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E-VOTING SYSTEMS: A TOOL FOR E-DEMOCRACY

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Abstract

Using electronic voting systems is divisive as some countries used such systems and others did not. Electronic voting (e-voting) is relatively a new concept based on its application that aims at reducing errors and improving the convenience and integrity of election process. This paper tried to explore the factors that influence the adoption of such systems in a university environment. The study utilized a sample of 302 bachelor degree students in a public Jordanian university and in relation to students' council election process. Results indicated that students were keen on the concepts of trust and usefulness of e-voting when adopting such systems. The study supported the findings of TAM in the area of technology acceptance. Conclusions are at the end of this paper.

Keywords: E-government, e-democracy, e-voting, students' elections.

1. INTRODUCTION

Yarmouk University (YU) is the second oldest university in Jordan and account for more than 30,000 students in 11 colleges and 53 departments. The university conducts a yearly election of students' council, where such event is considered the most important and might lead to critical disputes based on political and social issues. This study tried to explore how students will perceive electronic systems used in an election process and what factors will influence such process. The study utilized the technology acceptance model (TAM) with some extensions to it. Based on the literature e-voting refers to the use of computer or computerized voting equipment to cast ballot in an election, this term sometimes is used more specifically to refer to voting that takes place over the Internet (Storer and Duncan, 2004).

This study consist of five sections, the first two introduced the concept and reviewed the literature related to e-voting. The third section proposed a model based on the adoption concept of technology. The forth section reviewed the research method, and laid down the results. Finally, the sixth section discussed the findings and concluded with implications and future work.

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2. LITERATURE REVIEW

"E-government is the use of information and communication technologies and the Internet to enhance the accessibility to and delivery of all facets of government services and operations for the benefit of citizens, businesses, employees and other stakeholders, is continuously transforming public services delivery system" (Toe, Srivastava and LiJiang, 2008). On the other hand, e-democracy is defined as "the use of the Internet as a medium for democratically selecting political leaders, public policies, or both" (Johnson, 2006). E-democracy has two main objectives; the first one is to provide citizens with the accessibility to information and knowledge about the political process, services and choices available; and the second one is to make possible the transition from passive information access to active citizen participation. The main characteristics of e-democracy are dissemination of political information, e-voting and participation in e-decision making (Bozinis and Lakovou, 2005). When identifying e-democracy within e-government categories, it fits most under government-to-citizens (G2C) (Kitlan and Joseph, 2008; Bhatnagar, 2004).

2.1. E-voting

E-voting systems include three actors: voter, registration authorities and tallying authorities. Voters have the right for voting, and registration authorities register eligible voters before the "election day". These authorities ensure that only registered voters can vote and they vote only once on the election's day and tallying authorities collect the cast votes and tally the results of the election. Tallying authorities may be counter, collector and /or tallies (Cetinkaya and Cetinkaya, 2007).

The literature presents four categories of e-voting, depending on the level of security, privacy, and trust that they maintain; these categories are e-commerce, trust authority, individually verifiable and universally verifiable. In the first type there is no security except possibly on the communication channels. Ballot box stuffing is tolerated, the voter's privacy is not maintained and vote tampering is not prevented. It is suitable for Internet polling site. In trusted authority systems the election officials are trusted to maintain the integrity of the election, voter privacy is some how maintained and vote tampering is prevented in these system. This type of voting systems is suitable for small-scale voting, for which the election official can be trusted.

In individually verifiable systems conducting the e-voting process is secured, efficient and private elections are possible, the disadvantage of this type is that the voter is responsible for insuring that his vote has been accounted for in the final election tally, these systems are impractical for civic elections as no independent observer can verify the elections.

In the last category of Internet voting, universally verifiable, anybody can verify the election without compromising voter's privacy. Provision of this level of protection is difficult. These systems can only be used for yes/no election due to contradictions among requirements (Kahani, 2005).

E-voting system should also involve four phases: Voters register themselves to registration authorities and the list of eligible voters is compiled before the election day, on the election day registered voters request ballot or voting privilege from the registration authorities and the registration authorities check the credentials of those attempting to vote and only allow those who are eligible and registered before. Voter casts his vote and finally the tallying authorities count the votes and announce the election result (Cetinkaya and Cetinkaya, 2007).

2.2. Why Use E-voting

Election voting machines have provided a number of benefits to the election process. For example, direct recording electronic machines can be equipped with audio or tactile devices that allow disable citizen to cast ballot independently, they also help conduct election in more efficient and effective manner, like reducing the cost associated with printing ballot and hiring extra polling staff. Voting machines can also spit out election tallies much quicker and more accurately than exhausted polling station staff; they reduce human errors in generating election result and also reduce the cost of conducting election. So the major benefits of e-voting could be summarizing in the following points: reduced costs, increased participation and voting options, greater speed and accuracy placing and tallying votes, greater accessibility and flexibility for the disable (Data-monitor, 2008).

As we pinpointed few benefits of e-voting, some risks are associated with using and depending on electronic systems. Programming errors can be very simple like adding semi-colon in the wrong place can completely change a program. There are many risks experienced during the development stage of any system, product delivery, maintenance between elections and the pre-and post-election intervals. The greatest threat identified involves a person gaining access to a voting system and interring malicious code into the voting system software. This malicious code could exploit vulnerabilities in the voting software to spread virally from machine to machine causing voting machine to fail to record votes, failing to comply with legal requirement and calculating vote totals in a way that is inconsistent with legal requirements.

Applying technology to solve one problem may introduce other problems. For example, E-voting systems are introduced to eliminate paper and many other problems, but without a paper copy, the voters cannot check that their votes are correctly recorded and cannot independently validate votes' totals (Bishop and Wagner, 2007).

Electronic voting can be secure and confidential as paper-based voting. However, to work properly, such systems must first incorporate seven design principles. The first is proven security; all protocols and techniques must be mathematically proven secure. Second, trustworthy design responsibility; government security agencies should be responsible for creating secure voting system. Third, source code; must be

published and made publicly accessible. Forth, vote verification; it should be possible to verify that all votes have been correctly accounted for in the final election tally. Fifth, voters' accessibility; system should be accessible to all and easy to use. Sixth, ensure anonymization: techniques like onion routing must be used to ensure anonymization. And finally, expert oversight; team of experts selected and approved by all major parties taking part in election (Gerlach, 2009).

2.3. E-voting experiences around the world

The State of California allows e-voting machines to be used only under strict conditions. Polling stations won't be able to have more than one of those systems in place, and county registrars will have to take steps such as reinstalling the software and firmware for the devices and resetting them encryption key. E-voting systems were used by one quarter to one-third of California voters in November elections year 2006. But during state-sponsored review of the machines and their source code, a team of penetration tester found 15 security problems, including the ability to exploit flaws in windows (Klossner, 2007; Towns, 2008).

In the case of Florida State, the Florida legislature passed a bill that would require all voting districts in the state to replace most touch-screen voting systems with optical scan devices. The bill estimates the cost of replacing the touch-screen systems at $18.5 million (Songini, 2007). In America's voting systems shift from lever machines and hand-counted paper to optical scanners and touch screens with printed voter-verified paper audit trails and the system served an estimated 133 million voters on Nov.4 (Seligson, 2008).

On the other hand, and in the European Union countries, e-voting was introduced as a part of the federal and provincial elections in Belgium in November 1991, when two cantons were selected for an experiment in e-voting. Through a law of 11 April 1994, this experiment was broadened and institutionalized to 20% of all voting areas and since 1999, 44% of all voting is registered electronically to attain 100% by 2006 elections. The main objectives of Belgium government from shift to e-voting system are difficult to manage and control manual voting, reduced the costs, announce the result earlier and make the result more accurate (Towns, 2008; Vuyst and Fairchild, 2005).

2.4. Students' council elections cases

Cases of student council elections using e-voting system: In Brazil, the student council elections project was developed in a public school located in Serra azul, and it includes the electronic voting system, developed and used by the student and Some. Also, Cleveland high schools are choosing their student council leaders using e-voting machine (Ramos, 2006).

2.5. Students' council elections at Yarmouk University

Normally, the elections of students' council at any university and anywhere in the world, doesn't elicit much attention. In Jordan, the issue is different, as it is used as a yardstick to measure present and future trends of the Jordanian kingdom. Also, there is great emphasis on prestigious image of the position within the university society more than public service for the community.

A student candidate in Yarmouk University must have the following conditions (www.yu.edu.jo): he/she should have an accumulated average not less than 60%, must have at least a 12 credit hour load through the semester (a full time student), must not have less than 36 credit hour to graduate from the university, and did not have any warnings or punishments during his/her study at the university.

In the year 2009, a large fight broke out at Yarmouk University between students. This resulted in physical damages to windows, cars and buildings on campus, as well as some injury of people, including a security guards, the reason cited for the fight was students elections (Alrai Newspaper, 2009).

The objectives of the students' council election can be summarized in the following points (Rawashda, 2009):

1. Represent all students in the department and act as a voice for the interests, opinions, and concerns of that student body of the department.
2. Act as an intermediary between students and the faculty and administration in the department.
3. Represent the student body in faculty and staff committees and meetings.

Student council election process: In order to vote, a student must be listed in the enrollment services office. Voters must sign the student print-out. Election administrator then highlights each voter's name as he/she votes. Once a name has been highlighted and signed, the student may not vote again. Voter is given numbered election ballot. Voting will be by secret ballot. Voter fills out ballot (inside the polling booth) and places his/ her ballot inside the ballot box. (Rawashda, 2009).

3. THE ADOPTION PROCESS OF E-VOTING

One of the major issues in e-voting is the proper authentication of the voters and ensuring voters that the electronic election would address accuracy, privacy, verifiability and security issues requirement appropriately. In this paper we try to prove that e-voting system has some inherent advantages over paper based voting including a substantial decrease in voting errors. E-voting makes it possible to accommodate people with different disabilities, helping them vote without human assistance. In political environments, users need to be convinced that e-voting is robust, secured and safe. The experiences in different countries of the world and the literature reviewed showed that using information technology for different applications can

result in convenience, accuracy, time and cost savings. Thus, beside the major constructs proposed by TAM, this paper extended the model to the one shown in Figure 1, where it is hypothesized that the Intention to use e-voting systems will be influenced mainly by five predictors.

Research question: What are the major predictors of adopting e-voting systems?

Research hypotheses:

H1: Perceived usefulness will have a positive influence on intention to use e-voting systems.

H2: Perceived ease of use will have a positive influence on intention to use e-voting systems.

H3: Trust propensity will have a positive influence on intention to use e-voting systems.

H4: Perceived security will have a positive influence on intention to use e-voting systems.

H5: Perceived privacy will have a positive influence on intention to use e-voting systems.

In this study perceived security and perceived privacy are defined as to what extent the system is secured and private. On the other hand, Perceived usefulness is defined as to what extent the system is useful to the purposes of the user, and perceived ease of use as to the extent that the system is easy to use. Finally, trust propensity is defined as the extent to which the user can trust the system. This study used intention to use as a surrogate to usage for practical reasons and convenience of research application.

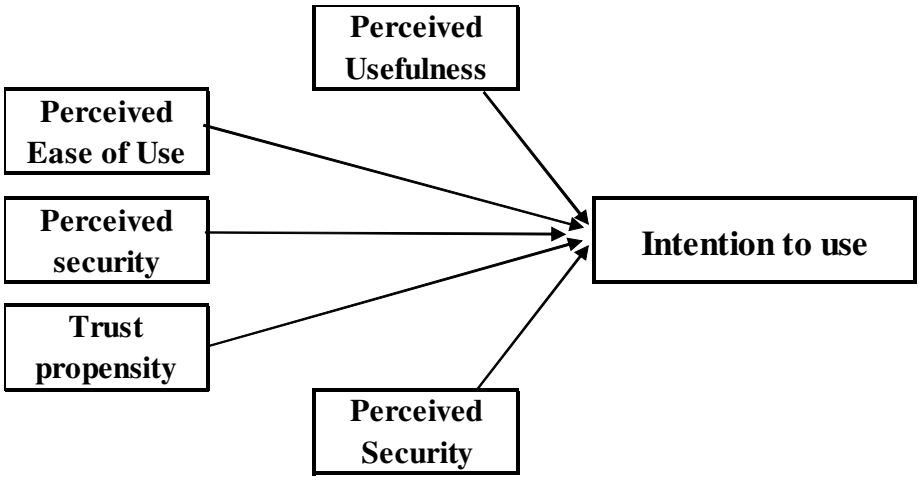

FIGURE 1 - THE RESEARCH MODEL

4. RESEARCH METHOD

This study used an empirical test to explore the set of hypotheses and answer the research questions. A survey was built to explore different aspects of students' acceptance of e-voting systems depending mainly on a 5 point Likert scale, with 1 indicating "strongly disagree" and 5

indicating "strongly agree". The sections visited were selected randomly among various colleges of Yarmouk University (YU) to diversify the sample and, majorly, based on instructor's cooperation and willingness to administer the survey in his class. One of the researchers visited 13 sections and only 6 sections approved the administration of the survey. The survey took on average 15 minutes and few minutes to talk about the research and introduce the project.

The questionnaire is divided into two main parts: 1) the demographic information which contains (3) questions. 2) Questions about students acceptance to implement e-voting systems in students council election in Yarmouk university which contains (23) questions. The survey contained no questions that identify student's identity. Table 1 contains a summary of the demographic data collected. The total size of the sample was 302, were 320 surveys were distributed and 18 were excluded because of missing data size.

TABLE 1 - DEMOGRAPHIC DATA OF THE SAMPLE

College	Total	Percentage
Economics & Business Administration	65	21.50%
Information Technology	79	26.20%
Islamic Studies	52	17.20%
Education	94	31.10%
Other	12	4.00%
Total	302	100%

Age	Total	Percentage
< 20	90	29.80%
20	74	24.50%
21	86	28.50%
> 21	52	17.20%
Total	302	100%
Gender	Total	Percentage
Male	77	25.50%
Female	225	74.50%
Total	302	100%

The questionnaire measured students' acceptance of e-voting systems using 6 constructs mainly adapted from the technology acceptance model (TAM). The variables were: intention to use (ITU), perceived ease of use (PEoU), perceived usefulness (PU), trust propensity (TP), perceived privacy (PP) and perceived security (PS). This research used ITU as a surrogate for usage of e-voting systems and as a dependent variable in the research model (Davis, 1989). The other five constructs were hypothesized to predict ITU and considered as independent variables in the research model.

The sample used in this study indicated that YU students knew about e-voting (194 students responded by YES when asked about e-voting systems, 64.2% of total sample). One the other hand, 35.8% (108 students) indicated that they never heard about e-voting systems.

The second part of questionnaire use items extracted from previous research to explore the TAM and the extension of the model. The items used for ITU, PU, PEoU are all from the original TAM (Davis, 1989; Davis,

Bagozzi and Warshaw,1989), but translated to Arabic and used in the survey. On the other hand, Trust items were adopted from the work of Pavlou (2003) and AbuShanab (2005). Finally, the items used for perceived security and perceived privacy were added by the authors based on their readings of the literature and the importance of such constructs. The e-government literature lacks such availability of instruments and empirical testing might be a rarity.

Results of reliability analysis of the scale used indicated good levels of internal consistency with respect to ITU, PU, PEoU and TP (0.822, 0.675, 0.799 & 0.792 respectively). On the other hand, the value of Cronbach's alpha was low in regards to PP and PS (0.583 & 0.484 respectively). Table 2 lists the values of the scales and their related items used with the sample size indicated.

TABLE 2 - CRONBACH'S ALPHA FOR THE USED VARIABLES

Variable Names	N	Number of items used	Cronbach's Alpha
Intention to Use	302	3	0.822
Perceived usefulness	302	5	0.675
Perceived Ease of Use	302	5	0.799
Trust	302	4	0.792
Security	302	3	0.484
Privacy	302	3	0.583

The research question under consideration can be answered by simply exploring the relations between each of the variables and ITU. First we conducted a Pearson correlation tests between each one of the variables and ITU, such test indicates the relationship between them in isolation of the collective competition on the variance. The results are shown in the correlation matrix in Table 3. All correlations were significant at the 0.01 level, which indicates the importance of each in predicting students' adoption expectations with respect to e-voting systems. The table also shows the means of each variable. We can see that all variables indicated high levels according to social sciences literature (1-2.5 as low, 2.5-3.5 as moderate, and 3.5-5 as high). The least was slightly below the high level category (Trust with a mean equal to 3.445), and the highest was perceived usefulness with a mean equal to 4.065.

We tried to replicate the TAM and entered only PU and PEoU in the first model, with ITU as the dependent variable. The results indicated a significant model at the 0.001 level with an $F_{2,299} = 38.004$. The coefficient of determination $R^2 = 0.203$, which is less than what the original TAM yielded ($R^2 = 0.36$). On the other hand, both predictors were significant in predicting ITU at the 0.001 level for PU, and at the 0.01 level for PEoU. Table 4 show the coefficient table of the regression analysis.

TABLE 3: MEANS OF VARIABLES AND THE CORRELATION MATRIX

Variable Names	Mean	Correlation Matrix					
		ITU	PU	PEoU	T	S	P
Intention to Use	3.759	1					
Perceived usefulness	4.065	0.417**	1				
Perceived Ease of Use	3.782	0.349**	0.482**	1			
Trust	3.445	0.526**	0.306**	0.289**	1		
Security	3.639	0.316**	0.387**	0.335**	0.402**	1	
Privacy	3.796	0.397**	0.419**	0.319**	0.493**	0.487**	1

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

TABLE 4 - REGRESSION COEFFICIENTS FOR REPLICATING THE TAM

Model Items	Unstandardized Coefficients		Standardized Beta	t	Sig.
	B	Std. Error			
Constant	0.831	0.340		2.443	0.015
Perceived usefulness	0.490	0.089	0.324	5.500	0.000
Perceived Ease of Use	0.248	0.076	0.193	3.272	0.001

Dependent Variable: ITU

TABLE 5 - COEFFICIENT TABLE OF THE REGRESSION MODEL

Model Items	Unstandardized Coefficients		Standardized Beta	t	Sig.
	B	Std. Error			
Constant	0.043	0.325		0.131	0.896
Perceived usefulness	0.318	0.086	**0.211**	3.722	0.000
Perceived Ease of Use	0.140	0.070	**0.109**	1.999	0.046
Security	0.003	0.067	0.003	0.047	0.963
Privacy	0.095	0.070	0.081	1.370	0.172
Trust	0.442	0.062	**0.39**	7.090	0.000

Dependent Variable: ITU

When competing on the variance not all variable will survive significance, and that is a result of competing on the same variance. It is more economical to use fewer variables to predict a dependent variable and this is one of the parsimonious aspects of the TAM. This study entered all variables at one time into this competition and resulted in a new set of variables that best predict ITU. Multiple regression was used to test the hypotheses mentioned and to see which variables will predict ITU. Results indicated that only perceived usefulness and trust propensity were significantly related to ITU at the 0,001 level. Also, PEoU was significant at the 0.05 level. On the other hand, PS and PP were both not significant in predicting the dependent variable. Results are shown in Table 5 below. Finally, as a model, the performance was better than the original TAM, were the predictors indicated a high value of coefficient of determination (R^2 = 0.364, with an

$F_{5,295}$ value = 33.863, $p < 0.001$). This value is considered slightly higher than the value resulted in the original TAM (36%).

5. DISCUSSIONS AND CONCLUSIONS

This study aimed at exploring the factors influencing the adoption process of Yarmouk University students of e-voting systems. The results indicated a full support of the original TAM, where perceived usefulness and perceived ease of use significantly predicted ITU. On the other hand, and improvement in the explanation of variance was achieved as the new proposed model extended the TAM with a new construct (trust propensity) and improved the variance from 20.3% (compatible to original TAM) to 36.4%. This result is important as the researchers used an Arabic instrument, where language might be a factor influencing the responses of subjects. Also, the instrument used can be improved when retested through other environments and technologies.

Regarding the hypotheses stated in section 3, the following table represents a summary of the results.

TABLE 6 - HYPOTHESES RESULTS

Hypothesis	Standardized Beta	t	Sig.	Result
H1: Perceived usefulness influence	**0.211**	3.722	0.000	Supported
H2: Perceived Ease of Use influence	**0.109**	1.999	0.046	Supported
H3: Trust propensity influence	**0.39**	7.090	0.000	Not Supported
H4: Perceived Security influence	0.003	0.047	0.963	Supported
H5: Perceived Privacy Influence	0.081	1.370	0.172	Not Supported

Dependent Variable: ITU

The explanation of variance was attributed to three variables: PU (Std. Beta = 0.211), PEoU (Std. Beta = 0.109) and TP (Std. Beta = 0.390). Such results indicate the importance of trust as a predictor of ITU. Yarmouk University students showed that their trust in e-voting systems is a major predictor of their acceptance.

This study suffered from one major limitation, which is the language issue that reduced the effect of two hypothesized predictors (PP & PS). The results imply for more research regarding the two variables, and to improve the reliability of the two scales used. One can infer that the number of items and the low consistency and reliability of scales were major deficiencies (both were the lowest among the six variables). Future work is needed to improve the instrument and test the new variables again. Also, to explore other factors related to e-voting system acceptance.

This research implies that usefulness and ease of use are still important to decision makers when implementing e-voting systems, but this research indicated that building trust is important.

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