An Application and Validation of the Socio-Technical Model*

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Abstract

Considering the Socio-Technical Model (STM) as a basis for ongoing research has revealed unexpected theoretical results. The research in question is an examination of the impact of technology on user trust and subsequent intent to use election systems. In the process of conducting this research, a new survey instrument was created based on a newly created theoretical foundation built on STM. Our interim findings have exposed an unexpected theoretical finding that suggests further consideration. The findings were a result of data validation done on the new survey instrument. These findings indicated that the principle components of STM may not be valid when tested. At the least, the components may be relevant in a non-equal way. Another possibility is that the model should be re-examined to determine if the components accurately reflect the nature of people and technology and their interactions with large scale systems.

Keywords

Election Systems, Cybersecurity, Socio Technical Model, Theory Development

1. Introduction

Research is currently underway to investigate the American electorate's perceptions of security in election systems and resultant intention to participate in elections [1]. The primary motivation for this research was the controversy surrounding the 2020 presidential election and subsequent propaganda campaign that is attempting to invalidate the results. As voting is the foundation of the American democratic system, the doubts and questions about the legitimacy of the voting system are critical to analyze.

To facilitate the research, a theoretical framework was developed to provide a framework and basis for the creation of a survey instrument. As the Socio-Technical Model (STM) deals with the interaction between technology and the users of the technology [2], it was selected as the base theoretical model to create the theoretical framework. STM was utilized in order to facilitate the analysis of the change in the election process as it relates to the use of IS systems in elections.

STM provides a lens to study information systems from the human interaction side as well as the technological side [2]. There are four primary components which make up the Socio-

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Technical Model: Structure, People, Technology, Tasks [3]. Due to the high amount of human interaction with technology throughout the whole election system, this theory will be able to effectively analyze the election system from the perspective of voter perceptions.

2. Considering the Socio-Technical Model

The first component of STM, structure, describes the social structures that support the system. In the context of US Presidential Elections, the structure of the system is complex. Presidential elections are a federal position but the election itself is managed at the state-level. Furthermore, within the state, there are separate localities that run the actual election. Therefore, this provides for the potential of weak policies and procedures for administering the election [4]. This is the general structure relating to the authority of election administration but the complexity continues in the fact that each of the 50 states has variations on the laws, power structures, and general policies that govern how they run elections. So, you might have a situation in one state, like Georgia, where the Secretary of State has the sole authority to make changes to policy but another state, like Arizona, where the state legislature has shared authority with the Governor.

The second component of STM, people, describes how individuals interact with the system under study. For election systems, people play a critical role as humans interact with all aspects of the voting system from the campaigns to counting the ballots. Of most importance, it is the individual conducting the primary transaction: voting. If a voter does not trust the system, their intention to use is very likely to be affected. If they believe that the systems used to administer the elections are insecure, they are unlikely to use the system.

The third component of the socio-technical model is technology [2]. In the context of election systems, the ballot counters, ballot markers, poll books, and other equipment used in the election administration would be the technology that falls under this component of the theoretical framework. As with all systems, technology changes and evolves over time. This is especially true if there are external forces that are influencing and motivating change. For example, population growth would predicate the need for more technology in election systems. A paper ledger might work for 10,000 people but would be unfeasible for 40,000,000 people.

The final component of the socio-technical model is tasks. Tasks deal with the interactions of the humans within the system. In the context of elections, this includes campaign ads, casting ballots, and ballot counting. These are just a few of the tasks that occur during the election and have critical effects on the overall election and the election results. If the processes involved in these tasks are tampered with in any way, it could potentially result in flawed results.

3. Creation and Application of the Theoretical Framework

Given the basis of STM, a new survey instrument was created to facilitate the research into voter perceptions' of trust in election systems. A theoretical framework was created whereby each component of STM was applied within the context of elections. Specific topic areas were created for each component that applied to election systems. The list below presents the results of this:

Table 1
STM Theoretical Framework Applied to Election Systems.

Socio-Technical Model Construct	Applied Election System Elements
Structure	Current election laws maintain election security Voter ID verification would increase security in elections New Laws and regulations are needed to ensure the security of elections Current policies are adequate to handle false information being spread Election results should be thrown out if the election laws are violated The federal government should regulate elections The federal government should not regulate elections Current election laws are easily understood/accessible Current election laws are difficult to understand/hard to access
Technology	Current equipment used adequately secures data Social Media has a negative impact on elections Stricter security standards are needed in election systems Security and encryption yields more trust in election systems Use of technology is a necessity in order to have accurate elections Technology is not needed to have an accurate elections Current voting equipment is user friendly Encryption is free of government overreach Agencies such as the CIA and NSA have access encrypted data
People	All eligible voters have an obligation to participate in the voting process Election officials effectively maintain the accuracy of the results Security of the voting process comes before ensuring all people can vote Ensuring all people can vote comes before the security of the election Voter perception is easily influenced by the news/information they hear Restricting early voting would increase security in election systems
Task	Current voting procedures are user-friendly Current voting procedures makes it difficult to cast a ballot Vote counting and verification procedures ensures accuracy in elections Election officials should be closely monitored during ballot counting and verificatio A paper record of each ballot is critical to accurate verification of the votes The ballot transportation method used can introduces security risks

A survey utilizing the election system elements was created. After building the survey, we conducted a pilot study to validate the survey instrument. A pilot study was conducted using google forms which collected responses from eligible voters in the United States. This group generally consists of all adults over the age of 18. There are however exceptions to this in some states. For example, in 11 states felons lose their voting rights indefinitely for some crimes.

In the pilot study, we collected 205 responses. This number of responses gives us sufficient data to be able to perform the validation on the survey [5]. The validation process for a survey deals with the process of assessing the dependability of the survey questions. The pilot study was conducted by creating an online survey and responses were obtained by making a post on social media, having others share the survey, as well as having the survey emailed out to different groups on campus. Diversity of response will be critical to the research as eligible voters include a wide variety of individuals.

The purpose of this pilot study is to validate the survey instrument since it is a new survey and has not been validated previously. Validation of the survey allows us to determine how well the data we collected covers the areas and topics that we are researching in this study [6]. The instrument was analyzed for each question to determine whether, based on responses, the questions asked are valid [7]. Since this study consists of a behavioral survey, having a survey that is valid is a requirement for this type of instrument.

4. Validating the Instrument

An analytical tool used for validating a new survey instrument is the Principal Component Analysis (PCA) test. The PCA test facilitates the determination of the correlation structure between the different variables [8]. This allows us to determine the correlation between the components of this study which looks at the move to online voting, enhanced security, perception of voters, and acceptance/use of the systems by the voters.

The Kaiser-Meyer-Olkin (KMO) value determines how adequate the sample size was from the data [8]. This value is calculated as a part of the principal component analysis. The KMO value for the data collected during the pilot study was 0.772. For the sampling to be determined adequate, it is better for the KMO value to be close to 1 with the minimum being 0.6.

The next value within the PCA analysis would be the p-value. A low p-value shows that the results are replicable and that the effect is large or that the result is of major theoretical, clinical or practical importance. This value should be close to 0 and determined to be acceptable if less than 0.1. The p-value was calculated to be less than 0.001. Therefore, this demonstrates that the likelihood that the data we collected from the pilot study was less than a 0.001% chance that it happened by chance.

After reviewing the results of the PCA analysis, it was determined that there are 2 main components within the survey instrument questions. The first main component found in the questions is the structure of elections and the technology used in elections. The other primary components in the questions are people and tasks. These components line up with the STM component but appear to be combined into a smaller number of components.

The PCA analysis revealed that some of the questions that we grouped together should be grouped differently based on the interpretation of the questions by the voters. For the most part, the PCA analysis showed a general theme between the two components, with only a few questions that did not seem to fit the general theme of the component.

As demonstrated in Table 2 above, most of the questions from the ST component, which is component 1, were strongly correlated with that component. However, some of them correlated with both components using the threshold of 0.3 and -0.3, the question ST1 was strongly correlated with both components. Most of the first component questions had negative loading which indicates that it is a negative correlation. ST7 from the first component was not a strong correlation with either of the components as the highest loading was in the first component as -0.148.

Within the second component, most of the item loadings were strong as most of them were higher than 0.4, however questions PT2 and PT6 were both lower than 0.3, which indicates that

Table 2
Question Loadings PCA Results.

Question	Comp 1	Comp 2	Question	Comp 1	Comp 2
ST1	-0.494	0.440	ST12	0.795	0.054
ST2	-0.748	0.279	ST13	0.333	0.040
ST3	-0.385	0.070	PT1	-0.001	0.449
ST4	-0.619	0.246	PT2	-0.160	0.279
ST5	-0.787	0.076	PT3	-0.14	0.701
ST6	0.468	-0.104	PT4	0.032	0.749
ST7	-0.148	-0.029	PT5	-0.51	0.655
ST8	0.709	0.166	PT6	-0.001	0.247
ST9	0.721	0.191	PT7	0.324	0.574
ST10	0.762	0.167	PT8	0.174	0.698
ST11	0.787	0.142	NA	NA	NA

it was not as strong of a correlation with the component as well as it did not show a correlation with component 1 as well.

Even though the PCA did not group the questions together as we had them grouped, they still demonstrated a general theme in the questions and some of the STM components merged together. The reasoning behind this could have been due to how respondents interpreted the questions as well as some of the questions do have some crossover between the four STM components.

5. Discussion

While the intent of the study was to examine the impact of technology on user trust and subsequent intent to use election systems, our interim findings have exposed an unexpected theoretical finding that suggests further consideration. STM has long informed scholars on the interaction between people and technology and is well established in the literature. Despite this well established application, our process of validating the STM based instrument did not support the validity of the theory itself.

The question loadings within the PCA test did not load well into the four core constructs of STM. This validation testing shows that structure and technology have an outsized impact on the system while people and tasks are much more minimally significant. Feedback from subject matter experts in quantitative data validation discussed the possibility that the way the questions were asked may have impacted the question loading. The survey is in the process of being adjusted to account for this possibility.

If the subsequent validation testing shows similar results, it opens the possibility that the theoretical foundation of STM should be revisited. The implication that the components of STM are equally impactful is fairly unlikely and should be investigated further. Perhaps refinement of the components themselves is called for as well.

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