UNIVERSITY OF CAPE COAST

A STUDY OF GENDER BIAS IN STUDENTS' HANDWRITING: A CASE STUDY OF THE TAMALE METROPOLIS

ABDULAI BABA YAKUBU ABDUL-RAUF

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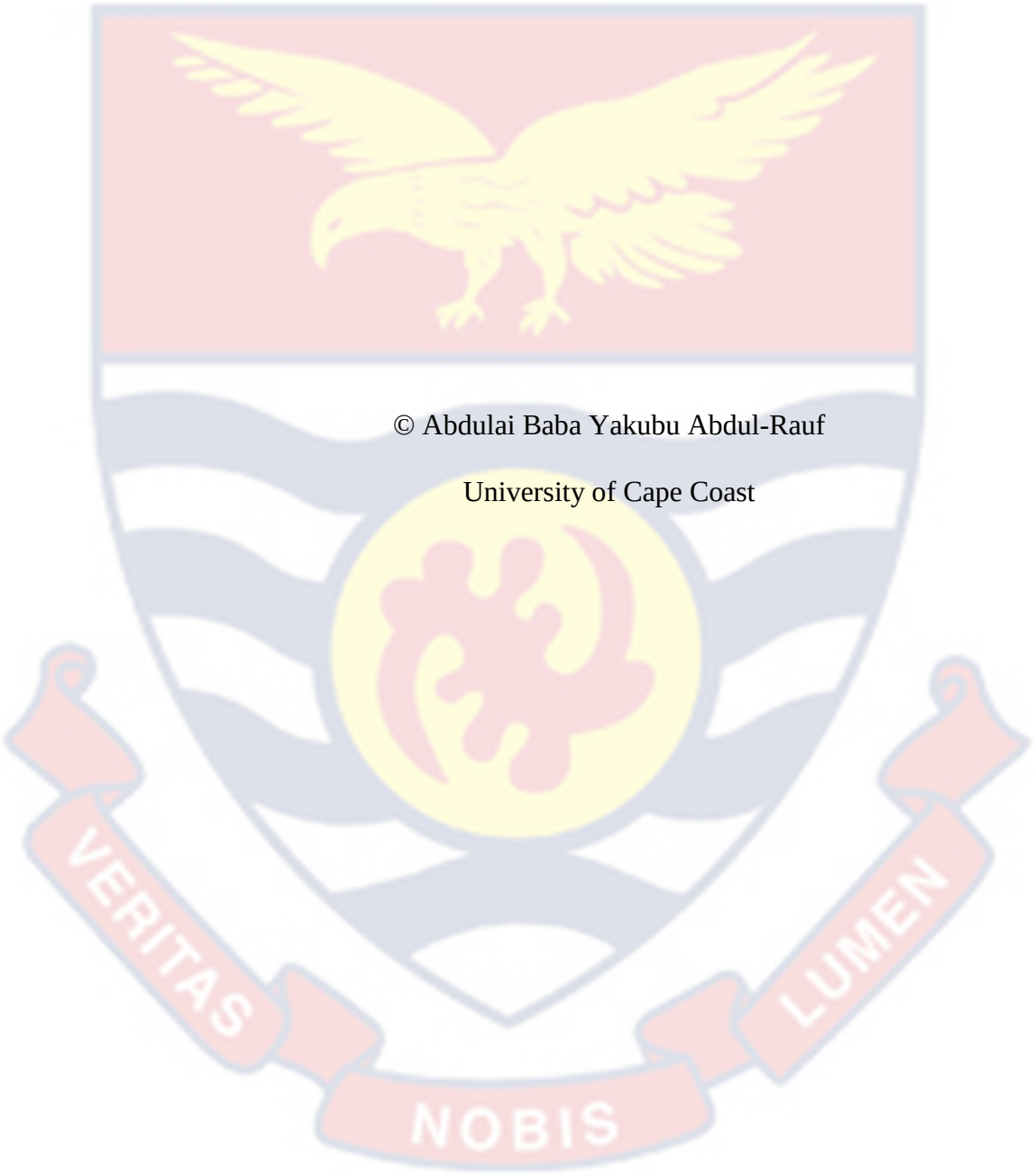

UNIVERSITY OF CAPE COAST

A CASE STUDY OF GENDER BIAS IN STUDENTS' HANDWRITING IN THE TAMALE METROPOLIS

BY

ABDULAI BABA YAKUBU ABDUL-RAUF

Thesis is submitted to the Department of Statistics of the School of Physical Sciences, College of Agriculture and Natural Sciences, University of Cape Coast in partial fulfilment of the requirements for the award of Master of Philosophy degree in Statistics.

JANUARY, 2023

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature..... Date……

Name**:** Abdulai Baba Yakubu Abdul-Rauf

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature..... Date……

Name: Dr. Eyiah-Bediako Francis

Co-Supervisor's Signature..... Date……

Name: Dr. David Kwamena Mensah

ABSTRACT

This study investigates gender bias in students' handwriting evaluation in the Tamale Metropolis in the Northern Region of Ghana. The study employed purposive, convenience, and simple random sampling for selecting students, as well as examiners. One-way ANOVA was used to examine the impact of different script levels on the identification of students' gender based on their handwriting. The t-test was used to assess the impact of examiners' level of experience in the identification of students' gender based on their handwriting. Students' gender was modelled using a binary logistic regression model. The study employed a test of proportion to estimate a cut-off for significant identification of gender by examiners. The study found that gender identification through handwriting becomes easier as students progress from basic through to tertiary education levels, with upper primary and tertiary level scripts being the least and most identified respectively. It was also revealed that only a few examiners demonstrate the ability to correctly identify students' gender based on their handwriting with a significant cut-off point of 65%. The study also found that the identification of students' gender based on handwriting is influenced by the examiner's experience and script level. Finally, the binary logistic regression model showed that the estimated probability of accurate gender identification by examiners increases with the examiner's experience level. Further studies must use larger and more diverse handwriting samples, explore additional factors such as specific writing tasks and handwriting characteristics, and replicate the study in different contexts to enhance the generalizability of the study finding findings.

KEY WORDS

Blind Marking

Cut-off

Examiners

Gender Bias

Handedness

Handwriting

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DEDICATION

To my family

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LIST OF ABBREVIATIONS

AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
BLE	Basic Level Examiner
CNN	Convolutional Neural Network
JHS	Junior High School
SHS	Senior High School
SLE	Secondary Level Examiner
TERT	Tertiary
TLE	Tertiary Level Examiner
UP	Upper Primary

CHAPTER ONE

INTRODUCTION

Background to the Study

According to gender commentators, sex bias is one major reason why more men seem to be successful in politics, academia, employment and so many other fields of human endeavours. In employment for instance men take up more sensitive positions than their female counterparts, and men are in higher positions in most firms and companies. Also, in academia until recently, some courses in the senior high schools (SHS) were seen to be reserved for the sexes; home economics for females and science, visual arts and technical engineering for their male counterparts whiles both sexes compete for allocations in the course of the general arts. In the early years of the SHS system, a male student was teased by his colleagues for being in the home economics class and a female student was discouraged from offering science, visual arts and technical engineering. Until recently, it was very strange to see a female commercial driver or a mate in a commercial vehicle, and it was not common to see males selling pieces of foodstuff or even food in our societies. Gender equality is also envisioned in our homes and workplaces, hospitals, courtrooms and other interpersonal spaces. Religiously, hardly would you have seen a female pastor or Imam or being an elder in a church or mosque but these days it is very common to see female pastors and Imams preaching the word of God in churches and mosques; respectively with some being elders in these churches and mosques.

To address the gender gap in the achievement of women in Ghana, several women's groups were established. Several organizations have been formed to support and empower women in Ghana, including the International Federation of Women Lawyers (FIDA), the Ghana National Association of Teachers' Ladies Association (GNATLAS), the National Commission on Women and Development (NCWD), Women in Broadcasting (WIB), the Women and Juvenile Unit (WAJU, now the Domestic Violence Victim Support Unit (DVVSU)), and many others. To encourage women to participate in active politics, activities like manual work (electrical work, masonry, plastering mechanical work etc.) and other works they must be motivated to be seen at different workplaces. According to Thomas, Umoh, and Umanah (2014), it is a common cultural phenomenon for specific tasks to be perceived as more suitable for males or females. However, these cultural expectations and gender roles can vary widely, and it is important to recognize that all individuals, regardless of their gender, are capable of completing a wide range of tasks. It is important to challenge and strive to break down traditional gender roles and expectations, and to recognize that all individuals should have equal opportunities and be able to pursue their interests and passions without being limited by their gender.

In 2001 the then President of Ghana His Excellency John Agyekum Kufour created a ministry for women's and children's affairs which was in charge of creating policies that support the establishment and advancement of women and children's affairs. Through the collective efforts of these groups, there is an increase in female representation in all areas of human endeavours be it politics, academia, commerce etc. Over the years, there has been a gradual

increase in the number of women represented in the Ghanaian parliament. The current 8th parliament has the highest number of women parliamentarians so far, with a total of 40. This is an increase of 10 women parliamentarians

from the previous parliament, which had 30 women parliamentarians.

This occurs due to the recognition by successive governments and organizations that achieving 'gender balance' is a crucial concern in the country. A well-informed understanding of the policy necessitates thorough research on its background. It is in light of this that Byrd, Lorelle and Donald (2021) in their research publication stated that while a case may be made for gender-specific interventions for aggression and conduct disorder among children and adolescents there is the need to realize the commonalities of effective intervention for both males and females.

Females all over the world are outspoken on the need for them to be equally recognized just as their male colleagues in all areas of human activities, at the Beijing Conference in 1995 as reported by Pavlic, Ruprecht and Sam-Vargas (2000), the First Lady of the United States of America, Hillary Clinton said they wanted a fundamental reconfiguration of society and made it clear that "If there is one message that echoes forth from this conference, let it be that human rights are women's rights, and women's rights are human rights, once and for all. Let us not forget that among those rights are the rights to speak freely and the right to be heard". Hillary Clinton further stated that it is true that women continue to face significant challenges and inequalities around the world. While there have been improvements in gender equality in some areas, there is still a significant gender gap that persists. Women continue to face inequalities in the workforce, such as the wage gap and lack of representation in leadership roles.

We must continue to strive for gender equality and work towards ensuring that all individuals, regardless of their gender, have equal rights and opportunities. In addition, women are often at a higher risk for poverty, discrimination, and violence. It is important to address these issues and work towards creating a more equal and just society for all people.

Minuo, Antonio and Donata (2020), studied the political gender gap and social dominance orientation and concluded that it is not uncommon for research to find differences in attitudes and behaviours between men and women. However, it is important to recognize that individuals of any gender can hold a range of political views and that there is often a great deal of diversity within groups. It is also important to note that individuals are not necessarily limited by their gender when it comes to their political views and that there can be many other factors that influence an individual's political beliefs and affiliations.

Santana (2016), stated that it is true that women continue to face significant challenges in the workplace, including in their representation in leadership positions. In many countries, women are under represented on the boards of private companies, and they often face barriers to advancement and equal pay. Additionally, women often bear a disproportionate burden of unpaid care and domestic work, which can impact their ability to participate fully in the workforce. It is important to address these issues and work towards creating a more equitable and inclusive workplace for all people. This can involve a range of initiatives, including policies to promote gender diversity and equal pay, as well as efforts to address the disproportionate burden of unpaid care work that falls on women.

When it comes to education in Ghana, one major issue that has to do with gender is enrolment and this has attracted a lot of concern in the country. There has been a gender gap in the enrolment of students in all levels of education in Ghana with female enrolment being the most affected gender. The World Bank report on the gender parity index (GPI) for Ghana, which is a measure of relative access to education of males and females for basic and secondary education averaged between 0.840 and 0.999 from 1971 to 2017. The ratio of 0.999 is an all-time high the lowest being 0.742 in 1985..

One important area that sex bias must be avoided at all costs in educational institutions is the conduct of examinations. An examiner who is a strong gender bias and who would be able to identify the gender of the owner of a script might be tempted to award undue marks to the student. There is a concern among some individuals that there may be gender bias during the evaluation of examination scripts by the examiners. As a solution to this issue, (Bradley, 1984) proposed the use of "blind" marking to eliminate bias based on gender and the "halo" effect in the evaluation of students' exams. According to data from a department, there is a possibility that examiners may assign lower marks to numbered scripts than to named scripts. Therefore, Bradley suggested that examiners should not know the names of the students whose exams they are grading to eliminate this bias. Contrary to her views, some argue that experienced examiners can still recognize the sex of a student of a particular script since male handwriting differs from that female handwriting (Forrcheh, 1989). If this is so then no matter what, favoritism concerning gender will continue.

No matter what, the evaluation of students' scripts needs to be done in a way to give equal opportunities to all students without favour for gender, ethnicity or race. This has raised serious issues for policy-makers to address in educational institutions since people are tempted to believe that very good handwriting fetches students marks that are not deserved. It is believed that every examiner would like and prefer working on neat handwriting to poor handwriting.

Lydia (1976) conducted a study on the impact of handwriting quality on teacher evaluations of written work. The research included 45 teachers and 36 students teachers. The results showed that variations in marks scored were significantly influenced by handwriting quality. The study also found that scripts with better handwriting consistently received higher marks, even if the content was the same, compared to those with poor handwriting.

Good handwriting has a distinctly developed structure as, in the beginning, middle and end, each critical point and supporting ingredient is organized in a sequence that is easy to follow. Constructive handwriting introduces interesting designs about a specific topic. The ideas are exhaustively expanded through the supporting ingredients. These ingredients are presented making use of strong sentences and certain words. Good handwriting also follows the fundamental standards of punctuation, spelling, capitalization and grammar.

The handwriting is edited with great care to make sure that the script is correct and easy to follow. This good handwriting seems to be associated with gender. It is believed that handwriting uses gender stereotypes of what gender an examiner thinks an author is whether masculine or feminine. As with voice,

one can change his or her handwriting by looking at people who are his/her age, gender, ethnicity, educational level and others. One can take a glance at a script and make a good guess as to whether the author is a male or a female. Studies have shown that an examiner of a script can make a pretty good guess of an author's gender identity based on the handwriting of the author. It should be noted that judging an author's gender could be arbitrary and also based on social custom and may not be scientific.

According to Koppel and Winter (2014) and Argomon, Koppel, Fine and Shimoni (2003), preliminary statistical studies show that gender appears to be demonstrated through writing style as well as actual handwriting. Recent studies at creating algorithms for gender detection by the writing style have produced some good accurate systems. They further noted it is not uncommon for research to find differences in the way that men and women communicate, and algorithms can identify some of these patterns in large samples of text. However, it is important to recognize that individuals are not limited by their gender when it comes to the types of topics they discuss and that there is a great deal of diversity within groups. Additionally, it is important to be cautious about making generalizations about entire groups of people based on limited data or stereotypes.

Mlama (2005) defined gender bias as a preference or prejudice toward one gender and results in unequal expectations, language usage and treatment. She stated that gender bias is stereotyping which happens at the early stage of children's learning. She further noted that some practices in the classroom reinforce gender bias against girls, some of these practices are: excluding girls from group leadership roles, consistently using male pronouns in student

activities, and using African proverbs that portray girls as inferior and reliant on boys.

As noted by Rubin and Greene (1992) in their study of gender-typical style in written language, they studied the writing of males and females and concluded that they write far more similarly than differently. However, differences due to the mode of discourse were more widespread than differences due to gender. Still, where male and female styles did separate, they differed in predicted directions. They noted for example that females used far more exclamation points than males do. Also, females were more likely than males to acknowledge the authority of opposing points of view.

Statement of the Problem

According to Forrcheh (1989), gender bias may lead to unequal opportunities and treatment of male and female students, with female students, particularly at risk of receiving lower grades and feedback on their handwriting. Purves (1992) highlights the impact of gender bias on students' self-esteem and motivation, stating that "gender bias in handwriting assessment can have detrimental effects on students' self-concept and academic achievement".

To address the gender bias in the evaluation of named scripts, Bradley (1984) suggested “blind marking”. However, this was countered by Forrcheh (1989), indicating that experienced examiners could still identify students’ gender by their handwriting. Among other findings, Purves (1992) supported the findings of Forrcheh (1989). Bulls and Stevens (1979), Forrcheh (1989) and Purves (1992) all indicate evidence of gender bias in student handwriting.

Conversely, Eyiah-Bediako et al (2002) found no enough statistical evidence to conclude that gender bias is prevalent in student handwriting, though only a few handwritings appeared to be gender-biased. According to Eyiah-Bediako et al. (2003), examiners were able to identify marginally more SHS scripts correctly than JHS scripts. However, Eyiah-Bediako et al (2002) did not consider the professional level of examiners and the typing hands of both examiners and students.

Though the above authors have identified gender bias issues, they failed to indicate the extent of correct identification of gender based on handwriting. Some attempts have been made to quantify the extent of identification locally, however, they also failed to identify the extent of correct identification.

The difficulty in identifying scripts is affected by some factors such as the level of scripts and examiner's level of experience. There is therefore the need to examine the contributing factors and determine the extent to which examiners correctly guess the gender of a student by their handwriting. Against this backdrop, this study sought to examine gender bias in student handwriting in the Tamale Metropolis in the Northern Region.

The Objective of the Study

The general goal of this study is to develop appropriate statistical methods for identifying student handwriting data. Specifically;

i. to compare the performance of examiners in identifying the gender of a student at various levels of education.

ii. to develop a method for estimating the appropriate cut-off and the significant number of examiners who identify the gender of students based on handwriting.

iii. to model gender in terms of available factors.

iv. to use the model to estimate probabilities of successfully predicting the gender of a student.

Significance of the Study

The significance of the study lies in its contribution to understanding the prevalence and implications of gender bias in educational settings. The study addresses an important social issue and has relevance at multiple levels, including academic, societal, and policy perspectives.

By investigating gender bias in students' handwriting, the study raises awareness about the potential biases that exist within educational systems. It highlights the need for a critical examination of practices and attitudes that may perpetuate gender stereotypes and discrimination. Understanding the presence and extent of gender bias in handwriting identification can lead to informed discussions and actions to promote equality and fairness in education.

The study contributes to the discourse on educational equality by shedding light on potential disparities in how students' work is evaluated and assessed based on their gender. Identifying and addressing gender bias in handwriting can help create a more inclusive and equitable learning environment, where students are evaluated based on their abilities rather than predetermined gender expectations.

Gender bias in handwriting can have long-term implications for students' self-esteem, confidence, and aspirations. By studying this phenomenon, the research provides insights into the experiences of students in the Tamale Metropolis and empowers them by validating their concerns. It offers an opportunity to challenge gender stereotypes and promote a positive self-image,

particularly among students who may feel marginalized or limited by societal expectations.

The findings of the study can inform educational policies and practices in the Tamale Metropolis and beyond. Policy-makers can use the research outcomes to develop guidelines that promote fair and unbiased assessment methods, ensuring that gender bias does not influence students' educational experiences and opportunities. Such policies can foster an inclusive learning environment that promotes the holistic development of all students.

The study focuses on developing appropriate statistical methods for identifying student handwriting data that contributes to the field of research methodology. By exploring the performance of examiners in identifying gender and modelling gender based on available factors, the study offers insights into the development of robust and reliable methods for gender identification. This can have implications for future research in handwriting analysis and related fields.

Scope of the Study

This study was conducted in the Tamale Metropolis in the Northern Region of Ghana. All participants (examiners and students) were from the Metropolis, and the schools where the students and examiners were selected are also located in the Metropolis.

Organization of the Study

This study is structured into five chapters: the First Chapter is the introduction. It comprises the background of the study, statement of the problem and objective of the study. Chapter Two is the literature review which looks at similar works done relating to the topic. Chapter Three takes a look at the

methodology to be employed during the study. Chapter Four is dedicated to the Results and Discussions whiles Chapter Five is the Summary, Conclusions and Recommendations.

Summary of the Chapter

There has been a lot of talk about gender bias in most areas of human endeavours and the education field is not left out in this regard. Some interventions have been taken by governments and NGOs to encourage women to participate in fields generally dominated by their male counterparts. Female groups have been formed in various workplaces to look into the promotions and developments of women in these places.

The primary goal of this study is to investigate gender bias in students' handwriting. Specifically, the study aims to estimate the proportion of examiners who can accurately identify the gender of a student based on their handwriting and to develop a model for predicting the probability of identifying a student's gender through handwriting.

This study aims to provide insight for policy makers working towards gender equality and equal opportunities for males and females in education, specifically in the Tamale Metropolis of the Northern Region of Ghana. The findings of this study can be used to inform policies and initiatives that address gender disparities in education.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter examines sources of information about gender bias on a global scale, as well as gender bias and its impact on education in Ghana. The review will also delve into the effects of gender bias on the education system in Ghana and explore the factors that contribute to gender bias in the general lifestyle of individuals in the country.

Gender Bias in the Society

Gender bias in society has been the focus of numerous research studies in recent years, and there is a growing body of evidence demonstrating the prevalence and impact of this bias. Gender bias refers to the unequal treatment or perception of individuals based on their gender, and can take many forms, such as discrimination, stereotypes, and prejudice.

One common manifestation of gender bias is gender discrimination, which refers to unequal treatment of individuals based on their gender. This can take many forms, including unequal pay and career opportunities, unequal access to education and healthcare, and unequal legal rights and protections. Some studies have documented the persistence of gender discrimination in various areas of society, such as the workplace, the education system, and the healthcare system (Kite, Deaux, & Miele, 1991; Jones, Murrell, & Jackson, 1999; Sealy, 2010).

Overall, gender issues encompass all aspects of the experiences and circumstances of men and women in society, including their relationships with each other, their access to resources, and their responses to changes,

interventions, and policies. Women and girls feel the negative effects of gender discrimination which could restrict access to education, lower standing in society, no or less freedom to take their own decisions concerning their family or personal life and lower wages for the jobs they do. These go a long way to affecting their choice of study areas, behaviours and attitudes towards relationships.

Gender bias also refers to a person receiving different treatment based on the person's real or perceived gender identity. Gender bias can be conscious, something a person is aware that he/she has, or unconscious, something a person is not aware of (implicit bias). Mlama (2005) defines gender bias as a preference or prejudice toward one gender and results in unequal expectations, language usage and treatment. It also stated that gender bias is stereotyping which happens at the early stage of children's learning. It further noted that some practices in the classroom reinforce gender bias against girls, some of these practices are: delegating group leadership positions to boys only, constant use of 'he' in learner activity references, and use of African proverbs that depicts girls as inferior and dependent on boys.

Susan, (2015) noted in her research "Breaking down barrier" noted that unconscious gender bias and other agendas in the workplace remain a significant barriers to women's career advancement and are difficult to identify and prevent. In her assessment, she noted that blind evaluation (hiding the physical attributes of job applicants) could be used to prevent implicit bias in the job selection process. It also observed that structured recruitment and performance evaluation process is crucial in minimizing implicit gender bias in hiring decisions.

Just as traditional fairy tales teach children socially desired qualities like honesty, bravery, and cooperation, gender bias still prevails in them. Most fairy tales portray females as being submissive and dependent on their male counterparts whiles males are portrayed as being brave, wit and powerful.

Cekiso (2013) highlighted that female characters in Disney films are frequently depicted with exposed stomachs and cleavage, leading to the objectification of women as sexual objects. Similarly, Martin and Kazyak (2009) found that these films often portray women being caught naked by male characters, implying that their value is primarily based on their physical appearance. The authors argued that gender norms in schools often disadvantage girls, and they emphasized that multiple aspects of school culture, including textbook content, classroom participation, and behavioural socialization, can reinforce gender stereotypes and biases. For example, they pointed out that in some classrooms, girls may have fewer opportunities than boys to participate in discussions, and that girls' opinions may be seen as inferior by their male peers in small-group and whole-class activities. They argued that gender bias is a significant concern for educators and families and that promoting gender inequality and bias can create imbalances in the classroom and limit future potential. They also noted that both schools and families can contribute to gender bias, sometimes without being aware of it. To address this issue, the authors argued that it is important to raise awareness and take concrete steps to counter these stereotypes and roles. Children learn from what they see and are guided to do, and if steps are not taken to counter gender biases, they may shape children's early experiences in harmful ways.

Gender norms are the social rules that dictate how boys, girls, men, and women should behave in society. These norms can be either static or universal and may change over time. Some gender norms lead to inequality, while others are positive, such as the norm that children should not smoke. Girls often perform more household chores than boys, which can take up a significant amount of their time and negatively impact their education.

Palacio (2019) defined gender bias as the prejudice displayed towards one gender over the other. She further stated that it might be implicit- moulded by our culture, upbringing or by personal experience. She further pointed out that when someone refers to an individual by their occupation, such as an engineer or doctor, it is often assumed that the individual is male, even if this is not necessarily true. She noted that males are not immune to gender bias, as it can be difficult for men to enter fields like early childhood education because it is often assumed that women are the ones who teach younger children. These biases, the author noted, are difficult to dispel and can carry over into the workplace.

Another common form of gender bias in society is gender stereotyping, which refers to the tendency to ascribe certain characteristics, behaviours, and roles to individuals based on their gender. Gender stereotypes are often deeply ingrained in societal attitudes and practices and can have a profound influence on individuals' self-perceptions, expectations, and opportunities. The pervasiveness of gender stereotypes has been extensively documented in various aspects of society, including the media, the educational system, and the workplace (Lippa, 2006; Schulz, Fan, Magidina, Marks, Hahn & Halperin, 2007; Fiske, 2012).

The impact of gender bias in our society can have extensive and enduring consequences, influencing individuals' opportunities, experiences, and outcomes across various domains. Gender bias can impede individuals' access to education, healthcare, and other resources, while also affecting their self-esteem, self-confidence, and mental health. Multiple studies have documented the detrimental effects of gender bias on individuals' psychological well-being and social functioning (Ridgeway & Correll, 2004; Skinner & Melzoff, 2019; Lockenhoff et al., 2014).

Despite the increased awareness of gender bias in academia and the growing number of initiatives to address issues of gender bias, the change is slow and inequalities still exist (Llorens et al, 2021). The authors noted that on average, men tend to initiate negotiations more frequently than women for better-starting salaries, working conditions, salary increases, and other job-related resources in the job market. They also pointed out that even when women do negotiate, they tend to be less successful in obtaining the desired outcomes and may face social costs for advocating for themselves in the workplace. To address this issue, the authors suggested that transparency is key in negotiations. They proposed that institutions should provide salary information and salary ranges for all employees at each academic level. They also noted that removing stereotypes from both parties in negotiations can improve women's performance.

Campbell and Muncer (1994) in their study on sex differences in social aggression, the authors examined the role of gendered personality differences and occupational roles in understanding these differences. They found that both occupational role and sex are important factors in an individual's expression of

aggression. Additionally, the researchers discovered that the impact of gendered personality traits was reduced when considering both sex and occupation. The data from their study strongly supported the idea that occupational factors are key in explaining sex differences in aggression, as proposed by social role theory while providing less support for the role of masculine and feminine personality traits.

One significant factor that affects students' career choices and subject interests is gender. In the past, certain subjects such as home economics, nursing, and secretaryship were typically seen as being more suitable for females, leading to males and females often choosing stereotyped occupations. (Thomas, Umoh & Umanah, 2014).

Gender Bias in Sports and Politics

One way gender bias manifests itself in sports. According to Eastman and Billings (2000), gender bias is shown through the unequal distribution of media coverage. For example, they noted that female athletes often receive less coverage than their male counterparts and that when they do receive coverage, it is often focused on their physical appearance rather than their athletic abilities. This unequal distribution of media coverage can harm the visibility and popularity of female athletes, and can ultimately impact their earning potential and opportunities. Another way in which gender bias shows itself in sports, according to Eastman and Billings, is through the use of gendered language. It was noted that female athletes are often referred to using gendered terms, such as "lady" or "girl," which can be diminutive and demeaning. They also noted that female athletes are often described using language that emphasizes their physical appearance, while male athletes are often described using language that

emphasizes their athletic abilities. They provided valuable insights into how gender bias can show itself in sports and highlighted the need for media outlets to be aware of how such bias can impact athletes. By providing equal coverage to male and female athletes, using gender-neutral language, and avoiding the perpetuation of gender stereotypes, media outlets can help to create a more inclusive and equitable sports environment.

Golder, Crabtree, and Dhima (2019) explored how gender bias manifests in legislative representation. They argue that, despite progress in increasing the number of women in political office, gender bias continues to pose a significant barrier to women's political representation. In their study, they found that "women are less likely to be selected as candidates by political parties, less likely to win elections, and more likely to be in a minority within legislative bodies". This unequal representation has significant consequences for women's policy priorities and voices, as well as for democratic representation more broadly.

The impact of gender bias on women in politics has been well-documented in the literature. Studies have shown that women face a variety of barriers to political participation, including discrimination, stereotyping, and hostile political environments (Krook, 2009). These barriers not only limit women's access to political office but also impact their ability to effectively represent their constituents once in office. Also, women in political office are often subjected to greater levels of scrutiny and criticism than their male counterparts. This can lead to self-censorship and a lack of confidence in speaking out on issues, ultimately undermining women's ability to effectively represent the interests of their constituents (Krook, 2009).

To address gender bias in legislative representation, Golder et al. (2019) suggested several potential solutions. These include measures to promote gender equality within political parties, such as quotas and affirmative action policies, as well as efforts to create a more inclusive and supportive political environment for women. In addition, they recommend increasing public awareness of the importance of gender equality in political representation and encouraging greater participation by women in the political process.

In summary, gender bias in legislative representation highlights the ongoing challenges faced by women in politics and the need for continued efforts to address gender bias and promote gender equality in the political sphere. As Golder et al. (2019) argue, "achieving gender equality in political representation is not only a matter of fairness but also a necessary condition for the effective functioning of democratic systems."

Gender Bias in Education

Gender bias is also evident in education as boys and girls are often treated differently. Teachers may have more interaction with boys and be more lenient with their behaviour while providing boys with more criticism and praise. There may also be differences in the extra attention given to boys versus girls, with boys demanding more attention and girls not receiving as much, leading to girls being quieter and more reserved. Boys may also dominate classroom discussions and have greater access to computers and technology. These behaviours can create a biased learning environment for boys and girls. (Dolan & Lynch, 2016).

Raina (2012) conducted a study to examine the impact of gender bias on the evaluation of teachers. The study involved a group of participants who were asked to review and evaluate teaching portfolios that differed only in terms of the gender of the teacher. The results showed that male teachers were consistently rated as more competent and effective than female teachers, even when their qualifications and teaching experience were the same. This finding suggests that gender bias significantly affects the evaluation of teachers, leading to discrimination and disadvantages for women based on their gender.

Gezici and Saygin (2022) explored the role of gender bias in educational videos. Using a novel machine learning algorithm, the researchers developed a method for automatically measuring gender bias in educational videos. They found that many popular educational videos exhibited strong gender bias, with male characters being significantly more prominent and visible than female characters. This finding suggests that gender bias may be perpetuated and reinforced through educational videos, potentially influencing the attitudes and beliefs of students.

According to Rosie (2016), education is a key aspect of social policy for promoting gender equality and empowering women. However, progress in education alone is not enough to achieve gender equality in education or other areas of life. While the number of girls has increased at all levels of education under the Millennium Development Goals (MDGs) and Education for All (EFA), access to education, opportunities, and freedoms gained through education remains unequal.

In their article "Practical Strategies for Detecting and Correcting Gender Bias in the Classroom," Sadker and Zittleman (2007) noted that gender bias often manifests itself in subtle ways, such as through the use of gendered language, the unequal distribution of classroom resources and opportunities, and the perpetuation of gender stereotypes. One of the key strategies for detecting and correcting gender bias in the classroom, according to them, is to be mindful of the language used in the classroom. For example, they noted that teachers should be careful not to use gendered language when referring to students, and should strive to use gender-neutral pronouns and occupational titles. They also suggest that teachers should be mindful of the way they distribute classroom resources and opportunities, and should strive to ensure that all students have equal access to these resources and opportunities. They further stated that a strategy for addressing gender bias in the classroom is to actively challenge gender stereotypes. This can be done through a variety of methods, such as incorporating diverse perspectives into lesson plans, using non-stereotypical examples in class discussions, and providing opportunities for students to engage with a wide range of activities and experiences. Their article provides valuable insights into how gender bias can manifest itself in the classroom and offers practical strategies for detecting and addressing such bias. By being mindful of the language used in the classroom, actively challenging gender stereotypes, and ensuring that all students have equal access to resources and opportunities, teachers can help to create a more inclusive and equitable learning environment.

Banks (1989) on the topic "Gender Bias in the Classroom," noted that gender bias often manifests itself through the perpetuation of gender stereotypes, the unequal distribution of resources and opportunities, and the use of gendered language.

One of the key ways in which gender bias exhibits itself in the classroom, according to (Banks, 1989) is through the perpetuation of gender stereotypes. These stereotypes can be reinforced through the use of gendered language, the distribution of classroom resources and opportunities, and the choice of lesson content. For example, Banks noted that girls may be discouraged from pursuing mathematics and science subjects, while boys may be discouraged from pursuing literature and the arts. Another way in which gender bias manifests itself in the classroom is through the unequal distribution of resources and opportunities. Banks (1989) again noted that girls may be given less attention and support from teachers, and may be less likely to be called on in class or to have their work displayed. This unequal distribution of resources and opportunities can harm girls' academic performance and overall well-being. Banks (1989) provided valuable insights into how gender bias can manifest itself in the classroom and highlighted the need for teachers to be aware of how such bias can impact students. By being mindful of the language used in the classroom, actively challenging gender stereotypes, and ensuring that all students have equal access to resources and opportunities, teachers can help to create a more inclusive and equitable learning environment.

Deirdre and Maryann (2008) conducted a study on gender balance and bias and found that many governments have demonstrated their commitment to gender equality through specific legislation. Gender equality is now recognized as a fundamental human right and was established as a goal at the Millennium Summit in 2000. The authors also pointed out that education at all levels, from primary to tertiary, addresses issues of gender equality and inequality in society.

Sheelagh conducted (2008) who studied gender balance and bias in the teaching profession and the impact of feminization, found that teaching young children has typically been dominated by women, which is a worldwide phenomenon influenced by economic development, the status of women in society, urbanization, cultural definitions of masculinity, and the value placed on children and child care. She also noted that there have been concerns raised by ministers, the media, and others in various countries about the high level of feminization in the teaching profession.

Sue and Simonetta conducted a study in 2000 on balancing gender in higher education, focusing on the experiences of senior women. They found that there are discrepancies in the career progression of younger and older women in academia. Older women, particularly those who have children, often encounter difficulties in advancing their careers due to the need to balance their responsibilities with those of their partners and children. Despite these challenges, older women in the study displayed strong entrepreneurial tendencies, demonstrating a skill for identifying and taking advantage of opportunities. They found that younger women were more self-confident and believed that gender equality had been achieved. The study, which was based on interviews with 22 senior women at a new university in the UK, also found

that older women tended to fit their family lives around their careers and that balancing their gender had become central to both their work and personal lives. Additionally, the study found that both younger and older women in academia tended to lack a sense of collective working or networking for the benefit of themselves or other women in the university. They concluded that while the number of senior women in academia may continue to grow, the deeply ingrained gendered culture within the university is likely to be challenged. This conclusion is based on the characteristics of the women in the study.

On the education front efforts have been made to bridge the gap between males and females in the enrolment of students in various levels of education. Now governments and organizations consider gender balancing as a major issue in policy making. Any good policy needs thoroughly thought-through background checks on it concerning gender balancing.

Eliasu and Felicia (2015) in their research "study on gender inequality in basic education in the Northern Region of Ghana: household and contextual factors in perspectives" stated that socio-economic factors such as availability of household resources, poverty, and high cost associated with girls' education and the high number of market days served as barriers to gender equality in basic schools in the Northern Region of Ghana. They again stated that socio-cultural practices like polygamy, fostering, attendance of festival celebrations, child preference, early marriage and menstruation are key factors that mitigate against quality and gender equality in basic schools in the region.

According to Udousoro (2011) study, there is no significant difference in the academic performance of male and female students in chemistry in their first year of secondary school. The research found that gender does not have an impact on student performance in this subject. However, the study did find a significant difference in the achievements of male and female students with high ability in mathematics in chemistry. These students tended to perform better in chemistry than their peers with low mathematics ability, regardless of their gender.

Gender Bias in Handwriting

Upadhyay, Singh, and Shukla (2017) found that there are significant differences between male and female handwriting and that handwriting samples can be used to identify a person's gender. This suggests that gender bias may be present in the way that male and female students write.

According to Suneet, Vaibhav, Vaid, and Gupta (2013), there are significant differences in the handwriting of males and females. The study analysed the handwriting samples of 100 male and 100 female writers and found that female handwriting was characterized by consistency in size, slant, inter-word space, and angle of cross bars, as well as circular dots over letters, gentle hooks and curves, and letter-ends with nice upwards strokes. Male handwriting, on the other hand, was characterized by inconsistency in size, inter-word space, slant, and angle of cross-bars, as well as letters with flourishes, sharp corners and ends, straight stems, and cramped and tiny counters in vowels. Their study results suggest that there are notable differences between male and female handwriting, though the authors were unable to determine the accuracy, precision, or broader social significance of these findings.

Bulls and Stevens (1979) conducted a study on the influence of the attractiveness of writing and penmanship on student grades. They investigated the relationship between the appearance of students' written work and their grades, with a focus on how factors such as neatness and legibility might affect academic performance. The results of the study may provide insight into the role that handwriting and presentation play in the evaluation of students' work. A single essay was used, which was either written neatly or written untidy or typed. The essays were then given to 72 markers for evaluation. They reported that there was no significant effect on essays attributed to masculine students. But feminine students with neat handwriting were evaluated favourably compared to untidy handwriting. A significant effect was also noticed between attraction and neatness in the handwriting in the evaluation of students' work. They concluded that society expects females to have neater handwriting than their male counterparts.

Lippa (1977) studied the ability to identify the sex of individuals based on their handwriting. He investigated the signs by which examiners rated handwriting along masculine and feminine facets, with emphasis placed on comparisons between "sex-type" and "androgynous" persons. This is the difference between a person who has only sex-appropriate characteristics and a person who has both masculine and feminine characteristics. These individuals were asked to rate themselves on several characteristics, some of these were greater social desirability for men and others for women. The t-ratio was used to calculate the difference between individual masculine and feminine scores. An individual was then classified as "androgynous" if the t-ratio was within plus or minus one (± 1) otherwise, that individual is classified as sex-typed. He

reported, among others, that the main signs examiners recorded in distinguishing between masculine and feminine handwriting were variability and neatness. Masculine handwriting is more variable and untidier, while feminine handwriting is perceived as being more precise, neat, and uniform.

Fogel, Rosenblum, and Barnett (2022) conducted a study on handwriting legibility in different writing tasks and identified which components could predict overall handwriting legibility. They found that there were significant differences in legibility across the tasks of copying-best, copying-quickly, and free-writing. The results of the study showed that on the handwriting legibility scale (HLS), the score for free writing was the highest among the three tasks, followed by the copy-fast score. The score for copy-best was the poorest. These findings suggest that handwriting legibility may vary depending on the specific task being performed and the time constraints involved.

Top (1991) conducted a study on gender bias in the assessment of handwriting in primary and secondary schools. The research examined the grades and feedback given to male and female students for their handwriting and found that female students consistently received lower grades and more negative feedback compared to male students, even when controlling for other variables such as age and writing ability. This bias was evident across a variety of handwriting characteristics, including legibility, fluency, and neatness. These findings suggest that there may be a gender bias in the way that handwriting is evaluated in education settings.

Liberto, Casula, and Pau (2022) also conducted a more recent study on gender bias in handwriting assessment, using a sample of over 1000 students from primary and secondary schools in Italy. Their study confirmed the findings of (Top, 1991), showing that female students received lower grades and feedback on their handwriting compared to male students. The study also found that teachers were more likely to use negative language when providing feedback to female students, which could further undermine their self-esteem and motivation.

Mulac and Lundell (1980) conducted a study on gender bias in the evaluation of students' handwriting in primary schools. They compared the grades and feedback given to male and female students and found that female students consistently received lower grades and more critical feedback compared to male students, even after controlling for other variables such as age and writing ability. These findings suggest that there may be a gender bias in the way handwriting is assessed in educational settings.

Ruble and Ruble (1982), who sought to investigate whether gender biases exist in the way that teachers perceive and evaluate students' handwriting, presented teachers with a set of handwritten samples from male and female students. The teachers were asked to evaluate the samples based on various criteria, including legibility, neatness, and overall quality. The study showed that teachers were more likely to rate the handwriting of male students as being of higher quality than that of female students. This finding suggests that gender bias may exist in the way teachers perceive and evaluate students' handwriting. This study has significant implications for educators, as it suggests that gender bias may influence the way that teachers perceive and evaluate students'

academic work. It also highlights the importance of being aware of and addressing potential gender biases in the classroom.

Another study by Graham and Perin (2007) who also investigated gender bias in students' handwriting, found that girls' handwriting is often rated as being of lower quality than boys' handwriting, even when the quality of the handwriting is objectively the same. This suggests that gender bias may be a pervasive issue in the evaluation of students' handwriting.

William (1996) conducted a study on the use of handwriting for identifying a person's gender. He conducted five experiments and found that male and female students were able to correctly identify the sex of a writer with an accuracy level of 75% using a small amount of material. The study also found that the age of the writer was not detectable in handwriting, but that sex or gender was present in handwriting. These findings suggest that handwriting may be useful for identifying a person's gender, though further research may be needed to confirm the accuracy and reliability of this approach.

Tenwolde (1934) in his study on sex differences in handwriting and found that there were no significant differences in the quality of penmanship based on the Thorndike Handwriting Scale from the fourth to the eighth grade. However, the study did find that teachers were able to correctly identify the sex of a writer with an accuracy level of 63% based on their judgement of 40 penmanship samples. These findings suggest that there may be some differences in handwriting between males and females, but that these differences may not be significant enough to be detected using certain measures of penmanship quality. It is widely believed that students with neat handwriting attract good marks when their work is evaluated.

A study (Briggs, 1970) on the effect of how handwriting style might influence examiners' assessment of students' work confirms this notion. He randomly selected students' work 10 essays from 15 essays and then arranged them for 10 students to copy out each of the 10 essays. He noted that essays and handwriting factors were significant. In 1980, he undertook a further study and reported that "very neat" handwritten work was significantly awarded higher grades than the others.

It is widely believed that females tend to have better handwriting than males. This was noted by Cordeiro, Castro and Limpo (2018), who noted that "Girls are generally better hand writers than boys, both on measures of overall quality and of letter formation. Girls also tend to write faster than boys." (Cordeiro, Castro & Limpo, 2018).

Erdogmus, Kabakus, Kucukkulahli, Takgil and Kara (2022), proposed a model based on a convolutional neural network (CNN) that automatically extracts features from a given handwritten sample and classifies its owner's gender, the model performed state-of-the-art baselines and is promising on such a task that even humans could not have achieved highly-accurate results for, as of yet.

Fleming (1999), in his study entitled "Quality by Design: What is it and how do we get there?", discusses the issue of biases in marking. The study highlights the possibility that when grading written work, teachers and other assessors may be influenced by a range of factors such as students' gender, ethnicity, socio-economic status, or the school they attend. These biases can lead to unequal treatment of students, with some receiving higher grades than they may deserve, while others are unfairly marked down. This can have

negative consequences for students, as grades are often used to determine academic progress and future opportunities. Educators need to be aware of these biases and work to mitigate their impact on the evaluation of students' work This can harm students' self-esteem and motivation, and even affect their future opportunities and success. To address this problem, he suggested the use of a "quality by design" approach, which involves setting clear standards and criteria for assessment and using consistent and objective methods to evaluate students' work. This approach can help to reduce the influence of biases and ensure that all students are assessed fairly and accurately.

Bradley (1984) conducted a study on sex bias in the evaluation of students' projects at several universities and polytechnic institutions. The study collected marks for student projects from the first and second markers in five different departments and analysed the data to compare the marks given by the first and second markers. The results showed that the second markers exhibited sex bias when marking named scripts, but there was no evidence of sex bias in other cases. (Bradley, 1984) suggested that sex bias in marking could be eliminated if scripts were assessed using blind marking, where the assessor does not know the identity of the student. These findings highlight the importance of implementing measures to reduce bias in the assessment of students' work.

Forrcheh (1989) conducted a study on sex and handwriting bias in the evaluation of students using data collected (Entwhistle, 1984). The research found that while examiners may hold gender stereotypes about handwriting, students did not necessarily conform to these expectations, as most markers had ambiguous evaluations. These findings suggest that bias in the assessment of student's handwriting may not always result in clear differences in grades or

feedback and that further research is needed to understand the complex factors that may influence the evaluation of students' written work.

Eyiah-Bediako et al (2002) also indicated that people, especially examiners, hold sex bias in handwriting, which is in support (Forcheh, 1989). In their investigation into sex bias in students' handwriting. They found that, notwithstanding the judges' opinions, only a few judges were able to show some evidence of the ability to correctly identify the sex of a writer by his/her handwriting. They further stated that there was not enough statistical evidence to conclude that sex bias is prevalent in students' handwriting, at least in the University Junior Secondary School and University Practice Secondary School.

Eyiah-Bediako et al. (2003) in their study on the determination of the probability of successfully identifying the sex of a student by his or her handwriting, stated that the probability of correctly identifying the sex of a student by his or her handwriting, irrespective of the judge's age or experience, was found to be about 61%.

Most of the previous research on sex and handwriting has focused on the quality of male and female handwriting and gender bias in general, rather than developing a model for the probability of successfully identifying handwriting as male or female. Some previous research has focused on ways to address the gender gap between men and women, and the statistical methods commonly used in these studies have included the t-test and the z-test. However, this current research aims to consider a broader range of statistical methods, including binary logistic regression models and conditional modelling, to more fully understand the issues at play. These different statistical approaches may

provide additional insights into the factors that contribute to the gender gap and how it can be addressed.

Chapter Summary

The literature review indicates that the sex of a student can be identified to some extent through their handwriting and that gender bias often works against women in a variety of settings, including education. These findings highlight the need to address gender bias and ensure that all students are treated fairly and equitably, regardless of their sex or gender.

Gender bias in society results in unequal treatment based on gender, leading to discrimination, stereotypes, and prejudice. This bias manifests as gender discrimination, restricting opportunities in areas like pay, careers, education, and healthcare. Women and girls are particularly affected, facing limited access to education, lower social status, restricted decision-making autonomy, and lower wages. Unconscious bias, including implicit bias, also contributes to this problem. Traditional fairy tales and media often reinforce gender bias by portraying females as submissive and dependent. Educational settings can further perpetuate bias by favouring boys over girls.

Gender bias is pervasive in both sports and politics, with female athletes receiving unequal media coverage that emphasizes their appearance instead of their skills. Similarly, women in politics face discrimination and hostile environments, hindering their access to office and their ability to effectively represent constituents. To address these biases, media outlets should provide equal coverage and use gender-neutral language, while political parties can promote gender equality through quotas and affirmative action. Creating inclusive environments, raising public awareness, and encouraging greater

female participation are crucial steps toward combating gender bias in both domains.

Gender bias in education is evident through the differential treatment of boys and girls. Teachers tend to interact more with boys and be more lenient towards their behaviour, while girls receive less attention. Boys often dominate classroom discussions and have better access to resources. Gender bias also affects the evaluation of teachers, with male teachers consistently rated as more competent. Educational videos often display strong gender bias, favouring male characters. Addressing this bias requires promoting gender equality, using gender-neutral language, and challenging stereotypes. However, achieving gender equality in education is not solely dependent on educational efforts, as socio-economic and socio-cultural factors can create barriers. Gender may also impact academic performance in specific subjects like mathematics.

Research by Upadhyay et al. (2017) suggests that there are notable differences between male and female handwriting, and handwriting samples can be used to determine a person's gender. (Suneet et al, 2013) and Lippa (1977) further emphasizes the distinct characteristics of male and female handwriting. Several studies, including those by Top (1991), Mulac and Lundell (1980), and Ruble and Ruble (1982), reveal gender bias in the evaluation of students' handwriting, with female students consistently receiving lower grades and more negative feedback compared to male students. This bias is also evident in studies by Liberto et al (2022) and Top (1991). Bulls and Stevens (1979) and Fogel et al (2022) investigate the impact of handwriting legibility on student grades, finding that neat handwriting, especially for female students, is more favourably evaluated. These studies underline the existence of gender bias in handwriting

assessment and highlight the importance of recognizing and addressing such biases in educational settings.

CHAPTER THREE

METHODOLOGY

Introduction

This chapter discusses the data collection techniques and reviews the method used for the analysis. The methods that will be reviewed are binary logistic regression, analysis of variance (ANOVA) and test of proportion.

Study Area

This research is being conducted in the Tamale Metropolis of the Northern Region of Ghana and focuses on education. The study collected data from schools including United Primary School, Dakpema Junior High School, Northern School of Business, and the University for Development Studies (script data) as well as St. Joseph's Basic School, Ghana Secondary School, and Tamale Technical University (examiners for identification). The study aims to study to develop appropriate statistical methods for identifying student handwriting data in these schools and universities in the Tamale Metropolis.

Data Collection

This research included data from four levels of education in Ghana: primary school, junior high school, senior high school, and tertiary (university or college) levels. Two types of data were gathered for the study: script data from 120 students, and identification data from 45 examiners who were asked to identify the handwriting as male or female. This data was used to examine the relationship between various factors, student performance, and other outcomes of interest.

Selection of Schools

For each level of education, Basic School, Junior High School, and Senior High School, a simple random sampling technique was used to select one school for the students' handwriting and another school for the selection of examiners. For the tertiary level of education, convenience and purposive sampling techniques were employed for the selection of both students and examiners.

Selection of Students for the Scripts Writing

There are 36 primary schools in the Tamale metropolis and out of this number one school was selected for the study. In selecting the school simple random sampling technique was used to select one primary school which happens to be United Primary School. The lottery method of simple random sampling was used. Each school's name was written on a piece of paper, folded and mixed and then put in a basin. The one paper was picked and opened to see the name of the school that is in the picked paper which happens to be United Primary School. This study was conducted in a school with 349 upper primary students, divided among classes four, five, and six. The purposive sampling method was employed to choose the specific class from which copies of the scripts were obtained for the study. The class selected was class five, this was selected because that class might have spent about two years since they started using the pen. Class four was not selected because they just started using pen and there would not be much difference in their handwriting. Also, class six was not selected because it is close to JHS. The expectation is that we consider enough class time intervals between the classes where the scripts were taken. The number of students needed for the writing of the scripts was 30. In all 15 males and 15 females were used.

Purposive sampling was again used to select left-handed students, this was because only six students were left-handed in the class (2 males and 3 females). The number of left-handed students was each subtracted from the required number of the corresponding gender. After this was done the remaining number of male students required was 13 and that of the females was 12. To obtain a sample of 30 students from the upper primary, simple random sampling was used. This involved writing the names of the right-handed male students on a piece of paper, folding the paper to conceal the names, mixing the folded papers, and then selecting the desired number of names from the mixed pile. This method of sampling was used to ensure that all students had an equal chance of being selected for the study. Thirteen papers were picked from the basin one after the other without replacement, opened and the names on the papers were written as part of those to take part in the script writing. The same thing was done for the remaining 12 right-handed female students too.

For the JHS, there are 29 schools in the Metropolis and again one school was selected for the writing of the scripts for identification. Simple random sampling was used to select the school and the school selected was Dakpema Junior High School. All 29 schools' names were written on a piece of paper, folded, mixed and put in a basin. One paper was picked from the basin and then opened. The picked paper had the name of the selected school which was Dakpema JHS. Purposive sampling was also used to select form two classes for the writing of the scripts. This class was selected because an interval was needed between the class and that of the upper primary class and the variation in their handwriting could have been clearer at the form two-stage.

Purposive sampling was used to select left-handed students as their number was small (2 males and 4 females). Simple random sampling was then used to select the remaining right-handed students after subtracting the number of left-handed students from their corresponding gender. The number of right-handed students sampled was 13 males and 11 females, making a total number of 30 students sampled. The names of the right-handed male students were written on a piece of paper, folded, mixed and then put in a basin. Thirteen folded papers were picked from the basin one after the other without replacement. The picked papers were then opened and they were added to the 2 left-handed male students to make up the number needed for the male students at the JHS level. The same process was used to pick the remaining 11 female students which with 4 left-handed students made up the 15 female students. Putting both male and female students picked together gave a total of 30 students needed at the JHS level to write the scripts for identification.

The simple random sampling technique was used to select a senior high school (SHS) for the study from the five SHSs in the Tamale Metropolis. This involved writing the names of the schools on pieces of paper, folding the papers to conceal the names, mixing the folded papers, and then selecting one school from the mixed pile. The selected school was the Northern School of Business, which offered four courses: business, home economics, general arts, and general science. At the time the data was collected, only form one and form two students were in school, as form three students were not present due to the tracking system in place at the SHS level of the educational system.

The form two class selected for the study was done by using simple random sampling. The simple random sampling technique was also used to select the science class for the sample, which consisted of 50 students (31 males and 19 females). Purposive sampling was used to select the left-handed students who were only 4 males and one female. Purpose sampling was used because of the small number in the class and then simple random sampling again was used to select the right-handed students. The remaining right-handed students were selected using simple random sampling after subtracting the number of left-handed students from their corresponding gender. The number of right-handed students sampled was 11 males and 14 females making a total of 30 students sampled for the SHS level.

At the time of data collection for this study, there were four tertiary institutions in the Metropolis, but only the University for Development Studies (UDS) and the Tamale Technical University were in session. Simple random sampling was used to select UDS from these two institutions to obtain scripts for the study. Purposive sampling was used to select the students for the script writing since it was not possible to have all the students at once to write the scripts. The students were approached one after the other and asked for about 10 minutes of their time to copy the standard script for me. The school was visited on several occasions before getting the required number of 30 students. In all, the number of left-handed students was six (2 males and 4 females) and 24 right-handed students (13 males and 11 females).

Selection of Examiners for Identification of Scripts

The data for the selection of examiners for the identification of scripts were from three levels; basic level examiners (BLE), secondary level examiners

(SLE) and tertiary level examiners (TLE). The BLE was sampled from the primary and JHS and the SLE was sampled from the SHS whiles the TLE were sampled from the tertiary institutions. For the basic schools the study considered schools with both primary schools and JHS, the number of basic schools left for consideration was 13. These 13 schools were written on a piece of paper, folded, mixed and put in a basin. A piece of paper was picked from the basin. The name of the school picked was St. Joseph School. This school has both primary and JHS. The headteachers of both primary and JHS were then contacted and spoken to about the study which they agreed. They also spoke to their teachers and asked then to cooperate with the researcher. The teachers were selected using simple random sampling. Before an examiner was considered for selection, he/she was asked whether he/she can differentiate between male and female script. If the answer to this question was no, he/she was not considered for selection. The number of examiners needed for the study was 45 examiners. This comprises 15 examiners from each level. As a precaution, the schools where the students (scripts) were taken were not considered for the selection of the examiners. This was because the teachers in the schools where the students were selected might be familiar with some of their students' handwriting.

The school that was selected for BLE was St. Joseph Primary and JHS using the simple random sampling technique. All the examiners answered yes to the earlier question 21 in all (12 male and 9 female). Simple random sampling was used to select 8 male examiners and 7 female examiners making the 15 examiners that were required at this level.

For the SLE, the school selected was Ghana Secondary School from 4 SHS using the simple random sample technique. The number of teachers that

answered yes to the question "Can you differentiate a male script from a female script?" was 19 (11 male teachers and 8 female teachers). Since the number of female examiners did not exceed the number that was required at the secondary level all of them were considered for the study. The required number for the male examiners was 7 and this was done using the simple random sampling technique bringing the number of examiners at the secondary to 15 examiners as required.

For the TLE, the school that was used for the examiners was Tamale Technical University since it was the only school left since UDS was where the scripts were taken. Most of the lecturers were not willing to be part of the study because they were busy. However, upon pleading 8 male lecturers and 7 female lecturers agreed to do the identification of scripts for this study. It must be noted that these were lecturers who also hold stereotypes in handwriting.

Copying and Identification of Scripts

The number of scripts for the handwriting to be identified for the study was 120 scripts from the four selected schools representing each level of the educational system. The number of total examiners to do the identification was 45 examiners.

The selected students were given a standard text (as attached in Appendix A (I, II, III and IV) to copy into an A4 sheet without being under any pressure to do so. The A4 sheet was coded from 001 to 030 for the upper primary, 031 to 060 for the JHS, 061 to 090 for the SHS and 091 to 120 for the Tertiary. All the 120 scripts and a scoring sheet as attached in Appendix B (I) were then given to the examiners to identify the handwriting into male and female handwriting. The examiners' age, experience (number of years he/she has been

teaching) and handedness were taken. They could not have been gathered at once to do the identification so they identified all 120 scripts one after the other till all the 45 examiners were done with the identification. The examiners' score sheets of identification were then marked and recorded using the score sheet in Appendix B (II).

Review of Some Statistical Methods

Logistic Regression

To accomplish the main objective of the study and given the nature of the data collected, it is advisable to utilize linear models of the form:

$$Y = X\beta + e \quad (3.1)$$

Where Y is the response variable, X is the matrix of predictor variables (also known as the design matrix), β is the vector of unknown parameters to be estimated, and e is the random error vector assumed to be normally distributed with a mean of 0 and variance. That is, e ~ N (0, δ^2).

Linear models are particularly useful for modelling continuous data. However, if it is clear that the conditions for linear models are not met, generalized linear models (GLM) can be used as an alternative method. Several situations may make linear models inappropriate and necessitate the use of generalized linear models, including (1) a lack of multicollinearity among the independent variables, (2) a linear relationship between the logit of the outcome and each predictor variable, and (3) a binary dependent variable. For detail discussion see (Kleinbaum, Dietz, Gail, Klein and Klein, 2002) and (LaValley, 2008). For this study, the focus will be on logistic regression.

There are three main types of logistic regression: binary logistic regression, where the response is binary without a natural order; ordinal logistic

regression, where the response variable has three or more levels or categories with a natural order; and nominal logistic regression, where the response variable is nominal without a natural order. In all of these types of logistic regression, the response variable may be either qualitative or quantitative. For this study, the discussion of the model will focus on binary logistic regression. Binary logistic regression is reviewed in detail since that is the aspect needed for this study.

The Binary Logistic Regression Model

As mentioned above, the response variable of a binary logistic regression model has only two possible values, for example, yes or no, male or female, success or failure. In this sort of situation, the objective is to model the probability p, of success in terms of the predictor variables, $x_1, x_2, x_3, \ldots, x_k$, which may be qualitative or quantitative. This could be done by modelling the probability p as follows;

Let y be gender; $y = \begin{cases} 1 \\ 0 \end{cases}$ $y_i \sim \text{Bern}(1, p), 0 < p < 1$

$$h(p) = X'\beta = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \ldots + \beta_k x_k \quad (3.2)$$

Where y is independently and identically distributed, X is a vector of the k predictor variables, β is a vector of the parameters $\beta_0, \beta_1, \beta_3, \ldots, \beta_k$ and $h(p)$is the link function given by;

$$h(p) = \ln\left(\frac{p}{1-p}\right) \quad (3.3)$$

$$\left(\frac{p}{1-p}\right) = \exp(X'\beta) \quad (3.4)$$

The simplest and more attractive alternative of Equation 3.1 is when $h(p) = p$, which leads to the model,

$$p = X'\beta = \beta_0 + \beta_1 x_1 + \ldots \beta_k x_k \quad (3.5)$$

However, it has a disadvantage that, for $\beta_i \neq 0$ and i = 0, 1, 2,…, k, the estimated values of p could be inconsistent with the fact that $0 \leq p \leq 1$.

Hence, to deal with the problem of inconsistency we need to define a link function $h(p)$ in Equation (5) as

$$h(p) = log\left(\frac{p}{1 - p}\right) \quad (3.6)$$

This function which is the natural logarithm of $\frac{p}{1-p}$, is referred to as the logit link function. Thus, Equation (5) becomes

$$log\left(\frac{p}{1 - p}\right) = \beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k \quad (3.7)$$

Thus, the above equation is called the general binary logistic model, since the term $\frac{p}{1-p}$ is referred to as the odds ratio (The ratio of the probability of success to the probability of failure). The odds ratio is a statistical measure that describes the relationship between the probability of an event occurring and the probability of it not occurring. It is often used in statistical modelling to assess the likelihood of an event occurring in a given situation. The odds ratio can be calculated by dividing the probability of an event occurring by the probability of it not occurring. Equation (3.3) may be written as

$$log(odds) = X'\beta = \beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k \quad (3.8)$$

The model is commonly used for analyzing multivariate data when the response variable is binary.

Estimation of the Parameters

Logistic regression is a powerful regression technique comparable to multiple linear regression and analysis of variance. Since the relationship between $log\left(\frac{p}{1-p}\right)$ and the predictor variable is linear, the exposition of the coefficients on the predictor variables is for their effects on $log\left(\frac{p}{1-p}\right)$. Manually estimating the regression coefficients can be difficult and confusing. However, advances in computer software programs for numerical optimization of non-linear functions have made it easier to estimate logistic regression. These programs can be found in most statistical software packages such as GLM, SAS, SPSS, R, and Python (the package in R was used in this study). Most of these programmes follow the maximum likelihood method for determining the regression coefficients, others follow the method of least square. Since R uses the maximum likelihood estimation (MLE) for the determination of the regression coefficients, it is briefly discussed below, for further discussion on MLE see (Trammer & Elliot. 2008).

Let Y be a random binary variable whose value is either 1 or 0, then, by rewriting Equation (7) as

$$\frac{p}{1-p} = exp(X'\beta) \tag{3.9}$$

The probability p, that Y = 1 is given by

$$p = \frac{exp(X'\beta)}{1 + exp(X'\beta)} \tag{3.10}$$

Considering each observation as a Bernoulli trial, for the nth observation

$$P(y = y_i) = p_i^{y_i}(1 - p_i)^{1-y_i} \quad (3.11)$$

Assuming all the n observations are independent, then the likelihood function can be written as

$$L = \prod_{i=1}^{n} p_i^{y_i}(1 - p_i)^{1-y_i} \quad (3.12)$$

Substituting (10) into (11) gives,

$$L = \prod_{i=1}^{n} \left(\frac{\exp(X'\beta)}{1 + \exp(X'\beta)}\right)^{y_i} \left(\frac{1}{1 + \exp(X'\beta)}\right)^{1-y_i} \quad (3.13)$$

The log of the likelihood function is thus given by

$$\ln L = \sum_{i=1}^{n} y_i \left(\frac{\exp(X'\beta)}{1 + \exp(X'\beta)}\right)^{y_i} + \sum_{i=1}^{n} (1 - y_i) \left(\frac{1}{1 + \exp(X'\beta)}\right)^{1-y_i}$$

$$= \sum_{i=1}^{n} y_i \left(\frac{\exp(\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k)}{1 + \exp(\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k)}\right)$$

$$+ \sum_{i=1}^{n} (1 - y_i) \left(\frac{1}{1 + \exp(\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k)}\right) \quad (3.14)$$

The parameter vector β is found by maximizing equation (3.14) using any effective techniques. However, it must be noted that many computer software programmes such as GLIM, SAS, R, SPSS and MINITAB among others can be used to compute β. R for instance, uses the iterative-reweighed least square

algorithm to obtain the maximum likelihood estimate of the parameter vector β in Equation (14).

The likelihood ratio is the χ^2 statistic $(-2\log \mathrm{L})$ statistic, which has a χ^2 distribution with degree of freedom (n - q), where n = total number of observations and q = number of parameters in the model. It is this statistic that is used to test whether the parameters are significantly different from zero. In such tests, the null and its corresponding alternative hypothesis are stated as:

$$H = \begin{pmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \\ . \\ . \\ . \\ \beta_k \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ . \\ . \\ . \\ 0 \end{pmatrix} \quad \text{and} \quad H_1 = \begin{pmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \\ . \\ . \\ . \\ \beta_K \end{pmatrix} \neq \begin{pmatrix} 0 \\ 0 \\ 0 \\ . \\ . \\ . \\ 0 \end{pmatrix}$$

R has provision for diagnosis measures and this allows accessibility to the validity of the model. Thus, how each parameter influences the data can be tested. The application of logistic regression will be demonstrated in chapter four, where a prediction model can be obtained.

Analysis of Variance (ANOVA)

ANOVA (analysis of variance) is a statistical technique that is used to analyze the variability in a data set and determine the influence of different factors on the outcome of interest. It separates the observed variability in the data into two parts: systematic factors that have a statistical effect on the data, and random factors that do not. There are several types of ANOVA: some commonly known ones are one-way ANOVA, which considers only one factor with k levels, and two-way ANOVA, which considers two factors with k and b levels. ANOVA is often used in regression analysis to determine the effect of independent variables on a dependent variable. One-way ANOVA is used to

analyse data from three or more groups to learn about the relationship between the dependent variable and the independent variables. For detail discussion see (Gordor & Howard, 2006), (Scheffe, 1999) and (Larson, 2008).

The following key assumptions are worth noting about ANOVA and must be satisfied. These are

i. The response variable should be normally distributed for each population.

ii. The variance of the response variable, denoted by δ^2, should be the same for all the populations considered.

iii. The observations must be independently and identically distributed.

For this study, we shall discuss one-way ANOVA in detail.

One-way ANOVA Model

The one-way ANOVA is based on the idea that the observations x_{ij} can be partitioned as follows:

$$x_{ij} = \mu + \tau_j + e_i \quad (3.15)$$

Where μ is the overall mean, $\tau_j = (\mu_j - \mu)$ constituting the factor with k levels (j = 1, 2, 3, k), $e_i = (x_{ij} - \mu_j)$ constitute the random error

Thus, Equation (15) becomes

$$x_{ij} = \mu + (\mu_j - \mu) + (x_{ij} - \mu_j) \quad (3.16)$$

Implies

$$x_{ij} - \mu = (\mu_j - \mu) + (x_{ij} - \mu_j) \quad (3.17)$$

Now replacing parameters μ and μ_j with their corresponding sample estimates $\bar{x}$ and $\bar{x}_j$ respectively we obtain

$$x_{ij} - \bar{x} = (\bar{x}_j - \bar{x}) + (x_{ij} - \bar{x}_j) \quad (3.18)$$

Now by squaring and summing Equation (18), we obtain

$$\sum_{i=1}^{n_i}\sum_{j=1}^{t}(x_{ij} - \bar{x})^2 = \sum n_j (\bar{x}_{.j} - \bar{x})^2 + \sum_{i=1}^{n}\sum_{j=1}^{t}(x_{ij} - \bar{x}_{.j})^2 + 2\sum_{i=1}^{n_i}\sum_{j=1}^{t}(\bar{x}_{.j} - \bar{x})(x_{ij} - \bar{x}_{.j}) \quad (3.19)$$

Expanding the term below gives zero. That is,

$$2\sum_{i=1}^{n_i}\sum_{j=1}^{t}(\bar{x}_{.j} - \bar{x})(x_{ij} - \bar{x}_{.j}) = 0$$

Hence, Equation (19) becomes

$$\sum_{i=1}^{n_i}\sum_{j=1}^{t}(x_{ij} - \bar{x})^2 = \sum n_j (\bar{x}_{.j} - \bar{x})^2 + \sum_{i=1}^{n}\sum_{j=1}^{t}(x_{ij} - \bar{x}_{.j})^2 \quad (3.20)$$

where $\bar{x}$ is the grand mean, $\bar{x}_j$ is the mean in the j^{th} factor level of j = 1,2, 3, … , k and n is the total observations.

$$\sum_{i=1}^{n_i}\sum_{j=1}^{t}\left(x_{ij}-\bar{x}\right)^2$$

$$= SS_{Total} \quad (3.21)$$

$$\sum n_j\left(\bar{x}_{.j}-\bar{x}\right)^2$$

$$= SS_{Tr} \quad (3.22)$$

$$\sum_{i=1}^{n}\sum_{j=1}^{t}\left(x_{ij}-\bar{x}_{.j}\right)^2$$

$$= SS_E \quad (3.23)$$

Thus, Equation (20) can then be written as

$$SS_{Total} = SS_{Tr} + SS_E \quad (3.24)$$

Where SS_{Total} is the total sum of squares, SS_{Tr} is the treatment sum of squares and SS_E is the error sum of squares.

The test statistic is given as

$$F = \frac{SS_{Tr}/(t-1)}{SS_E/(n-t)} \quad (3.25)$$

In ANOVA, the F-statistic is used to test the null hypothesis that there is no difference between the means of different groups or levels of a factor. The F-statistic follows an F-distribution with $t-1$ and $n-t$ degrees of freedom, where t is the number of factor levels and n is the total sample size. If the calculated F-statistic is large enough, it can be used to reject the null hypothesis and conclude that there is a significant difference between the means of the groups or levels. The F-distribution is a continuous probability distribution that is used to describe the distribution of the F-statistic in statistical tests. It is often

used in ANOVA to determine the statistical significance of the results. The hypothesis for the one-way ANOVA is stated as:

H_0: $\mu_1 = \mu_2 = \ldots = \mu_t$ (Equality of means for all factor levels)

H_1: $\mu_i \neq \mu_j$ for some, i ≠ j (at least one mean is different from the rest)

The F test statistic can be presented in an ANOVA table as follows;

Table 1: Sample of ANOVA table

Source of variation.	DF	SS	Mean Squares	F
Treatment	$(t-1)$	SS_{Tr}	$SS_{Tr}/(t-1)$	$\frac{SS_{Tr}/(t-1)}{SS_E/(n-t)}$
Error	$(n-t)$	SS_E	$SS_E/(n-t)$	
Total	$n-1$	SS_{Total}		

Source: Author's Construct (2023)

Estimation of Examiners who Significantly Identified the Scripts

In this study, the binomial approximation of the normal distribution would be used to find the cut-off point for the examiners who can significantly identify the script. A test statistic is derived that would help in the estimation of the cut-off point that would be used to find the number of examiners who significantly identified the scripts.

It is expected that an examiner who has a special technique of identifying the sex of a student by his/her handwriting as claimed by examiners must be able to identify significantly higher than just 50% of the scripts correctly. Getting just 50% of the script identified correctly does not give evidence of using a specific approach, in the identification.

The aim here is to find out how many examiners significantly identified the scripts correctly higher than 50%, that is a cut-off point above which a score would be deemed as significant.

Since the test is about proportions, the appropriate test to be used is the binomial approximation to the normal distribution (test of proportion).

The hypothesis for this test is:

$$H_0: P = P_0$$

$$H_1: P \neq P_0$$

The test statistic for the proportion is given as follows;

$$z = \frac{x - \mu}{\sigma} \tag{3.26}$$

Where $\mu = np, \sigma = \sqrt{np(1-p)}$ and $p = \frac{x}{n}$. x is the number of correct identifications and n is the total number of trials.

$$z = \frac{x - np}{\sqrt{np(1-p)}} \tag{3.27}$$

$$z = \frac{p_s - p_0}{\sqrt{\frac{p_0(1-p_0)}{n}}} \tag{3.28}$$

$$P_s = p_0 + Z\left[\frac{p_0(1-p_0)}{n}\right]^{1/2} \tag{3.29}$$

Chapter Summary

The study was conducted in the Tamale Metropolis, located in the Northern Region of Ghana, using data collected from four schools representing different levels of the Ghanaian educational system: United Primary, Dakpama JHS, NOBISCO, and UDS. The data for the examiners were collected from St. Joseph's School for the BL, Ghana Secondary School for the SLE and Tamale Technical University for the TLE. Data collected include the sex, handwriting and handedness of 30 students from each level giving a total of 120 students who participated in the study. Information that was collected on examiners

includes age, experience (number of years the examiner has been teaching), handedness, sex, level of teaching (either basic level, secondary level or tertiary level), their judgements of students' sex and their judgements of students' handedness. As a precaution, schools, where scripts were taken, were not contacted again by the examiners because some of the tutors may be familiar with their students' handwriting. The chapter reviewed the statistical methods that are appropriate for this study. The techniques discussed include binary logistic regression, analysis of variance, and the test of proportion.

CHAPTER FOUR

RESULT AND DISCUSSION

Introduction

This chapter focuses on the results obtained from the implementation of the methods developed in Chapter Three. Deductions and expositions on the results are considered in this chapter of the thesis as well.

Overview of the Data

This section will look at the performance of the examiners at all four levels of the scripts and the performance of examiners on each of the scripts. Table I in Appendix D shows the overall performance of each of the examiners including their age, experience and their gender. It also indicates whether they write with their right or left hand. The most successful male examiner in the identification is number 24. He teaches at the senior secondary school level. He is 31 years old with 11 years of experience and writes with his right hand. He was able to identify the sex of 91 scripts out of 120 trials correctly representing 75.8%. The lowest score for the male examiner is number 11, he is 42 years old with one year of experience and teaches in the basic school. He writes with his right hand and had 57 successful identifications out of 120 which represents 47.5%.

The most successful female examiner is number 22, she is 32 years old with 4 years of experience and teaches in the senior secondary school. She identified 86 scripts out of 120 trials correctly, representing 71.7% and the least successful female examiner is number 4, she is 47 years old with 16 years of experience and teaches in the basic school. She writes with her right hand. She was able to identify the gender of 52 scripts correctly out of 120 trials which

represents 43.3%. The overall most successful examiner is examiner number 24.

It is also interesting to note that only 9 examiners scored 60% or better, consisting of only 20% of the examiners. The female examiners' score was between 43.3% and 71.7%, whereas that of the male examiners was between 47.5% and 75.8%

Table II in Appendix D shows the number given to each script, whether the writer uses the right or left hand, gender and the percentage correctly identified. From Table II, the most identified male script is number 116, it is a male student script that uses the right hand. It was correctly identified by 39 examiners out of 45 examiners representing 86.7%. It happens to be the most identified script. The script was from the tertiary level. While the least identified male script is number 13, it was correctly identified by 10 examiners which represents 22.2% and the student writes with the left hand and also from the upper primary level.

The most identified female script is number 105 which was correctly identified by 9 examiners, this represents 20.0% and the student writes with the right hand. It is also interesting to observe that less than one-third of the scripts received less than 50% successful identification. Another interesting observation from Table II in Appendix D, is that out of 20 left-handed scripts, only 5 had identification of more than 50%. even two of them were from the tertiary level.

Performance of Examiners

Examiners' Performance by Level of Student Scripts

Table 2 below shows the summary of the examiners' performance at various levels of the students (scripts).

Table 2: Summary of Examiners' Performance by Levels of Students (scripts)

Level	Min	Mean	Max
UP	10.00	18.70	29.00
JHS	11.00	21.40	35.00
SHS	9.00	19.33	28.00
TERT	16.00	24.23	33.00

Source: Author's Construct (2023)

Table 2 indicates that the highest mean is 24.23 which is the mean for the tertiary level and the lowest mean is 18.70 which represents the mean for the upper primary level. The mean shows that the tertiary-level scripts were identified more than the other levels. Also, the JHS level scripts were the second most identified scripts followed by the SHS level scripts and the upper primary level scripts were the least identified.

Since the identification of the scripts by level seems to suggest differences, we need to perform further tests to confirm the differences or otherwise. The box plot is used to further illustrate the differences. Figure 4.1 is the box plot of the performance of the examiners at the various levels of the scripts.

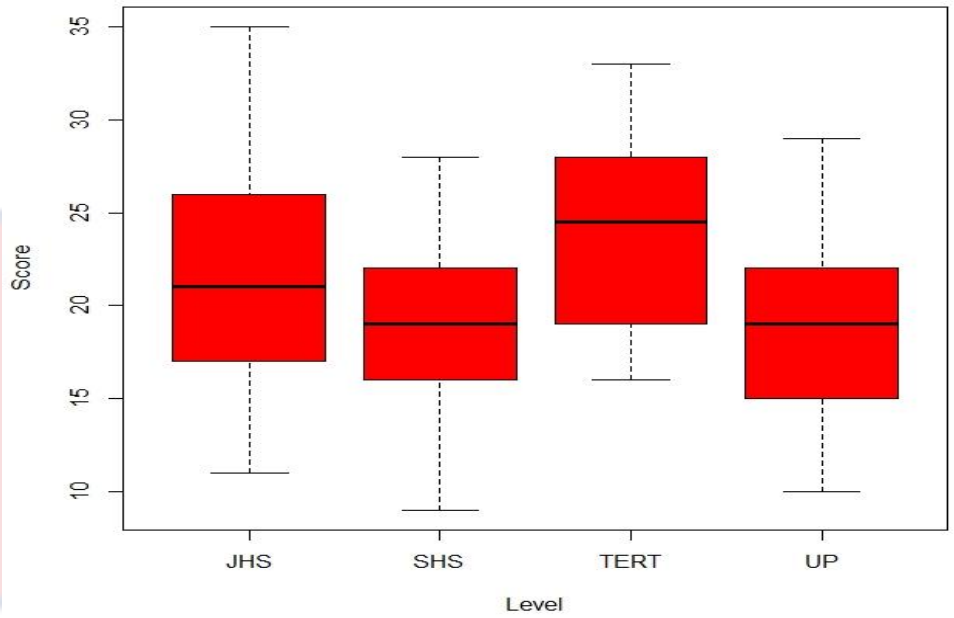

Figure 1: Box plot of Examiners' Performance at the Various Levels

(Author's Construct)

Figure 1 indicates that the tertiary level scripts have the highest median followed by the JHS level scripts and SHS level scripts while the upper primary level scripts have the lowest median. This result shows that examiners performed better on the tertiary-level scripts than on the other levels.

Since there is suspicion that the performances of the examiners at the various levels of the scripts are not the same, there is the need for hypothesis testing using the analysis of variance (ANOVA). Table 3 shows the result of the analysis of the variance of the examiners' performance at the various level of students (scripts).

Table 3: ANOVA Results of Examiners' Performance at the Various Levels

	Df	Sum Sq.	Mean Sq.	F value	Pr(>F)
Level	3	560	186.54	6.602	0.00037
Residuals	116	3278	28.25		

Source: Author's Construct (2023)

In Table 2, the p-value of 0.00037 falls below the significance level of 0.05. Therefore, there is sufficient statistical evidence to reject the null hypothesis. Consequently, there exists a disparity in the mean performance of the examiners across different levels. These findings indicate that the examiners' performances in identifying scripts vary across the different levels. A follow-up needs to be conducted to find which ones are different. Table 3 is Tukey's Honestly Significant Difference Post-hoc Test which is a follow-up test for one-way ANOVA

Table 4: Tukey's Honestly Significant Difference Post-hoc Test

Levels	Mean Dif.	Lower	Upper	p Adjusted
SHS-JHS	-2.0666667	-5.6442038	1.5108705	0.4373458
TERT-JHS	2.8333333	-0.7442038	6.4108705	0.1710044
UP-JHS	-2.7000000	-6.2775371	0.8775371	0.2064131
TERT-SHS	4.9000000	1.3224629	8.4775371	0.0028883
UP-SHS	-0.6333333	-4.2108705	2.9442038	0.9672462
UP-TERT	-5.5333333	-9.1108705	-1.9557962	0.0005698

Source: Author's Construct (2023)

According to Table 3, the p-value for the TERT-SHS pair is 0.0028883, which is lower than the significance level of 0.05. Similarly, the p-value for the UP-TERT pair is 0.0005698, also below the 0.05 significance level. These results suggest that both pairs exhibit significant differences.

Performance of Examiners by Levels of Teaching

Figure 2 shows the box plot of examiners' performance by the level of education they teach

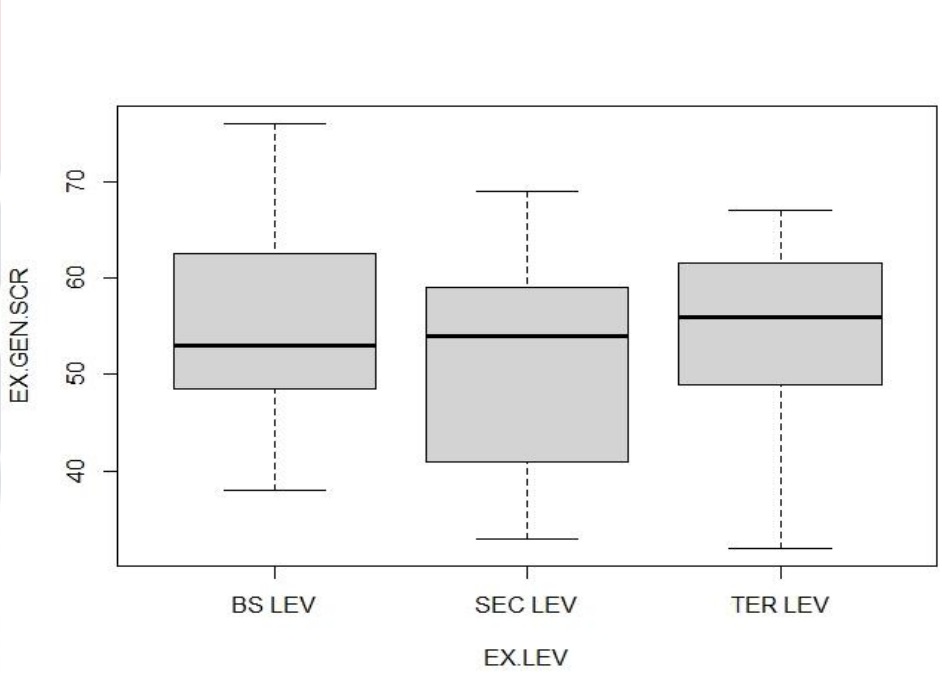

Figure 2: Box plot of Examiners' Performance by Their Levels

(Author's Construct)

Based on the observations in Figure 2, it appears that the median score for tertiary-level examiners surpasses the median score of the basic and secondary-level examiners. This suggests a potential disparity in performance among the examiners based on their levels. Considering the apparent performance difference, it is necessary to conduct hypothesis testing, specifically using analysis of variance (ANOVA), to confirm or refute this observation.

Table 4 shows the results of the ANOVA for the performance of the examiners by their level of teaching.

Table 5: One-way ANOVA test results of Examiners' level of teaching

	Df	Sum Squares	Mean Sum Squares	F-value	Pr(>F)
EX.LEV	2	27	13.4	0.086	0.918
Residuals	42	6576	156.6		

Source: Author's Construct (2023)

Hypothesis

H_0**:** True difference in means between groups is zero

H_1: True difference in means between groups is greater than zero

Since the p-value of 0.918 is greater than 0.05, we cannot reject the null hypothesis. There is, therefore, no significant difference in the examiners' performance based on their level of teaching. The test results show that the level of the examiner does not differ from one examiner to the other. That is, given a set of scripts, any examiner whether a basic-level, secondary level or tertiary-level examiner is expected to almost get the same number of correct identifications. The next test is to compare the performance of the male and the female examiners.

Performance of Examiners by Gender

Figure 3 shows the box plot of examiners' performance by gender

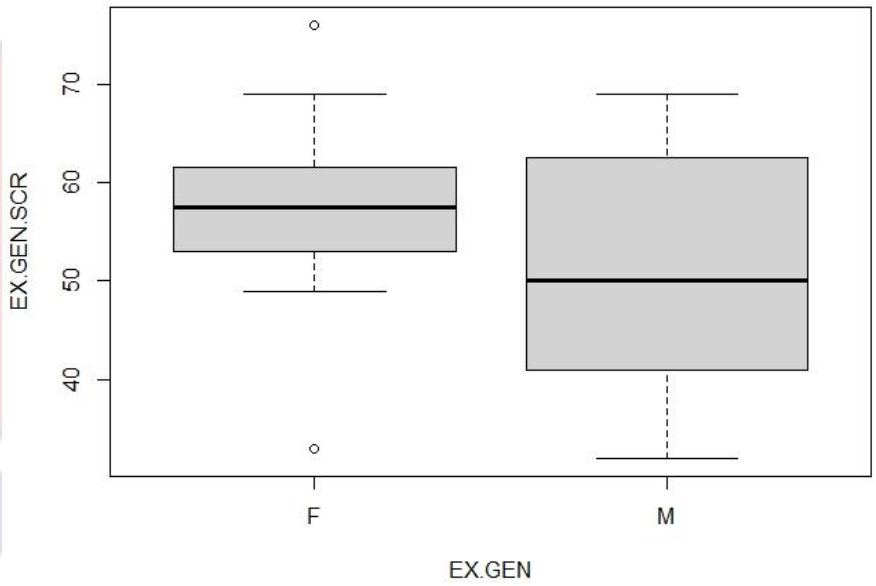

Figure 3: Box plot of examiners' performance by gender (Author's Construct).

Based on the information presented in Figure 3, the median score of female examiners surpasses the median score of male examiners. This indicates that, on average, female examiners performed better than their male counterparts. Additionally, the box plot suggests that male performance exhibits greater variability compared to female performance. To further investigate and confirm the observed differences, hypothesis testing is required to determine whether there is a significant disparity in the performance between the two genders.

The two-sample t-test was used to determine if there is a significant difference between the mean scores of female examiners and male examiners.

The hypothesis for this test is

H_0: True difference in means between female examiners and male examiners is zero

H_1: True difference in means between female examiners and male examiners are greater than zero.

The results of the t-test, obtained using the R software, indicated a t-value of 1.9503 and a degree of freedom of 42. The p-value was found to be 0.02892 at a significance level of 0.05. Since the p-value is lower than the significance level, we can reject the null hypothesis and conclude that there is a statistically significant difference in the performance of female and male examiners. The above results indicate that if female examiners and male examiners are given the same set of scripts, the female examiners are expected to make more correct identifications than the male examiners. This goes to confirm what was observed in the box plot (Figure 4), where the female examiners' box had a higher median than the male examiners.

Estimation of Proportion of Examiners who Significantly Identified the Scripts

The test aims to examine whether examiners could identify the scripts by a workable guide and not just mere guesswork. To test whether the examiners could significantly identify the scripts, there was the need to take a critical look at the performance of the examiners. This was done by using a normal approximation to the binomial distribution. This method is used to establish a cut-off mark for which an examiner is considered as having a workable guide to perform the identification.

That is the cut-off mark is the mark examiners should score to be seen as using a special technique in identifying the sex of the students through their handwriting and not just using mere guesswork to get the sex of the students correctly through their handwriting. Table 4.5 shows the alpha level, hypothesized value and the cut-off mark for examiners' performance. The cut-off obtained using Equation (28) with p_0 = 0.5, z = 1.64 and n = 30 is shown in Table 6

Table 6: Cut-off for Significant Performance

Alpha Level	Hypothesized Value	Cut-off Mark
0.05	0.5	65%

Source: Author's Construct (2023)

Table 6 shows that for an examiner to be seen to have a special technique in identifying the sex of students through their handwriting the examiner must score 65% or better.

Table 6 below shows the number of examiners who scored significantly at each level of the students (scripts).

Table 7: Number of Examiners Who Scored Significantly different from mere 50% at Each Level of scripts.

Level of Students	Number of Examiners	Percentage (%)
UP	2	4.44
JHS	3	6.67
SHS	5	11.11
TERT	8	17.78

Source: Author's Construct (2023)

Table 7, shows that 2 examiners scored 65% or better which represents 4.44% for the UP level, that for the JHS 3 examiners represented 6.67%, then 5 examiners for SHS which is 11.11% and then 8 examiners for the tertiary level representing 17.78%. In total, only 18 examiners out of the 45 examiners were able to significantly identify the sex of students by their handwriting. This number represents 40% of the total number of examiners (45) who participated in the study.

Considering all the scripts, the value of n now becomes 120 trials, this gives a corresponding P_s value of 57%. That is an examiner must score 57% or better to be considered to have a workable guide for identifying the script. As depicted in Appendix D (Table I), 22 examiners achieved a score of 57% or higher, representing 48.89% of the total examiners. This finding suggests that nearly half (48.89%) of the examiners possessed a functional guide for accurately identifying the scripts.

The results above show that the handwriting of students gets better as they progress on the academic ladder. Some sample handwriting of students from the UP and tertiary levels are shown in Appendix C (I to IV), they show the handwriting in their original forms.

Binary Logistic Regression Analysis

In this section, two binary logistic regression models were used to model the performance of examiners in identifying the gender of students based on their handwriting. The choice of the two models was necessitated by the need to address an issue of multicollinearity as the age and experience of the examiners were highly correlated (Pearson's product-moment correlation coefficient of 0.6741991) as predictor variables. In the first model, the variable

Age was discarded since it was not a significant predictor. In the second model, which is the conditional binary logistic regression model, the experience of an examiner was modelled linearly as a function of their age. A statistical test was performed to determine whether the correlation between two variables is statistically significant. The test statistic t = 67.069 is associated with a degree of freedom of 5398 and a p-value less than the predetermined significance level of 0.05, indicating that the correlation is considered statistically significant.

In the latter, though an examiner's age was not a significant predictor, it was imperative not to lose vital information as an examiner's age was highly correlated with their experience. The existence of collinearity between experience and age can impact the fitting performance of any model constructed using these predictors. Consequently, the predictive performance of the associated model may also be affected. In light of this, we consider treating the above issue using the conditional modelling principle. In particular, we modelled experience in terms of age and use the result as a predictor in the overall model. The result of the above conditional model is presented in Table 9.

Binary Logistic Regression Model without the Age Variable

Table 8 shows a summary of the results of a binary logistic regression analysis of the performance of examiners in identifying the gender of a student based on the student's handwriting. The table includes the coefficients and odds ratios for each of these variables, as well as the reference group for each variable.

Table 8: Summary of Results of Binary Logistic Regression Analysis

Coefficient	Estimate	Std. Error	Z Value	Pr(>|Z|)	Odds Ratio
Intercept	-0.268231	0.074884	-3582	0.000341	0.7647310
Experience	0.030655	0.004402	6965	3.29E-12	1.0311296
Male	-0.023841	0.055446	-0.43	0.667205	0.9764408
UP	-0.119683	0.07738	-1547	0.12194	0.8872017
SH	0.029925	0.077365	0.387	0.698898	1.0303775
TT	0.367028	0.078114	4699	0.00000262	1.4434385

AIC: 7391.503 BIC: 7431.068

Source: Author's Construct (2023)

The examiners' performance is affected by their gender and experience as well the level of the scripts.

The intercept in a binary logistic regression analysis gives us an idea of the expected chance of correctly identifying a student's gender based on their handwriting, assuming all other factors remain the same. In Table 8, we can see that the intercept value is -0.268231. This means that, when all the other variables are at their default levels, there is a predicted log-likelihood of correctly identifying the gender.

We also have something called the odds ratio, which is a way to understand the chance of the outcome when there are no predictor variables considered. In this case, the odds ratio for the intercept is 0.7647310. This suggests that when we don't have any other variables in the model, the odds of correctly identifying a student's gender based on their handwriting are approximately 0.76 times lower compared to when we have other predictors included.

So, in simpler terms, the intercept and odds ratio in the analysis help us understand the expected chances and the impact of different variables when it comes to correctly identifying a student's gender based on their handwriting.

Experience Level of Examiner

The coefficient for Experience in the binary logistic regression analysis represents the change in the predicted log odds of the outcome for a year increase in an examiner's experience level, holding all other predictor variables constant. As shown in Table 8, the coefficient for Experience is 0.030655, indicating that a year increase in an examiner's level of experience is associated with an increase in the predicted log odds of an examiner correctly identifying a student's gender based on the latter's handwriting by 0.030655.

The odds ratio represents the change in the predicted odds of the outcome for a year increase in an examiner's experience level. From Table 8, the odds ratio for Experience is 1.0311296, which suggests that a year increase in an examiner's experience level is associated with an increase in the predicted odds of an examiner correctly identifying a student's gender based on the latter's handwriting by approximately 1.03 times. Put differently, the odds ratio of 1.0311296 for Experience means that a year increase in an examiner's level of experience is associated with a 3.1% increase in the odds of an examiner correctly identifying a student's gender based on the latter's handwriting.

Gender of Examiner

The coefficient for Gender in the binary logistic regression analysis represents the change in the predicted log odds of the outcome for a male examiner compared to a female counterpart, holding all other predictor variables constant. As displayed in Table 8, the coefficient for Gender is -

0.023841, indicating that being a male examiner is associated with a decrease in the predicted log odds of correctly identifying a student's gender based on the latter's handwriting by 0.023841. The odds ratio for Males represents the change in the predicted odds of the outcome for a male examiner compared to a female examiner. As shown in Table 8, the odds ratio for Males is 0.9764408, which suggests that being a male examiner is associated with a decrease in the odds of correctly identifying a student's gender based on the latter's handwriting by 0.9764408 times.

Level of Script

The coefficients for the Script levels in the binary logistic regression analysis represent the change in the predicted log odds of the outcome for each level of handwriting compared to the reference level (Junior High School), holding all other predictor variables constant. As shown in Table 8, the coefficients for UP, SH, and TT are -0.119683, 0.029925, and 0.367028, respectively. They indicate that compared to the Junior High School handwriting level and holding all other predictor variables constant, the predicted log odds of correctly identifying a student's gender based on Upper Primary level handwriting decreases by 0.119683 times; for Senior High School level handwriting, the log odds increase by 0.029925 times and for Tertiary level handwriting, the log odds increase by 0.367028 times, the highest among all.

The odds ratios represent the changes in the odds of an examiner correctly identifying a student's gender based on the latter's handwriting for each level of handwriting compared to the reference group (Junior High School

level). The odds ratios for UP, SH, and TT are 0.8872017. 1.0303775 and 1.4434385 respectively.

The odds ratio for UP is 0.8872017, indicating that the predicted odds of an examiner correctly identifying the gender of a student based on Upper Primary level handwriting are approximately 0.89 times lower when compared to a student with Junior High School level handwriting (the reference group). This suggests that, based on student handwriting, examiners have a lower probability of correctly identifying the gender of an Upper Primary student than correctly identifying the gender of a Junior High School student.

The odds ratio for SH is 1.0303775. This indicates that the predicted odds of an examiner correctly identifying the gender of a student based on Senior High School level handwriting are approximately 1.03 times higher when compared to Junior High School level handwriting (the reference group). This suggests that examiners have a slightly higher probability of correctly identifying the gender of a Senior High School student than correctly identifying the gender of a Junior High School student.

The odds ratio for TT is 1.4434385, indicating that the predicted odds of an examiner correctly identifying the gender of a student based on Tertiary level handwriting are roughly 1.44 times higher when compared to Junior High School level handwriting (the reference group). This suggests that, based on student handwriting, examiners have higher chances of correctly identifying the gender of a Tertiary level student than correctly identifying the gender of a Junior High School student. Overall, the chances of an examiner correctly identifying a student's gender based on his/her handwriting are very high for tertiary-level handwriting.

Table 9: Summary of Results of Linear Regression Analysis

Coefficients	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	-8.139817	0.283134	-28.75	<2e-16
Age of Examiner	0.434704	0.006481	67.07	<2e-16

Source: Author's Construct (2023)

As shown in Table 9, there is a statistically significant linear relationship between the predictor variable (Age) and the outcome variable (Experience). The model has an R-squared value of 0.4545 indicating that about 45% of the variance in an examiner's experience level can be explained by their age. The coefficient of Age (0.434704) indicates that, on average, for every one-year increase in an examiner's age, there is a 0.434704-unit increase in their experience level. The p-value of less than 2.2e-16 indicates that the relationship between examiners' age and experience is highly statistically significant, with a very low probability of observing this relationship by chance.

Conditional Binary Logistic Regression Analysis Results

We consider conditional modelling of experience and age of examiners in treating multicollinearity (collinearity) identified in the previous model using experience and age (Table 9). The resultant of the above model is used as a single predictor in the model considered here. This allows the relationship existing between experience and age that would affect the estimation of the fitting performance of the current model to be handled automatically. This implies experience used as a predictor here is updated. The result of the above conditional modelling is presented in Table 10. In particular, a summary of the results of the conditional binary logistic regression analysis of the performance of examiners in identifying the gender of a student based on the student's

handwriting. The table includes the coefficients and odds ratios for each variable, as well as the reference group for each variable.

Table 10: Results of Conditional Binary Logistic Regression Analysis

Coefficients	Estimate	Std. Error	Z value	Pr(>|Z|)	Odds Ratio
Intercept	-0.227411	0.090247	-2.520	0.01174	0.7965934
Experience	0.024433	0.006373	3.834	0.000126	1.0247336
Male	0.018458	0.054922	0.336	0.73681	1.0186296
UP	-0.118346	0.077127	-1.534	0.124923	0.8883889
SH	0.029976	0.077114	0.389	0.69748	1.0304298
TT	0.364939	0.077867	4.687	2.78E-06	1.4404259

AIC: 7426.172 BIC: 7465.737

Source: Author's Construct (2023)

As shown in Table 10, the coefficient for the intercept term is -0.227411 and the odds ratio is 0.7965934. This means that the predicted odds of correctly identifying the gender of a student based on their handwriting is approximately 0.79 times lower when all the predictor variables are held constant. This suggests that the intercept term harms the performance of examiners in identifying the gender of a student based on their handwriting. That is, based on a student's handwriting, the chances of an examiner correctly identifying the student's gender by mere guessing are low.

Experience Level of Examiner

According to Table 10, the coefficient for the Experience variable is 0.024433 and the odds ratio is 1.0247336. This indicates that for each increase of one unit in an examiner's experience level, the predicted odds of correctly

identifying a student's gender based on handwriting increase by approximately 1.02 times. This suggests that the experience level of an examiner has a positive effect on their performance in identifying the gender of a student based on their handwriting.

Gender of Examiner

According to Table 10, the coefficient for the Male variable is 0.018458 and the odds ratio is 1.0186296. This means that the predicted odds of a male examiner correctly identifying a student's gender based on handwriting are about 1.01 times higher than for a female examiner. This suggests that male examiners may have a slightly higher probability of correctly identifying the gender of a student based on their handwriting compared to female examiners.

Level of Script

It can be seen in Table 10, that the coefficient for the UP variable is -0.118346 and the odds ratio is 0.8883889. This indicates that the predicted odds of an examiner correctly identifying the gender of a student based on Upper Primary level handwriting is roughly 0.89 times lower compared to when based on Junior High School level handwriting (the reference group). This suggests that, based on student handwriting, examiners have a lower probability of correctly identifying the gender of an Upper Primary student than when correctly identifying that of a Junior High School student.

The coefficient for the SH variable is 0.029976 and the odds ratio is 1.0304298 as shown in Table .8. This indicates that the predicted odds of an examiner correctly identifying the gender of a student based on Senior High School level handwriting are approximately 1.03 times higher compared to when based on Junior High School level handwriting (the reference group). This

means that, based on student handwriting, examiners have a higher probability of correctly identifying the gender of a Senior High School student than correctly identifying the gender of a Junior High School student.

According to Table 10, the coefficient for the TT variable is 0.364939 and the odds ratio is 1.4404259. This means that the predicted odds of correctly identifying a student's gender based on handwriting are about 1.44 times higher for examiners who use TT handwriting compared to examiners who do not use TT handwriting. This indicates that the predicted odds of an examiner correctly identifying the gender of a student with a Tertiary level handwriting are 1.44 times higher when compared to a student with Junior High School level handwriting (the reference group). This implies that, based on student handwriting, examiners have a higher probability of correctly identifying the gender of a tertiary-level student than correctly identifying the gender of a Junior High School student. Overall, examiners have the highest chances of correctly identifying the gender of a tertiary-level student based on the latter's handwriting.

Model Fit and Selection

On one hand, the true binary logistic regression model in which the variable Age was discarded is associated with a change in deviance of 92.16869, a change in degrees of freedom of 5, a p-value of 2.35275e-18 and an AIC of 7391.50. The model fits significantly since the chi-square value of 92.16869 has a p-value less than 0.001.

On the other hand, the conditional binary logistic model in which examiners' experience was conditioned on their age is associated with a change in deviance of 57.49912, a change in degrees of freedom of 5, a p-value of

3.990176e-11 and an AIC value of 7426.2. The model also fits significantly since it has a chi-square value of 57.49912 with a p-value less than 0.001.

However, the true binary logistic regression model has a lower Akaike Information Criterion (AIC) value of 7391.503 compared to that of the conditional binary logistic regression model, 7426.172. Again, the true binary logistic regression model has a lower BIC value of 7431.068 compared to the conditional binary logistic regression model's BIC value of 7465.737. This indicates that the true binary logistic regression model fits the handwriting data better than the conditional binary logistic regression model. Put differently, the binary logistic regression model without the variable Age better explains the performance of the examiners in identifying students' gender based on handwriting, then the conditional binary logistic regression model.

Some Estimated Success Probabilities from the Models

To further assess the performance of the models, some probabilities were estimated based on randomly generated values for the predictor variables (Gender, Age and Experience of Examiner as well as Script Level). Figure 4 below shows a grid of scatter plots of the estimated success probabilities from the binary logistic regression model without the variable Age.

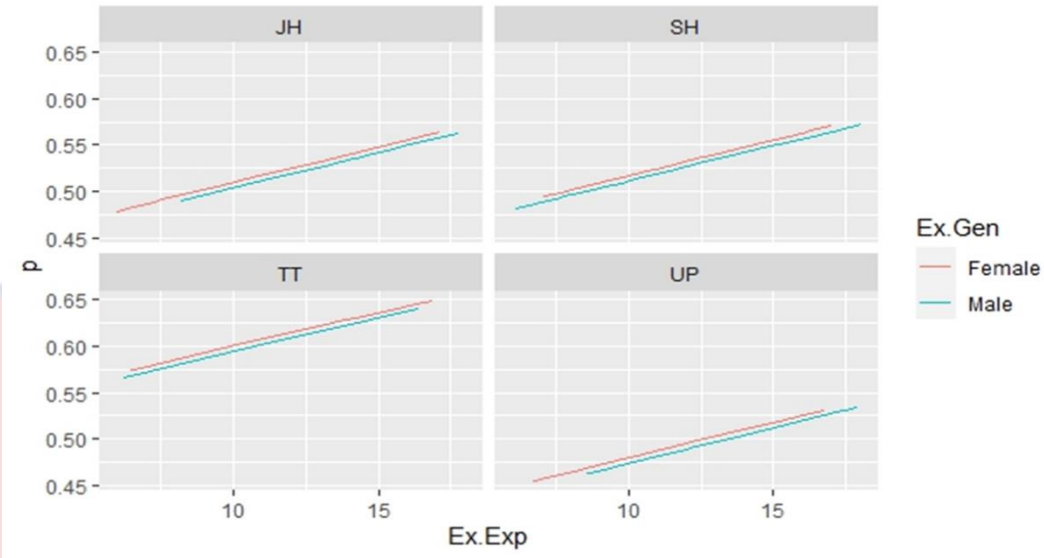

Figure 4: Scatter plots of Estimated Success Probabilities from Binary Logistic Regression Model without Age (Author's Construct)

In Figure 4, the four scatter plots show a positive relationship between the probability of correctly identifying a student's gender based on his/her handwriting and the examiner's level of experience. That is, as an examiner's level of experience increases, his/her probability of correctly identifying a student's gender based on the latter's handwriting also increases. However, female examiners tend to perform slightly above male examiners as shown by the red trend line lying right above the green trend line. These results are consistent with the results of the preliminary analysis.

In Figure 5 below, a similar grid of four scatter plots of the probability of correctly identifying a student's gender based on his/her handwriting and the experience level of an examiner is plotted.

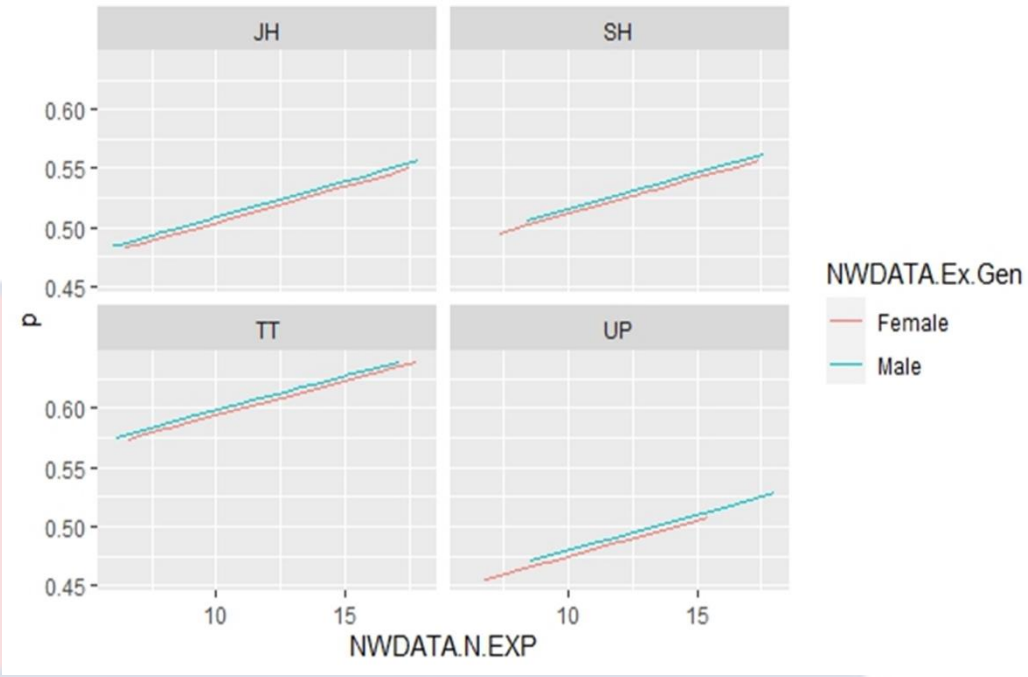

Figure 5: Scatter plots of Estimated Success Probabilities from Conditional Binary Logistic Regression Model (Author's Construct)

It is shown in Figure 5 that the probability of an examiner correctly identifying a student's gender based on the latter's handwriting is directly related to the experience level of the examiner. That is the probability of an examiner correctly identifying a student's gender based on the latter's handwriting increases as the examiner's experience level increases. Nonetheless, the performance of the male examiners is slightly above that of the female examiners. This is inconsistent with the results of the preliminary analysis and contradicts the observation from Figure 5. The inconsistency could be attributable to the variable Age. It is therefore important for future studies to examine how the age and gender of examiners could influence their chances of correctly identifying a student's gender based on the latter's handwriting while controlling for the level of the script and experience level of the examiner.

Discussion of Results

The results indicated a significant difference in the identification of scripts by gender, with the identification becoming easier as one moves from lower levels to higher levels of education. The upper primary scripts were the least identified, while the tertiary level scripts were the most identified. This result is consistent with the findings of Goldberg (1968) which stated that male articles attracted better rates better than female articles. Also, Goldberg (1968) indicated that female students were generally more favoured than male students in script marking and grading. Consistently, the findings of Bradley (1984) also showed evidence of gender bias in the evaluation of named scripts.

Out of the 45 examiners, only 18 (40%) obtained a cut-off mark of 58% or better, indicating that only a few of the examiners demonstrated the ability to correctly identify scripts by gender. This finding aligns with previous research by Eyiah-Bediako et al. (2002), suggesting that even though examiners held gender bias in handwriting, only a minority of them showed evidence of the ability to identify scripts correctly by gender. Forrcheh (1989) also revealed that experienced examiners were able to identify the gender of students by their handwriting.

The study also established that examiners' age was not a significant factor in predicting students' gender based on handwriting. The key variables influencing the prediction were the examiners' experience and the level of students (scripts). This finding highlights the importance of experience in handwriting analysis and suggests that age may not contribute significantly to accurate gender identification. Bediako et al (2002) found a similar result which

indicated that examiners' age was not statistically significant in the identification of students' gender by their handwriting.

The model shown in Table 8 can be used to predict the probability of correctly identifying the gender of a student based on handwriting, considering the examiners' experience and the level of the student's script. That is, the gender of a student can be modelled with moderate probabilities. This aligns with the findings of Bediako et al (2003) which reveal that the probability of correctly identifying the gender of a student by his/her handwriting is fairly low.

Chapter Summary

This chapter presented and discussed the results of the analysis of the handwriting data. The chapter discussed the performance of the examiners in identifying the gender of students based on handwriting across different levels of education. The chapter also discussed the results on the cut-off point for significant performance among examiners. The results of the binary logistic regression model for the gender of the students were also discussed in this chapter. Finally, the chapter discussed the estimated probabilities from the binary logistic regression model in light of the examiners' performance in identifying the gender of students based on handwriting.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview

In this chapter, a comprehensive synopsis of the entire study is provided, encompassing key aspects from the introductory chapter to the results and discussion. The study conclusions will be derived from this comprehensive summary, and pertinent recommendations will be formulated based on the results.

Summary

This chapter presents the summary of the entire work done in the previous four chapters of the thesis. The study took place in the Tamale Metropolis in the Northern Region of Ghana and aimed to investigate gender biases in students' handwriting at different educational levels. The performance of the selected examiners in identifying students' gender based on their handwriting was evaluated, and the proportion of examiners who significantly identified the gender of students by their handwriting was also estimated.

A multi-stage sampling technique (purposive and simple random sampling) was used to recruit participants, with both students and examiners. The schools where the data of the students (scripts) were collected are United Primary School, Dakpema Junior High School, Northern School of Business SHS and the University for Development Studies. That of the examiners were collected at St. Joseph Basic School, Ghana Secondary School and Tamale Technical University. In all 120 students and 45 examiners were selected to participate in the study. The sampled students were then given a standard text to copy for the examiners to identify the gender of the script writers through

their handwriting. All 120 scripts were given to the 45 examiners to identify their gender one after the other. The age, experience, hand used in writing (left hand or right hand) and gender of the examiners were taken. Apart from the writing of the students, the gender of the students was also taken which was used to mark the identifications of the examiners. All the examiners selected held sex stereotypes in handwriting and answered yes to the question "Can you differentiate male and female scripts"

The methods that were used for the analysis of the data were the ANOVA, the test of proportion, the binary logistic model and other routine tests. The test of proportion was used to find the cut-off point for examiners who significantly identified the sex of students through their handwriting. If an examiner does not score this mark or better than the examiner is seen to be using guess work to identify the gender of the students. The preliminary results show that there was no clear difference between the identification of right-handed and left-handed scripts. Also, the hand used by examiners (left hand or right) did not have any effect on the identification of scripts. Where the examiner teaches whether basic level, secondary level or tertiary level did not have any effect on the identification of scripts.

Also, there were clear significant differences in the level of script identification. It is interesting to note that the gender of the examiner showed significant differences when the t-test was used. However, the examiner's gender in the model did not show any statistical significance. The established cut-off of 65% showed that only 18 examiners (40%) were able to identify the scripts significantly. Other interesting results show that 2 out of 45 examiners identified the UP scripts significantly. Similarly, 3 examiners, 5 examiners and

8 examiners significantly identified the JHS, SHS and tertiary levels respectively. Considering the 120 scripts at a go the cut-off established was 58%. The established number of examiners who significantly identified the scripts was 18 examiners constituting 40% of the examiners.

The model developed showed that the model without the examiners' age could be a better prediction model. In both models, the level of students' (scripts) and examiners' experience was statistically significant.

Conclusions

The conclusions of the study are drawn from the results obtained in Chapter 4. Firstly, the study found a statistically significant difference in the identification of the students' gender based on their handwriting by examiners at different levels of education. The study also revealed that identification becomes quite easier as one moves from a lower level to a higher level. Thus, it was seen clearly that the least and most identified scripts were the upper primary script and the tertiary level scripts respectively.

Out of the 45 examiners, only 18 (40%) obtained the cut-off mark of 65% or better. This indicates that even though the examiners hold gender bias in handwriting only a few of them showed evidence of the ability to correctly identify the gender of students by their handwriting, which is in support of the finding of Eyiah-Bediako et al (2002).

From the binary logistic regression models, the examiners' age was not statistically significant in the prediction of students' gender based on their handwriting. The statistically significant variables for the identification of students' gender are the examiners' experience and the level of students (scripts).

Finally, the study found that the probability of correctly identifying the gender of students by examiners based on their handwriting increases from the upper primary level through to the tertiary level of education. The positive trend in correct identification of students' gender was associated with a better performance on the part of the female examiners when age was not considered in the model. However, the positive trend in students' gender identification by examiners was characterised by a better performance on the part of the male examiners when their experience level was conditioned on their age.

Recommendations

The study has some limitations that should be considered. These limitations include the constraints related to time, sample size, geographical location, and the methodology used for collecting sample handwriting.

Conducting a comprehensive study on gender bias in students' handwriting within a limited time frame can restrict the depth and breadth of the research findings. Time constraints limited the ability of the study to employ a larger sample size and more variables that could enhance the understanding of gender bias in handwriting. Future studies should use larger and more diverse handwriting samples to increase the generalizability of the study findings. Further studies should consider other factors such as specific writing tasks and characteristics of handwriting to enhance the accuracy of gender identification.

The study used a sample size of 120 students and 45 examiners which though may be suitable for a localized study, may not be representative of the entire population. The study focused specifically on the Tamale Metropolis which subjects the study findings to influence by unique social, cultural, and contextual factors specific to this region. Thus, the generalizability of the study

results to other geographical locations or cultural contexts is limited. Further studies should replicate the study in different contexts to widen the generalizability of the study findings and provide insights into potential cultural or regional variations in gender bias in handwriting. Lastly, it is imperative to conduct sensitivity analysis to determine a new cut-off point as the sample size increases would contribute to refining the methodology for gender identification.

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APPENDICES

APPENDIX A

I: SAMPLE TEXT FOR UPPER PRIMARY LEVEL

FOR UPPER PRIMARY

One day Anansi went to God to complain that his wife was nothing more than an extra mouth to feed. He also complained that she was eating his share of the food at home.

God asked Anansi, what would you like me to do about this problem?

God, please give me a wife with no mouth upon her face replied Anansi.

II: SAMPLE TEXT FOR JHS LEVEL

FOR JUNIOR HIGH SCHOOL

What does COVID-19 look like?

COVID-19, or the corona virus, is so tiny we can't see it. But it spreads in the coughs and sneezes of people who are sick, and when they touch people or things around them. People who are sick get a fever and a cough and can have some trouble breathing.

So, we can't fight it because we can't see it?

We can fight it that's why we need you to be safe. The virus affects many kinds of people, and everyone can help us fight it. Children are special and they can help too. You need to stay safe for all of us.

III: SAMPLE TEXT FOR SHS LEVEL

FOR SENIOR HIGH SCHOOL

One night, after being served his portion of gruel, Oliver asks for a second helping. This is unacceptable, and Oliver is sent to work as an apprentice to an undertaker. Eventually, after suffering repeated mistreatment, Oliver runs away and heads for London. He soon finds himself in the presence of the Artful Dodger, who tells him to stay at the house of an "old gentleman" (named Fagin) with several other boys. Oliver learns that these boys are trained pickpockets. On an outing, Oliver witnesses the boys take a handkerchief from Mr Brownlow, an elderly man, which prompts Oliver to run away in fear and confusion.

IV: SAMPLE TEXT FOR TERTIARY LEVEL

FOR TERTIARY

In a pre-dawn TV address on 24 February, President Vladimir Putin declared Russia could not feel "safe, develop and exist" because of what he claimed was a constant threat from modern Ukraine.

Immediately, airports and military headquarters were attacked, then tanks and troops rolled in from Russia, Russia-annexed Crimea and its ally Belarus. Big cities have been shelled, neighbourhoods razed to the ground and millions of Ukrainians have fled their homes.

And yet Russia bans the terms war or even invasion, threatening journalists with jail if they do. For President Vladimir Putin this is a "special military operation". Many of his justifications for war were false or irrational.

APPENDIX B

I: SCORE SHEET FOR UPPER PRIMARY

FOR RESEARCHER AND EXAMINER USE ONLY

SCRIPT CODE	GENDER PREDICTION (BY EXAMINER)	WHICH HAND (RIGHT OR LEFT HANDWRITING)	MARK (RESEARCHER USE ONLY)
001			
002			
⋮			
030			
031			
032			
⋮			
060			
061			
062			
⋮			
090			
091			
092			
⋮			
120			

Note: 001 - 030 for Upper Primary School; 031 - 060 for Junior High School 061 - 090 for Senior High School; 091 - 120 for Tertiary Level.

II: SCORE SHEET FOR RESEARCHER

FOR RESEARCHERS USE ONLY

EXAMINER'S CODE	AGE	GENDER	EXPERIENCE	SCORE
001				
002				
⋮				
015				
016				
017				
⋮				
030				
031				
032				
⋮				
045				

Notes

001 - 015 for Basic Level Examiners

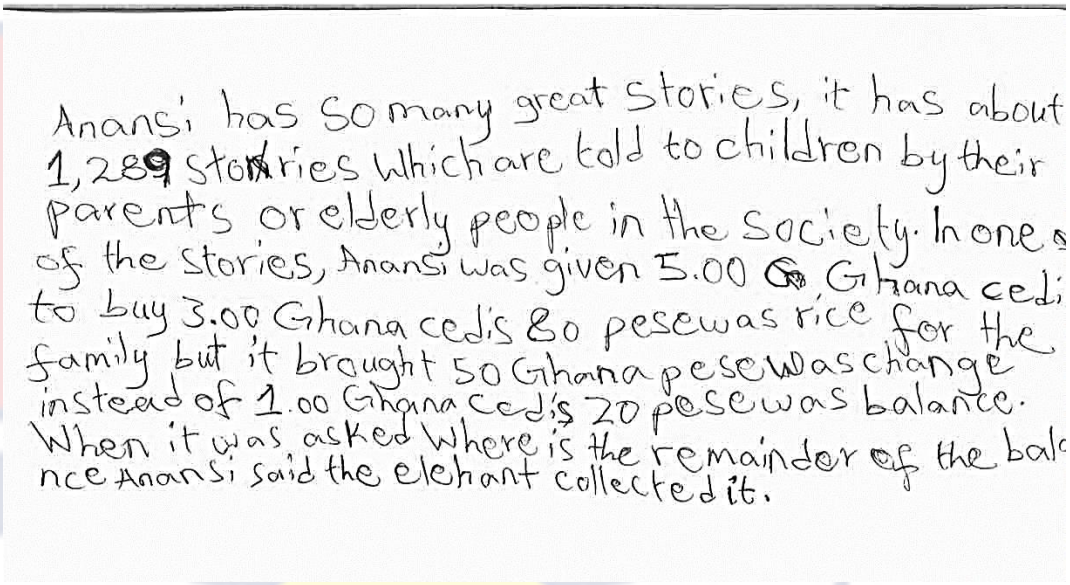
016 - 030 for Secondary Level Examiners

031 - 045 for Tertiary Level Examiners

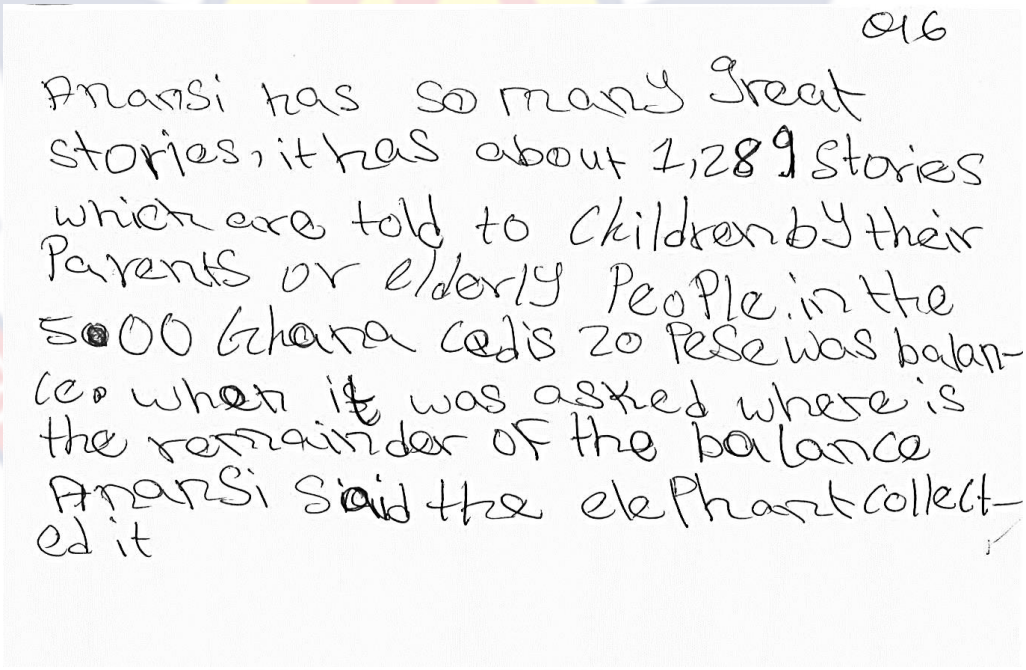
APPENDIX C

SAMPLES OF LEAST AND MOST IDENTIFIED SCRIPTS

C1


Anansi has so many great stories, it has about 1,289 stories which are told to children by their parents or elderly people in the society. In one of the stories, Anansi was given 5.00 Ghana cedis to buy 3.00 Ghana cedis 80 pesewas rice for the family but it brought 50 Ghana pesewas change instead of 1.00 Ghana cedis 20 pesewas balance. When it was asked where is the remainder of the balance Anansi said the elephant collected it.

C2


046

Anansi has so many great stories, it has about 1,289 stories which are told to children by their Parents or elderly People in the 5.00 Ghana cedis 20 Pesewas balance when it was asked where is the remainder of the balance Anansi said the elephant collected it

C3

105

In a pre-dawn TV address on 24 February, President Putin declared Russia could not feel "safe, develop and exist" because of what he claimed was a constant threat from modern Ukraine.

Immediately, airports and military headquarters were attacked then tanks and troops rolled in from Russia, Russian-annexed Crimea and its ally Belarus. Sine the invasion Russia has released over 1,245 missiles in to Ukraine destroying over 23,987 properties and rendering almost 1,000,000 people homeless.

C4

116

FOR TERTIARY

In a pre-dawn TV address on 24 February, president Putin declared Russia could not feel "safe, develop and exist" because of what he claimed was immediately, airports and military headquarters were attacked, then tanks and troops rolled in from Russia, Russian-annexed Crimea and its ally Belarus. Sine the invasion Russia has released over 1,245 missiles into Ukraine destroying over 23,987 properties and rendering almost 1,000,000 people homeless.

APPENDIX D

I: OVERALL PERFORMANCE OF EXAMINERS

S/N	Age	Exp.	Gender	Hand	No Iden.	Percentage
1	34	7	F	R	70	58.3
2	38	10	M	L	70	58.3
3	35	8	F	R	58	48.3
4	47	16	F	R	52	43.3
5	50	30	M	R	64	53,3
6	35	6	F	L	68	56.7
7	28	5	F	R	60	50.0
8	31	7	M	R	70	58.3
9	26	4	M	L	66	55.0
10	33	5	F	R	64	53.3
11	42	1	M	R	57	47.5
12	51	2	M	L	71	59.3
13	29	4	F	R	70	58.3
14	37	3	M	R	73	60.8
15	39	6	F	L	57	47.5
16	38	1	M	R	60	50.0
17	40	1	F	L	58	48.3
18	30	4	M	L	61	50.8
19	39	8	M	R	65	54.2
20	43	7	M	R	59	49.2
21	27	3	F	R	63	52.5

22	32	4	F	L	86	71.7
23	28	2	F	L	64	53.3
24	31	11	M	R	91	75.8
25	34	10	M	R	77	64.2
26	43	14	F	L	64	53.3
27	51	17	M	R	71	59.2
28	39	12	M	L	71	59.2
29	43	14	M	L	64	53.3
30	54	20	M	R	71	59.3
31	43	6	M	R	63	52.5
32	49	16	M	R	68	56.7
33	39	4	M	L	69	57.5
34	54	10	M	R	81	67.5
35	55	14	F	L	69	57.5
36	51	6	F	L	73	60.8
37	53	7	F	R	72	60.0
38	56	8	F	R	69	57.5
39	56	10	F	R	79	65.8
40	59	20	M	L	73	60.8
41	54	20	F	R	65	54.2
42	57	21	F	R	67	55.8
43	52	9	M	R	69	57.5
44	51	5	F	L	70	58.3
45	59	23	F	L	64	53.3

II: NUMBER OF EACH SCRIPT IDENTIFIED

Script No	Hand	No Ide.	Gender	Percentage (%)
001	R	21	M	46.7
002	R	15	F	33.3
003	R	19	F	42.2
004	R	22	M	48.9
005	R	17	M	37.8
006	L	16	F	35.6
007	R	19	F	42.2
008	R	18	M	40.0
009	L	12	F	26.7
010	R	15	M	33.3
011	R	21	F	46.7
012	R	21	F	46.7
013	L	10	M	22.2
014	L	14	F	31.1
015	R	13	M	28.9
016	R	9	F	20.0
017	L	22	M	48.9
018	L	19	F	42.2
019	R	26	F	57.8
020	R	19	M	42.2
021	R	26	M	57.8
022	R	29	F	64.4

023	R	11	M	24.4
024	R	16	F	35.6
025	R	26	M	57.8
026	R	25	M	55.6
027	R	13	M	28.9
028	R	19	F	42.2
029	R	18	M	40.0
030	R	22	F	48.9
031	R	17	M	37.8
032	R	16	F	35.6
033	R	18	F	40.0
034	R	28	M	62.2
035	R	35	M	77.8
036	L	23	F	51.1
037	R	21	F	46.7
038	R	16	M	35.6
039	R	15	F	33.3
040	R	22	F	48.9
041	R	28	M	62.2
042	R	29	F	64.4
043	R	18	F	40.0
044	R	22	M	48.9
045	R	21	M	46.7
046	L	19	F	42.2
047	R	33	F	80.0

048	R	25	F	62.2
049	R	28	F	62.2
050	R	18	M	40.0
051	R	11	F	24.4
052	R	23	F	51.1
053	R	18	M	40.0
054	R	19	M	42.2
055	R	17	F	37.8
056	L	13	M	28.9
057	L	12	M	26.7
058	L	22	F	48.9
059	R	29	F	64.4
060	L	26	F	57.8
061	R	28	M	62.2
062	R	19	F	42.2
063	R	27	F	60.0
064	R	18	F	40.0
065	R	19	M	42.2
066	R	16	M	35.6
067	R	18	M	40.0
068	L	11	M	24.4
069	R	15	M	33.3
070	R	13	M	28.9
071	R	17	M	37.8
072	R	13	M	28.9

073	L	16	M	35.6
074	L	22	M	48.9
075	L	27	M	60.0
076	R	28	F	62.2
077	R	21	F	46.7
078	R	19	F	42.2
079	R	17	F	37.8
080	R	15	M	33.3
081	R	25	M	55.6
082	R	22	F	48.9
083	R	17	M	37.8
084	R	19	F	42.2
085	R	23	F	51.1
086	R	28	F	62.2
087	R	21	M	46.7
088	R	20	F	44.4
089	R	19	F	42.2
090	R	16	F	35.6
091	R	19	F	42.2
092	R	21	F	46.7
093	R	22	F	48.9
094	R	27	F	60.0
095	R	27	M	60.0
096	R	28	M	62.2
097	R	25	M	55.6

098	R	19	F	42.2
099	R	31	M	68.9
100	R	19	M	42.2
101	R	28	M	62.2
102	R	31	M	68.8
103	R	33	M	73.3
104	R	24	F	53.4
105	R	38	F	84.4
106	R	21	M	46.7
107	R	30	M	46.7
108	L	22	F	48.9
109	R	19	F	42.2
110	R	20	F	44.4
111	L	18	F	40.0
112	R	17	F	37.8
113	R	25	F	55.6
114	R	25	M	55.6
115	R	16	M	35.6
116	R	39	M	86.7
117	L	19	M	42.2
118	L	33	F	73.3
119	L	21	F	46.7
120	L	31	M	68.9