**AN AUTOMATED AND REWARD BASED PAPER RECYCLING INITIATIVE**

**BY**

**AMAEFULE MERCY CHIMNONSO**

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**IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A BACHELOR OF SCIENCE (B.Sc.) IN COMPUTER SCIENCE**

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# DECLARATION

I Amaefule Mercy Chimnonso, hereby declare that this research project titled “An Automated and reward based paper recycling initiative” has been carried out by me under the supervision of Engr. Dr. M.M Liman. It has not been presented for the award of any degree in any institution. All sources of information are specifically acknowledged by means of references.

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# CERTIFICATION

This is to certify that Amaefule Mercy Chimnonso, 2019/SC/CSC/0077 undertook this research work titled “An Automated and reward based paper recycling initiative” has been examined and meets the requirements for submission to the Department of Computer science, Faculty of Computing, Federal University of Lafia, in partial fulfillment for the award of Bachelor of science (B.Sc.) Computer Science Degree 2024.

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Engr. Dr. M. M. Liman Date

(Project supervisor)

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Dr. Timothy Moses Date

(Head of Department)

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(External Examiner) Date

# DEDICATION

This report is dedicated to God Almighty, my parents and siblings for their constant love and support and to my Mentor Mr. Nicholas Efewengbe Aminaho.

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# ABSTRACT

## CHAPTER ONE: INTRODUCTION

## 1.1 Background of study

Schools, as hubs of learning and activity, generate substantial amounts of paper waste. This waste stems from various sources, including teaching activities, administrative tasks, and school projects. Higher institutions, in particular, tend to produce more paper waste than primary and secondary schools due to their extensive research activities, administrative documentation, and higher volume of printed materials required for lectures and assignments (ETM Recycling, 2024). In 2005, Europe produced 99.3 million tonnes of paper, generating 11 million tonnes of waste. During the same period, 47.3 million tonnes of recycled paper were produced, generating 7.7 million tonnes of solid waste (CEPI, 2006). The continuous growth in recovered paper consumption is driven by technological advancements, competitive pricing, environmental awareness, and regulatory influences. Despite challenges, the recycling rate in Europe reached a record high of 72.2% in 2009 (CEPI, 2006).

Paper production has significant environmental impacts, particularly due to the use of raw materials and energy-intensive processes involved. The manufacturing process of paper involves the use of toxic chemicals, and paper mills are among the worst manufacturing polluters. The decomposition of paper in landfills releases methane, a potent greenhouse gas that significantly contributes to climate change. This underscores the importance of recycling efforts to mitigate these detrimental effects (Hughes, 2022).

Recycling paper is a crucial process in environmental conservation, significantly contributing to the reduction of greenhouse gas emissions. Recycling requires 70% less energy and water compared to manufacturing new paper products from raw materials, and recycling one ton of paper saves 17 trees and conserves 3.3 cubic yards of landfill space (Hughes, 2022). By recycling paper, the reliance on harmful paper mills is reduced, leading to a decrease in air pollution by up to 74% (Hughes, 2022). This illustrates the direct environmental benefits and necessity of promoting paper recycling initiatives, particularly in large-scale generators of paper waste, such as schools and educational institutions.

However, recycling technologies can mitigate these negative effects and provide economic benefits. Recycling reduces environmental loading by conserving natural resources and decreasing the emission of harmful compounds (Cabalova et al., 2011). The production of paper from recycled fibers consumes less energy and reduces environmental pollution. Pati, Vrat, and Kumar (2008) proposed a mixed integer goal programming (MIGP) model to optimize the paper recycling network system. While their approach aimed to indirectly benefit the environment and improve the quality of waste paper reaching recycling units, it may have oversimplified the complex realities of recycling networks. The model's effectiveness in real-world applications could be limited by its reliance on idealized assumptions and potential failure to account for practical challenges such as fluctuating market demands, transportation inefficiencies, and variations in waste paper quality. Furthermore, the indirect environmental benefits claimed may need more rigorous quantification and validation.

Given these challenges and findings, the development of a web system to facilitate the collection of paper from schools for recycling companies is a strategic approach to enhance recycling efforts. This system will not only streamline the process but also encourage active participation from schools by rewarding them for their contributions to environmental conservation.

## 1.2 Statement of problem

Despite the benefits of paper recycling, many schools lack efficient systems to manage their paper waste and connect with recycling companies. The traditional methods of paper collection are often cumbersome, leading to lower participation rates and less effective recycling outcomes. Schools generate a substantial amount of paper waste, and without an organized system to facilitate recycling, much of this paper ends up in landfills, contributing to environmental degradation.

Current challenges include:

1. **Inefficient Collection Processes**: Schools often have no streamlined method to gather and track paper waste, leading to inconsistent and ineffective recycling practices.
2. **Lack of Incentives**: There are few incentives for schools to participate in recycling programs actively. Without rewards or recognition, the motivation to recycle diminishes.
3. **Limited Awareness and Engagement**: Schools and students may lack awareness about the benefits of recycling and the environmental impact of their paper waste, resulting in lower engagement.
4. **Connectivity Issues**: Schools may face difficulties in connecting with recycling companies efficiently, leading to delays and logistical challenges in the recycling process.

To address these issues, a web-based system designed to manage and incentivize paper recycling in schools is proposed. This system will provide schools with a virtual platform to monitor their paper recycling activities, earn rewards, and view their contributions to environmental conservation. By fostering a competitive yet rewarding environment, the system aims to increase participation and effectiveness in paper recycling, thereby contributing to broader environmental sustainability efforts.

1.3 Aim and Objectives

Aim

The aim of this project is to develop a web-based system that facilitates the efficient collection and management of paper recycling activities between schools and recycling companies. The system aims to incentivize schools to participate actively in paper recycling by providing a platform to track their contributions, earn rewards, and foster a competitive environment.

Objectives

1. Develop a User-Friendly Interface: Create a web system with a user-friendly dashboard that allows schools to easily register, monitor their paper submissions, view their accumulated points, see top- performing schools and get rewards
2. Enable Smart Notifications and Engagement: Integrate Gemini AI to send personalized notifications to schools based on their recycling patterns, thereby increasing engagement and participation.
3. Facilitate Admin Operations: Provide a tool for recycling company administrators to record the weight of paper submissions, update points, and manage rewards efficiently.

1.4 Significance of the Study

This project holds significant importance as it tackles critical issues related to paper waste management in educational institutions and beyond. Its potential impact spans environmental conservation, educational initiatives, community engagement, and technological advancement.

One of the significance is promoting paper recycling; the project contributes to substantial environmental benefits. It reduces greenhouse gas emissions, conserves natural resources, and decreases the usage of landfill space – crucial steps in mitigating climate change and promoting sustainability. The project's integration into schools allows for the education of students about environmental conservation, instilling sustainable habits among young adults. Schools play a pivotal role in shaping future generations, making this project's educational impact invaluable. Next is the sense of community and collaboration among schools, students, and recycling companies this project brings, strengthening relationships and fostering a shared goal. Lastly, the incorporation of technology in the recycling process showcases how modern advancements can be leveraged to solve real-world problems, driving positive environmental outcomes and improving waste management practices.

## 1.5 Scope of study

The scope of this study encompasses the development and implementation of a web-based system designed to facilitate paper recycling initiatives in higher institutions. The primary aim is to streamline the process of collecting and recording paper waste generated by these institutions and incentivize their participation in recycling programs through a points-based reward system. This system will include functionalities for school registration, virtual bin management, submission tracking, and reward allocation. The study will focus on the design and deployment of the user interface for both school users and recycling company administrators, the integration of a smart notification system powered by GEMini AI to enhance user engagement, and the evaluation of the system's impact on paper recycling rates within the participating institutions.

1.6 Organization of work

This project is organized into five chapters, each focusing on a distinct aspect of the study. The first chapter introduces the project by presenting the background of the study, the problem statement, the aim and objectives, the significance, and the scope of the study, along with the definition of key terms. Chapter Two reviews the relevant literature, including the theoretical framework, related works, and identified research gaps. Chapter Three details the system analysis, design, and methodology, providing a thorough analysis of the existing system, justifications for the new system, the methodology adopted, and specifications including program modules, database design, and system flowchart. Chapter Four covers the implementation, testing, results, and documentation of the new system, highlighting system requirements, development, testing procedures, results, and documentation practices. Finally, Chapter Five concludes the study, summarizing the findings, providing conclusions, and offering recommendations for application and areas for further research. This structured approach ensures a comprehensive examination and clear presentation of the project development process.

1.7 Definition of terms

* + **Paper Waste**: Paper products that are discarded after use in various activities, including administrative tasks, academic work, and general operations within an institution.
  + **Recycling**: The process of converting waste materials into new materials, in the project context involves reprocessing paper waste into usable paper products.
  + **Virtual Bin**: A digital representation of the physical collection bin used to track the volume and weight of paper waste submitted by an institution for recycling.
  + **Points-Based Reward System**: A system where institutions earn points based on the amount of paper waste they submit for recycling, which can then be redeemed for rewards.
  + **Smart Notification System**: An AI-powered feature designed to send personalized tips, reminders, and engagement messages to users based on their activity and participation levels in the recycling program.
  + **Gemini AI**: A specific artificial intelligence technology utilized in the system to enhance user engagement and optimize notification delivery.
  + **Recycling Company Administrator**: The user responsible for managing the recycling process, including verifying paper submissions, updating points, and overseeing reward distribution.
  + **User Interface (UI):** The visual and interactive components of the web-based system that users interact with to perform various tasks related to paper submission.
  + **Environmental Impact**: The effect that the activities related to paper production, waste, and recycling have on the natural environment, including factors like energy consumption, pollution, and resource conservation.
  + **Higher Institutions**: Refers to post-secondary education establishments such as universities, colleges, and technical schools where advanced education and research are conducted
  + **Gamification**: The process of adding game elements and mechanics to non-game contexts to increase engagement and motivation.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical Framework

The rise of web-based applications and gamification techniques has opened up new avenues for promoting environmental sustainability practices, particularly in the realm of paper recycling. These technological advancements offer innovative solutions that not only motivate participation but also enable precise tracking of recycling progress.

Gamification can be effectively implemented digitally to bridge the gap between recycling behavior and knowledge. Functional solutions are preferred, with several gamified mechanisms proving effective in promoting recycling. These include feedback systems, awards, achievements, collaborative and competitive elements, and supplementary functions (Helmefalk & Rosenlund, 2020). Such approaches have the potential to make recycling more engaging and motivating for participants.

In higher education settings, several key factors influence recycling intentions and behaviors. These include environmental concern, attitudes towards recycling, social norms, institutional environmental policies, and the availability of recycling facilities. Universities play a crucial role in increasing awareness of environmental issues and shaping sustainable behaviors among students and staff (Sallaku et al., 2019). This highlights the importance of comprehensive approaches that address both individual attitudes and institutional support for recycling initiatives.

While gamification shows promise in changing behaviors, there are still gaps in our understanding of its effectiveness. The field lacks a unified taxonomy for gamification and motivational affordances, and there is a need for more studies linking specific gamification elements to psychological outcomes. To address this, a structured approach using Structural Equation Modeling can help validate the effects of gamification on behavioral change in various sustainability domains (Ourdas & Ponis, 2023). This methodological advancement could lead to more effective design of gamified recycling systems.

Innovative approaches to raising awareness about recycling and environmental sustainability can take various forms. For instance, games that build upon familiar concepts while incorporating real-world elements can be particularly effective. By challenging players to engage in simulated recycling activities, such games can reinforce proper recycling habits and promote ecological responsibility across different age groups (Sá Escudeiro & Gouveia Campos, 2023). This gamified approach demonstrates the potential for technology to make environmental education more engaging and impactful.

These insights collectively demonstrate the potential of web-based and gamified approaches to enhance recycling behaviors and environmental awareness. By combining technological solutions with behavioral insights, it's possible to create effective recycling initiatives, particularly in educational settings. Future web-based recycling initiatives aimed at schools should leverage these advancements in gamification principles and data management strategies. The goal is to create scalable and engaging platforms that not only boost recycling rates but also foster a culture of environmental stewardship among young people.

2.1.1 **Automated Systems for Recycling**

Automated systems for recycling have emerged as a promising solution to address the challenges of waste management in smart cities and improve the efficiency of recycling processes. These systems leverage advanced technologies such as artificial intelligence, machine learning, and computer vision to enhance the sorting and classification of recyclable materials.

One approach to automated recycling involves the use of digital models that can automatically sort and classify waste according to recycling requirements. By combining image processing techniques with artificial neural networks (ANN) and feature fusion, these systems can achieve high accuracy in waste classification. For instance, a model utilizing various extracted features and machine learning algorithms has demonstrated an accuracy of 91.7% in sorting waste across three categories. This digital-enabled approach has the potential to significantly improve waste sorting services and recycling decisions throughout the value chain in smart cities (Mohammed et al., 2023).

Another significant advancement in automated recycling systems is the integration of robotics with sophisticated visual and manipulation capabilities. These robotic systems are designed to operate in the heterogeneous, complex, and unpredictable environment of waste sorting facilities. By incorporating deep learning technologies and computer vision modules, these robots can identify and sort items with high precision. The development of low-cost computer vision modules based on deep learning has made it possible to create effective autonomous robotic systems for categorizing and physically sorting recyclables according to material types (Koskinopoulou et al., 2021).

The implementation of such robotic systems in waste processing plants has shown promising results, even under difficult and demanding industrial conditions. These systems not only improve the processing of recyclables but also offer the potential to increase the overall efficiency and effectiveness of recycling operations. The availability of open-source datasets and image processing scripts for object identification, masking, and synthetic placement against multiple backgrounds further facilitates research and development in this field (Koskinopoulou et al., 2021).

In addition to advancements in sorting and classification, automation plays a crucial role in calculating points and rewarding participants in recycling initiatives. When the weight of paper is recorded using digital scales, the system can automatically calculate and assign points to the respective schools. This immediate calculation and allocation of points streamline the reward process, ensuring accuracy and enhancing user engagement. The integration of automation for point calculation contributes to the seamless operation of the recycling initiative, encouraging more schools to participate actively.

The integration of these automated systems into the recycling process represents a significant step towards realizing the circular economy vision for smart cities. By improving the accuracy and efficiency of waste sorting and classification, and automating the point calculation and reward process, these technologies can help overcome practical difficulties in recycling and accelerate progress towards sustainable waste management practices.

2.1.2 Gamification in Recycling Initiatives

Gamification has emerged as a promising approach to improve recycling rates and promote environmentally friendly habits. By incorporating game-like elements into recycling initiatives, gamification can address the current lack of knowledge and incentives that often hinder effective recycling practices.

Functional and digital implementations of gamification have shown potential in bridging the gap between recycling behavior and knowledge. Several gamified mechanisms have proven effective in motivating and engaging people to recycle. These include goals, awards, challenges, user engagement, achievements, collaborative and competitive elements, and supplementary functions. By incorporating these elements, recycling initiatives can make the process more engaging and rewarding for participants, ultimately influencing positive recycling behavior (Helmefalk & Rosenlund, 2020).



Figure 2.1: Gamification Approach (Tenfold, 2018)

The application of gamification in recycling initiatives aligns well with the principles of a circular economy, which emphasizes decreasing the use of new raw materials and minimizing waste disposal through reuse and recycling. By promoting recycling and environmentally friendly habits through gamification, consumers can be encouraged to engage in sustainability thinking, which is crucial for effective resource recycling.

Both utilitarian (effectiveness and efficiency) and hedonic (playfulness) values of gamified recycling websites contribute to users' cognition- and affect-based attitudes, satisfaction, and behavioral intentions (Hsu & Chen, 2021). These factors, in turn, influence users' willingness to continue using the service and spread positive word-of-mouth. The effectiveness, efficiency, and playfulness of gamified recycling platforms, along with the confirmation of users' expectations, play significant roles in shaping attitudes and satisfaction levels. The impact of gamification may vary depending on users' cultural backgrounds. The effects of value on attitudes in a gamification context can be moderated by collectivistic versus individualistic user orientations. This finding highlights the importance of considering cultural factors when designing and implementing gamified recycling initiatives (Hsu & Chen, 2021). By leveraging gamification in recycling initiatives, website managers and environmental organizations can develop more effective strategies to motivate users' continued engagement with recycling services. This approach not only enhances individual recycling behaviors but also contributes to broader environmental sustainability goals by extending product life cycles and promoting a circular economy mindset.

2.1.3 User Engagement and Environmental Education

Environmental education plays a crucial role in addressing climate change and promoting sustainable lifestyles. It not only increases knowledge but also encourages changes in attitudes and behaviors. To enhance the effectiveness of environmental education, innovative approaches such as gamification have gained attention, particularly for engaging youth in pro-environmental behaviors.

Gamification platforms designed for environmental education can significantly impact pro-environmental behavioral change. Key elements that increase the success of these platforms include meaning, ownership, social influence, achievability, challenge, and credibility. The more attributes enclosed in the gamification design, the stronger physical and mental connections it builds with participants. This insight can guide educators in selecting best practices and help gamification designer’s better influence behavioral change through game mechanics (Ouariachi et al., 2020). However, the traditional knowledge-attitudes-behavior pathway that underpins much of environmental education practice has been challenged. Recent research suggests that certain types of knowledge are more likely to influence behaviors than others, and working with existing attitudes is generally more effective than attempting to change them. Environmental education programs can benefit from expanding their focus beyond knowledge and attitudes to include outcomes such as nature connectedness, sense of place, efficacy, identity, norms, social capital, youth assets, and individual wellbeing (Krasny, 2020). To enhance the effectiveness of environmental education programs, educators can construct theories of change that target specific intermediate outcomes likely to lead to environmental behaviors and collective action. By planning activities to achieve these intermediate outcomes, programs can more effectively foster long-term environmental actions. In some cases, directly engaging participants in desired behaviors or collective actions can lead to changes in efficacy, sense of place, and other intermediate outcomes, which in turn promote future environmental actions (Krasny, 2020).

Evaluation is crucial for assessing the impact of environmental education programs. Both quantitative and qualitative methods can be employed to measure changes in environmental behaviors and intermediate outcomes. Surveys and qualitative evaluation guidelines can help educators assess the effectiveness of their programs and make data-driven improvements (Krasny, 2020).

By incorporating these insights into environmental education initiatives, educators and program designers can create more engaging, effective, and impactful experiences that foster long-term pro-environmental behaviors and contribute to broader sustainability goals.

2.2 Review of related Works

The study of automated and reward-based paper recycling initiatives is supported by various studies that delve into the application of gamification, the use of advanced technologies, and the development of pro-environmental behaviors. These studies collectively highlight the potential of integrating innovative approaches to enhance recycling rates and foster environmentally friendly habits especially in higher institutions. Technological advancements offer innovative solutions that motivate participation and enable precise tracking of submission progress. Recent research has demonstrated the potential of these approaches in enhancing recycling behaviors and environmental awareness.

Zhang et al. (2020) address the challenge of household waste recycling in cities by designing a smart incentive-based recycling system using Internet of Things (IoT) and data analysis technologies. Their system comprises four key components: amount pattern discovery, price adjustment suggestion, waste-collection amount forecasting, and information sharing among stakeholders. The researchers implemented their system in a pilot community in Shanghai, analyzing data on 19 specific recyclable items over a seven-month period. The results showed a significant increase (229.3%) in the recyclable waste-collection amount. Their two-month trend analysis and fortnight forecasting capabilities aim to help recycling businesses plan more rationally. The new information-sharing platform facilitated smoother collaboration among stakeholders in household waste recycling and reduction efforts.

Gibovic and Bikfalvi (2021) conducted a pilot project in Catalonia, Spain, to encourage plastic recycling among families using a virtual reward token called RECICLOS. The study introduced gamification elements through raffles and lotteries, along with a webapp prototype for registering recycled plastic. Over a six-week period, 1,053 families (10% of the target population) registered for the scheme.

The researchers emphasize the multidimensional aspects of recycling activities and their strong connection to human behavioral patterns. They argue that mobile technologies have significant potential in this field due to the high demand for communication and interaction. The results suggest that varied, effective, and innovative incentive schemes can influence people's recycling habits positively.

Urquijo (2018) developed a system, WasteApp, an application developed as part of the European URBAN-WASTE project to promote sustainability in waste generation from tourist destinations. The app uses gamification to raise awareness about correct waste disposal in 11 European cities. Users interact with QR codes on waste containers and social media to accumulate points, which can be redeemed for prizes from partner entities.

The app includes features such as a QR code reader, a map showing container locations, available prizes, and a point tracking system. Users can earn points by scanning QR codes on containers (limited to twice daily) or by interacting on social media with a specific hashtag. This innovative approach aims to engage both tourists and local inhabitants in proper waste management practices. The use of reward systems to motivate students in educational institutions especially in waste management improves potential benefits and participation level. While acknowledging the potential benefits of rewards in stimulating learning and encouraging good behavior, Renard (2020) also notes that some students works better when there is a constant reward. The article explores both advantages and disadvantages of reward systems for schools. Renard (2020) offers suggestions for implementing effective reward systems, including creative ideas for school’s use and examples of reasonable rewards for students and schools. Renard (2020) emphasizes on the importance of carefully considering how to structure and implement reward systems to maximize their positive impact on student motivation and learning outcomes.

Gamification has emerged as a promising strategy to improve recycling rates and address the current lack of knowledge and incentives that often hinder effective recycling practices. Helmefalk and Rosenlund (2020) and Hsu and Chen (2021) both explored the potential of gamification in motivating recycling behavior. Their findings reveal that solutions that involve gamification can be effectively implemented digitally to bridge the gap between behavior and knowledge. These studies identified several gamified mechanisms that can promote recycling, including feedback systems, awards, achievements, collaborative and competitive elements, and supplementary functions. Ouariachi et al. (2020) further reinforced these findings, emphasizing that meaning, ownership, social influence, achievability, challenge, and credibility are core elements for successful gamification platforms. Collectively, these studies demonstrate that gamification elements can make recycling more engaging and motivating for participants, ultimately influencing positive recycling behavior. In the context of a circular economy and environmental education, research has shown the importance of integrating cognitive and affective aspects in promoting sustainable behaviors. Hsu and Chen (2021) found that effectiveness, efficiency, playfulness, and confirmation contribute to cognition- and affect-based attitudes and satisfaction, which in turn influence repetitive usage and word-of-mouth intentions. Similarly, Krasny (2020) argued for expanding the focus of environmental education beyond knowledge and attitudes to include outcomes like nature connectedness, sense of place, efficacy, and social capital. Both studies highlight the need for a holistic approach to environmental education that considers multiple factors influencing behavior change.

The application of automated systems in recycling has shown significant promise in improving the efficiency and accuracy of waste sorting. Mohammed et al. (2023) and Koskinopoulou et al. (2021) both explored advanced technological solutions for waste management. Mohammed et al. proposed a digital model using artificial neural networks (ANN) and feature fusion techniques, achieving 91.7% accuracy in sorting waste across three categories. Koskinopoulou et al. took this a step further by integrating robotics with sophisticated visual and manipulation capabilities for recyclable sorting. Both studies demonstrate the potential of digital-enabled and robotic approaches to improve waste sorting services and recycling decisions throughout the value chain in smart cities and industrial settings.

The integration of technology and behavioral insights in recycling initiatives has shown promising results across various studies. Helmefalk and Rosenlund (2020), Hsu and Chen (2021), and Ouariachi et al. (2020) all demonstrated how gamification can increase user engagement and motivation in recycling activities. Meanwhile, Mohammed et al. (2023) and Koskinopoulou et al. (2021) showcased the potential of automated and robotic systems in enhancing the efficiency of waste sorting processes. These technological advancements, combined with the behavioral insights provided by Krasny (2020) and others, offer a comprehensive approach to improving recycling rates and fostering environmental stewardship.

These studies collectively highlight the growing importance of innovative approaches to waste management and recycling, demonstrating the potential of integrating web-based applications as well as the potential of digital technologies and incentive systems in promoting sustainable behaviors. From smart city applications to gamified recycling initiatives and educational reward systems, these diverse approaches demonstrate the multifaceted nature of addressing environmental and educational challenges in contemporary society.

2.3 Research Gaps

The reviewed literature provides valuable insights into the application of gamification, advanced technologies, and behavioral approaches in promoting recycling and sustainable behaviors. However, several research gaps specific to automated and reward-based paper recycling initiatives are evident. One significant gap is the lack of understanding regarding the long-term behavioral impact of these initiatives, particularly in the context of paper recycling. While the studies demonstrate short-term improvements in recycling rates and user engagement, there is need for solutions that follow people's waste submission habits over a longer period to see if these systems can really make a lasting difference in how we recycle paper and stick to eco-friendly habits, which can be enhanced by facilitated by automated and reward-based systems. There is also a gap in understanding the integration of technological solutions within paper recycling initiatives. While individual studies explore the effectiveness of automated systems and reward mechanisms separately, research that combines these approaches could provide comprehensive solutions for enhancing paper recycling rates and improving waste management efficiency. A lot of research focuses on small-scale projects or specific situations. This shows that we need more studies that look at bigger, more flexible ways of doing things that can work in many different places where people recycle paper. There's also a gap in understanding how automated and reward-based programs affect learning outcomes like understanding the environment and being aware of sustainability. It's important to study how these programs can distract students or staffs in schools and other learning places. The last gap explains how existing systems do not give enough attention to how cost-effective and sustainable these initiatives are in the long run. We need research that looks at whether they make economic sense, their impact on the environment, and whether they can be maintained over time. This information is crucial for informing stakeholders and policymakers properly.

CHAPTER THREE

SYSTEM ANALYSIS, DESIGN AND METHODOLOGY

**3.1 Analysis of the Existing System**

The existing system for paper recycling in educational institutions involves a structured process where recycling companies collect paper waste from schools. It lacks a centralized, automated, and user-friendly platform. Typically, schools and recycling companies rely on manual processes involving operation through a series of steps designed to manage and facilitate the collection, transportation, and processing of recyclable paper. Schools typically gather paper waste in designated bins, which are then picked up by recycling companies on scheduled collection days. The collected paper is transported to recycling facilities, where it is weighed, sorted, and processed into new paper products. This process is labor-intensive, prone to errors, and lacks transparency, though it aims to reduce environmental impact of paper waste, promote sustainability, and encourage responsible waste management practices within educational institutions but the absence of real-time data and analytics makes it difficult to monitor progress, identify inefficiencies, and engage schools in a meaningful way to enhance their recycling efforts.

**3.1.1 Data Flow of the Existing System**

The existing system involves several manual steps:

1. Paper Collection Request: Schools contact the recycling company via phone or email to request paper collection.
2. Scheduling: The recycling company schedules a pickup, which is often communicated back to the school through phone or email.
3. Paper Weighing: Upon collection, the recycling company manually weighs the paper and records the weight on paper logs or spreadsheets to be used for accurate tracking and report and rarely for compensation
4. Data Entry: The collected data is later entered into a computer system for record-keeping and reporting purposes.
5. Communication: Updates on the collected paper and corresponding points are communicated back to the school through email or phone.

**3.1.2 Advantages of the Existing System**

The existing system aims to reduce environmental impact of paper waste, promote sustainability and encourage pupils and students in waste management practices, below are other advantages of the manual collection system.

1. Simplicity: The manual system is straightforward and does not require advanced technical skills.
2. Cost-Effective: Initially, it may be cheaper as there is no need for an investment in technology or training.
3. Flexibility: Schools and recycling companies can adapt the process to their specific needs without being constrained by a predefined system.

**3.1.3 Disadvantages of the Existing System**

Despite the simplicity the existing system might offer, there are additional factors that diminish its overall effectiveness, they include:

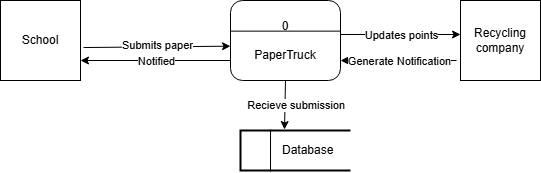
1. Inefficiency: Manual data entry and communication are time-consuming and prone to delays.
2. Error-Prone: Manual recording and data entry can lead to errors and inconsistencies.
3. Lack of Transparency: There is no centralized system to track and monitor progress in real-time.
4. Limited Engagement: Schools have limited visibility into their recycling efforts and progress, reducing motivation.
5. Data Management Issues: Storing and retrieving paper logs and spreadsheets can be cumbersome and inefficient, especially over the long term.

3.2 Analysis of the new system

The proposed web-based system represents a major advancement in managing and improving the efficiency of paper recycling efforts in schools. It will have a user-friendly interface allowing schools to track their recycling bins, get personalized tips from an AI assistant, and view progress in real-time. An automated points and rewards system will accurately calculate rewards based on the weight of paper recycled, eliminating manual errors. Schools can track their progress towards rewards.

The system will also provide detailed analytics dashboards for schools and an administrative interface for recycling companies to manage rewards, points, and data on participating schools. By encouraging higher recycling participation through transparency, engagement, and rewards, the system aims to increase paper recycling volumes and reduce paper waste environmental impact. The system is designed to be scalable and adaptable, easily integrating more schools/companies and adapting to future technological and regulatory changes.

Finally, the new system leverages automation, real-time data, personalization, and simplified administration to address limitations and significantly improve the management of paper recycling initiatives in schools.



***Fig. 3.1: Level 0 Data Flow Diagram of the New System***

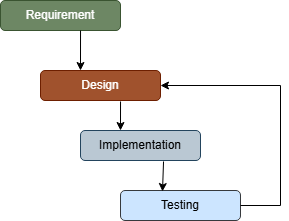
**3.2.1 Justification of the New System**

The justification for developing a new system is rooted in the need to streamline the process of collecting and recycling paper from schools, enhancing both environmental and operational efficiency. The current system, while functional, suffers from several limitations that hinder its overall effectiveness. The new system offers a comprehensive solution to overcome these shortcomings. First off, it automates the process of tracking paper weights and calculating rewards, eliminating the potential for human error and ensuring fairness in the distribution of incentives. Next is the integration of an AI assistant provides personalized guidance and recommendations, fostering greater engagement and participation from schools. Furthermore, the real-time data collection and analysis capabilities enable continuous monitoring and optimization of recycling efforts, identifying areas for improvement and maximizing environmental impact. The scalable and adaptable nature of the new system ensures its long-term viability, allowing for seamless integration of new participants and the ability to evolve alongside technological advancements and changing regulations. The new system represents a strategic investment in promoting sustainable waste management practices, fostering a collaborative ecosystem between schools and recycling companies, and ultimately contributing to environmental conservation efforts.

3.3 Methodology Adopted

The methodology adopted for the development and implementation of the new paper recycling system is Agile, In Agile development; the software development process is divided into multiple iterations, each iteration encompassing the phases of requirements gathering, design, implementation, and testing. When errors or defects are discovered during testing, the development team iterates back to the design phase to incorporate necessary changes or improvements based on the feedback and issues encountered during testing, it is crucial in ensuring its effectiveness, reliability, and scalability. The methodology encompasses a systematic approach that includes several key phases:

* Requirements Gathering: The first phase involves gathering requirements from stakeholders, including schools, recycling companies, and system administrators. This process includes identifying functional and non-functional requirements, user roles, system interfaces, and data management needs.
* Design and Architecture: The next phase focuses on designing the system architecture, user interfaces, database structures, and integration of AI-driven features. The design phase considers scalability, security, usability, and performance aspects to ensure a robust and user-friendly system.
* Development: Following the design phase, development activities commence, where coding and implementing the system components.
* Testing: While the development process is ongoing, rigorous testing, including unit testing, and integration testing, is conducted to identify and rectify any issues or bugs.

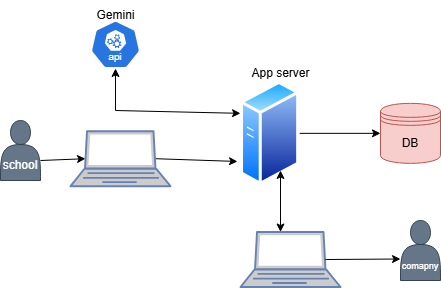


***Figure 3.2: Development Model***

3.4 High-Level Model of the New System

The high-level model of the new paper recycling system provides an overview of its architecture, components, and interactions. The system can be divided into several key modules:

* User Interface Module: This module includes interfaces for schools (users), recycling company workers (admins), and system administrators. Each interface is designed to cater to specific user roles and functionalities, providing an intuitive and user-friendly experience.
* Data Management Module: The system incorporates a robust database management system (DBMS) to handle data related to schools, recycling activities, rewards, points, notifications, and system logs. Data integrity, security, and accessibility are key considerations in this module.
* AI Integration Module: Powered by Gemini AI, the system integrates AI-driven features for smart notifications and engagement tips. The AI module enhances user experience, personalization, and decision-making capabilities within the system.
* Communication Module: This is the Application server that communicates between schools, recycling companies, and administrators; this module includes messaging functionalities, email notifications and real-time updates. Clear and efficient communication channels are essential for smooth operation and coordination.



***Fig. 3.4: High Level Model of the New System***

3.5 Specification

The system specifications cover various critical aspects of the new paper recycling system, including program module specifications, database development and design, input/output considerations, algorithm design, and system flowchart. These specifications provide a comprehensive blueprint for system development, implementation, and testing, ensuring that the new system meets all functional, performance, security, and usability requirements.

**3.5.1 Program Module Specification**

The proposed system will be developed as a web application, consisting of multiple interconnected modules. Each module will be responsible for handling specific functionalities and features of the system. The following modules are proposed:

1. **User Management Module**: This module will handle user authentication, authorization, and account management for both schools and recycling company administrators.
2. **Paper Tracking Module**: This module will allow schools to log and track the paper waste they generate and submit for recycling. It will also enable recycling companies to record the weights of the collected paper and update the corresponding school's virtual bin.
3. **Points and Rewards Module**: This module will automate the calculation of points based on the weight of the recycled paper. It will also manage the rewards system, allowing schools to track their progress and claim rewards upon reaching specific point thresholds.
4. **Analytics and Reporting Module**: This module will provide comprehensive analytics and reporting capabilities for both schools and recycling companies. It will generate various reports, such as leaderboards, individual school performance, and overall recycling statistics.
5. **Notification and Communication Module**: This module will integrate with the Gemini AI assistant to provide personalized notifications, tips, and recommendations to schools based on their recycling activity and engagement levels.
6. **Administrative Module**: This module will offer a centralized interface for recycling company administrators to manage school registrations, update rewards, and oversee the overall system operations.

3.5.2 Database Development tool

For the development of the database component, MongoDB will be utilized as the database management system. MongoDB is a popular NoSQL database that uses a document-oriented data model, providing flexibility, scalability, and high performance. Its ability to handle semi-structured data and its rich querying capabilities make it a suitable choice for this project.

3.5.3 **Database Design and Structure**

MongoDB utilizes a flexible schema design, allowing documents within a collection to have varying structures. The proposed database structure will consist of the following collections:

* **Schools**: This collection will store information about registered schools, including login credentials, contact information, and associated details such as school name, address, email, phone number, and virtual bin data (weight and points).
* **Recycling Submissions**: This collection will log the details of each paper recycling submission, including the date, weight, points earned, and references to the associated school and recycling company documents.
* **Rewards:** This collection will store information about the available rewards, their point thresholds, descriptions, and an array of school references for schools that have claimed each reward.
* Notifications: This collection will maintain a record of notifications sent to schools, including the notification content, timestamp, and a reference to the recipient school document.

The database design follows a denormalized approach, embedding related data within documents to optimize query performance and reduce the need for complex joins. For example, the school document will contain the virtual bin data, eliminating the need for a separate collection. The use of references (Object IDs) between collections allows for efficient data retrieval and maintains data integrity by ensuring referential integrity constraints. MongoDB’s flexible data model allows for easy modifications and additions to the schema as the project requirements evolve.

3.5.4 Input/output Design

The input and output design for the paper recycling system will focus on providing a user-friendly and intuitive interface for both schools and recycling companies. The following input and output components will be included:

Input:

* School Registration Form: This form will allow new schools to register with the system, capturing details such as school name, address, contact information, and login credentials.
* Recycling Company Data Entry Form: Recycling companies will have access to a form to record the actual weight of the paper collected from each school and confirm the submission.

Output:

* School Dashboard: This dashboard will provide schools with an overview of their virtual bin, including the current weight of paper submitted, points earned, and leader boards.
* Analytics and Reports: Both schools and recycling companies will have access to detailed analytics and reports, such as recycling trends, individual school performance, and overall program statistics.
* Notifications Tips: The system will generate personalized notifications for schools, powered by the Gemini AI assistant, to encourage based on their participation level.

The input and output components will be designed with a responsive and intuitive user interface, ensuring a seamless experience across various devices and platforms.

3.5.5 Data Dictionary

The data dictionary provides a comprehensive overview of the data elements used within the paper recycling system, their descriptions, and their data types.

1. Schools:
   1. School ID (Primary Key)
   2. School Name
   3. Address (Street, City, State)
   4. Contact Information (Email)
   5. Login Credentials (Email, Password)
   6. Virtual Bin (Points)
2. Paper Submissions:
   1. Submission ID (Primary Key)
   2. School ID (Foreign Key)
   3. Submission Date
   4. Weight
   5. Points Earned
3. Rewards:
   1. Reward ID (Primary Key)
   2. Reward Name
   3. Reward Description
   4. School Claimed
4. Notifications:
   1. Notification ID (Primary Key)
   2. School ID (Foreign Key)
   3. Notification Content
   4. Timestamp

The data dictionary ensures a consistent understanding of the data elements across the system, facilitating effective communication and maintenance.

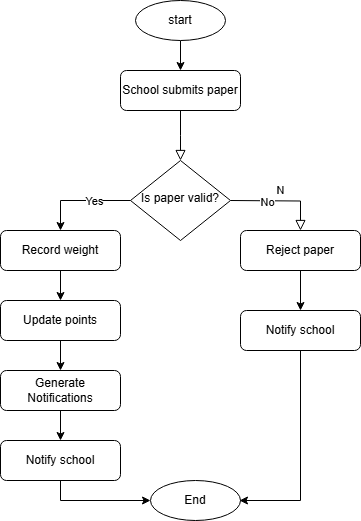
**3.5.6 Algorithm**

* Validates user input for new school registrations
* Checks if the school already exists in the database; if not, creates a new school document and virtual bin
* School submits paper and it’s validated
* Creates a new submission record in the database and updates the school's virtual bin weight and calculated points
* Sends confirmation notifications for successful registrations and submissions
* Analyzes recycling activity data to identify patterns and trends
* Generates personalized notification tips using Gemini AI based on the analysis
* Sends tailored notification tip to respective schools
* Assign rewards from the list of available rewards and send notification if schools have reached the threshold for rewards eligibility
* When Schools collects reward, marks rewards as claimed and updates reward list

This algorithm encompasses the entire process of school registration, paper recycling submission, reward calculation, and notification generation using Gemini AI. It ensures that schools are rewarded only when they reach the specified threshold and receive personalized notifications based on their recycling activity.

3.6 System Flow chart

The flowchart diagram below shows the relationship between different components in the system. It shows how the system accepts inputs, processes it to produce output



***Fig. 3.4: Flowchart of the New System***

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