IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 9, September 2024

DOI: 10.17148/IJARCCE.2024.13909

Analyzing Usability Requirements for Effective Implementation of Biometric Technology: A Case Study of Kenyan Secondary Schools

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Abstract: Biometric technology has gained popularity since it focuses on the use of human traits in authentication unlike traditional conventional systems and/or uni-modal biometric security systems. Integrating biometric technology in educational Schools aims to enhance security and streamline administrative processes. However, there is limited understanding of the extent to which this technology has been adopted in Secondary Schools and the specific usability requirements necessary for its effective implementation. The purpose of the study therefore analyze usability requirements for the adoption of biometric technology in secondary schools in western Kenya. The study adopted a pragmatic perspective, employing a survey design targeting Schools using biometric technology. Data was collected via questionnaires, observation checklists, and interviews. Findings revealed significant positive correlations between system properties, user actions, and communication and feedback, enhancing engagement and trust. However, perceived benefits showed moderate correlations, and time-saving perceptions negatively correlated with extensive feedback, suggesting optimization needs. The study concluded that successful implementation hinges on user-centered experience and adoption. While generally positive, concerns about fraud prevention and legal compliance persist. Recommendations include comprehensive training programs, regular technology reviews, and user-centered design improvements, emphasizing routine maintenance and seamless integration into existing infrastructure. Further studies should investigate the long-term impact on user experience and operations, explore adoption in various settings, examine legal and ethical considerations, analyze technical and logistical challenges, conduct cost-benefit analyses, test new usability features, and understand diverse user experiences.

Keywords: Adoption, Biometric technology, Communication, Implementation, Security, Usability

I. INTRODUCTION

The evolution of data security saw the development of more secure encryption methods, moving from simple techniques like invisible ink to complex algorithms involving permutations and secret keys [1]. However, as digital data processing became essential in handling vast amounts of information, the need for more robust and efficient identification methods grew. Biometric technology emerged as a solution by utilizing individuals' unique physiological or behavioral characteristics for identification and access control. This technology operates on the principle that each person can be accurately identified by their intrinsic traits, such as fingerprints, iris patterns, facial features, or behavioral attributes like voice patterns [2]. Unlike traditional methods, which rely on possession or knowledge, biometric systems authenticate users based on who they are, making them inherently more secure and convenient.

In recent years, biometric technology has become increasingly integrated into various sectors, including education. Secondary schools are adopting biometric systems to enhance security, streamline administrative tasks like attendance tracking, and improve overall efficiency [3]. These systems automate processes that were previously manual, reducing errors and unauthorized access. The usability and acceptance of biometric technology have been bolstered by advancements in sensor technology and pattern recognition systems, making them more accurate and user-friendly [2]. This technology has not only improved security but also contributed to a more seamless and efficient educational environment. As schools in Kenya and other developing countries face challenges such as attendance tracking and security concerns, biometric technology offers a promising solution. By leveraging biometric systems, schools can ensure accurate student identification, automate routine tasks, and enhance overall safety measures [4]. However, the adoption of biometric technology requires careful consideration of infrastructure, cultural factors, and ethical implications to ensure successful implementation and acceptance among users.

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This research was designed to investigate the adoption of biometric technology use in Secondary Schools in Kenya, while highlighting the usability issues that result from this adoption. Usability is the attribute that makes a product easy to understand, easy to learn, easy to use, and attractive to users [5]. Usability has various definitions, sometimes defined as "how usable something is" [5]. Since [6] attempted to define usability systematically; many other researchers shifted their focus to studying usability factors, such as learnability, ease of use, memorability, efficiency, and user satisfaction. Prior studies considered various factors when evaluating usability. Early studies carried out by the International Organization for Standardization classified usability into three components: effectiveness with regard to suitability for a particular purpose, efficiency, which means the time or process required for the task, and user satisfaction (ISO 9241-11). ISO has primarily defined usability as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (ISO 9241-11). Recently, usability has been further defined as "easy and effective to use, and enjoyable from the user's perspective" [7]. Based on its varied definitions, it is evident that usability is not just "look and feel" of biometric systems [8]. Usability is a key goal for the design of any interactive software that is not to be used by trained technical computer specialists, popular terms such as "user-friendly" have entered everyday use. Both usability and user-friendliness were initially understood to be a property of interactive software [5]. A literal understanding of usability requires interactive software to be inherently usable or unusable. When studying usability, software either is usable or not, unusable software could be made usable through re-design. A more realistic understanding sees usability as a property of interactive use and not of software alone. This is why the term *quality in use* is preferred for some international standards, because this opens up a space of possible qualities of interactive performance, both in terms of what is experienced, and in terms of what is achieved, for example, an interaction can be 'successful', 'worthwhile', 'frustrating', 'unpleasant', 'challenging' or 'ineffective'. For many security and privacy mechanisms and applications, usability has emerged as one of the dominant quality attributes or non-functional requirements apart from most common ones like confidentiality, integrity, and availability. Usability can be visualized as an intrinsic characteristic that impacts end users' decisions to use a security and privacy mechanism, generally referred to as acceptance [9]. It can be summarized with a phrase; there is no weaker security or privacy mechanism than the one that users simply do not use. According to [10], usability can be defined in terms of three orthogonal contributing factors, i.e., effectiveness, efficiency, and satisfaction. However, effectiveness and efficiency must also be adequately captured and stored to meet usability criteria. It is important to note that usability has been defined by different authors highlighting some aspects that have not been captured in the ISO standard.

Nielsen [11] defines usability as a "quality attribute" that assesses how easy user interfaces are to use. For instance, in his argument, [11] defines usability through five dimensions: learnability, efficiency, memorability, error tolerance and prevention and satisfaction. In his discussion, Nielsen considers complex systems that require training operators before use, hence highlighting the importance of being resilient to user error and the importance of learnability. Consequently, attention is required to explore mechanisms that can validate usability requirements by using measurable dimensions [12], such as 1) ease of learning, 2) efficiency to use a security or privacy mechanism, 3) ease of memorizing, 4) understandability of a task and 5) subjective satisfaction, to design numerous security and privacy mechanisms. The word "usability" also refers to methods for improving ease-of-use during the design process [13]. To be usable, a product or service must consider, at minimum the five basic dimensions of usability namely learnability, efficiency, memorability, error tolerance and prevention as well as satisfaction. These usability dimensions differ depending on the context and target users. For smaller systems like BT's, experts note that the major focus of usability practitioners might be learnability. For complex systems however (jet planes, nuclear power plants) critical dimensions like error tolerance, error prevention, memorability and efficiency should be considered. When discussing usability in BT's, it's important to note that there could be other factors that supersede usability, such as user experience. In cases where this is applicable to a certain product or service then there are additional dimensions to be considered such as aesthetics, pleasure and consistency with moral values. However such dimensions should still find support on usability foundations. It is important to realize that usability is not a single, one-dimensional property of a user interface or technology. Usability has multiple components and is traditionally associated with five attributes as discussed herein;

A. Learnability

Learnability is the fundamental usability attribute. Most systems need to be easy to learn because the first experience most people have with a new system is that of learning how to use it. Ease of learning is mostly applicable to the novice user's experience on the initial part of learning how to navigate through a technology. According to [14] the word *learnability* signifies how quickly and comfortably a new user can begin efficient and error-free interaction with the system, particularly when he or she is starting to use the system. In his definition therefore both objective and subjective facets of learnability are considered: the speed of learning (quickly) and the subjective satisfaction of the learner (comfortably). The goal of the learning process is efficient and error-free interaction [14]. In other literatures the terms *ease-of-learning* and learnability often have been used interchangeably.

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For example, according to [15] learnability comprises the usability attributes of satisfaction, effectiveness, and efficiency that are evaluated within a context of a new user. In the ISO 9241 standard (International Organization for Standardization [ISO], learnability is also defined through the three attributes of efficiency, effectiveness, and satisfaction. [16] Define learnability as the ease with which new users can begin effective interaction and achieve maximal performance. These definitions of learnability are geared towards user experience and tend to address a criterion that includes effectiveness or efficiency that can be used to measure the learning results. Although this could hold, [17] argues that the term *learnability* should also cover expert users' ability to learn functions that are new to them. In as much as this perspective is important, the aspect of learnability can be feasible if it concentrates on one group of users, namely new users. Of great importance is that learnability can be used in determining system acceptability as was noticed early (e.g. [19]). [18] Found out that learnability is correlated with user satisfaction. Learnability of complex systems is especially critical, as the complexity tends to make the unproductive learning period longer than what is desired by the user and the managers in the organization.

Based on the current considerations of learning how to use new technology there are contradicting views of how learnability relates to usability. Some researchers consider learnability to be a sub concept of usability (e.g., [20]). [11] Presents five sub attributes of usability: learnability, efficiency, memorability, errors, and satisfaction. This tends to agree with [20] that learnability is a sub attribute of usability, however in other literature, Nielsen presents 10 usability heuristics that should be considered when designing user interfaces and learnability is not included in this discussion. Other authors like [16] divide usability into the three attributes of learnability, flexibility, and robustness. On the other hand Lin et al. (1997) list eight usability attributes: compatibility, consistency, flexibility, learnability, minimal action, minimal memory load, perceptual limitation, and user guidance. Of importance are [20] who have discussed the relationship of learnability and usability in their publication.

They refer to several studies indicating that the concepts of learnability and usability are strongly related and even congruent. [21], for example, found that procedural complexity underlies both the performance of experts and the learning of novices; this means that in the wake of new technology the user has to start by learning how to use first before the actual performance of the task. [22] Have also stated that the concepts of usability and learnability are congruent. According to them learnability and usability can be used interchangeably. However, there are other researchers (e.g., [23]) who have noted that sometimes learnability and usability may be contradictory: that in some technology, issues that improve learnability could actually reduce usability. This is true especially when one seeks to clarify issues related to the question of how learnability and efficiency relate to each other. However largely according to this literature it is agreeable therefore that, learnability is an important attribute of usability and thus contributes highly to how efficient and effective the user will be while using the new technology.

Learnability studies concentrate on the effect of the user interface design on learnability of the user (see [20][18]. In essence, the user interface is crucial for learnability, because, it essentially forms the link between the user and the system. Different researchers stress various issues as determinants of user interface/technology learnability. [24] Emphasize the effect of consistency. According to them if every aspect on a new interface is consistent, then learnability of this interface will be easy for the user, both novice and expert. [25] On the other hand emphasize the naturalness of interaction that the user would proceed to learn and use a new interface with very minimal assistance. [16] Presented five principles that support user interface learnability: predictability, synthesizability, familiarity, generalizability, and consistency. [20] Found four factors that determine the learnability of a system: transparency of operation, transparency of purpose, accommodation of the user, and the sense of accomplishment.

The two first elements are determined by the user interface design and, according to [20], the accommodation of the user and the sense of accomplishment follow them causally. Applying these principles to user interface design helps in designing systems that are easy to learn. However, to improve learnability, the correspondence between the system and users' expectations must be analysed too, as expectations have a remarkable effect on learning. Users' expectations may cover the scope, underlying concepts, and basic functionality of the system. On improving the learnability of a complex systems, [26] among others, have stated that differences between the users' expectations and the actual system can cause learning difficulties.

BTs, like all other user interfaces have learning curves that start out with the user being able to do nothing (have zero efficiency) at time zero (when they first start using it). In some instances, there are exceptions which include the so-called walk-up-and-use systems, such as museum information systems, that are only intended to be used once and therefore need to have essentially zeroed learning time, allowing users to be successful from their very first attempt at using them.

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However it's important to note that, the standard learning curve does not apply to cases where the users are transferring skills from previous systems, such as when they upgrade from a previous release of a word processor to the new release [27]. Unlike BT's in cases where the technology is being phased, the assumption is that the new system is reasonably consistent with the old; users therefore should be able to start a fair bit up on the learning curve for the new system [28]. Ease of learning is probably the easiest of the usability attributes to measure, with the possible exception of subjective satisfaction. In BT's as in other technologies, a researcher can simply pick some users who have not used the system before and measure the time it takes them to reach a specified level of proficiency in using it. Of course, the test users should be representative of the intended users of the system, and there might be a need to collect separate measurements from complete novices without any prior technology experience and from users with some typical experience. In earlier years, learnability studies focused exclusively on users without any computer experience, but because many people now are exposed to computer use, it is becoming more important to include such users in studies of system learnability.

The most common way to express the specified level of proficiency is simply to state that the users have to be able to complete a certain task successfully. Alternatively, one can specify that users need to be able to complete a set of tasks in a certain, minimum time before one will consider them as having "learned" the system. When analysing learnability, one should keep in mind that users normally do not take the time to learn a complete interface fully before starting to use it. On the contrary, users often start using a system as soon as they have learned a part of the interface. For example, a survey of business professionals who were experienced personal computer users [29] found that four of the six highest-rated usability characteristics (out of 21 characteristics in the survey) related to exploratory learning: easy-to-understand error messages, possible to do useful work with program before having learned all of it, availability of undo, and confirming questions before execution of risky commands. Because of users' tendency to jump right in and start using a system, one should not just measure how long it takes users to achieve complete mastery of a system but also how long it takes to achieve a sufficient level of proficiency to do useful work.

Learning of a new technology by users fits into a learnability curve, as shown in the **Figure 1** below. Highly learnable systems have a steep incline for the first part of the learning curve and allow users to reach a reasonable level of usage proficiency within a short time. The learning curve actually represents a continuous series of improved user performance and not a dichotomous "learned"/"not learned" distinction. It is still common, however, to define a certain level of performance as indicating that the user has passed the learning stage and is able to use the system and to measure the time it takes the user to reach that stage.

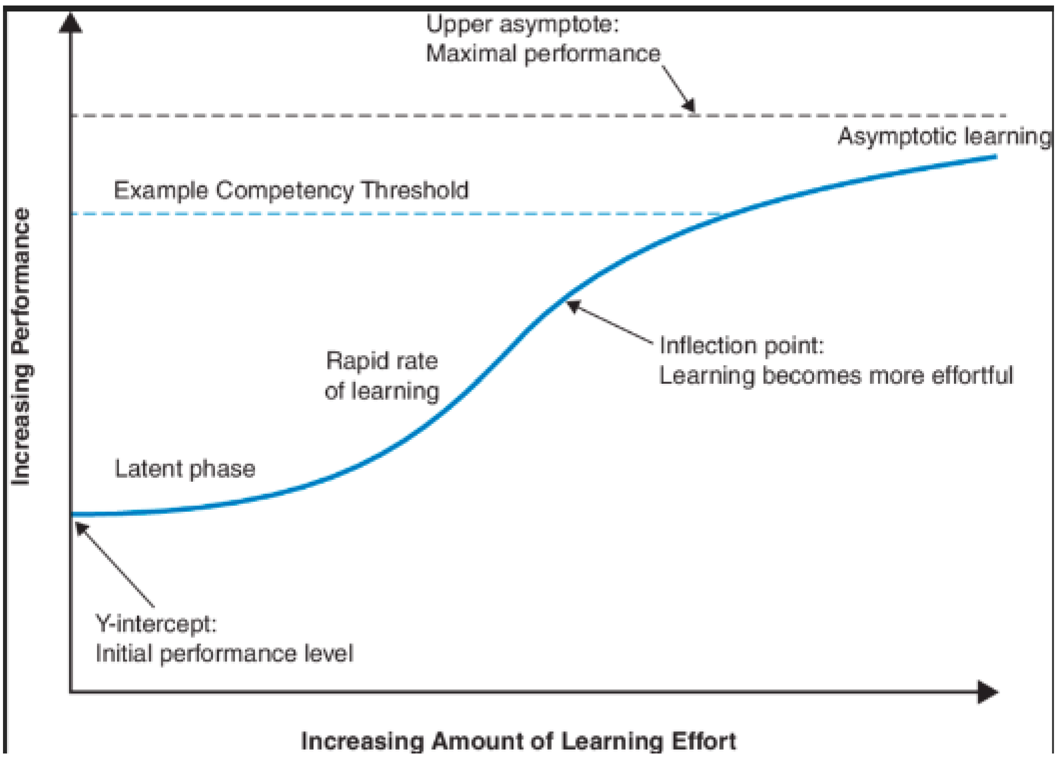

Figure 1: Learning Curve

DOI: 10.17148/IJARCCE.2024.13909

B. Efficiency of Use

Efficiency refers to the expert user's steady-state level of performance at the time when the learning curve flattens out. Of course, users may not necessarily reach that final level of performance any time soon. For example, some operating systems are so complex that it takes several years to reach expert-level performance and the ability to use certain composition operators to combine commands [30] [31]. Also, some users will probably continue to learn indefinitely, though most users seem to plateau once they have learned "enough" [32] [33]. Efficiency means how fast a user can perform tasks once she has learned to use a system. Here one has to examine the number of steps (or indeed clicks/keystrokes) to achieving the objective; can they be reduced? This will help develop efficient processes. However there are some users who don't need to learn to use a system fully, but are satisfied when they have learned its basic functionality. One way to improve efficiency is by adding hidden shortcuts for frequently used functions. Also, simplicity in interaction and visual design can make a more efficient UI possible, if done properly. So as to maximize efficiency, you need to examine how your users prefer to work, are they interacting via a smartphone or a desktop computer with a large keyboard and mouse? The two require very different approaches to navigation. To measure efficiency of use for experienced users, one obviously needs to access the very experienced users. For systems that have been in use for some time, "experience" is often defined somewhat informally, and users are considered.

II. RESEARCH METHODOLOGY

Every research work is based on some underlying paradigm that directly informs what will constitute that research and the methods to be employed [34] [35]. There are various paradigms that can be adopted in any research work. Although there were areas in this study where interpretivism was employed, this research was grounded in pragmatism paradigm. Pragmatic approach to research involves using the method which appears best suited to the study [36]. Each observation made in this study was quantified based on a measurement scale that facilitated empirical analysis. The researcher's role was limited to data collection [37] that was to enable an objective understanding of the research area. The adoption of this paradigm was informed by the fact that pragmatic approach grants freedom to the study to use any of the methods, techniques and procedures typically associated with quantitative or qualitative research [38][39]. Being able to mix different approaches in this study was of advantage in that it enabled triangulation of a variety of data sources. The findings were then used objectively to develop the model. The study adopted survey design. According to [40], survey research design allows a researcher to explore and fully describe observed phenomena in the study this was suitable for achievement of objective of the study. The study intended to collect large amount of data making the survey research design a more preferred methodology as it is suitable for collecting large amounts of data from large [40] Surveys were appropriate for this research because the questions explored self-reported beliefs or user behaviors [41].

The geographical location of this research study was Western region, Kenya. Western was purposively selected as a suitable study site because of its proximity to the study availability of facilities, and logistical considerations. Western Kenya also has Schools where this new technology is being rampantly adopted; therefore, some Secondary Schools in the region have adopted use of biometric technology for authentication. Furthermore, in this region most Secondary Schools were suffering from data integrity issues and other security breaches and required good and stricter authentication methods. This study targeted secondary schools that had currently employed the use of biometric technology. These schools were those that were using at least one biometric technology for authentication or management of the schools routine. This was because data collected from such schools would be of relevance to the objectives of the study. At the school level, the study targeted persons-in-charge of BT in the learning school as well as those using the BT.

Purposive sampling was used to identify the first secondary school(s) that would provide a starting point for snowball. This study used snowball sampling to identify specific schools that had implemented desired biometric technology (BT). This technique was appropriate given that many Secondary Schools in Kenya today do employ authentication systems, but very few (usually unknown) utilize biometric technology. In this study also, schools of interest were difficult to locate hence snowball was the applicable technique as it is a non-probability sampling technique that was appropriate to use when a study has such members of a population [42]. By identifying few initial Secondary Schools that use BT the study then proceeded by snowball thus allowing this initial school to recommend other Secondary Schools that used Biometric technology for authentication. To minimize on sample biasness, where a sampled school referred the study to more than one other school, simple random sampling was used to identify to which school the study should proceed. At school level, the study used purposive sampling to identify members with unique knowledge on BT that existed in their particular learning school. These individuals were mainly persons-in-charge of the BT and those that manage the implemented biometric technology.

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International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.102 ⋇ Peer-reviewed & Refereed journal ⋇ Vol. 13, Issue 9, September 2024
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The study then used simple random sampling to select BT users in these Secondary Schools for purposes of obtaining data on the usability requirements of the biometric technology used in Secondary Schools in Kenya. Snowball sampling being a non-probability sampling method, the size of the sample is usually a sample ratio of size of the population [43] [44]. In the study, the overall population size was unknown due to lack of official statistical data in regard to Secondary Schools that used biometric technology. Faced with this challenge, the study did not base its sample size on mathematical theory for determining the sample size [43] [44]. The study selected cases gradually as the study progressed during data collection. Through snowballing the study identified 13 schools of which three questionnaires were administered to the teacher in-charge of biometric technology in these Schools and the teacher teaching ICT subject. For snowball, a sufficient sample size is believed to have been gathered when the Schools under study start referring the researcher back to already sampled Secondary Schools.

The study used questionnaires, observational checklists and interviews in data collation. Questionnaires were used for the study because they are free from the bias of the researcher thus they offer respondents time to provide well thought out answers. The study had a large sample thus the use of questionnaires was appropriate. In addition, in situations where the researcher may not have sufficient face-to-face interactive time with the respondents questionnaires come in handy and this was the case for the study. There was one set of questionnaire administered to the respondents in the selected Secondary Schools who made up the sample. The questionnaire consisted of a set of questions printed and arranged in a definite order, as per the objectives, on a form [40].

This questionnaire consisted of structured questions to capture quantitative data. The questionnaire also contained two sections: a section for capturing the demographic information of the BT used and another section that attempted to quantify the characteristics of the BT users. Observation technique was utilized to facilitate the achievement of study usability objective which involved gathering data by watching behavior, events, or noting physical characteristics in their natural setting. By being covert the research aimed to not influence the behaviour of BT users. The researcher observed behavioural traits of the BT users.

The instruments credibility was attained by assessing the instruments validity and reliability. Validity of a test is a measure of how well a test measures what it is expected to measure [45] 46]. The study used face, content and constructs validity to determine the validity of the research tools. Content validity was achieved when the questionnaires was pre-tested on a set of respondents especially those with knowledge in the adoption, use and implementation of biometric technology. This enabled the researcher to review the questionnaire items based on the pilot respondents so as to ascertain if there were quality responses. Face validity was achieved through a panel of experts who judged the survey tools based on the appearance, relevance and the representativeness of its elements [47]. Construct validity of the tools was assessed by the supervisors and research experts and by the use of standardized measures of adopted BT performance. The model that was designed was validated using the data provided by the management and other users of the biometric technology adopted in these Secondary Schools to ascertain if it met the specified requirements. The expert finding are as in Table 1 Likert scale of 1-10

Table 1: Validity Scores

Experts	Content Validity	Construct Validity	Average
EXPT-1	0.80	0.90	**0.850**
EXPT-2	0.90	0.85	**0.875**
EXPT-3	0.75	0.80	**0.775**
EXPT-4	0.80	0.90	**0.850**
Average	**0.810**	**0.860**	**0.835**

The validity scores in Table 3.1 indicate a generally strong level of agreement among experts on both content and construct validity, with content validity averaging at (0.810) and construct validity at (0.860). The combined average of (0.835) reflects robust overall validity of the assessed instrument. Specifically, the high construct validity scores suggest that the instrument effectively measures the theoretical constructs it is intended to, while the content validity scores

Reliability is the measure of how accurate and precise an instrument or measurement procedure is [48]. It means that the instrument used is stable and will collect the same data if used in other similar studies.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

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DOI: 10.17148/IJARCCE.2024.13909

Reliability test ensured that there was no ambiguity in the questions and those tools of data collection served the intended purpose. In order to test for internal consistence of these tools, Cronbach's alpha coefficient was used as a measure of this reliability [49].

According to [50] when the Cronbach alpha coefficient is greater than 0.7, the instrument is considered reliable. Questions set items that indicated an alpha of less than 0.5 were reviewed in order to raise the co-efficient. This study relied on a pilot study to test for content validity of the instruments. This verified the reliability of the questionnaires to be used.

Both equivalence and stability aspects of the research instruments were verified from the analysis of data emanating from the pilot study. This provided a forehand opportunity to examine effectiveness of the instrument to be administered to the target population [51].

This pilot study was conducted in Finlay Flower Company in Naivasha. This private company had adopted and was using the Biometric Technology since 2012 and had used it for the past ten years successfully [43]. It was also among the few private organization known for BT use outside the targeted study area. Table 3.1 presents Cronbach's Alpha coefficients for two key constructs related to biometric technology: the adoption of biometric technology use and usability requirements. Table 2 provides a summary of Reliability Statistics obtained.

Table 2: Reliability Statistics

	Cronbach's Alpha	**N of Items**
Adoption of biometric technology use	.937	23
Usability Requirements	.908	19

The data indicate high reliability for both constructs measured by Cronbach's Alpha, with the adoption of biometric technology showing a value of .937 across 23 items, and usability requirements showing a value of .908 across 19 items. The high Cronbach's Alpha for both constructs indicates strong internal consistency, making the data suitable for further analysis and interpretation in the context of studying the adoption and usability requirements of biometric technology.

After data had been collected, it was edited organized and coded into SPSS software as well as python for analysis thereafter data was analyzed using descriptive statistics as well as inferential statistics. The results were tabulated, the information structured in order so that it could be easily and effectively communicated.

III. RESULTS AND DISCUSSION

A. Usability Requirements of Biometric Technology

Usability requirements refer to the criteria and standards used to evaluate the ease of use and user experience of a product, system, or technology. In the context of biometric technology adoption, usability requirements encompass factors such as user interface design, ease of enrolment and authentication, user feedback mechanisms, and overall user satisfaction.

This section provides an analysis of usability requirements for biometric technology use within Secondary Schools. It is divided into six main parts: Descriptive Statistics on Usability Requirements, M-Estimators Analysis, Model Summary, Coefficients, Collinearity Diagnostics and ANOVA with Tukey's Test for Non-additivity.

B. Descriptive Statistics on Usability Requirements

This section offers a descriptive analysis of statistics pertaining to the usability requirements and user perceptions surrounding the implementation of biometric technology within Schools.

The focus is on understanding how various usability factors and user perspectives influence the adoption and effectiveness of biometric technologies designed to enhance security and operational efficiency in Secondary Schools. This is summarized in Table 3.

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.102 ⪤ Peer-reviewed & Refereed journal ⪤ Vol. 13, Issue 9, September 2024
DOI: 10.17148/IJARCCE.2024.13909

Table 3: Descriptive Statistics on Usability Requirements

	Mean	Std. Deviation	Kurtosis	
	Statistic	Statistic	Statistic	Std. Error
Actions on the biometric technology are predictable	3.8471	.27878	-.619	.788
I am familiar with the adopted biometric technology	3.6529	.28416	-1.854	.788
Actions performed on the biometric technology are consistent	4.2000	.20301	-2.129	.788
Learning to use the biometric technology is easy	4.4000	.00000	.	.
The use of biometric technology in my school saves time	4.0000	.00000	.	.
My school has a competitive edge in terms of security due to biometric technology use	4.2000	.00000	.	.
I trust the biometric technology in use	4.2000	.00000	.	.
Communication regarding the biometric technology in use was well done	4.6000	.00000	.	.
Biometric technology use is easy to remember	4.6000	.20301	-2.129	.788
My computer skills enable me use the biometric technology	4.2000	.20301	-2.129	.788
A manual is in place for reference when using biometric technology	4.2000	.20301	-2.129	.788
I get feedback from the biometric technology every time I use it	4.2000	.20301	-2.129	.788
The biometric technology use in my school is stable	4.2000	.20301	-2.129	.788
The adopted biometric technology warns me when I make a mistake	4.0000	.00000	.	.
The biometric technology performs automatic check for errors on the entered data	4.0000	.00000	.	.
I have a positive attitude when using the biometric technology	4.0000	.00000	.	.
I have control over the biometric technology used in my school	4.2000	.20301	-2.129	.788
I like using the biometric technology to accomplish my tasks	4.0000	.00000	.	.
The biometric technology in use rejects poor quality data samples	4.0000	.00000	.	.
Valid N (list wise)				

The findings in Table 3 provide insightful perspectives on the usability requirements and user perceptions of implementing biometric technology within a learning school. From the findings, users generally find actions on the biometric technology to be somewhat predictable, as indicated by a mean score of 3.8471. However, the standard deviation of 0.27878 suggests some variability in this perception. This is affirmed by the negative kurtosis value of -0.619 suggesting a distribution slightly flatter than normal, hinting at varied user experiences regarding predictability. This variability may stem from differing experiences among users regarding the consistency of the technology's actions.

In terms of familiarity with the adopted biometric technology, users rated their familiarity at 3.6529, which is lower than expected. This finding, coupled with a standard deviation of 0.28416, suggests a disparity in user knowledge and comfort levels with the technology. Additionally, the kurtosis values for familiarity (-1.854) indicate distributions that are heavier-tailed than normal, suggesting that the experiences of users might be more varied than the mean and standard deviation reveal. This variability might reflect underlying issues such as differing levels of technology proficiency among users thus, addressing this gap through comprehensive user training programs as support mechanisms could lead to more uniform user proficiency.

Interestingly, users perceive actions performed on the biometric technology as highly consistent, with a mean score of 4.2000. This high level of consistency, coupled with a small standard deviation of 0.20301, indicates strong agreement among users. The negative kurtosis value of -2.129 indicates some variability in perceptions, but overall, there is strong agreement among users regarding consistency. Such consistency is crucial for instilling trust in the technology and ensuring reliable outcomes when users are interacting with the technology.

Furthermore, users unanimously agree that learning to use the biometric technology is easy, reflected by the perfect mean score of 4.4000 and the absence of standard deviation. This finding suggests that the user interface and training materials are effective in facilitating user understanding and proficiency on the biometric technology. Moreover, users believe that the use of biometric technology saves time, rating it at 4.0000. This perception, coupled with a lack of variability (standard deviation of 0.00000), underscores the efficiency gains associated with biometric technology adoption. However, their main concern was the use of this technology within high populations, the long queues and time taken then used to pose a great challenge to this factor.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁒ Peer-reviewed & Refereed journal ⁒ Vol. 13, Issue 9, September 2024

DOI: 10.17148/IJARCCE.2024.13909

Furthermore, users strongly believe that their Schools gain a competitive edge in terms of security due to the use of biometric technology, with a mean score of 4.2000. The absence of standard deviation suggests uniformity in this perception, these findings is critical for reinforcing user trust and confidence in the school's security measures. These findings provide valuable insights into user perceptions of biometric technology adoption and use within the Secondary Schools underscoring the importance of biometric technology as a robust authentication measure.

C. **M-Estimators Analysis**

The findings in this section presents scores obtained from different M-Estimators like (Huber's M-Estimator, Tukey's Biweight, Hampel's M-Estimator, and Andrews' Wave) for various usability requirements related to biometric technology use in Secondary Schools. The analysis of these M-Estimators yields valuable insights into user perceptions. Each estimator offers a unique perspective on the usability aspects, which is crucial for understanding the challenges and strengths of biometric technology implementation in Secondary Schools. Table 4 summarizes the findings

Table 4: M-Estimators

	Huber's Estimator[a]	M-Tukey's Biweight[b]	Hampel's Estimator[c]	M-Andrews' Wave[d]
Actions on the biometric technology are predictable	3.8085	3.8037	3.8174	3.8040
I am familiar with the adopted biometric technology	3.5205	3.4312	3.5090	3.4312
Actions performed on the biometric technology are consistent	4.2000	4.2000	4.2000	4.2000
Biometric technology use is easy to remember	4.6000	4.6000	4.6000	4.6000
My computer skills enable me use the biometric technology	4.2000	4.2000	4.2000	4.2000
A manual is in place for reference when using biometric technology	4.2000	4.2000	4.2000	4.2000
I get feedback from the biometric technology every time I use it	4.2000	4.2000	4.2000	4.2000
The biometric technology use in my school is stable	4.2000	4.2000	4.2000	4.2000
I have control over the biometric technology used in my school	4.2000	4.2000	4.2000	4.2000

a. The weighting constant is 1.339.
b. The weighting constant is 4.685.
c. The weighting constants are 1.700, 3.400, and 8.500
d. The weighting constant is 1.340*pi.
e. Learning to use the biometric technology is easy is constant. It has been omitted.
f. The use of biometric technology in my school saves time is constant. It has been omitted.
g. My school has a competitive edge in terms of security due to biometric technology use is constant. It has been omitted.
h. I trust the biometric technology in use is constant. It has been omitted.
i. Communication regarding the biometric technology in use was well done is constant. It has been omitted.
j. The adopted biometric technology warns me when I make a mistake is constant. It has been omitted.
k. The biometric technology performs automatic check for errors on the entered data is constant. It has been omitted.
l. I have a positive attitude when using the biometric technology is constant. It has been omitted.
m. I like using the biometric technology to accomplish my tasks is constant. It has been omitted.
n. The biometric technology in use rejects poor quality data samples is constant. It has been omitted.

Table 4 reveals that Huber's M-Estimator (known for its robustness against outliers) yields scores that indicate moderate predictability of actions on the biometric technology (3.8085) but slightly lower familiarity with the technology (3.5205). These values from Huber’s M-Estimator suggest that while users generally find the technology's actions predictable, there are challenges in user adaptation and familiarity. This slightly lower familiarity score suggests potential areas for improvement in user adaptation and training programmes.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⪿ Peer-reviewed & Refereed journal ⪿ Vol. 13, Issue 9, September 2024

DOI: 10.17148/IJARCCE.2024.13909

Tukey's Biweight, assigns less weight to outliers, it provides similar scores for predictability (3.8037) but lower scores for familiarity (3.4312) compared to Huber's M-Estimator. This indicates that outliers have less influence on the estimation, highlighting potential challenges in user familiarity which requires attention. Hampel's M-Estimator, incorporates multiple thresholds to down weigh the outliers. This yields slightly higher scores for both predictability (3.8174) and familiarity (3.5090) compared to other estimators. This suggests a more optimistic assessment of user perceptions, potentially influenced by the down weighting of outliers. However, the study underscores that effectiveness of this approach is likely to vary depending on the specific threshold values chosen. Lastly, Andrews' Wave Estimator utilizes a wavelet transformation to address outliers. It provided similar scores for predictability (3.8040) but lower scores for familiarity (3.4312). This indicated that while predictability remained consistent, familiarity was more susceptible to outlier influence. While this approach addresses outlier influence, the lower familiarity scores suggest that user adaptation and training efforts need to be intensified if technology use and adoption is to be effective in Secondary Schools. While evaluating these findings, it's essential to consider the limitations and strengths of each estimator. While robust against outliers, M-Estimators offer a challenge as they do not fully capture the complexity of user perceptions.

This research highlights the importance of user training programs, the impact of demographic factors on user perceptions, and the effectiveness of different authentication methods. Incorporating these insights can enrich our understanding of usability requirements for biometric technology use in Secondary Schools better.

This analysis of M-Estimators offers valuable insights into usability requirements for biometric technology use in Secondary Schools. By addressing both predictability and familiarity, Secondary Schools can enhance the effectiveness of biometric technology implementation and ensure a seamless user experience.

D. Model Summary

Table 5 presents the model summary detailing the relationship between predictors—specifically, "I have control over the biometric technology used in my school" and "Actions on the biometric technology are predictable"—and their impact on the dependent variable. This summary evaluates the regression model's effectiveness in quantifying how perceived control and predictability influence attitudes or behaviors related to biometric technology use in Secondary Schools. Key metrics such as coefficients, standard errors, and significance levels provide insights into the strength and direction of these relationships, contributing to a nuanced understanding of factors shaping user perceptions and operational dynamics of biometric technology adoption.

Table 5: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.498[a]	.248	.200	.31280	.248	5.121	2	31	.012

a. Predictors: (Constant), I have control over the biometric technology used in my school, Actions on the biometric technology are predictable

In Table 5, the model summary uncovers the intricate relationship between certain predictors and an dependent variable, offering valuable insights into technology adoption and use dynamics within secondary school settings. With an R Square value of 0.248, the model suggests that approximately 24.8% of the variance in the dependent variable can be elucidated by the included predictors. The Adjusted R Square, standing at 0.200, adjusts for the number of predictors in the model, providing a more precise estimation of its goodness of fit.

Furthermore, the Std. Error of the Estimate, approximately 0.31280, delineates the average difference between observed and predicted values by the regression model, indicating its predictive accuracy. The change statistics provide additional depth to the analysis, indicating a significant increase in R Square when the predictors are added to the model. This is evidenced by the F Change statistic of 5.121 with a significance level of 0.012.

The predictors scrutinized in the analysis encompass perceptions of control over biometric technology within the school and the predictability of actions concerning this technology. These factors are integral in shaping individuals' behaviors and attitudes toward technology adoption and use in Secondary Schools. While these findings align with some existing research emphasizing the importance of control and predictability in technology adoption within school settings [52]. There are also divergent perspectives highlighting alternative factors such as perceived usefulness and ease of use.

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 9, September 2024
DOI: 10.17148/IJARCCE.2024.13909

E. Coefficients

Table 6 presents the coefficients derived from the regression model, detailing the relationships between predictors and the dependent variable. The coefficients include unstandardized coefficients (B), standardized coefficients (Beta), t-values, and significance levels (Sig.), providing insights into the strength and direction of these relationships. These coefficients offer a quantitative basis for understanding how perceived control and predictability of biometric technology impact organizational outcomes within Secondary Schools. Additionally, collinearity statistics such as tolerance and variance inflation factors (VIF) assess multi-collinearity among predictors, ensuring the robustness and reliability of the regression model's findings. This analysis aids in refining strategies for enhancing technology governance and user perceptions in biometric technology adoption and use across Secondary Schools. This is summarized in Table 6 below.

Table 6: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.722	4.194		.887	.382		
	Actions on the biometric technology are predictable	.404	.447	.322	.903	.373	.191	5.240
	I have control over the biometric technology used in my school	-.325	.614	-.188	-.529	.601	.191	5.240

a. Dependent Variable: Moderating Variable

From Table 6, the findings present unstandardized coefficients for two predictor variables, "Actions on the biometric technology are predictable" and "I have control over the biometric technology used in my school," in relation to a dependent variable labelled as the "Knowledge levels of the user". The positive coefficient (B = 0.404) associated with the predictor variable "Actions on the biometric technology are predictable" suggests that as users perceive the predictability of actions on biometric technology to increase, there is a corresponding positive influence on the dependent variable, labelled as the "Knowledge levels of the user." This implies that users who find the actions on the biometric technology more predictable are more likely to have a positive experience or engagement with the technology.

Conversely, the negative coefficient (B = -0.325) linked to the predictor variable "I have control over the biometric technology used in my school" indicates that as users perceive they have more control over the biometric technology, there is a decrease in the dependent variable. This suggests that users who feel they have more control over the technology may not necessarily perceive it as moderating their experience positively. Previous studies have found that perceived predictability positively influences user satisfaction and trust in biometric technology use [54], while at the same time the impact of user control on technology acceptance may vary depending on the context and design of the technology itself [55].

F. Collinearity Diagnostics

Table 7 presents collinearity diagnostics, crucial for assessing the multi-collinearity among predictors within the regression model. Multi-collinearity occurs when predictors are highly correlated with each other, potentially compromising the model's reliability in estimating the unique contribution of each predictor to the dependent variable. The diagnostics typically include tolerance and variance inflation factors (VIF). The findings are summarized in Table 7 below.

Table 7: Collinearity Diagnostics

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions		
				(Constant)	Actions on the biometric technology are predictable	I have control over the biometric technology used in my school
1	1	2.993	1.000	.00	.00	.00
	2	.007	20.958	.00	.08	.03
	3	.000	166.983	1.00	.92	.97

a. Dependent Variable: Moderating Variable

The findings in Table 7 reveal the dimensionality of usability requirements for biometric technology use in Secondary Schools, as indicated by Eigenvalues and Condition Index values across three dimensions.

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 9, September 2024

DOI: 10.17148/IJARCCE.2024.13909

Dimension 1, with an Eigenvalue of (2.993 and a Condition Index of 1.000), appears to be the most significant dimension. This explains a substantial portion of the variance within the data and exhibits low collinearity between predictor variables. However, the variance proportions associated with this dimension, including the constant term and the predictors "Actions on the biometric technology are predictable" and "I have control over the biometric technology used in my school," are all at (0.00). This indicates that these predictors contribute minimally to explaining the variance within this dimension. Therefore, a further analysis of the other dimensions is necessary to fully understand the structure of usability requirements for biometric technology use.

On the other hand, Dimension 2 has a small Eigenvalue of (0.007) and a relatively high Condition Index of (20.958), this suggests a less significant dimensionality compared to Dimension 1. However, it still contributes some variance to the overall understanding of usability requirements, particularly with regards to the predictors included. Going further, Dimension 3 is characterized by an Eigenvalue of (0.000) and a high Condition Index of (166.983). This is of negligible importance in explaining the variance in usability requirements. The extremely small Eigenvalue suggests that this dimension contributes very little to the overall impact on the usability requirements under study.

While Eigenvalues and Condition Index values provide insights into the dimensionality and collinearity of the data, the interpretation of Eigenvalues relies on arbitrary cut-off points, and small changes in data can lead to variations in dimensionality assessment. Additionally, the Condition Index may be influenced by multi-collinearity, which can affect the stability and reliability of the model. In other studies, [55] investigated the dimensionality of usability requirements for biometric technology in various contexts, providing valuable insights into the factors influencing user perceptions and experiences but their findings do not include the predictors in this study.

G. ANOVA with Tukey's Test for Nonadditivity

Table 8 presents ANOVA with Tukey's Test for Nonadditivity, a statistical analysis used to assess interactions between predictors and their combined effects on the dependent variable. This method evaluates whether there are significant differences in the dependent variable based on various combinations of predictor variables, beyond their individual effects. ANOVA tests the overall significance of these interactions, providing insights into the non-additive effects of predictors on the outcome. The findings are summarized in Table 8 below.

Table 8: ANOVA with Tukey's Test for Nonadditivity

			Sum of Squares	Df	Mean Square	F	Sig
Between People			8.500	33	.258		
Within People	Between Items		18.906	8	2.363	204.427	.000
	Residual	Nonadditivity	.237[a]	1	.237	10.360	.001
		Balance	6.013	263	.023		
		Total	6.249	264	.024		
	Total		25.156	272	.092		
Total			33.656	305	.110		
Grand Mean = 4.1444							

a. Tukey's estimate of power to which observations must be raised to achieve additivity = 3.783.

The ANOVA with Tukey's Test for Nonadditivity provided in Table 8 offers valuable insights into the dynamics of user responses towards biometric technology adoption and use in Secondary Schools. This is particularly useful for understanding how different components of the study contribute to overall variance and whether there are significant interactions affecting the data's additivity. The findings indicates that "Between People" variability with a sum of squares of (8.500) and a mean square of (0.258), suggesting a wide range of user responses which is attributed largely to individual differences in familiarity, expertise, and or attitudes towards the biometric technology itself. Within individual responses, the "Between Items" variance is particularly pronounced, with a sum of squares of (18.906) and a mean square of (2.363), yielding a highly significant (F-value of 204.427, $p < 0.000$). This highlights distinct perceptions across different usability aspects, which includes factors like ease of use, reliability, feedback and effectiveness. Moreover, the test for Nonadditivity in the residuals, which has a sum of squares of (0.237) and a mean square of (0.237, results in an F-value of 10.360 with a significance of 0.001). This result suggests significant interactions between individuals and specific items, indicating that user responses are influenced by complex factors possibly including the context of use or specific combinations of usability features. The total variance captured in the model with a grand mean of (4.1444) emphasizes generally positive perceptions towards the technology, yet the noted significant variance and interactions point to areas that might require closer attention, such as specific usability enhancements or tailored user training programs.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁒ Peer-reviewed & Refereed journal ⁒ Vol. 13, Issue 9, September 2024

DOI: 10.17148/IJARCCE.2024.13909

This insight underscores the complex dynamics of how users interact with biometric technology in use in educational environments. Research in the field of biometric technology often emphasizes the importance of user-centered design and usability for successful implementation. [56] Highlight the critical role of user perception in the adoption of biometric technology, noting that security does not automatically equate to higher user acceptance. Thus they stress the importance of nuanced usability evaluations to enhance technology adoption and satisfaction [57] [57][58].

H. Correlation on Usability Requirements

This section provides a correlation analysis that examines the relationships between usability requirements and other variables of interest, identifying patterns of association and dependency. In order to reduce the complexity on the correlation analysis, the study re-grouped the variables of the biometric usability requirements into six (6) main thematic areas. These areas included: The properties of the biometric having variables (actions on the biometric technology are predictable, actions performed on the biometric technology are consistent, I trust the biometric technology in use, and the adopted biometric technology warns me when I make a mistake, the biometric technology performs automatic check for errors on the entered data, the biometric technology in use rejects poor quality data samples and the biometric technology use in my school is stable), user action on the biometric having (I am familiar with the adopted biometric technology, learning to use the biometric technology is easy, biometric technology use is easy to remember, my computer skills enable me use the biometric technology, I have a positive attitude when using the biometric technology, I have control over the biometric technology used in my school and I like using the biometric technology to accomplish my tasks), communication and feedback having (communication regarding the biometric technology in use was well done and I get feedback from the biometric technology every time I use it), system benefits, (My school has a competitive edge in terms of security due to biometric technology use), help regarding biometric technology use, (A manual is in place for reference when using biometric technology) and time, (The use of biometric technology in my school saves time). Table 9 gives the summary of the findings.

Table 9: Correlations on Usability Requirements

		Properties of the Biometric	User Actions on the Biometric	communication and feedbacks	Technology's benefits	The use of biometric technology in my school saves time	A manual is in place for reference when using biometric technology
Properties of the Biometric technology	Pearson Correlation	1					
	Sig. (2-tailed)						
	N	34					
User Actions on the Biometric	Pearson Correlation	.718**	1				
	Sig. (2-tailed)	.000					
	N	34	34				
Communication and feedbacks	Pearson Correlation	.744**	.741**	1			
	Sig. (2-tailed)	.000	.000				
	N	34	34	34			
Technolgy's benefits	Pearson Correlation	.236	.296	.317	1		
	Sig. (2-tailed)	.179	.089	.068			
	N	34	34	34	34		
The use of biometric technology in my school saves time	Pearson Correlation	-.067	-.271	-.457**	-.123	1	
	Sig. (2-tailed)	.706	.122	.007	.488		
	N	34	34	34	34	34	
A manual is in place for reference when using biometric technology	Pearson Correlation	.830**	.876**	.801**	.370*	-.344*	1
	Sig. (2-tailed)	.000	.000	.000	.031	.046	
	N	34	34	34	34	34	34

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁒ Peer-reviewed & Refereed journal ⁒ Vol. 13, Issue 9, September 2024

DOI: 10.17148/IJARCCE.2024.13909

Table 9 provides analysis on various areas which include; the properties of the biometric technology, user actions on the biometric technology, communication and feedback, technology benefits, time-saving perceptions, and the availability of a reference manual. The finding reveals a strong positive correlation (r = 0.718, p = 0.000) between the properties of the biometric technology and user actions. This indicates that better properties, such as predictability, consistency, and reliability of the biometric technology, are closely associated with positive user interactions. When the biometric technology is user-friendly and dependable, users tend to interact with it more effectively and with greater satisfaction.

Similarly, a high positive correlation (r = 0.744, p = 0.000) exists between the properties of the biometric technology and the communication and feedback received. This suggests that effective communication and timely feedback about the biometric technology enhance user trust and experience. Users feel more confident and satisfied when they receive clear feedback and communication regarding the technology. The relationship between user actions and communication and feedback is also significant (r = 0.741, p = 0.000). This strong correlation implies that positive user actions are heavily influenced by the quality of communication and feedback. When users are well-informed and receive prompt feedback, their interactions with the biometric technology improve, leading to a more positive overall experience.

In contrast, the perceived benefits of the biometric technology show only moderate correlations with its properties (r = 0.236, p = 0.179), user actions (r = 0.296, p = 0.089), and communication and feedback (r = 0.317, p = 0.068), none of which are statistically significant at the 0.05 level. This suggests that while these factors are related to the perceived benefits of the biometric technology, other elements may also contribute to the perceived advantages. Interestingly, the perception of time-saving through the use of biometric technology has a negative correlation with communication and feedback (r = -0.457, p = 0.007). This indicates that while effective communication and feedback are essential, they may also lead users to perceive the technology as more time-consuming due to the thoroughness of the feedback processes. Other correlations with time-saving perceptions, such as those with the properties of the biometric (r = -0.067), user actions (r = -0.271), and technology benefits (r = -0.123), are not significant, showing no strong relationship between these variables.

The availability of a reference manual shows strong positive correlations with the properties of the biometric (r = 0.830, p = 0.000), user actions (r = 0.876, p = 0.000), and communication and feedback (r = 0.801, p = 0.000). This underscores the importance of having a reference manual to support users, significantly enhancing their interaction with the technology. Additionally, a positive correlation with technology benefits (r = 0.370, p = 0.031) indicates that a reference manual contributes to the perceived advantages of the technology. However, a negative correlation with time-saving perceptions (r = -0.344, p = 0.046) suggests that while the manual is beneficial, it may also be seen as time-consuming to consult.

I. Thematic Analysis on Usability Requirements

This section examines the thematic analysis focusing on usability requirements (UR) within the context of biometric technology adoption and use in Secondary Schools. In terms of usability, respondents emphasized the technology's user-friendly nature and efficiency in access control processes. RP10 highlighted, "***User-friendly, quick access,***" indicating the seamless experience provided by biometric authentication methods. This sentiment was echoed by RP9 and RP12, who emphasized the effectiveness of biometric technology in enhancing security measures employed in the school and streamlining access processes. Security and privacy concerns were prevalent among respondents. RP11 expressed, "***Enhances security, storage concerns,***" reflecting the ongoing challenge of balancing security enhancements with stringent data protection measures. This concern underscores the need for robust policies and practices to safeguard biometric data against potential misuse. Maintenance requirements emerged as critical for ensuring the continuous functionality of biometric technology. RP13 outlined, "***Regular updates, cleaning, IT troubleshooting,***" highlighting proactive measures essential for maintaining system reliability and addressing operational challenges promptly. The findings were summarized and tabulated in table 10.

Table 10: Summary of the usability requirements of biometric technology

Category	Main Observation and Responses
Authentication Procedure	• Authentication involves presenting biometric data (fingerprint, face, hand geometry) for system matching to grant access. • Users experience varying effectiveness and speed in accessing secured areas, depending on the technology used (RP1).
User Feedback and Satisfaction	• Users generally find biometric technology usable, effective, and user-friendly. • It enhances security and provides quicker access to authorized areas, contributing to overall satisfaction (RP2).

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 9, September 2024
DOI: 10.17148/IJARCCE.2024.13909

	• Satisfaction is notably related to improved security measures and ease of use (RP3).
Security and Privacy Concerns	• While users acknowledge enhanced security, concerns persist regarding data privacy, storage security, and potential misuse of biometric data (RP4). • Secure storage and stringent access control policies are essential to mitigate these concerns (RP5).
Responsiveness and Feedback	• Biometric systems provide immediate feedback and error prompts, with IT support addressing errors promptly (RP6). • User feedback mechanisms are in place to enhance system reliability and user experience (RP7).
Data Privacy Measures	• Schools implement data encryption, strict access policies, and secure storage practices to protect biometric data from unauthorized access and misuse (RP8). • Compliance with data protection regulations is emphasized to ensure secure handling of biometric information (RP9).
System Administration	• System administration includes regular updates, sensor cleaning, and IT support to maintain the reliability and functionality of biometric systems (RP10). • Proactive maintenance efforts are crucial to ensuring continuous system operation (RP11).

J. **Challenges associated with the adoption and use of BT**

Biometric technology introduces various challenges and considerations in its implementation. Issues such as failure to enrol, false acceptance and rejection rates, and concerns over spoofing and compromised biometrics highlight the importance of robust and secure measures. Function creep, where biometric data is used beyond its intended scope, raises ethical and privacy concerns. Furthermore, complexities in the enrolment process and privacy infringements underscore the need for clear policies and advanced security protocols to safeguard personal data and ensure reliable system performance. Difficulties encountered while using the adopted Biometric technology in the surveyed Secondary Schools is indicated in Table 11.

Table 11: Difficulty Encountered in Adoption of BT

Difficulties Encountered	**Frequency**	**Percent**
Failure to enrol	8	23.5
False acceptance and rejection rate	9	26.5
Spoofing	2	5.9
Compromised biometrics	2	5.9
Function creep	2	5.9
Consent	2	5.9
Time consuming	5	14.7
Others (Difficult process to follow, Infringes in privacy)	4	11.8
Total	**34**	**100.0**

The adoption of biometric technology (BT) in Secondary Schools is accompanied by various challenges, as highlighted by reported difficulties in its implementation. As indicated in Table 11 A significant issue, noted by (23.5%) of respondents, is the failure to enrol, indicating problems in successfully registering biometric data into the system. This initial hurdle can hinder the usability and effectiveness of the technology from the outset. Another critical concern is the false acceptance and rejection rate, reported by (26.5%) of respondents, which undermines security by inaccurately recognizing or denying access to authorized users. Security vulnerabilities such as spoofing (5.9%) and compromised biometrics (5.9%) further exacerbate risks associated with BT, potentially allowing unauthorized access or compromising user privacy. Function creep (5.9%) and challenges related to obtaining user consent (5.9%) highlight ethical and operational issues, including the expansion of biometric technology use beyond initial intentions and ensuring compliance with privacy regulations. Operational inefficiencies are also significant, with (14.7%) citing the time-consuming nature of biometric authentication processes as a barrier to efficient usage.

Additionally, (11.8%) mention miscellaneous challenges such as complex operational procedures and perceived privacy infringements. These issues collectively underscore the multifaceted nature of challenges in BT adoption and use within educational settings, necessitating comprehensive strategies to address technical, operational, ethical, and legal considerations. Mitigating these challenges requires comprehensive protocols for enrolment accuracy, enhanced system security against spoofing, clear consent mechanisms, and streamlined operational procedures to improve efficiency and user acceptance.

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 9, September 2024
DOI: 10.17148/IJARCCE.2024.13909

Table 12 documented the useful comments on the extended challenges

Table 12: Useful Comments on the Challenges

Useful Comment	Frequency	Percent
Some users have experienced compromised biometric data, leading to authentication issues.	5	14.7
Authentication is taking longer than expected, mainly due to false rejections during the process.	10	29.4
Some users find the enrollment process confusing and challenging, leading to enrollment failures.	6	17.6
Some users are uncomfortable with the biometric system's potential privacy implications, especially regarding data storage.	13	38.2
Total	34	100.0

The findings in Table 12 reveal several recurring challenges and user concerns associated with the adoption and use of biometric technology (BT) in the Secondary Schools. A notable finding is the widespread concern among users regarding the security and privacy implications of biometric systems, particularly related to data storage. With (38.2%) of respondents expressing discomfort about these issues, it's clear that addressing data protection measures and enhancing transparency in data handling are crucial for fostering user trust. Another prominent issue identified is the prevalence of authentication delays caused by false rejections, reported by (29.4%) of respondents. This point to usability concerns and the need for biometric technology to improve accuracy and reliability in authentication processes. Moreover, (17.6%) of users encountered difficulties during the enrollment process, indicating potential complexities in system setup and user interaction that may deter adoption or lead to user frustration.

These findings suggest several implications for Secondary Schools implementing biometric technology. First, there is a critical need to prioritize stringent data security measures, including encryption and strict access controls, to alleviate user concerns about privacy and data misuse. Clear communication about these measures is required in order to build confidence among users. Second, enhancing the reliability and efficiency of authentication procedures is essential to improve user experience. Addressing false rejection rates through better system calibration and user training is likely to mitigate delays and frustration during access attempts. Lastly, simplifying the enrollment process and providing comprehensive user training is likely to minimize initial challenges and errors, thereby increasing adoption rates and user satisfaction.

II. CONCLUSION

The study concludes that the successful implementation of secure biometric technology in Secondary Schools hinges predominantly on user-centered experience and adoption. The findings reveal a generally positive reception of biometric technology among users, who exhibit confidence in the technology's security and appreciate the training they have received.

High levels of familiarity and perceived effectiveness underscore the technology's acceptance, though some concerns about fraud prevention and legal compliance persist. In terms of usability, the study highlights strong correlations between system properties, user actions, and communication, indicating that predictable, consistent, and well-communicated systems enhance user engagement and trust. However, issues such as time-saving perceptions and the impact of feedback suggest areas where user experience could be further optimized.

III. ACKNOWLEDGMENT

We would like to express my profound gratitude to Almighty God for the good health and protection granted us throughout this study period. The successful completion of this research paper is credited to the support and encouragement from Kibabii University, the School of Graduate Studies (SGS), the School of Computing and Informatics (SCAI), and the Department of Computer Science.

We appreciate **Dr. Anselemo Peters** for the guide throughout this work. I also want to thank the National Commission for Science, Technology and Innovation (NACOSTI) for granting us a research permit and scholarship. We are deeply thankful to **Dr. Daniel Muyobo** and his family for their moral support and intellectual guidance. Finally, to our families, immense gratitude for their unwavering moral and material assistance throughout this academic journey. We say thank you all.

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 9, September 2024
DOI: 10.17148/IJARCCE.2024.13909

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International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.102 ⁘ Peer-reviewed & Refereed journal ⁘ Vol. 13, Issue 9, September 2024
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