output power. The diesel generator's working power constraints are as follows:

$$L_{\min} \le \frac{P_{gen}}{Y_{gen}} \le 1 \quad (7)$$

Where L_{min} is the diesel engine's minimum load rate.

Also, the carbon emission $CO_2(P_d)$ generated by a diesel generator has the following formula [15],

$$CO_2(D_d) = a + b.P_d + c.P_d^2 \quad (8)$$

Where a, b, and c are the diesel's carbon emission coefficients; the values of these coefficients (evaluated from practice) are 28.1444, 1.728, and 0.0017, respectively. [11].

Battery: The function of electric energy for each charge and discharge is,

$$E_b = C_b.U_b.D.\mu_b \times 10^{-3} \quad (9)$$

In equation, D is the maximum permitted discharge depth; μ_b is the discharge efficiency; C_b is capacity of a single lead-acid battery and U_b is a rated voltage of supply.

The battery's output power is generally determined by its stable working voltage and controlled working current, which is around 0.1 CA.

$$P_b = C_b.U_b \times 10^{-4} \quad (10)$$

The primary limitations that affect a microgrid's ability to operate at the lowest possible cost are those related to transmission capacity between a microgrid and a larger grid, generation capacity, power balance, placement of the microgrid energy storage system, etc. [16–19]

Power Balance Constraints:

$$\sum_{i=1}^{N} P_{gen,j} + P_{buy}(t) - P_{sell}(t) = P_{load} \quad (11)$$

Where P_{load} is the necessary power of the load and $P_{gen,j}$ is the producing power of the generating units (PV, fan, and energy storage) in any given period of time.

Generation Capacity Constraints:

$$P_{DGi}^{\min} \le P_{DGi} \le P_{DGi}^{\max}, (i = 1, 2, ...N) \quad (12)$$

Where $P_{DGi}^{\max}$ and $P_{DGi}^{\min}$ are the maximum and minimum generating power of the ith generating unit, respectively.

Transmission Capacity Constraints between (Large Grid and Microgrid):

$$P_{Line}^{\min} \le P_{Line} \le P_{Line}^{\max} \quad (13)$$

Where $P_{Line}^{\min}$ is the minimum and $P_{Line}^{\max}$ is maximum power transmission capacities, respectively.

Location Constraints of Microgrid Energy Storage System: When determining and optimizing the placement and capacity of an energy storage system, consideration should be given to the system's allowed range of voltage variation and power balance.

IV. OPTIMIZATION ALGORITHMS

In the field of research, microgrid optimization is one of the most significant and difficult objectives. Numerous research have been carried out to ascertain the ideal microgrid structure in order to lower energy consumption and enhance economy and dependability. Numerous research in the literature demonstrates that several methods can be used to tackle the optimization of a microgrid. Genetic Algorithms (GAs) are the most commonly utilized algorithm type [20–32]. For instance, Li et al. used a GA to determine the lowest microgrid cost with the goal of choosing the ideal size for microgrid components [23]. Bin et al. [20] created an optimal configuration model of a hybrid AC/DC microgrid taking into account the microgrid life-cycle cost. The model was solved using the elitist Non-Dominated Sorting Genetic Algorithm (NSGA-II). Furthermore, Simulated Annealing (SA) was employed by numerous researchers [24–31] to overcome the issue. Battery scheduling for a home microgrid was the optimization problem that Aiswariya et al. solved using a SA optimization tool [24].

Another popular algorithm is the PSO algorithm [22–37]. To solve a unique operation optimization model for a stand-alone microgrid, Zhang et al. created an effective search algorithm by merging the PSO and SA algorithms [32]. Furthermore, fuzzy decision optimization must be used for many decisions because of the fuzzy environment [38–41; 49]. To evaluate a Battery Energy Storage System (BESS), for instance, Zhao et al. suggested an integrated fuzzy-MCDM (multi-criteria decision making) model [49]. In light of the microgrid's resilience, researchers have employed resilient techniques to enhance the microgrids' versatility and adaptability [42–44].

A decision-driven, stochastic, adaptive, robust microgrid operation optimization model was, for example, presented by Ebrahimi [42]. Furthermore, there exist alternative approaches to address the issue, including gray cumulative prospect theory [108–48], moth flame optimization, ant colony optimization technique, and Grey Wolf Optimization (GWO). Sharmistha et al., for instance, employed GWO, a recently created optimization technique, to maximize the usage of renewable energy sources and reduce a microgrid's energy cost [45]. To find the lowest operation cost, Wang et al. constructed an operation optimization model and optimized it using the moth flame optimization algorithm [46]. Zhao et al. suggested a novel MCDM model integrating the best worst approach to choose the best planning program; this model is relevant and feasible during the assessment and selection process [47].

Generally speaking, there are a few special techniques to deal with optimization problems: robust methods, fuzzy algorithms, SA, PSO, GA and enhanced algorithms, and other algorithms (GWO, moth flame optimization, etc.).

Table 1 provides an overview of their characteristics and related research.

GA is a type of non-deterministic quasi-natural algorithm that offers a powerful method for optimizing intricate systems. Based on earlier studies, a GA has been employed by numerous academics to address the microgrid optimization problem.

Zhao et al. established a dynamic economic dispatch model of a microgrid and used an NSGA-II variation to address the model [22], taking into account the interests of numerous stakeholders. In the end, the model in their study can aid in enhancing the power marketing economy and intelligent service by taking into account the total economic optimization of multi-objective and multi-interest groups within the microgrid.

Table 1. The most popular algorithms' features and associated research.

Algorithms	Features
GA and Improved GA [19-23]	1. Performs quick and random search. 2. The speed is slow, and the programming procedure is complicated. 3. Motivated by the evaluation function and an easy-to-use search process. 4. Is simple to integrate with different algorithms and can be expanded
SA [24-28]	1. The computation method is easy and has several things in common. 2. Suitable for handling complex nonlinear optimization problems 3. Long running time, parameter sensitivity and slow convergence
PSO (including Improved PSO) [32-35]	1. Quick search, Inaccurate and difficult convergence 2. There are fewer parameters to change, and the process is memorized. 3. Is unable to address combinatorial and discrete optimization issues efficiently
Fuzzy algorithms [38-40]	1. Able to produce a more acceptable, scientific assessment that is comparable to the real quantitative evaluation. 2. The computation is intricate, and the subjective determination of the index weight vector
Robust method [42-44]	1. The model's uncertainty is upfront taken into account. 2. The constructed optimization model is able to adjust to the impact of slight parameter changes within a specified set of uncertainties.

V. CONCLUSION

In order to present a typical system structure that consists of an energy generation system, an energy storage system, an energy distribution system, and energy end consumers. We first described the system structure based on the review articles that have already been published. After that, we looked at the optimization techniques used for microgrids and discovered that the most popular ones are simulated annealing and genetic algorithms.

Future microgrid optimization will be far more challenging due to the growing complexity of microgrid systems and their operating environments. In this situation, solving the issue might need the application of artificial intelligence (AI) and machine learning (ML) techniques. As a result, we can say that even though microgrid operation optimization has advanced at a fairly rapid rate in recent years, much work remains.

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To design a controller for the solar power Inverter to nullifying the temperature effect

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Abstract**—***The output waveform of sine triangle pulse width modulation at different modulation index is a crisp waveform. This waveform can be completed by adding another waveform. It is called a clamp waveform. This concept is called C to C concept or clipper clamper concept. The single-phase controller circuit is shown below. According to this circuit, anti-parallel diodes with constant DC supply connect to the grid supply. The extension of this circuit i.e. the 3-φ clamper circuit has been shown in The output of controller circuit is added up with NPC inverter.*

Keywords**— Pulse Width Modulation, Neutral Point Clamp, Controller.**

I. INTRODUCTİON

In the past ten years, power electronic inverters with high efficiency/high power density performance have gained more and more attention in a variety of home and commercial applications, including motor drives, grid-connected photovoltaic systems, and electric vehicles [1], [2]. The most crucial elements for these kinds of converters to have good final outcome are decreased voltage stress across the power electronic switches, enhanced modulation, and decreased/mitigated values of the high frequency common-mode voltage (HF-CMV) and leakage current [2]. By lowering the weight and dimensions of the output filters in grid-connected inverters, removing or detaching the galvanic transformer and increasing the number of inverter output voltage levels can also aid in the achievement of a high power density design [3]. In light of the aforementioned, transformer-less grid-tied photovoltaic systems are regarded as an effective, small, and well-liked option in recent years, which has led to the widespread release of numerous commercialized versions of recently created inverters [4], [5].

Pulse-dropping occurs when the inverter operates in an over-modulation (OM) area in order to maximize the DC bus voltage (VDC). Numerous researches claim that 1.154 VDC is the greatest DC bus voltage that can be used without pulse-dropping. THD decreases as a result of lower order harmonics appearing in the output waveform as a result of the inverter operating in the over-modulation area. An apparatus called a clamper circuit has been developed to reduce such harmonics. Thus, the methodology for this paper work incorporates the following: reduction of lower order harmonics in the total output waveform in the over-modulation zone.

II. OPERATİNG PRİNCİPLE

Over-modulation (OM) can be defined in terms of modulation index k.

$$k = \frac{V_{RN}}{V_{mpt}} \quad (1)$$

It can be similar with transformer turn ratio in our case its value more than one.

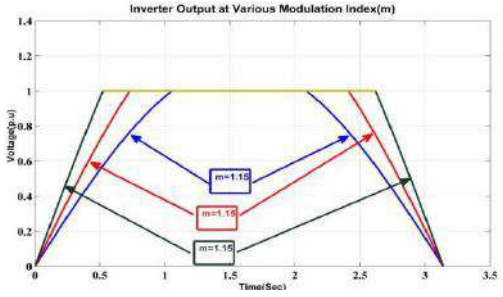

Fig.1. Voltage waveform (in PU) at different modulation indexes (k>1)

In Fig. 1, if the k is more than 1, then the clipping waveform appears so pulse dropping increases (as shown in fig. 2). Therefore, the switching of each switch get reduces (fig. 2).

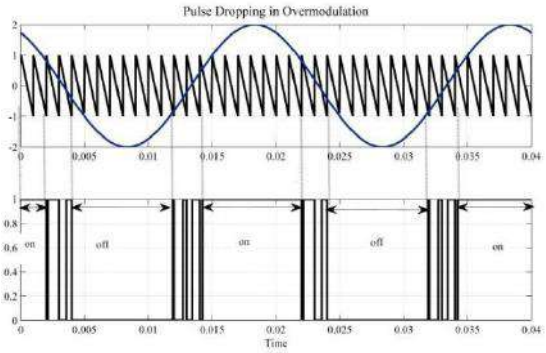

Fig.2. Pulse failure in R phases

In fig. 2, the arrow region shows R-phase waveform (i.e., pulse failure). The upper switches device will be continuously switched on. Similarly, on the next pulse dropping, it is continuously off here. Therefore, there are no pulses (pulse failure) at the on and off region; it is well known as pulse failure.

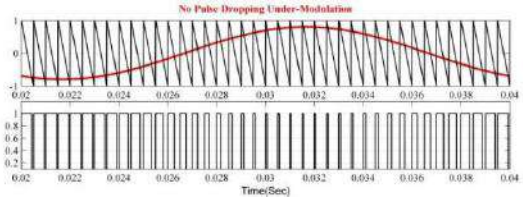

Fig.3. No pulse failure in under-modulation(UM)

By comparing fig. 2 and 3, the pulse failure in under and over modulation is shown. By increasing in k (modulation indexes) pulse dropping increase get increases.

2.1 C to C Concept

The output waveform of sine triangle pulse width modulation at different modulation index (shown in Figure. 1) is a crisp waveform. This waveform can be completed by adding another waveform. It is called a clamp waveform. This concept is called C to C concept or clipper clamper concept.

The single-phase controller circuit (Fig.: 4(a)) is shown below. According to this circuit, anti-parallel diodes with constant DC supply connect to the grid supply. The extension of this circuit i.e. the 3-φ clamper circuit has been shown in Fig. 4(b). The output of controller circuit is added up with NPC inverter.

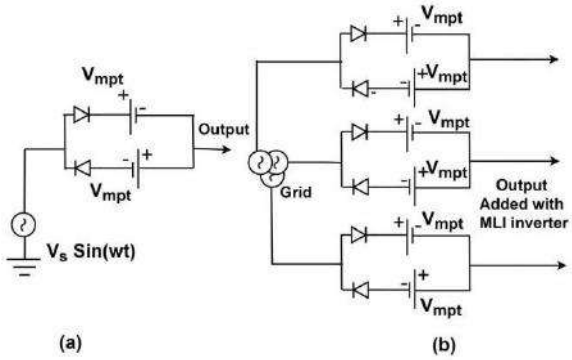

Fig.4. (a) 1-φ (b) 3-φ clamped circuits

2.2 Mathematical Modelling of the Controller and NPC convertor

The affiliated Mathematical modeling of the controller and NPC converter is based on C to C concept (i.e. clipper-clamper concept). The mathematical equations of this NPC convertor waveform has been written by equation 2. Similarly, the controller circuit wave-form at the same modulation indexes (k) has shown in equation 3 (by considering k>1) i.e. NPC convertor output wave-form

$$F(x) = \{k \sin wt, \quad 0 < wt \le \sin^{-1}\frac{1}{k} \quad 1 \quad , \sin^{-1}\frac{1}{k} \le wt \le 180 - \sin^{-1}\frac{1}{k} \quad k \sin wt \ , \ 180 - \sin^{-1}\frac{1}{k} \le wt \le 180 \ \} \quad (2)$$

And controller output wave-form is

$$F(x) = \{0 \ , \quad 0 < wt \le \sin^{-1}\frac{1}{k} \qquad f(x) = k \sin wt - 1 \quad , \sin^{-1}\frac{1}{k} \le wt \le 180 - \sin^{-1}\frac{1}{k} \le wt \le 180 \, , f(x) =$$

$$0, 180 - \sin^{-1}\frac{1}{k} \leq wt \leq 180\ \} \quad (3)$$

For harmonic analysis of these we note that the resultant is eventually equations (Eq. 2 and 3) are converted into the frequency (w) domain by using Fourier series in order to obtain the Fourier coefficient, [20] it has been represent in equation no.4.

$$= \frac{2}{180}\left(\int_0^{\frac{1}{k}} k\sin(x) * sin\ sin\ \frac{n*180*x}{180} * dx + \int_{\frac{1}{k}}^{180-\frac{1}{k}} 1 * sin\ \frac{n*180*x}{180} * dx + \int_{180-\frac{1}{k}}^{180} ksin(x) * sin\ \frac{n*180*x}{18055} * dx\right.$$

$$= \frac{2}{18055}\left(\int_0^{\frac{1}{k}} ksin(x) * sin(nx) * dx + \int_{\frac{1}{k}}^{180-\frac{1}{k}} 1 * sin(nx) * dx + \int_{180-\frac{1}{k}}^{180} k * sin(x) * sin(nx) * dx\right. \quad (4)$$

2.2.1 NPC converter output:

By using eq. 4 harmonics spectra of each part of the inverter has been shown by eq. 5 to 7.

$$\frac{2}{180}\int_0^{\left(\frac{1}{k}\right)} ksin(x) * (sin(n.x))\ dx = \frac{2k*sin\left(n\left(\frac{1}{k}\right)\right)\sqrt{\frac{k^2-1}{k^2}} - ncos\left(n\left(\frac{1}{k}\right)\right)}{180(n^2-1)} \quad (5)$$

$$\frac{2}{180}\int_{\left(\frac{1}{k}\right)}^{180-\left(\frac{1}{k}\right)} 1 * sin(n.x)\,dx = \frac{180 * cos\left(n\left(\frac{1}{k}\right)\right) - cos\left(n\left(-180 + \left(\frac{1}{k}\right)\right)\right)}{2n} \quad (6)$$

$$\frac{2}{180}\int_{180-\left(\frac{1}{k}\right)}^{180} k\sin(x) * (sin\ (n.x)\ )dx = \frac{2}{180(n^2-1)}\left(k\left(\frac{1}{2}sin\left((n-1)\left(\left(\frac{1}{k}\right)\right)\right)n + \frac{1}{2}sin\left((n-1)\left(\left(\frac{1}{k}\right)\right)\right) - \frac{1}{2}\right.\right.$$
$$sin\left((n+1)\left(-180 + \left(\frac{1}{k}\right)\right)\right)n + \frac{1}{2}sin\ \left((n+1)\left(-180 + \left(\frac{1}{k}\right)\right)\right) + \frac{1}{2}(n-1)180\ + \frac{1}{2}sin\ (n-1)180 - \frac{1}{2}$$
$$\left.\left.sin\ (n(n+1)180) + \frac{1}{2}sin\ (n-1)\right)\right) \quad (7)$$

Similarly, for the controller

$$b_n^{'} = \frac{2}{180}\int_0^{180} f'(x) * sin\ \frac{n*180*x}{180} * dx$$

$$= \frac{2}{180}\left(\int_0^{\frac{1}{k}} 0 * sin\ \frac{n*180*x}{180} * dx + \int_{\frac{1}{k}}^{180-\frac{1}{k}} (sin(x)\ - 1) * sin\ \frac{n*180*x}{180} * dx + \int_{180-\frac{1}{k}}^{180} 0 * sin\ \frac{n*180*x}{180} * dx\right)$$

$$= \frac{2}{180}\left(0 + \int_{\frac{1}{k}}^{180-\frac{1}{k}} (k * sin(x)\ - 1) * sin(nx) * dx + 0\right) \quad (8)$$

2.2.2 Controller output:

By using Eq. 8 Fourier transform of an active filter output (as shown by Eq. 9).

$$\frac{2}{180}\int_{\left(\frac{1}{k}\right)}^{\left(\frac{1}{k}\right)} (k\ sin\ (x) - 1) * sin\ (n.x)\ dx = \frac{2}{n(n^2-1)180}\left(1\left(\frac{-1}{2}\left((n-1)\left(-180 + \left(\frac{1}{k}\right)\right)\right)n^2 + \frac{1}{2}k\ sin\ \left((n+1)\left(-180 + \left(\frac{1}{k}\right)\right)\right)n^2\right.\right.$$
$$+cos\left(n\left(\left(\frac{1}{k}\right)\right)\right)n^2 - \frac{1}{2}k\ sin\left((n-1)\left(-180 + \left(\frac{1}{k}\right)\right)\right)\ n - n.k\ sin\left(\left(\frac{1}{k}\right)\right)\sqrt{\frac{k^2-1}{k^2}} - \frac{1}{2}k\ sin\ \left((n+$$

$$1)\left(-180+\left(\frac{1}{k}\right)\right)n-cos\left(n\left(-180+\left(\frac{1}{k}\right)\right)+cos\left(n\left(\frac{1}{k}\right)\right)\right)\right) \quad (9)$$

all electrical quantities are in per unit.

2.3 Boundaries and Limitations

Some boundaries and limitations are identified at the time of study and some assumptions have been considered for accomplishment of the work.

- Forward voltage drop of diode is not considered because the DC input voltage is higher; therefore, it can be neglected.
- DC ripple voltage effect is assumed to be zero due to filtering circuit.
- The delayed time is neglected.
- Turn on voltage drop and turn off leakage current is neglected.
- The load has sufficient reactive power to support identical voltage and current waveform.
- Grid supply (used by Controller) should have a very low THD.

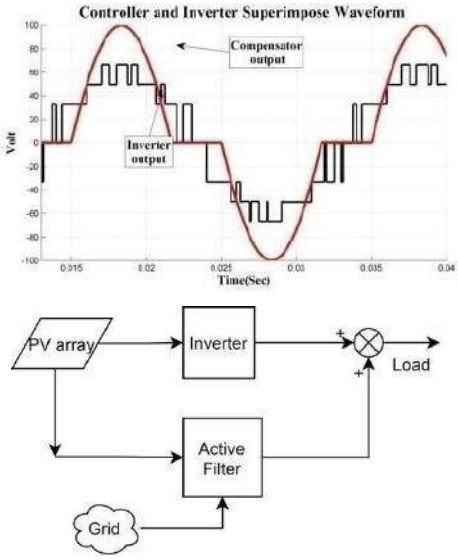

Fig. 6. (a)Super-impose controller and NPC convertor (b) Block diagram of the complete system

III. RESULTS

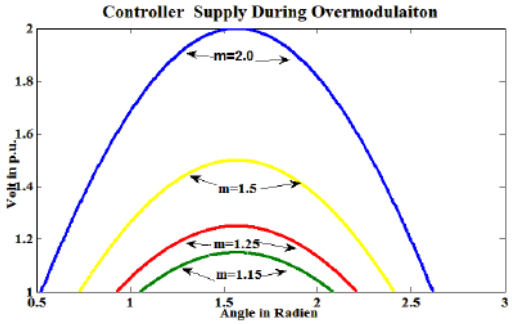

Fig.5 Controller output wave-form at different modulation indexes(k)

The output waveform of a 1-φ clamper circuit with the same modulating indexes is shown in Fig. 5. The modulation index (K) depends on the peak value of the carrier wave and the DC voltage. Suppose due to an increase in temperature, the PV array output voltage reduces [6], it results into modulating index increase from 1.15 to 2, and then the output of the controller is also changed shown in Fig. 5.

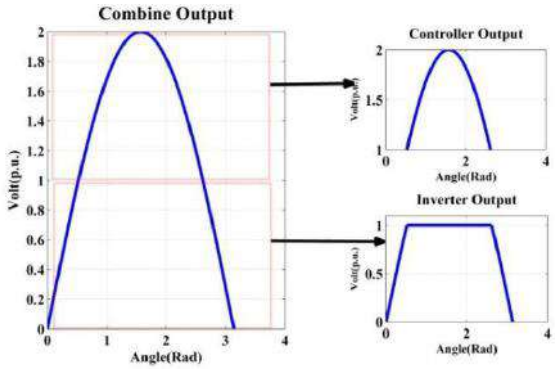

Fig.7. Controller and NPC converter

IV. CONCLUSİONS

The controller supply opposite polarity harmonics (with respect to the NPC converter), and after merger this, we can nullify the over-all total harmonic distortion. Increment in modulation index also reduces the fundamental voltage so controller also supply the additional fundamental supply.

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Rurbanisation of a Small Village: A Case Study of Sardoi under the Vishwakarma Yojana

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Abstract— *India's rapid urbanization presents significant challenges, including overburdened infrastructure and strained resources in cities. The Vishwakarma Yojana program seeks to address this by promoting rurbanisation, the development of rural areas with urban-like amenities. This research paper examines the approach towards rurbanisation in the small village of Sardoi using the Vishwakarma Yojana framework. Through a case study approach, the paper analyzes Sardoi's socio-economic status, identifies key development areas, and proposes a tailored rurbanisation plan. The paper further assesses the potential benefits and challenges associated with implementing the Vishwakarma Yojana in Sardoi.*

Keywords— ***Rurbanisation, Vishwakarma Yojana, Sardoi, Rural Development, Infrastructure Development, Socio-Economic Development***

I. INTRODUCTION

India's economic growth story in recent decades has been intricately linked with rapid urbanization. Fueled by aspirations for better job opportunities, education, and healthcare, millions of people have migrated from rural areas to urban centers. While this migration has contributed to economic dynamism, it has also cast a long shadow in the form of overburdened infrastructure, strained resources, and social challenges in cities.

Metropolises across India grapple with inadequate housing, congested transportation systems, and a growing strain on essential services like water supply and sanitation. Overcrowded slums and informal settlements emerge around city centers, reflecting the struggle to keep pace with the influx of population. These issues highlight the urgent need for a more balanced approach to development, one that acknowledges the importance of revitalizing and strengthening rural areas.

The concept of rurbanisation has emerged as a potential solution to this challenge. Rurbanisation focuses on developing rural areas with urban-like amenities, incentivizing residents to remain in their villages or return from urban centers. It aims to bridge the gap between rural and urban living standards, fostering development within rural areas while alleviating the strain on cities.

The Government of India's Vishwakarma Yojana program is a crucial step in this direction. This program identifies geographically contiguous rural settlements with high development potential and designates them as "cluster villages." These clusters receive funding for infrastructure development, skill development initiatives, and economic activity generation projects.

By promoting rurbanisation, the Vishwakarma Yojana program seeks to create a win-win situation. It aims to improve the quality of life in rural areas while simultaneously alleviating the pressure on urban infrastructure and resources. However, the success of such programs hinges on a deep understanding of specific needs of individual villages.

This research paper delves into the case of Sardoi, a small village aiming to leverage the Vishwakarma Yojana framework. Through a detailed case study approach, the paper analyzes Sardoi's socio-economic status, identifies crucial development areas, and proposes a tailored rurbanisation plan. The paper further assesses the potential benefits and challenges associated with implementing the Vishwakarma Yojana in Sardoi, contributing to the ongoing

discourse on sustainable rural development strategies in India.

The following sections will explore the specific details of Sardoi's situation, outlining its current challenges and opportunities for growth. We will then delve into a proposed rurbanisation plan, examining projects aimed at infrastructure development, social service improvement, and economic diversification. Finally, the paper will analyze the potential benefits and challenges associated with implementing the Vishwakarma Yojana in Sardoi, offering valuable insights for future endeavors in rurbanisation strategies.

1. Research Objectives:

This research paper aims to:

1. Analyze the socio-economic status of the village of Sardoi.
2. Identify key development areas in Sardoi aligned with the Vishwakarma Yojana framework.
3. Propose a rurbanisation plan for Sardoi outlining specific infrastructure and economic development projects.
4. Evaluate the potential benefits and challenges associated with implementing the Vishwakarma Yojana in Sardoi.

II. METHODOLOGY

This research employs a case study approach, focusing on the village of Sardoi. Data collection methods include:

- **Secondary Data Analysis:** Reviewing government reports, census data, and other published materials to understand Sardoi's demographics, economic activities, existing infrastructure, and social indicators.
- **Field Visits:** Conducting site visits to Sardoi to observe village conditions, meet with local residents and stakeholders, and collect primary data through surveys and interviews.
- **Literature Review:** Examining relevant academic literature on rurbanisation, the Vishwakarma Yojana program, and rural development strategies.

Case Study: Sardoi Village

Sardoi is a small village located in [District Name], [State Name], India. (Replace bracketed information with actual details). Based on secondary data analysis and preliminary field visits, here's a preliminary profile of Sardoi:

- **Population:** [Insert population figure].
- **Demographics:** Predominantly [dominant caste/community] population with a presence of [other communities] (if applicable).
- **Economic Activities:** Agriculture is the primary source of income, with a limited presence of [mention other occupations, if any].
- **Infrastructure:** Limited access to [list existing infrastructure: electricity, roads, sanitation, healthcare facilities etc.].
- **Social Indicators:** Low literacy rate (mention specific figures if available), limited access to [mention social services: education, healthcare].

III. KEY AREAS FOR DEVELOPMENT IN SARDOI UNDER VISHWAKARMA YOJANA

Based on the initial assessment of Sardoi's status and the core principles of the Vishwakarma Yojana, several key areas for development emerge:

- **Physical Infrastructure:** Upgrading existing roads to connect to nearby towns and markets, constructing drainage systems to address waterlogging, ensuring reliable electricity supply through renewable energy sources like solar power, improving sanitation facilities through individual household latrines, and developing a sustainable water supply network.
- **Social Infrastructure:** Building new schools and healthcare facilities, expanding access to digital connectivity to bridge the digital divide, and promoting skill development programs to enhance employability.
- **Economic Development:** Encouraging agro-processing industries to add value to agricultural produce, supporting rural tourism initiatives to leverage local heritage and culture, and promoting entrepreneurship opportunities to diversify the village economy.
- **Sustainable Practices:** Integrating renewable energy sources like solar power to reduce reliance on fossil fuels, promoting water conservation techniques like rainwater harvesting, and implementing effective waste management programs to ensure environmental sustainability.

IV. PROPOSED RURBANISATION PLAN FOR SARDOI

Phase 1: Infrastructure Development (12 Months):

- **Project 1.1:** Upgrade 5 kilometers of village roads to connect Sardoi to nearby market towns, improving

access and facilitating transportation of goods and services.

- **Project 1.2:** Construct a comprehensive drainage system to mitigate waterlogging issues during the monsoon season, protecting homes and infrastructure.
- **Project 1.3:** Install a solar power microgrid to provide a reliable electricity supply, reducing dependence on traditional sources and promoting sustainable energy practices.
- **Project 1.4:** Construct individual household latrines to improve sanitation facilities and promote hygiene practices in the village.
- **Project 1.5:** Develop a sustainable water supply network with borewells or rainwater harvesting systems to ensure year-round access to clean drinking water.

Phase 2: Social Infrastructure Development (18 Months):

- **Project 2.1:** Construct a new primary school to cater to the growing student population and improve access to quality education.
- **Project 2.2:** Upgrade the existing healthcare facility or build a new one to provide essential medical services to the village community.
- **Project 2.3:** Expand internet connectivity through Wi-Fi hotspots or fiber optic networks to bridge the digital divide and facilitate access to information and communication technologies.
- **Project 2.4:** Implement skill development programs in collaboration with vocational training institutes or NGOs, focusing on areas like agriculture, food processing, or handicraft production to enhance employability and income generation opportunities.

Phase 3: Economic Development (24 Months):

- **Project 3.1:** Establish an agro-processing unit to add value to agricultural produce, such as a milk chilling plant, a rice processing mill, or a fruit and vegetable processing facility. This initiative will reduce post-harvest losses and increase income for farmers.
- **Project 3.2:** Develop rural tourism initiatives by identifying heritage sites, promoting local crafts, and providing training for homestays. This will diversify the village economy and create employment opportunities in the tourism sector.
- **Project 3.3:** Facilitate microfinance schemes and entrepreneurship development programs to support the creation of small businesses in various sectors like food processing, handicrafts, or tailoring.
- **Project 3.4:** Establish a village market complex to provide a platform for local vendors to sell their produce and crafts, boosting the local economy and creating opportunities for livelihood generation.

Phase 4: Sustainability (Ongoing):

- **Project 4.1:** Promote water conservation practices through rainwater harvesting systems, drip irrigation technologies, and community awareness campaigns.
- **Project 4.2:** Implement effective waste management programs by establishing waste collection systems, segregating waste at source, and promoting composting methods for organic waste.
- **Project 4.3:** Encourage the use of renewable energy sources like biogas plants or solar cookers for domestic purposes to reduce reliance on fossil fuels and promote environmental sustainability.
- **Project 4.4:** Organize regular workshops and awareness campaigns on sustainable practices to encourage community participation in environmental conservation efforts.

V. POTENTIAL BENEFITS OF VISHWAKARMA YOJANA IN SARDOI

The potential benefits of implementing the Vishwakarma Yojana in Sardoi extend far beyond the initial improvements in infrastructure, economic development, and social services. Here's a deeper exploration of these benefits and their long-term positive impacts:

1. Enhanced Quality of Life:

- Improved Health Outcomes: Upgraded healthcare facilities, access to clean water and sanitation, and potential reduction in air pollution due to renewable energy adoption can lead to a healthier population in Sardoi. This translates to lower healthcare costs, increased productivity, and a longer life expectancy for residents.
- Educational Attainment: A new primary school and improved access to digital connectivity will create a more conducive learning environment for children in Sardoi. This can lead to higher literacy rates, increased educational attainment, and better career prospects for future generations.
- Social Cohesion and Community Development: The rurbanisation plan can foster a stronger sense of community spirit in Sardoi. Improved infrastructure and social services can create spaces for interaction, recreation, and cultural activities. Skill development programs can

empower women and youth, leading to greater social inclusion and participation in community development initiatives.

2. Economic Empowerment and Diversification:

- Increased Household Income: The creation of new employment opportunities through agro-processing, rural tourism, and small businesses will directly impact household income levels in Sardoi. This will empower families, improve their purchasing power, and contribute to a higher standard of living.
- Reduced Poverty: Increased economic activity and income generation opportunities have the potential to significantly reduce poverty levels in Sardoi. This can lead to improved access to basic necessities, educational opportunities for children, and better healthcare services.
- Entrepreneurship and Innovation: The rurbanisation plan can stimulate entrepreneurship within the village. Microfinance schemes and business development programs can empower individuals to start their own ventures, fostering innovation and diversification of the local economy. This can lead to the creation of new products and services, catering not only to local needs but also potentially expanding to nearby markets.

3. Increased Investment and Sustainability:

- Attracting Investment: Improved infrastructure and a skilled workforce can attract external investments in Sardoi. This can lead to further economic growth, the creation of new businesses, and the development of new industries that complement the existing rural economy.
- Sustainable Practices and Environmental Benefits: Promoting renewable energy sources, water conservation techniques, and effective waste management can create a more sustainable future for Sardoi. This reduces the village's ecological footprint, promotes environmental awareness within the community, and helps mitigate the effects of climate change on the local environment.
- Resilient Rural Development: A well-planned rurbanisation strategy can contribute to a more resilient rural development model. Improved infrastructure, diversified economy, and a skilled workforce can better equip Sardoi to withstand unforeseen circumstances like natural disasters or economic downturns.

4. Addressing Urbanization Challenges:

- Reduced Pressure on Cities: By improving living conditions and economic opportunities in Sardoi, the Vishwakarma Yojana can deter residents from migrating to overburdened cities. This can alleviate pressure on urban infrastructure and resources, leading to improved living conditions and a more balanced regional development pattern.
- Preserving Rural Culture and Heritage: Rurbanisation doesn't necessitate the complete transformation of Sardoi into an urban center. The plan can incorporate elements that preserve the village's unique cultural heritage and traditions. This can be achieved through promoting local crafts and cuisine in rural tourism initiatives, or integrating traditional knowledge and practices into sustainable development strategies.

5. Fostering Innovation and Replication:

- Learning Model for Other Villages: The success of the rurbanisation plan in Sardoi can serve as a learning model for other villages facing similar challenges. Sharing best practices, knowledge transfer, and replicating successful projects can contribute to a broader national framework for sustainable rural development.
- Promoting Innovation in Rural Development: The implementation of the Vishwakarma Yojana in Sardoi can pave the way for further innovation in rural development strategies. Pilots and demonstration projects can be implemented to test new technologies, approaches, and financing mechanisms tailored to the specific needs of rural communities.

By realizing these potential benefits, the Vishwakarma Yojana can create a ripple effect that extends beyond Sardoi. It can contribute to a more balanced regional development model, reduce the strain on urban infrastructure, and empower rural communities to chart a sustainable and prosperous future.

VI. CHALLENGES OF IMPLEMENTING VISHWAKARMA YOJANA IN SARDOI

While the Vishwakarma Yojana offers a promising pathway for rurbanisation in Sardoi, translating vision into reality necessitates confronting several significant challenges. Here's a closer look at the potential hurdles that may need to be overcome:

1. Funding Availability:

The success of the rurbanisation plan in Sardoi hinges on securing adequate funding for the proposed projects. The Vishwakarma Yojana provides financial assistance, but the allocated budget may not cover all project costs. Here are some potential issues:

- Limited Government Resources: The government may face limitations on the total funds allocated to the program, potentially requiring prioritization among different cluster villages.
- Matching Funds: The program might require villages to contribute matching funds for project implementation, which could be a challenge for communities with limited financial resources.
- Sustainability of Funding: Rurbanisation is a long-term endeavor. Ensuring a consistent flow of funds for maintenance, operation, and potential future upgrades of infrastructure projects is crucial.

Strategies for Overcoming Funding Challenges:

- Public-Private Partnerships (PPPs): Collaborating with private companies for infrastructure development projects can leverage private sector investment and expertise.
- Community Mobilization: Engaging the Sardoi community in fundraising activities and resource mobilization efforts can foster a sense of ownership and encourage greater participation.
- Exploring Alternative Funding Sources: Sardoi can explore grants offered by NGOs, international development agencies, or corporate social responsibility initiatives.

2. Community Participation and Ownership:

Active participation and a sense of ownership from the Sardoi community are vital for the long-term success of the rurbanisation plan. Potential challenges include:

- Social Resistance: Changes to existing infrastructure or economic activities may be met with resistance from some community members. Addressing concerns through open communication and ensuring equitable distribution of benefits is crucial.
- Lack of Awareness: Residents may require clear explanations of the program's goals, potential benefits, and potential impacts on their lives. Effective communication and community engagement strategies are essential.
- Skill Gaps and Capacity Building: Implementing skill development programs may require assessing existing skills within the community and identifying potential gaps. Collaborating with training institutions or NGOs can bridge these skill gaps.

Strategies for Fostering Community Participation:

- Community Meetings and Workshops: Regular meetings and workshops can inform residents about the rurbanisation plan, address concerns, and encourage feedback.
- Formation of Village Committees: Establishing village committees with diverse representation can facilitate participatory decision-making and ensure everyone's voices are heard.
- Capacity Building Initiatives: Providing training programs on project management, financial literacy, and leadership skills can empower community members to actively participate in the planning and implementation process.

3. Land Acquisition and Resource Management:

Developing infrastructure projects often necessitates land acquisition. Here are some potential challenges:

- Land Disputes: Disagreements between landowners and the government regarding land acquisition can lead to delays and legal complications.
- Resource Allocation: Sustainable management of water resources for new projects and ensuring equitable access to water for all residents is crucial.
- Environmental Impact Assessments: Careful consideration of the potential environmental impact of infrastructure projects is necessary, and mitigation measures must be implemented.

Strategies for Addressing Land Acquisition and Resource Management Issues:

- Fair Compensation and Negotiations: Open and transparent communication with landowners is key. Fair compensation for acquired land and exploring alternative sites if feasible can minimize conflict.
- Water Resource Management Plans: Developing sustainable water management plans that promote conservation and ensure equitable access for all residents is crucial.
- Environmental Impact Assessments and Mitigation: Conducting thorough environmental impact assessments and implementing mitigation measures such as tree planting or waste management systems is essential.

4. Skill Development and Employability:

Skill development programs are a cornerstone of the Vishwakarma Yojana, but challenges may arise:

- Identifying Relevant Skills: Matching skill development programs with the actual needs of the evolving job market in Sardoi and surrounding areas is important for ensuring employability of trainees.
- Quality of Training and Certification: Providing high-quality training programs with recognized certifications can enhance the effectiveness of skill development initiatives.
- Bridging the Skill Gap: Sardoi's existing workforce may require additional training to adapt to new technologies or industries introduced through the rurbanisation plan.

Strategies for Effective Skill Development:

- Market Research and Industry Collaboration: Collaborating with local businesses and industry experts to identify in-demand skills for the region ensures program relevance.
- Partnering with Training Institutions: Partnering with established training institutions or NGOs with expertise in delivering skill development programs can maximize effectiveness.
- Focus on Continuous Learning: Promoting a culture of continuous learning within the community through workshops and skill-upgradation programs can enhance long-term.

VII. CONCLUSION

The case of Sardoi exemplifies the potential and challenges associated with implementing the Vishwakarma Yojana program. By addressing infrastructure deficiencies, fostering economic diversification, and promoting social development, rurbanisation offers a promising pathway for improving the quality of life in rural areas and mitigating the strain on overburdened cities.

The proposed rurbanisation plan for Sardoi outlines a roadmap for achieving these goals. Upgrading infrastructure, building a new school and healthcare facility, and expanding digital connectivity will lay the foundation for a more developed and connected village. Developing agro-processing units, promoting rural tourism, and encouraging small businesses will create new employment opportunities and diversify the local economy. Prioritizing sustainable practices like renewable energy sources, water conservation, and waste management will ensure long-term environmental benefits. However, the success of this plan hinges on overcoming challenges related to funding, community participation, land acquisition, and skill development. Effective communication, fostering a sense of ownership within the community, and adopting a collaborative approach are crucial. Continuous monitoring and evaluation of the implemented projects will be essential to ensure they meet their intended objectives and adapt to evolving circumstances.

The rurbanisation of Sardoi can serve as a model for other villages seeking to leverage the Vishwakarma Yojana framework. By learning from both successes and challenges, India can chart a course for sustainable rural development, creating a more balanced and prosperous future for its citizens across the nation.

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Frabication of an eco-friendly corrosion inhibitor from Terminalia catappa leaf concrete reinforcement in seawater

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Abstract— *Metal corrosion is one of the most challenging problems facing industries. Using corrosion inhibitors is one reasonable approach to protecting metal surfaces. Due to the toxicity of industrial corrosion inhibitors, researchers are continuously searching for green, economical, and friendly alternatives. The present study focuses on the application of Terminalia catappa leaf extract to mitigate the corrosion of concrete reinforcing steel in a simulated seawater environment. The dry product from the Terminalia catappa leaf extraction process was determined to have amino functional groups in polyphenols. Polarization results demonstrate that the corrosion current density decreases from 8.87 A/cm^2 (for samples soaked in blank solution) to 5.12 µA/cm^2 when adding the optimal concentration of 0.004% of Terminalia catappa leaf extract. 3.5% NaCl solution. Electrochemical impedance spectroscopy (EIS) analysis showed that the inhibition efficiency reached over 90% at this concentration after 24 hours of soaking.*

Keywords— ***extraction, Terminalia catappa, corrosion inhibitor, concrete reinforcement, seawater.***

I. INTRODUCTION

The marine and coastal atmospheres often contain high concentrations of aggressive substances and changes in wet and dry conditions due to rain and monsoons. The influence of the marine and coastal atmospheres on metallic materials is mainly shown through the aggressive nature of chloride ions in the air and the specific conditions of the coastal climate of each region. The steel corrosion rate in seawater increased significantly with temperature and aeration; the rate decreased with increased carbon content and with a change from dry blasting to wet blasting. Field tests in tropical seawater were carried out at 2 and 12 m depths. No significant difference in corrosion rate was found at these two depths. Average corrosion rates of 0.53 and 0.35 mm/year were measured for exposure periods of 2 and 12 months, respectively.[1-7]

Reinforced concrete was invented and applied in the mid-19th century. However, it was only in the late 19th and early 20th centuries that it was used to construct marine structures. Reinforced concrete structures can work sustainably in a non-aggressive environment for over 100 years. Meanwhile, in aggressive coastal environments, steel reinforcement and concrete corrosion lead to cracking and destruction of concrete and reinforced concrete structures, which can appear after 10 to 30 years of use. The durability of reinforced concrete structures depends on environmental aggression and the quality of the materials used.[2, 8-11]

Currently, many measures have been researched and applied to minimize the effects of metal corrosion. Among the anti-corrosion measures, environmentally friendly corrosion inhibitors are among the most influential and economical methods. Limiting the corrosion process can be achieved by increasing anodic or cathodic polarization, reducing the movement or diffusion of ions onto the metal surface, increasing the resistance of the metal surface, etc. According to theory, the organic inhibitors used need to be well adsorbed on the metal surface for good inhibition. Typically, aromatic compounds containing heteroelements

such as O, N, S, and P will interest research because these heteroelements are electron-rich elements and are readily adsorbed on metal surfaces. Through the process of creating electron-accepting bonds with metal atoms. In addition to heteroatoms, the aromatic ring is an essential factor that enhances the adsorption process. The pi-electron system will increase the electrostatic interaction between the inhibitors and the metal surface.[10, 12-16] In this paper, the extraction of *Terminalia catappa* leaf and the corrosion inhibition effect of concrete reinforcement in seawater were studied.

II. EXPERIMENTS

Chemicals

Macklin Company (China) provided the gallic acid (98.5%) and Folin-Ciocalteu's phenol reagent (2N). Xilong Company (China) provided the ethanol (96%), sodium chloride (99.5%), and sodium carbonate (99.5%).

Preparation of Terminalia catappa leaf extract

Leaves of *Terminalia catappa* are harvested in the morning. After being cleaned, the leaves were dried till the mass didn't alter. Ultimately, a fine powder is made from the dried leaves. Using ultrasonic diffusion, the dried *Terminalia catappa* was mixed with ethanol at a 5 g/100 ml ratio for 60 minutes. For two hours, the polyphenols were extracted at 60 ^{o}C. Via vacuum filtration, the *Terminalia catappa* extract was gathered.

Using gallic acid as the standard reagent, the Folin-Ciocalteu technique was used to determine the polyphenol concentration17-20. The solution was then tested at a wavelength of 713 nm using UV-vis spectroscopy. The following formula can be used to calculate the extract's polyphenol content:

C = 25.302 * Abs - 0.3903 (R^2 = 0,9916)

The infrared spectrum of polyphenols extracted from *Terminalia catappa* leaf in the range of 4000–400 cm^{-1} demonstrates the presence of characteristic functional groups.

Weight loss method

Prepare eight small CB300 steel samples with a cross-section of 1 cm^2 and a thickness of about 5-8 mm, then grind the surfaces and calculate the total area of the samples. Prepare samples soaked in 100 ml of mixture with different extract ratios of 0%, 0.002%, 0.004%, 0.006%, 0.008%, and 0.01% with 3.5% NaCl. Mark and soak CB300 steel samples in different concentrations. Measure the amount of corrosion every day. Calculate the corrosion rate according to the following formula:

$$\rho = \frac{m_0 - m_t}{S \times t} = \frac{\Delta m}{S \times t}$$

In there:

- ρ: corrosion rate;

- m_0: weight of the metal sample before testing (g) or (mg);

- m: weight of the metal sample after the experiment (g) or (mg);

- S: metal surface area (cm^2);

- t: time (hour) or (day, night) or year.

Polarization curve method

The CB300 steel electrode sample had its surface smoothed and then soaked in a 3.5% NaCl solution with a ratio of 0.002% to 0.04% almond leaf extract for 30 minutes before measurement to create a surface coating. All electrochemical measurements were performed on an Autolab PGSTAT12/30/302 at room temperature in a three-electrode system consisting of a reference electrode (RE) of Ag/AgCl, an auxiliary electrode (CE) of Pt metal plate, and a CB300 steel electrode sample prepared as the working electrode (WE) as shown in Figure 1.[21-24]

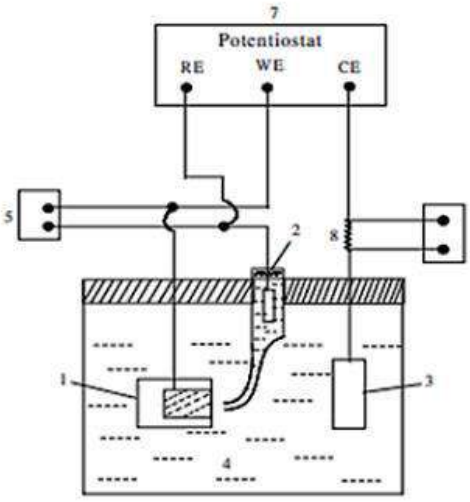

Fig. 1: Diagram of the electrochemical measurement method.

1. Working electrode (WE); 2. Reference electrode (RE) - Ag/AgCl electrode; 3. Auxiliary electrode (CE) made of Pt; 4. Electrolyte solution (3.5% NaCl solution); 5, 6. Carmilivol; 7. Potentionstat; 8. The sample resistance has a known value

Electrochemical impedance spectroscopy method

The steel electrode sample has a smooth surface. Electrochemical impedance spectroscopy (EIS) analysis was performed at OCP in the frequency range of 100 kHz ÷ 0.1 Hz. The EIS spectra were fitted using Nova 2.1.5

software. Before measuring the total resistance, the electrode surface was coated with a varnish solution and soaked in a mixture of 3.5% + 0.002% to 0.01% NaCl solution. Experiments were repeated three times for each extract concentration. All impedance measurements were performed on an Autolab PGSTAT12/30/302 at room temperature in a three-electrode system consisting of an Ag/AgCl reference (RE) electrode, a Pt auxiliary (CE) electrode, and a steel reinforcement sample as the working electrode (WE). The standard circuit model is shown in Figure 2.[25-28]

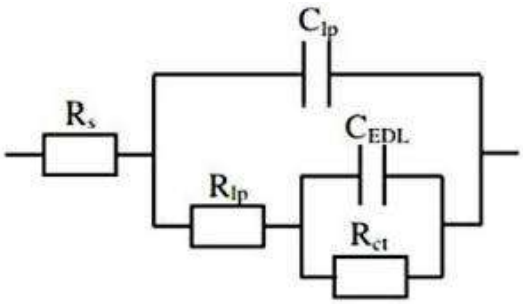

Fig. 2: The equivalent circuit is used to fit the EIS spectrum.

III. RESULTS AND DISCUSTION

Characterization of Terminalia catappa leaf extract

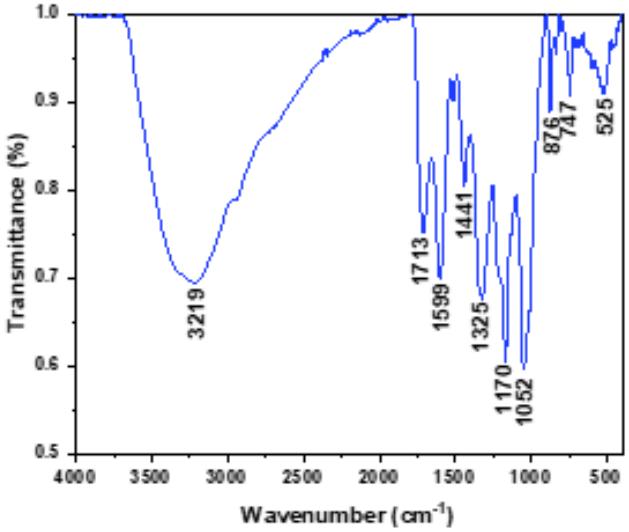

Fig. 3: FTIR spectroscopy of dried extract of Terminalia catappa leaf.

Figure 3 displays the FTIR spectroscopy of a dried extract from *Terminalia catappa*, demonstrating the presence of unique functional groups. In the wavenumber range, an oblique peak of significant prominence is observed at 3219 cm^{-1}. Polyphenolic compounds are characterized by the symmetric and asymmetric relaxation vibrations of the polymer hydroxyl group (O–H), also known as H-bond relaxation, which are represented by the range 3400–3200 cm^{-1}. There may be a link between the -C=O group and the six-carbon aromatic ring, as shown by a vibration that may be detected at 1713 cm^{-1}. The wavenumber at 1599 cm^{-1} is in the range of 1550 - 1650 cm^{-1}, representing strong in-plane NH_2 scissor absorption. Additional proof of the existence of the -CH- group of methylene on aromatic rings stretching is provided by the C-H linkage-related deformation variations at wavenumbers 1441 cm^{-1} in the ranges 1430–1470 cm^{-1}. The wavenumber at 1170 cm^{-1} is in the range of 1000-1250 cm^{-1} assigned to the vibration of the C-N bond in the aliphatic amine functional group. The region between 1000 and 1100 cm^{-1} is sometimes referred to as the fingerprint zone because it contains a large number of unique low-intensity single bands that are associated with specific functional groupings. A vibration at 1052 cm^{-1} is linked to the stretching of -C-O-C-. Finally, the wavenumber at 747 cm^{-1} is responsible for the C-H bond of the phenyl radical.

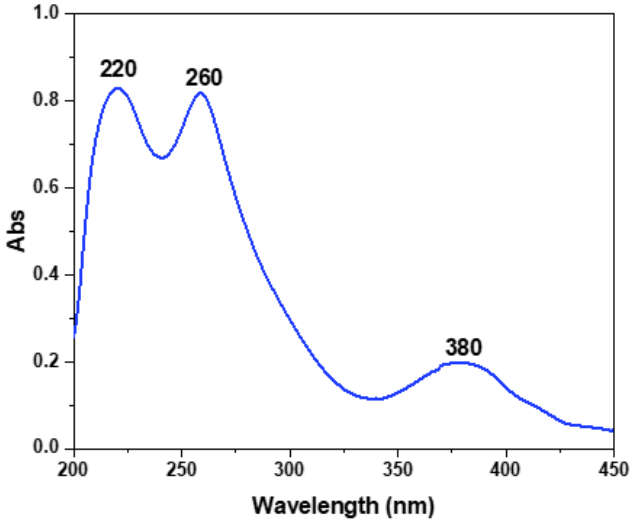

Fig. 4: UV-Vis spectroscopy of dried extract of Terminalia catappa leaf.

Figure 4 displays the UV-Vis photometric spectrum of the leaf extract from Terminalia catappa. Two nearby peaks on the spectrum, located at 220 and 260 nm, are thought to represent the polyphenols found in Terminalia catappa leaves. Furthermore, a smaller peak was also detected at 380 nm. The equation used to quantify the polyphenol content in the Terminalia catappa extract was used to compute the polyphenol concentration using the UV-Vis photometric technique. The extract of *Terminalia catappa* showed a polyphenol content of 24,291 mg/L.

Weight loss method

The weight loss method was used to preliminarily evaluate the corrosion inhibition of the extract on CB300 steel reinforcement in 3.5% NaCl solution. Experiments were conducted with different concentrations of *Terminalia*

catappa leaf extract after different time periods. The results are recorded in Figure 5 and Table 1.

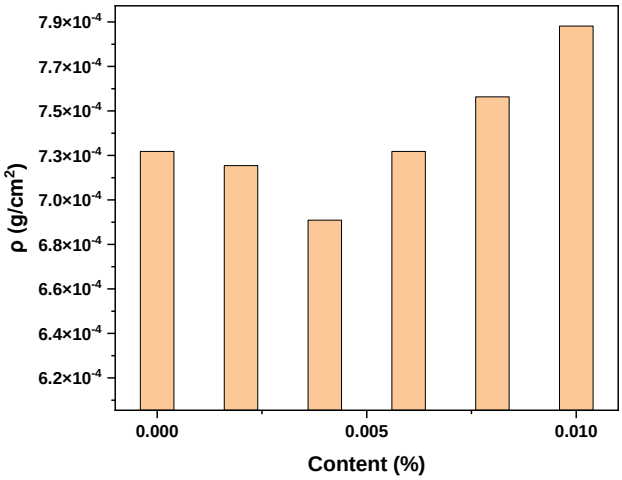

Fig. 5: Graph of the effect of Terminalia catappa leaf extract concentration on steel corrosion rate.

Within the survey, steel samples were immersed in a simulated seawater environment with a concentration of 0.004% Terminalia catappa leaf extract for the best corrosion resistance. The reason may be that the polyphenol component in Terminalia catappa leaf extract is acidic, so, at high concentrations, it will increase the possibility of corrosion from 0.006% to 0.01% of the extract.

Table 1. Time-dependent weight loss results with different extract contents.

Time, days	2	7	9	13	16	21	23	28	30
Content, %	Weight loss (mg)								
0.00%	0.65	0.48	0.45	0.50	0.60	0.56	0.45	0.52	0.30
0.00%	0.60	0.38	0.40	0.43	0.47	0.38	0.35	0.32	0.35
0.00%	0.35	0.34	0.55	0.33	0.33	0.40	0.45	0.38	0.25
0.01%	0.65	0.48	0.30	0.48	0.33	0.44	0.40	0.52	0.50
0.01%	0.65	0.42	0.35	0.40	0.43	0.46	0.60	0.34	0.30
0.01%	0.35	0.48	0.40	0.27	0.40	0.40	0.35	0.34	0.30
0.02%	0.75	0.38	0.45	0.45	0.27	0.56	0.45	0.40	0.50
0.04%	0.05	0.50	0.25	0.37	0.47	0.34	0.50	0.36	0.45

Polarization curve method

Figure 6 and Table 2 show that the adsorption of the extract changes the anode dissolution process as well as the development of hydrogen at the cathode, clearly the addition of *Terminalia catappa* leaf extract from 0.002% to 0.006% has reduced the corrosion current density, corrosion speed, corrosion voltage increase. On the contrary, with the addition of extract from 0.008% to 0.04%, the corrosion potential increased by increasing icorr, corrosion rate and decreasing E_{corr}. This can be explained that *Terminalia catappa* leaf extract is acidic, and when added at high concentrations, it will increase the corrosion ability of steel reinforcement. This finding suggests that *Terminalia catappa* leaf extract can be classified as a type of mixed inhibitor in seawater solution.

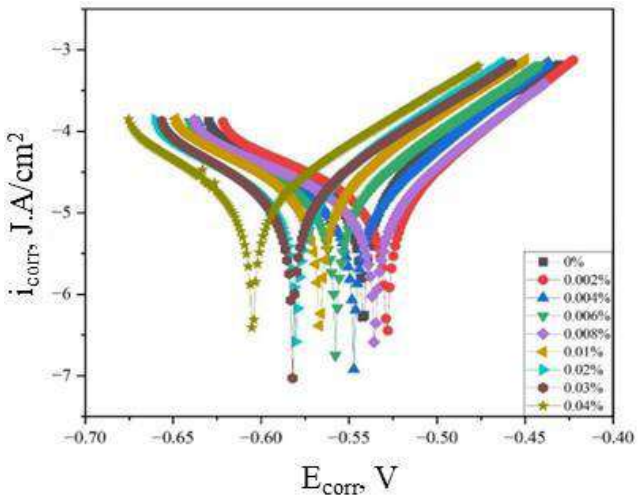

Fig. 6: Potentiodynamic polarization curves recorded in 3.5 wt.% NaCl solution for the steel at different Terminalia catappa leaf extract contents.

Table 2. Corrosion potential (E_{corr}), corrosion current density (i_{corr}), corrosion rate (v_{corr}), and inhibition effect (H_{in}).

Contents (%)	0%	0,002%	**0,004%**	0,006%	0,008%	0,01%	0,02%	0,03%	0,04%
E_{corr} (V)	-0,543	-0,530	**-0,548**	-0,559	-0,537	-0,568	-0,581	-0,583	-0,606
i_{corr} (A/cm²)	8,87	6,76	**5,12**	7,18	7,75	7,77	8,34	9,22	10,5
v_{corr} (mm/năm)	0,1031	0,0786	**0,0594**	0,0834	0,0901	0,0903	0,0969	0,1071	0,1220
H_{in} (%)	0	23,76	**42,39**	19,11	12,61	12,42	6,01	-3,88	-18,33

Electrochemical impedance spectroscopy

From Figure 7, we see that the EIS curve of the sample containing a concentration of 0.004% of the *Terminalia catappa* leaf extract has the shape of the largest radius and is almost a perfect circle. This shows that the varnish layer containing 0.004% extract has very poor electrical conductivity and high corrosion resistance in NaCl solution. The EIS curve of varnish-coated steel reinforcement samples with a concentration of 0.006% to 0.01% extract will have a gradually smaller radius shape and be deformed compared to samples without extract. It has been shown that at high concentrations, the varnish layer is affected by the presence of *Terminalia catappa* leaf extract, reducing the electrical conductivity and corrosion resistance of the original varnish layer. The explanation for the interaction between the composition of the *Terminalia catappa* leaf extract and the varnish layer becomes stronger as the concentration of the extract increases, based on the concave characteristic of the Nyquist graph. Ion diffusion becomes stronger the higher the concentration of *Terminalia catappa* leaf extract because *Terminalia catappa* leaf contain active ingredients such as polyphenols, flavonoids, and tannins, which can form complexes with metal ions in the varnish layer. Thus, we can conclude that the impedance response of the metal increases with the inhibitor concentration, from 0.002% to 0.004%, and decreases when the inhibitor concentration ranges from 0.006% to 0.01%.

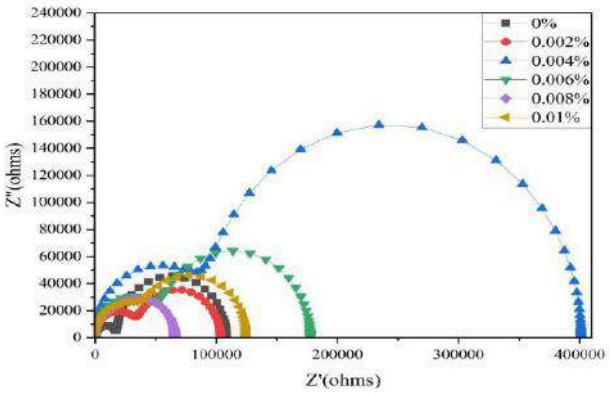

Fig. 7: Electrochemical impedance spectroscopy recorded in 3.5 wt.% NaCl solution for the steel at different Terminalia catappa leaf extract contents.

IV. CONCLUSION

The research results on Terminalia catappa leaf extract to minimize concrete reinforcement corrosion in simulated seawater environments are positive. Corrosion current density decreased from 8.87 A/cm^2 (for samples soaked in a 3.5% blank NaCl solution) to 5.12 µA/cm^2 when adding 0.004% *Terminalia catappa* leaf extract. Electrochemical impedance spectroscopy (EIS) shows that the inhibition efficiency is over 90% at the same concentration after 24 hours of soaking. *Terminalia catappa* leaf extract contains many polyphenols, which inhibit the corrosion process of concrete reinforcement in a seawater environment.

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