Development of Graphical User Interface Student Electoral System

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Abstract - *The study was conducted to design and obtain evidence concerning the software quality and acceptance of a graphical user interface (GUI) student electoral voting system. The intention of this research is three-fold; firstly, a system based on ISO 9126 software quality characteristics, secondly, a system that conforms to the current hardware and software standard and lastly, improve student participation to decision-making. Designing a usable system in the context of the user's perception (needs) and let these perceptions dictate the design is therefore a great challenge. This study used descriptive-development research method. Data were collected thru guided interviews and survey questionnaires from the respondents. The researcher adopted the Princeton Development Methodology through the entire life cycle of the software development process. A very substantial majority of the respondents stated that for them, the new voting system is highly acceptable as compared to the old system both in terms of development (maintainability and portability) and implementation (efficiency, functionality, reliability and usability) requirements of the ISO 9126. The researcher came to conclude that usability is tied to the four software characteristics. Users' perception about software quality-implementation requirement is correlated specifically with usability. Based on data and the problems encountered, respondents' placed low importance on metrics if it is not well represented in the interface. When the interface fails, users are more likely to take longer to vote, failing efficiency targets and be less reliable, weakening functionality*

Keywords: *E-voting, ISO 9126, software quality characteristics, student electoral system, princeton development methodology*

INTRODUCTION

The supreme student government/ council duly recognized by the school administration fulfills a range of responsibilities as student body representative in the local colleges and universities in the Philippines. The council acts as a voice for the interests, opinions, and the concerns of the students. Yearly, educational institutions conduct student elections. Such event is considered very important since each position plays a prestigious role within the academic institution [1]. Eventually, the elected student council president will seat as a voting member of the Board of Trustees (BOT) or Board of Regents (BOR) [2]. Voter participation is significant to implicit legitimate election results. As a way to encourage voting participation and speedup vote results, student organizations turn to Technology [3].

However, technology alone is not enough to increase participation [4]. Technology must also consider what the user needs and wants. Understanding that students are becoming more and more visually inclined is crucial to attract and get their attention [5]. This trend toward the visual is harnessing more visual content strategies to increase engagement and participation from students. This "want" is what primarily marked the development of the GUI student electoral system. Furthermore, the quick turn-around of technology, restrictive products of proprietary software for customization [6]-[7] and software compatibility concerns during deployment [8]-[9] are the reasons why this study was conceptualized.

Also, it is always a voter preference to verify and assess the validity of the election process and at the same time project results. Partial poll results offers

high degree of transparency. Best practice now requires voting results be distributed in a fast and accessible means to observers and voters which is a vital activity to promote democracy and transparency [10].

This study employs the student electoral process adopted by the Central Student Council, the student body within Camarines Sur Polytechnic Colleges (CSPC). As empirical study, a student election analysis was initiated at CSPC.

OBJECTIVES OF THE STUDY

The main intention of the study is to develop a generic GUI student electoral system for secondary and tertiary academic institutions. Specifically, this study also aims to determine the significant difference in the level of acceptability between the software quality of the new GUI electoral system versus the existing system in terms of ISO 9126 characteristics.

METHODS

This study used descriptive- development research designs. Descriptive research using Chi Square test to quantify the respondents' level of acceptability between the software quality of the old and new systems while for development, through the entire life cycle of the software development process, the Princeton Development Methodology (PDM) [11] was adopted. Figure 1 displays the framework of PDM.

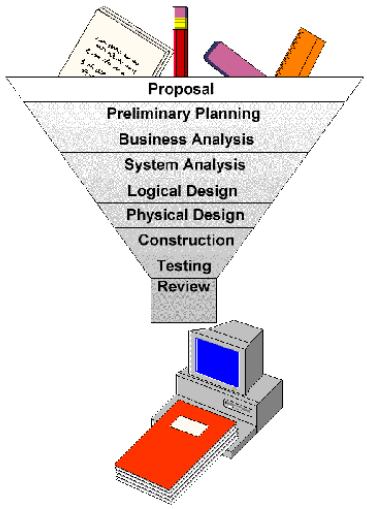

Figure 1 PDM Conceptual Framework

RESPONDENT

The research population of this study covers the 3, 925 students from the five (5) academic departments and the entire population of IT faculty members teaching major subjects only. The two groups of respondents were officially enrolled students and active faculty members for 1st semester of SY 2014-2015. The first group of respondents will assess the first four (4) of the ISO 9126 software quality metrics (efficiency, reliability, functionality and usability). The last group will evaluate the remaining two metrics (portability and maintainability). The college departments are as follows:

i. 1, 529 students or 39.0% from the College of Management and Entrepreneurship (CME)
ii. 1, 177 students or 30% from the College of Engineering (COE)
iii. 816 students or 20.8% from the College of Information Communication Technology (CICT)
iv. 245 student population or 6.2% from College of Health Care Technology (CHCT)
v. 158 students or 4% of the total student population from the College of Education, Arts and Sciences (CEAS).

Out of 3, 925 students at CSPC and with a marginal error of 0.05, the total sample size of respondents is 363. They will be considered the first group of respondents. On the other hand, since the CICT faculty teaching major subjects are just a handful, all fifteen (15) faculty members will be the second (2nd) group of respondents as IT expert evaluators to assess the portability and maintainability capability of the old and the new system.

INSTRUMENT

Keeping in view the objectives of the research, a guided interview was developed and executed to pursue in-depth information to further investigate the problems encountered by the respondents in the old system outlined with the ISO 9126 metrics [1]: efficiency, functionality, reliability, usability and maintainability. The guided interview also extracted ideas and opinions to what electoral design best suite to treat and ease the problems before the development of the new system.

Conjointly, a survey questionnaire was developed to extract respondents' level of acceptance and determine the significant difference of the old and new system in terms of ISO 9126 metrics [12]. Respondents fully tested the system through a user acceptance test and each respondent was made to fill

and answer the questionnaire immediately after each test.

PDM PHASES

Adopting the PDM software life cycle, in the Iniatiation phase, a guided interview was facilitated to extract ideas and opinions from the respondents about their election experiences with the existing student electoral system in terms of the software quality metrics (efficiency, functionality, reliability, usability, maintainability and portability). Answers were found to be common for most of the respondents reflected in Table 1.

Table 1. Ranking of the Common Problems Encountered in the existing system

Common Problems	Rank
Text-based interface	1
Screen not so attractive	2
Difficulty in identifying candidates	3
Laborious election process	4
Sequence of activities was noti intelligently organized	5
No control over the voting order	6
No poll result feature	7

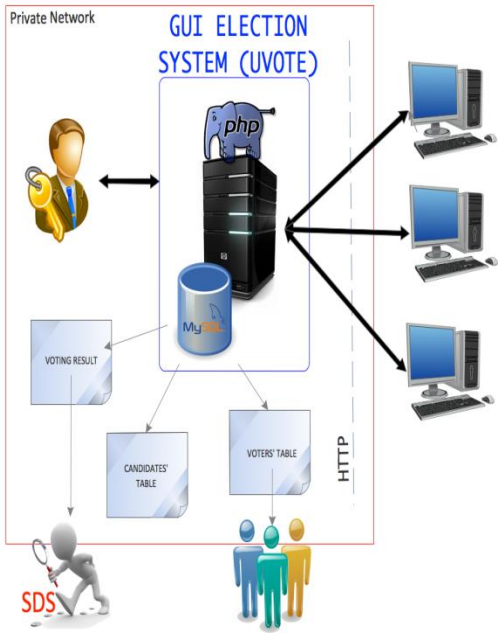

Figure 2 GUI Election System's Architecture and Participating Parties

In the analysis phase, it was found out that the existing system was tiresome, particularly on the part of the administrator. Several tedious format conversions and column arrangements are necessary to process the loading of the student database into the existing system. Figure 3 showcases the new activity diagram of GUI system for the administrator. In the Logical Design phase, a new system architecture was designed to validate relationships between different participanting parties. Each participating party is decribed in Figure 2.

- Voter – represented by the workstations. The e-voter will receive their login username and encrypted password (key pairs) from JPCS during the election day.
- The GUI Electoral System – represented by the the server. Receives and processes the votes. Generates the key pairs of the e-voters.
- Administrator – represented by the admin with key. Manages the system.
- Independent Student Organization – represented by the group of people. Distributes the key pairs to e-voters.
- SDS – Student Development Services. Represented by a man with magnified glass. Verifies the voting results. Solves disagreements and grievances using the recorded information from the system.

The activity flow, triggering events and inputs to the system was the focus in the Physical Design phase. Figures 3-4 reflects the voting activities of the admin and e-voters respectively.

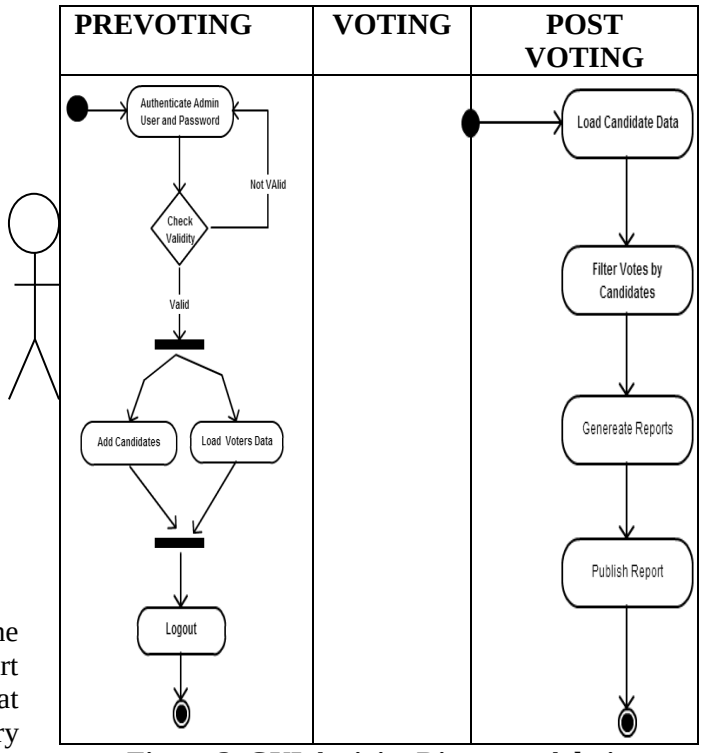

Figure 3. GUI Activity Diagram: Admin

In pre-voting, the administrator will:

- Enter candidates' information such as the position and the party,
- Load voters' data.

In post-voting, the administrator will:

- Generate reports such the keys pairs, list of candidates, positions and party, and winning candidates.
- Publishes the partial poll results.

In voting, the e- voter identifies himself in the system then casts his vote (voting stage). The e-voter will select the candidate from the interface ballot. Once the e-voter has casted his vote, it is not possible to remove his vote from the tally.

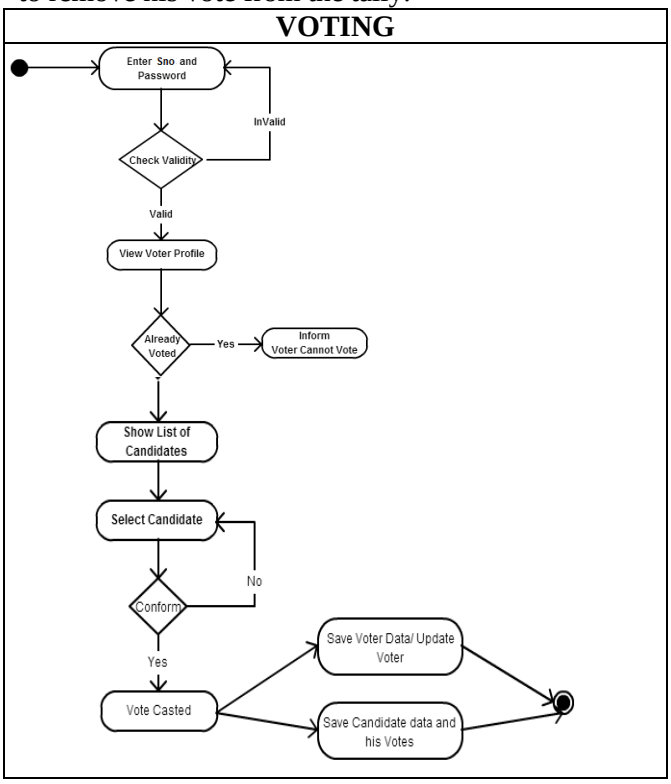

Figure 4. GUI Activity Diagram: e-Voter

The actual construction and testing of the initial version of the GUI was done in the Development phase. The GUI system was built using the software platform PHP version 5.5 for the frontend and MySQL 5.7 for the database backend. The figure below is the screenshot of the GUI system.

Figure 5 Cast-A-Vote screen

DATA ANALYSIS

To help structure the findings and acquire the opinions of the respondents out from the survey questionnaire provided during the user acceptance test, Weighted mean and ranking were used to interpret the result in numerical data and extensively determine the respondents' level of acceptance between the software quality of the old and new systems. On the other hand, to identify whether or not the difference between the old and new systems are statistically significant, Chi Square test was utilized.

The two voting systems average weighted mean per criterion was interpreted using the following Likert scale value: 4.20- 5.0 with a verbal interpretation (VI) of Strongly Agree (SA), 3.40- 4.19 with a verbal interpretation of Agree (A), 2.6- 3.39 with verbal interpretation of Fairly Agree (FA), Disagree (D) if scale ranges 1.8- 2.59 and Strongly Disagree (SD) if the scale is equal or below 1.79.

RESULTS AND DISCUSSION

Given the software quality metric Efficiency, which is concerned with the system's time and resource behavior, Table 2 reflects the assessment of the old and new systems as perceived by the student respondents.

Respondents rated the old system 2.39 with a verbal interpretation of Fairly Agree. Broadly speaking, efficiency speaks of the systems' productivity. The old system failed to efficiently use its resources wisely like in the manner of displaying the candidates in a "right-way" which was deemed ineffective by the respondents that affected the efficacy of the system and adversely slowed the election process.

Table 2. Students Efficiency Rating

CRITERIA	Old System			New System		
	WM	VI	R	WM	VI	R
1. The system provided on-screen help tool tips.	3.26	FA	1	4.66	SA	4
2. I was able to complete voting quickly and easily.	2.62	FA	2	4.85	SA	2
3. The system significantly speedup the election process.	2.38	D	3	4.85	SA	2
4. The system displays my selected line-up of candidates.	1.31	SD	4	4.99	SA	1
AVERAGE	**2.39**	**FA**		**4.84**	**SA**	

The total student average weighted mean for the new system under the same criterion clearly revealed that respondents were satisfied and felt the significant improvement in the election process. Respondents strongly agreed that the new system is very efficient with 4.84 average weighted mean. Unanimously, the sub-criterion- **The system displays my selected line-up of candidates**, helped them greatly to quicken their selection and finish voting easily thus ranked 1st in the table. When the system's resources are used intelligently to operate quickly with straightforward, multitasking approach to produce desired requirements and conditions; productivity is achieved.

Respondents rated the old system 3.58 with a verbal interpretation of Agree or indicate marginal (average) functionality. Functions such as correctness of information and authorization access control are the strong points of the old system. However, one highly structured function- the display of partial poll results is missed in the old system that is regarded a requirement and appropriate by the respondents for an election system such as in a student electoral system. In fact, during the survey interview, most of the respondents highly spoke and requested this feature. They consider the feature an essential function of the election system.

As seen in the third row of Table 3, most of the respondents were delighted of the additional feature. In fact, the sub-criterion ranked first in the survey. Clearly, respondents positively recognized the manner in which the new system handled functionality particularly on levels of accuracy and interoperability (sub-criterions 2 and 4) to improve intended performance. As proof, the functionality criterion got an average weighted mean of 4.96 or adjectival interpretation of strongly agree in all departments.

Table 3. Students Functionality Rating

CRITERIA	Old System			New System		
	WM	VI	R	WM	VI	R
1. List of candidate options was adequately presented in the system.	3.68	A	1	4.95	SA	3
2. The information (such as on-screen messages, candidates presented and other documentation) provided with this system was accurate.	4.59	SA	3	4.97	SA	2
3. The system provided a partial poll results and updates the result every hour.	1.43	SD	2	4.99	SA	1
4. The system did not allow unauthorized voter to access and vote.	4.61	SA	4	4.94	SA	4
AVERAGE	**3.58**	**A**		**4.96**	**SA**	

Table 4. Students Reliability Rating

CRITERIA	Old System			New System		
	WM	VI	R	WM	VI	R
1. The system prompts me if I made a bad input data.	3.88	A	2	5.0	SA	1
2. The system gave error messages that clearly told me what to do.	4.15	A	1	5.0	SA	1
3. Whenever I made a mistake in voting, I could recover easily and quickly.	3.31	FA	3	4.98	SA	4
4. The system has all the functions and capabilities I expect it to have.	2.33	D	4	4.99	SA	3
AVERAGE	**3.42**	**A**		**4.99**	**SA**	

A reliable system must be able to perform intended function under specified design limits such as catching errors for bad inputs or precise error messages to properly direct users in operating the system. The concept of a failure-free system is one of the quality characteristics that users require from a system. It is

not enough just to make a system accurately perform a specified task; it must also perform properly under design operating limits, offer informative feedback, and must recover easily and quickly. The reliability criterion of the old system was rated 3.42 or an adjectival rating of Agree, which is shown in Table 4. This reflects that the old system fairly exhibits the definition of a reliable system.

Solidly, with a highly favored average weighted mean of 4.99 or adjectival interpretation of Strongly Agree, the respondents conceded that the new system exhibits a high reliability performance. Sub-criterions 1 and 2, which both ranked first in Table 4 and got a 100% response percentage in the Talley sheet, satisfied and fulfilled the expectations of the respondents with respect to the system's ability to withstand section failure and catch faulty response while interacting with the system. The clearly stated instruction in the dialog boxes, which guided them on what next to do after every wrong move, also pleased the respondents.

Table 5. Students Usability Rating

CRITERIA	Old System			New System		
	WM	VI	R	WM	VI	R
1. It was easy to learn to use this system even for novice computer users.	2.42	D	2	5.0	SA	1
2. The system used multimedia components (such as graphics, icons, symbols) for easy recognition and navigation.	1.21	SA	4	5.0	SA	1
3. The organization of information on the system screen is clear.	2.50	FA	1	4.99	SA	4
4. The interface of the system is pleasant and visually-oriented.	1.43	SD	3	5.0	SA	1
AVERAGE	**1.89**	**SD**		**4.99**	**SA**	

Tailored system software is usually designed according to the needs and specifications of users, developed based on end-users' recommendations to elevate positive customer experience. The old system was rated 1.89 or an adjectival interpretation of Strongly Disagree for the Usability criterion. This result reflects that respondents prefer a clear and visually inclined interface at the same time well defined, logically structured, and easy-to-follow navigation, which is weakly reflected in the old system. Majority of the respondents found using the old system to be extremely frustrating because the interface was not user-centered; user's requirements are not met and reflected in the interaction design. Evaluation is typically low for usability criterion when more time and effort are required for the respondent to make navigation and action choices.

This metric particularly got the highest weighted mean with respect to its sub-criteria but adversely the lowest in the old system. In fact, during the interview, most of the respondents concern was the text-based interface of the system. Basically because respondents consider the text-based interface of the old system a problem in terms of ease-of-use and navigation. Since respondents are students who are visually inclined and are after visual consistency, the initiative of the researcher to embed multimedia components in the system to improved system's navigation impressed the respondents thus fashioned a positive respondent experience. The staggering average weighted mean of 4.99 or an adjectival interpretation of Strongly Agree is an obvious reference that the respondents liked the visual orientation of the interface.

Table 6 shows that in terms of maintainability, the old system got an average weighted mean of 2.48 with an interpretation of Disagree.

Table 6. IT Experts' Maintainability Rating

CRITERIA	Old System			New System		
	WM	VI	R	WM	VI	R
1. The system code is composed of individual callable functions that are isolated into low-level modules.	3.20	FA	2	4.60	SA	3
2. The code exhibits the use of basic, commonly used techniques and structures.	3.27	FA	1	4.87	SA	1
3. The system code is made simpler by using a high-order programming language.	1.13	SD	4	4.73	SA	2
4. It would be easy to identify the root cause of error or failure with this kind of code.	2.33	D	3	4.13	A	4
AVERAGE	**2.48**	**D**		**4.58**	**SA**	

This result supplies an insight on the qualities of the programming effort, such as code quality and approach for compatibility, exerted in developing the old system. Maintainability is a very important aspect during development particularly because the amount of effort necessary to make modifications is impacted by code readability, object orientation and modularization. IT expert-evaluators generally agreed, though the old system may have met its operational requirements but maintenance-wise, the old system is poorly designed and documented. In the perspective of many programmers the greater the amount of effort exerted to identify the root cause of failure within the software, the lesser viable and cost-effective the system becomes.

IT experts' assessed the system as highly maintainable as manifested by the average weighted mean of 4.58. They strongly agreed that the modification ability of a software is influenced by the code quality and coding style adapted to develop the system. Subsequently, the programming language used must not affect the evolvement of a system to meet user requirements. It is for this reason that the new system was developed using PHP over Visual FoxPro in the old system. IT experts, under sub-criterion 3, also favored the use of PHP as a high-order programming language since Visual FoxPro has cease software support which is a dominant factor in a systems' responsiveness to changing requirements and updates. Evaluators also appreciated the modularized code of the new system, which means the system is easy to maintain hence ranked third (3^{rd}) in the previous table.

The result in Table 7 is an overview of the assessment experience of the IT experts. They rated the old system as portability non-compliant. The old system was developed using VFP 6.0, which has compatibility issues with the current standard operating system also utilized at the IT Laboratories (1&2). Consequently, it required enormous effort to install the system. The database backend of the old system, MS Access, also no longer adheres to the advance SQL commands and standards. The evaluators find it hard for the old system to be adapted to different environments without applying too much effort or action other than those provided for this purpose of the system. The old system failed to consider the portability criterion. This explains the average weighted mean of 1.30 or adjectival rating of Strongly Disagree.

Table 7. IT Experts' Portability Rating

CRITERIA	Old System			New System		
	WM	**VI**	**R**	**WM**	**VI**	**R**
1. Installing the system can easily be carried out by any IT-Professional on site.	1.20	SD	3	4.13	A	4
2. The database used relates to Open SQL conformance.	2.00	D	4	5.00	SA	1
3. The system can be utilized in different operating environments.	1.00	SD	1	5.00	SA	1
4. The system conforms to the standard and current hardware requirements.	1.00	SD	1	5.00	SA	1
AVERAGE	**1.30**	**SD**		**4.78**	**SA**	

The changing hardware standard and requirement must be considered from design down to deployment. Evaluators understand that requirements and operating environment of software will continually change thus the need for an adaptable, installable and conformant system is a must. The average weighted mean or Strongly Agree adjectival rating, reflected in Table 7, is a testament that the new system displayed these characteristics convincingly. The system was coded using PHP and MySQL. Both are open source programming software that conforms to current software and hardware standard. The new system is also platform friendly so it can easily be installed from one specified environment to another.

Table 8. Chi Square result

Criterion-Type of System	*Observed (0)*	*Expected (E)*	*O- E*	*(O- E)^2*	*(O-E)^2/ E*
Efficiency-Old	2.39	3.66	-1.27	1.6129	0.44
Functionality-Old	3.58	3.66	-0.08	0.0064	0
Reliability-Old	3.42	3.66	-0.24	0.0576	0.02
Usability-Old	1.89	3.66	-1.77	3.1329	0.86
Maintainability-Old	2.48	3.66	-1.18	1.3924	0.38
Portability-Old	1.30	3.66	-2.36	5.5696	1.52
Efficiency-New	4.84	3.66	1.18	1.3924	0.38
Functionality-New	4.63	3.66	0.97	0.9409	0.26
Reliability-New	4.99	3.66	1.33	1.7689	0.48
Usability-New	5.00	3.66	1.34	1.7956	0.49
Maintainability-New	4.58	3.66	0.92	0.8464	0.23
Portability-New	4.78	3.66	1.12	1.2544	0.34

This table shows the distribution of the observed and expected values, that is, the cell values the researcher would expect to find if there was no

relationship between the old and new system. The computed Chi Square statistic is 5.406 with *df* = 1, the exact *p- value* is equals to 0.0201. Therefore, by conventional criteria this difference is considered to be statistically significant. The researcher rejected the null hypothesis (with a 5% probability of error) and accepts the research hypothesis that there is a significant difference between the software quality of the old and the new student electoral system. In terms of the ISO 9126 metrics (efficiency, reliability, functionality, usability, maintainability and portability), the new system is way better and dominantly satisfactory over its old counterpart.

CONCLUSION AND RECOMMENDATION

Users' perception about software quality-implementation requirement is correlated specifically with usability. Based on data and the problems encountered, respondents' placed low importance on metrics if it is not well represented in the interface. When the interface fails, users are more likely to take longer to vote, failing efficiency targets and be less reliable, weakening functionality.

By a very substantial majority based on the data collected, the new voting system is highly acceptable as compared to the old system both in terms of development (maintainability and portability) and implementation (efficiency, functionality, reliability and usability) requirements of the ISO 9126 software quality metrics. From a very low 20% vote turnout rate using the old system, the new graphical user interface electoral system was able to boost vote rate to more than 60% of the eligible voters. This very intriguing boost of voters can probably be correlated with the new system's graphical user interface. This research is consistent across others to date in that students prefer graphical user interface which was very effective that it made a great impact on the voting experience of the students.

Old software gets increasingly complex over time. Technical software compatibility and complexity will require more programmer effort particularly the "act of maintaining" the software particularly if conformance to hardware and software is impossible. So it is no longer practical to continue maintaining and enhancing the old election system.

Most of the problems identified with the old systems are visual content-related. Though the current research may not have focused on a thorough investigation of the usability relevance with the other software quality metrics-development requirements. But the researcher recommends that programmers must focus more on the usability metric to be able to develop an agreeable software product application to truly satisfy its users.

The researcher also categorized the metrics based on requirements. Therefore, related research activities that can widely examine the organization of software quality metric into category, based on respondent requirement, is a nice challenge to our future researchers.

Researcher also encourages further quality evaluation of the system's security and infrastructure. These areas are vital in analyses of possible security hazards and infrastructure compliance of the system to software and hardware standard. Researching them can provide not only technical, but also practical election benefits. The research is just a single study which can be fully definitive and generalized if further empirical work is done to support the study.

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