Electronic Voting system for efficient Students' Elections in Kabarak University, Kenya.

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Abstract:

Student elections in universities have over the years been conducted manually, hence causing them to become very expensive, logistically complex, tedious and involving exercises; and often with low accuracy levels. This study examines the challenges of conducting student elections manually and presents an electronic alternative that demonstrates great advantages of reduced time and efficiency. The electronic voting system developed and tested at Kabarak University is a result of a consultative engagement with the student fraternity and utilizes a very basic but efficient approach to guarantee the sanctity of the process and accuracy in the tallying of the results. The system and development process served to demonstrate the applicability of electronic voting not only in the higher education context, but also in other contexts that require an infusion of efficiency in the voting processes.

Keywords: electronic voting, electoral efficiency, student elections

1. Introduction

Kabarak University is a private chartered institution of higher learning located in Nakuru county of Kenya. The institution, founded in 2002 currently has over 4,000 students enrolled in various programs at the university. As part of its efforts to involve students in the running of the institution, the university facilitates a yearly election of student leadership to the university student union. Populating 12 elective positions across two campuses begins with the application and vetting of candidates, the preparation of ballots and other election materials, the casting and counting of ballots and the declaration of results. In the past, this process has been undertaken manually in its entirety and has progressively become very expensive as well as logistically complex with the growth in students' population, at about 6,000 in the year 2018. Apart from the other electoral processes, vote counting particularly has been observed as the most difficult, complex and time-consuming aspect, taking at least 8

hours and, in some cases, being completed in the succeeding morning after elections day, as was the case in 2017. This has been found to take its toll on the election officials as well as aspirants who have to be on their feet for at least 24 hours. Other challenges observed in the manual approach include the casting of a great number of ballots in the wrong ballot boxes as well as the great number of printed ballots that remain after the election, this being occasioned by lower voter turnout. These challenges notwithstanding, the proposal to adopt an electronic voting system for student elections had not been accepted and implemented mainly due to the lack of trust in such a system in the university. This study outlines the process that was followed in achieving a successful election in November 2016 using an electronic voting system developed and piloted in the year 2017.

Statement of the Problem

High level efficiency is expected in every electoral process. However, as a result of manually conducted students' elections, Kabarak university has recently experienced myriads of challenges as elections remained: very expensive; logistically complex, time-consuming, inaccurate and wasteful. So much money has been used annually in conducting the elections- which are tedious to manage, takes long in vote counting and tallying, leads to casting of a great number of ballots in the wrong ballot boxes, and material wastage as great number of printed ballots remain unused after the elections. If this trend remained, the university election officials as well as aspirants would continue to face effects of inefficiency associated with manual election systems. This necessitated development of an efficient electronic voting systems for Kabarak University.

2. Objective of the Study

The main objective of this study was to develop an electronic voting system to improve students' electoral efficiency in Kabarak University.

3. Literature Review

3.1 Electronic voting

Electronic voting refers to the use of Information and Communications Technology in the process of casting and counting of ballots in elections and referenda. The main objectives of the use of technology in the process are to introduce efficiency as well as to increase trust and

transparency in the electoral process. (International Institute for Democracy and Electoral Assistance, 2011).

Electronic voting systems have two main categories of functions; (i) internal functions that are concerned with the handing of election data as encryption, randomization, communications, data integrity, audit trails and information security, and (ii) end user functionality that is used by both election managers and voters such as electronic voter registers, user authentication and validation, election managers interfaces and voter interfaces for use in creation of elective positions, candidates, voting and tallying of results (Ikonomopoulos, Lambrinoudakis, Gritzalis, Kokolakis, & Vassiliou, 2002).

3.2 Electronic voting (e-voting) approaches

There are a number of approaches that have been developed for electronic voting over the years. These include punch card systems, optical scan voting systems, direct recording electronic voting machines and internet voting. Internet voting in particular allows voters to cast their votes from any location as long as they can connect to the server hosting the elections system.

3.3 Opportunities of e-voting

e-voting presents a number of opportunities that are often times unavailable in the manual voting process. This mode of voting can allow persons with various disabilities to vote by themselves and in secrecy, it allows for remote voting thus increasing the potential of voter turnout, it has the potential to reduce the operational costs and logistical complications of running an election, and it allows for faster vote counting and delivery of final election results (ACE Project, 2018a)

3.4 *State of the art in electronic voting systems in universities*

Electronic voting in universities is a practice that is rapidly gaining acceptance. There are a number of documented systems in use for a variety of voting scenarios such as student elections and for various on campus evaluations and selections. Today, an increasing number of universities are turning to electronic voting systems, whereas others are including a digital component in their voting process to reap the associated advantages of efficiency. In India,

Makungu, Munyao and Mwai (2015) developed student electronic voting systems for Easwari Engineering College. The system worked well on the aspects of allowing for the registration of voters, creation of elections, and listing contesting students' candidates. However, conducting elections lacked efficiency as the system was marred with problems of transparency of the electoral process. Herrnson et al. (2006) developed an electronic voting system with natural experiments conducted in the US - Florida and Michigan learning institutions. However, voters exuded less confidence and further raised concerns, casting doubts about accuracy of votes recorded in the systems. This highlighted the challenge of lack of transparency of the electoral system. García-Fernández, García and García-Sánchez (2018) used data collected from an online survey of 590 learners across eleven academic schools and faculties at a UK university to develop an electronic voting system, which functioned with success. However, due to variations of the electoral processes from universities, it is not certain that the same system could be applied in Kabarak University. Moreover, transparency of voting and entire electoral process was not considered in the systems' development.

Arabiat, Al-Basheer, Sabri and Hiary (2017) developed an electronic voting system for The University of Jordan. The system could help in the creation of contested positions, addition of candidates, casting of votes and the tallying of results. However, an independent audit conducted on the system found that it was very hard to determine the integrity levels of voter data recorded in the system, hence causing unreliable resultant electoral process. Besides, the observations manifested that the system could not provide the intended transparency of the electoral process.

Adekitan, Matthews, John and Uzairue (2018) concluded a project on implementation of e-voting System for covenant university Student Union Government Elections in Nigeria. The electronic voting system prevented fraud and election rigging only by avoiding the traditional smuggling of ballot paper into boxes. The systems' competence in infusing sanity in the entire electoral process was hard to test since the system was mainly focused on transparency when casting votes and not other equally important electoral processes. Taban, Konde, and Sebwato (2017) presented a proposed system framework to be adopted in Muni University - Uganda. While the proposed system showed that it could alleviate most operational cost and inefficiencies associated with manual voting systems, the e-voting systems was not put to practice and has not phased out the manual voting system in the university. In Kenya similar systems have also been developed for use in student elections. Examples include one for the

Taita Taveta University college (Nzoka, Muthama, & Mung'ithya, 2013), Baraton University (Kenya Television Network, 2015), The Catholic University of Eastern Africa (CUEA, 2016) and the Jomo Kenyatta University of Agriculture and Technology (JKUAT, 2018). These systems in general all allow for the creation of elections, the registration of voters, the creation of elective posts and addition of candidates, the casting of votes and the tallying of results. However, analysis of practical effects of cost reduction, electoral efficiency and tremendous savings on time as a result of application of the above systems is not documented, hence remain unknown and could not be relied upon, even with customization to help in Kabarak university elections.

3.5 Challenges of electronic voting

There are however many user and technological challenges facing the widespread adoption of electronic voting. Voters are greatly concerned with assurances that they will be able to use the technology to vote, that only one vote will be cast per voter, that the vote will be secret, that the vote will not be changed, that the vote will not be lost and that not fake or additional votes will be introduced into the system. Technological challenges include software flaws that can interfere with the voting process by way of system crashes or inaccuracies, the general vulnerability of computer networks and the internet in particular that predisposes the system to attacks and infiltration, difficulty in auditing votes without compromising the secrecy of the vote and insider attacks intended to sabotage or manipulate votes by way of changing selections or casting additional votes (Norwegian Ministry of Local Government and Regional Development, 2006)

4. Methodology

The rapid prototyping approach (NASA, 2004) depicted in Figure 2 was followed in the development of the electronic voting system.

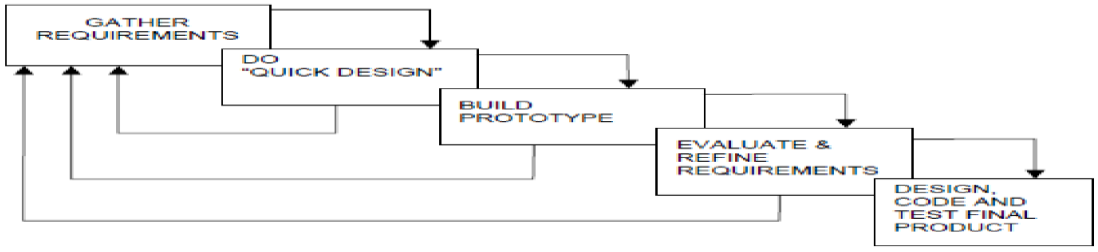


Figure 2: Rapid prototyping by NASA (2004)

- **Requirements gathering:** The initial requirements were sourced from the chairman of the electoral commission. In subsequent iterations the students were involved in testing and generating new requirements
- **Quick design:** The system development team proceeded to develop an initial design of the system.
- **Prototype building:** The system development team developed an initial prototype for testing by the student community.
- **Evaluate and refine requirements:** The prototype was tested over several sessions with students where concerns on a variety of issues mainly on security were raised and addressed in subsequent development iterations.
- **Design, code and test final product:** Once the system had been tested sufficiently and substantial user feedback obtained the system development team proceeded to finalize the system in readiness for a mock election.

4.1 System Testing Process for Electronic Voting.

4.1.1 Alpha testing: The system was first subjected to intensive and extensive testing by the system development team and the chair of the electoral commission to ensure that there were no system errors in readiness for the end user / alpha testing stage. This testing was repeated in every iteration after user feedback was received.

4.1.2 *Beta testing:*

- The system was tested by a group of students in several sessions that climaxed in a mock election that was held on the day of the actual student elections on the 21st of November 2017.
- This testing was extended to actual training sessions held in November 2018 where users were given online access to the system to test its functionality and usability.
- The feedback received from users was that the system was very easy to use with minimal training.

5. Results

5.1 The Kabarak University Electronic Voting System.

5.1.1 System users

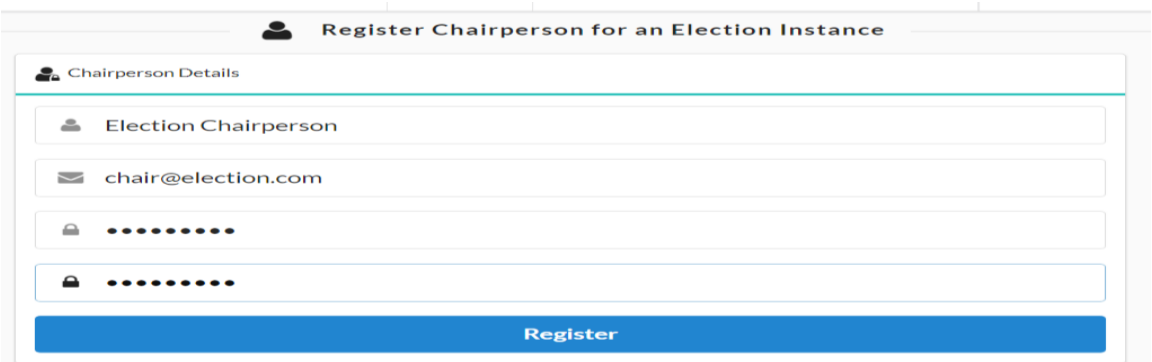
The system has four types of system users as described below;

1. **System administrator:** The system administrator creates the system account for the chair of the electoral commission.
2. **Chairman:** The chairman performs the following functions; creating elections, creating elective positions, adding candidates and their photos to the elective positions, registers voters, creating clerks, generating the login token for voters, accessing and displaying the elections results
3. **Clerks:** The clerks verify the identity of the voters, activate their accounts and issue a login token to them
4. **Voters:** the voters make their selections from the available candidates from the elective positions available for a given election.

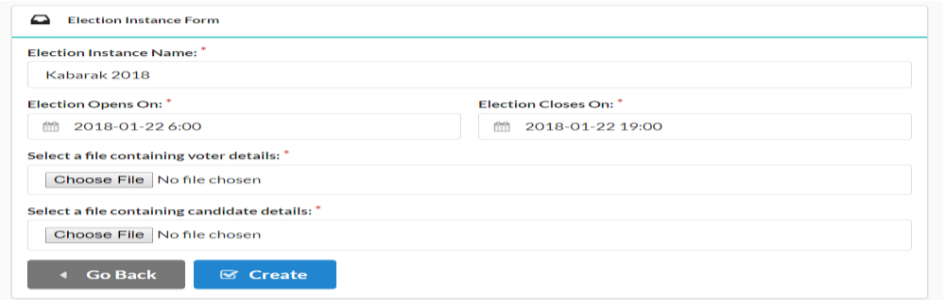
5.1.2 System safeguards for vote integrity

1. **Offline approach** – The system is hosted on a server not connected to the internet in order to reduce the chances of interference with the vote and voting process.
2. **Voter registration** – The voters for the election are validly registered students for the semester downloaded from the university ERP in line with the student organization constitution.
3. **Token generation** – A random sequence of six alpha numeric and special characters that is issued at random to the voter. One a token has been used by a voter it is not usable by another voter.

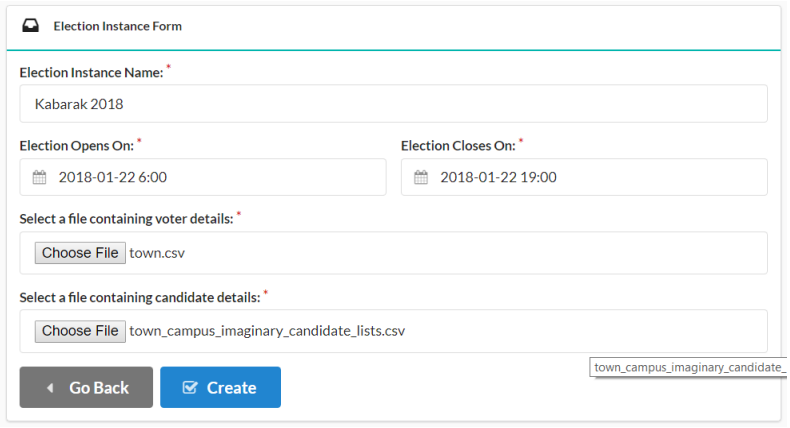
5.1.3 The elections system



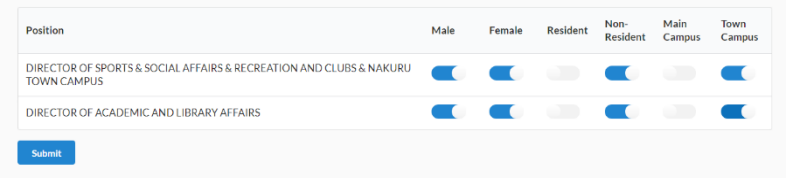
System Admin Creates the chair of the electoral commission



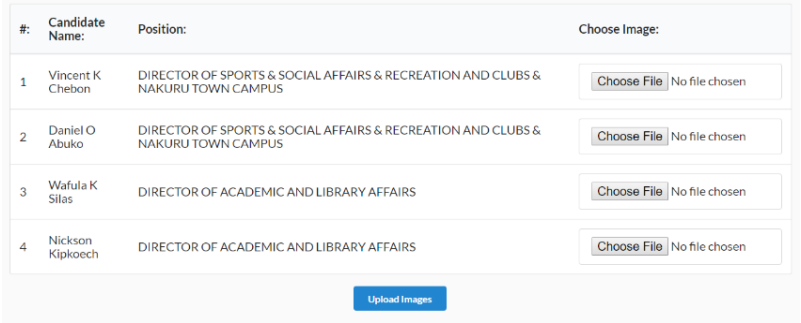
Chair of the electoral commission creates an election and specifies the start and end times for the election.



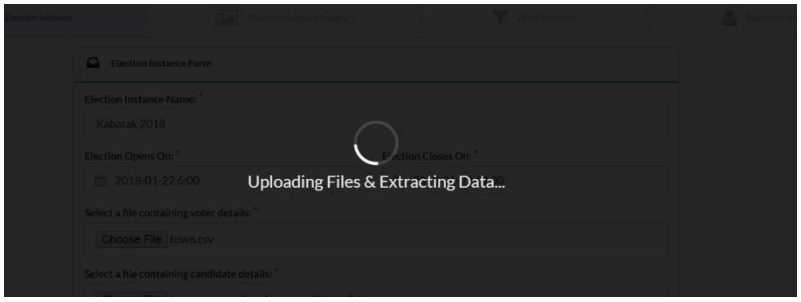
Chair of the electoral commission creates the elective positions



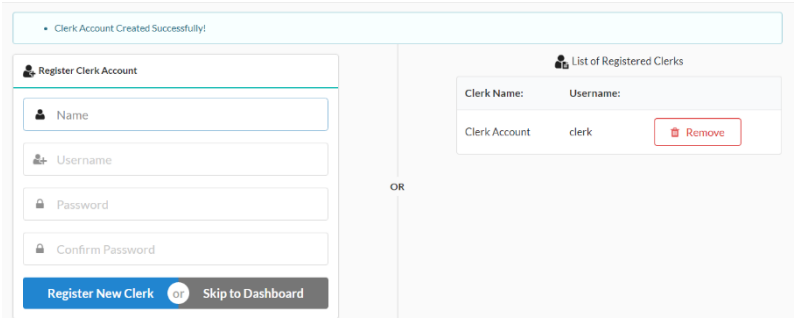
Chair of the electoral commission sets the criteria for voting for the various positions



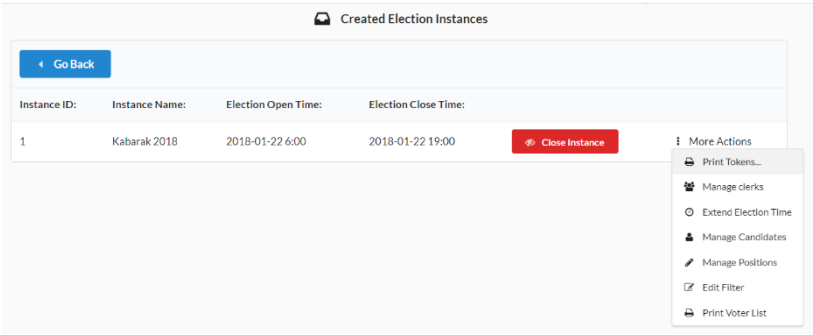
Chair of the electoral commission creates candidates and uploads photos



Chair of the electoral commission uploads the voters



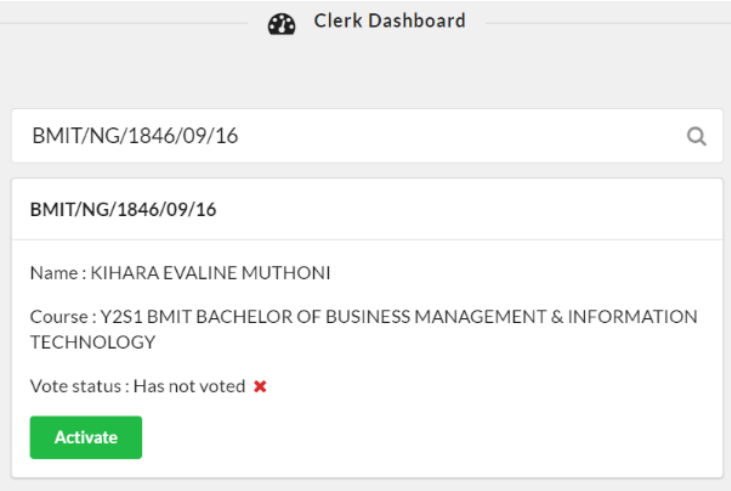
Chair of the electoral commission creates the clerks



Chair of the electoral commission generates the login tokens

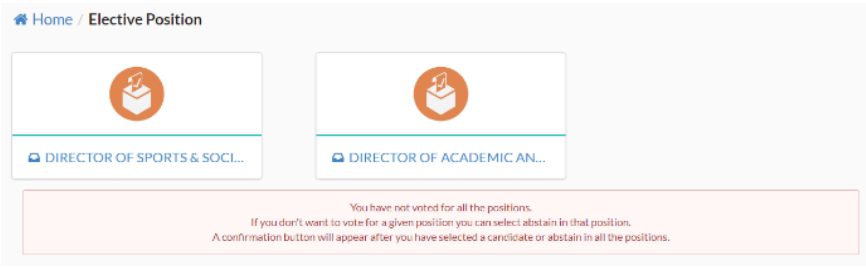
BUpD59#@	Sixr3*	KvR56@	XMmv1!
DTbtW78*!	LChk5-	Arff2-	DqrP4*-
PzsE1*	FApH9_@	NInv4!*	SEvxW5*!

Sample login tokens

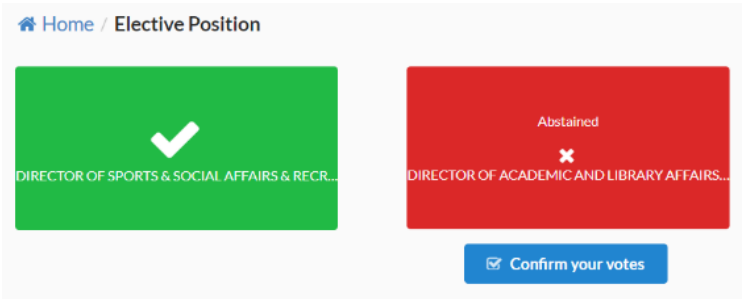


Clerk activates the voter account

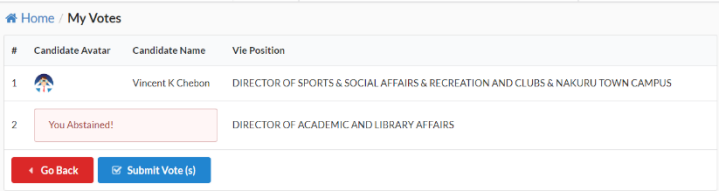
Clerk issues a login token



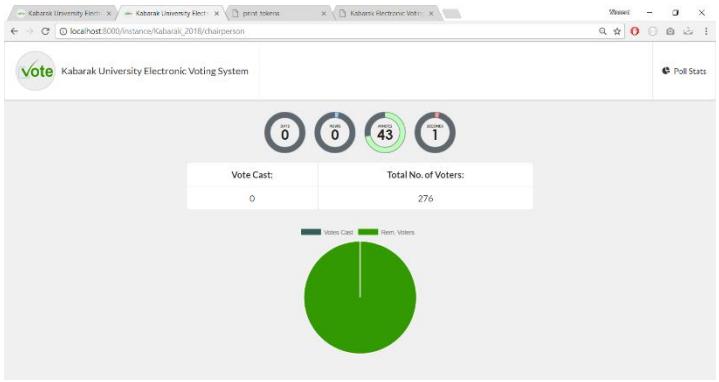
Voter views available elective positions



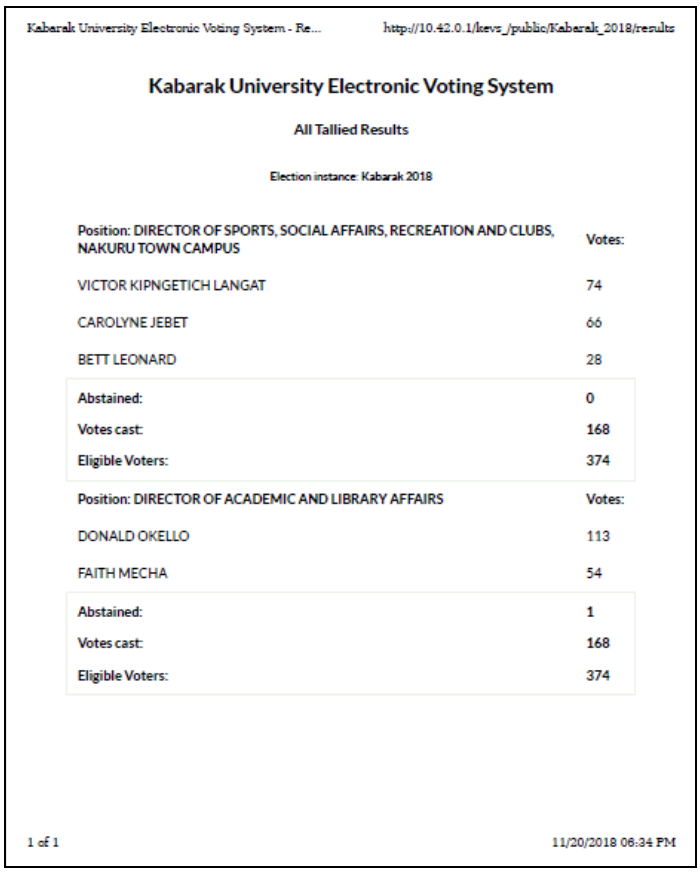
Voter makes selection for an elective position



Voter confirms votes and submits



Election statistics displayed as voting continues



Election results displayed by the system

5.1.4 Mock Election:

The system was subjected to testing in a mock election held on the same day as an actual student election on 21st November 2017.

5.1.4.1 The setup: The setup for the election utilized one laptop serving as the server, 5 desktop computers for the voting, a 24-port switch, 2 laptops for the clerks and a projector for displaying the voting progress.

5.1.4.2 The process: The process was a simple five step procedure; (i) the voter provided identification for account activation, (ii) The voter was issued a login token, (iii) the voter logged in and cast their votes, (iv) the voter's left index finger was marked as they left the voting station and (v) at the end of the exercise the chairman of the electoral commission logged into the system and displayed the results.

Figure 3: The mock election

5.1.4.3 *The outcomes:* A total of 781 out of a possible 3,713 eligible voters took part in the mock election, the average time taken per voter from the point of activation was 7 minutes and 12s.

5.1.5 The Actual Election:

The system was utilized in the student elections on 21st November 2018.

5.1.5.1 The setup:

1. The setup for the election was done in two locations; The university main campus and the Town Campus.
2. The main campus setup utilized a desktop computer as the server, 5 desktop computers for the clerk stations, 20 desktop computers for the voters, a 24-port switch, a 10-port switch and a projector for displaying the voting progress.
3. The town campus setup utilized a desktop computer as the server, 1 desktop computers for the clerk stations, 3 desktop computers for the voters, a 24-port switch and a projector for displaying the voting progress.

5.1.5.2 The process: The process was a simple five step procedure;

1. The voter provided identification for account activation.
2. The voter was issued a login token
3. The voter logged in and cast their votes
4. The voter's left index finger was marked as they left the voting station and
5. At the end of the exercise the chairman of the electoral commission logged into the system and displayed the results.

5.1.5.3 *The outcomes:* A total of 2,054 out of a possible 5,995 eligible voters took part in the election, the average time taken per voter from the point of activation was 3 minutes.

6. Discussion

The manual voting process at Kabarak University is getting increasingly complex and difficult with the growth in student population. The process is further complicated by the desire by the voters to have the ballots counted one by one for each position. This process, in the November 2017 election, took 12 hours for a student population of 4,000 and was likely to take even longer with more students expected to participate in the elections in 2018.

6.1 Unique system features

The Kabarak University electronic voting system differs from other systems used in universities in a number of key respects;

1. It ensures that the voter can only vote once by means of a unique, randomly generated and assigned login token that is only usable once by the voter. This ensures that no other pre-generated passwords can be used to facilitate double voting.
2. It ensures that the voter must make a choice in all elective positions for which they are eligible to vote even if the choice is to abstain. This makes it easy to account for all voters and votes cast.
3. It keeps the voters and stakeholders informed of the voting progress by means of a display of the number of voters who have cast their votes in real time.

The system is however developed in order to allow for any kind of vote given its generic approach where the system only requires the creation of an election, voter registration, creation of elective positions, casting of votes and the tallying of votes. It is similar in this respect to the other university electronic voting systems as well as some commercial solutions such as the POLYAS electronic voting system (POLYAS, 2015).

6.2 System development highlights

The system was proposed and development undertaken under the guidance of the chair of the electoral commission, a key expert and stakeholder in the process. The system development itself was undertaken by computer science students at the university and tested by the wider student community.

The development and testing of the electronic voting system was successful for a number of reasons;

1. User involvement in the development and testing process which ensured that the correct specifications were identified and built into the system.
2. Simple technological approach to the system development with the first version being deployed offline for simplicity and user confidence building.
3. The use of complex and randomly generated one-time login tokens that ensured that no double voting was possible.

6.3 Advantages of the electronic voting system to Kabarak University

The use of the electronic voting system was of great benefit to the university in the ways outlined in the table below.

	Manual	**Electronic**	**Remarks**
Process / no of steps	1. Voter identification 2. Issuing of ballots at 10 different stations 3. Marking of ballots 4. Casting of 10 ballots 5. Marking of finger 6. Vote tallying at the end of the voting period	1. Voter activation upon production of student ID 2. Voter verification and issuance of login token 3. Voting 4. Marking of finger 5. Vote tallying at the end of the voting period	The number of steps is less by one in the electronic voting process
Average voting time	Approximately 15 mins	< 3 mins	The time taken was reduced by 80% in the electronic voting system
Vote tallying	12 hours	Seconds	The vote tallying is instant in the electronic system and the results were declared in 15 minutes
Spoilt / misplaced votes	Approximately 20% of votes cast	None	There were no spoilt votes in the electronic system
Wasted ballots	20% of those printed	None	There were no wasted ballots in

			the electronic system.
Election Costs	The election in 2017 cost KES 523,900	The election in 2018 cost KES 506,500	There was a slight reduction (3.3%) due to less stationery requirements.

The electronic voting system was able to save the university and students both time and money expended in the running of the student elections.

7. Conclusions and recommendations

7.1 Key findings

The key finding in the study was that the electronic voting system is feasible and practical for use in student elections

7.2 Recommendations for further research

The following are the key recommendations for further research emanating from the study.

1. There is need to explore suitable approaches to create confidence among the voters for the use of an internet connected electronic voting system. This approach can make use of a two or three factor authentication process that sends a password to the user email, followed by a four-digit PIN to the voter's phone for login and then another four-digit PIN to the voter's phone for vote submission.
2. There is need to develop an approach, possibly with the infusion of a distributed ledger mechanism, to allow for the audit of the vote in a manner that does not compromise the secrecy of the vote.

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