EAI Endorsed Transactions
on Scalable Information Systems
Research Article EAI.EU

Systematic Literature Review: A Novel Framework for Evaluating Electronic Voting Systems Artifacts.

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Abstract

INTRODUCTION: Electronic Voting Systems (EVS) play a vital role in modern democratic elections, to sustain high levels of reliability, security, and user-friendliness. Recognizing the critical importance of EVS, this paper initiates a systematic literature review to explore the landscape of EVS design, specifically focusing on introducing a novel framework for evaluating software engineering artifacts.
OBJECTIVES: The primary objective of this study is to conceptualize a novel framework tailored for EVS design, addressing identified gaps in the existing literature. The research aims to offer a structured and systematic approach, guided by Design Science Research Methodology (DSRM) principles, to address the multifaceted challenges posed during EVS implementation.
METHODS: To achieve the stated objectives, this paper conducts a thorough literature review that scrutinizes existing EVS implementations. The review highlights the strengths and vulnerabilities of these implementations, leading to the proposal of an innovative DSRM-based framework. The framework facilitates comprehensive requirement elicitation, meticulous design, robust development, rigorous demonstration, thorough evaluation, and effective communication of EVS artifacts.
RESULTS: The study conceptualizes a novel framework for EVS design, which offers a structured and systematic approach supported by DSRM principles. The framework provides a mental model for DSRM within the purview of Information Systems (IS) and software engineering. This serves as a valuable guide for researchers, offering a template to facilitate theory-testing research related to EVS design, evaluation, and implementation.
CONCLUSION: The adoption of the proposed framework is anticipated to stimulate progress in the domain of complex systems, such as EVS. The envisioned far-reaching implications for various engineering disciplines are expected to revolutionize the design, evaluation, and communication of intricate systems in both academic and practical contexts. Ultimately, this study aims to make a significant contribution to the enhancement of EVS technologies, ensuring their seamless integration into democratic processes worldwide with a focus on robustness, security, and usability.

Keywords: Electronic Voting System (EVS), Stakeholder Consultations, Usability Testing, Systematic Literature Review, Software Engineering.

Received on DD MM YYYY, accepted on DD MM YYYY, published on DD MM YYYY

doi: 10.4108/____________

1. Introduction

E-voting systems have widespread popularity due to their versatile capabilities and broad applicability across various domains [30] [31]. Many different domains require process automation, and achieving this often involves the collaboration of varied techniques with powerful computational capabilities, under complex scenarios [32] [33]. The choice of these systems within different domains can depend on a variety of factors, which encompasses data analysis, pattern exploration, the impact of attributes, influential parameters, constants, and the imperative for automation [34] [35]. The applicability of the e-voting system is extensive, across domains such as data computation, fraud detection, and real-time intelligence capabilities.

The concept of utilizing electronic devices for political elections predates the advent of the Internet in the mid-1980s, even before the inception of the Advanced Research Projects Agency Network (ARPANET) and the National Science Foundation Network (NSFNET) [36]. Voting machines were developed globally in the mid-19th century [37]. Electronic voting (EV) represents a system in which election data is captured, recorded, processed, and stored primarily as digital information in real time for future reference [38]. Elections involve the selection of individuals for public or political office through a structured voting process. The reliability, security, and efficiency of EV systems are very important for ensuring trustworthy and credible elections [39]. In contrast, traditional voting methods, such as hand-counted paper ballots, are riddled with problems, including susceptibility to fraud, errors, and inefficiency leading to disputed polls by citizens [40]. The contemporary landscape of computer science, featuring artificial intelligence (AI), machine learning, natural language processing, and computer vision technologies, has the potential to redefine the entire EVS design, evaluation and the voting process [41] [42]. EVS can revolutionize democratic governance by enabling citizens to participate in secure and reliable elections without geographical constraints or undue external influences. E-voting encompasses various forms of electronic voting, from touchscreen kiosks at polling stations to online voting without territorial boundaries. This research is motivated by the need to address the challenges associated with traditional paper-based voting systems and some of the problems associated with the e-voting system implementation due to lack of a unified framework to evaluate the e-voting systems to the desired standard during implementation without technical or operational problems.

The study seeks to conduct a comprehensive survey of EVS applications and technologies, offering technical insights to overcome the limitations of the systems, as a catalyst to build trust and enhance electoral confidence through alternative methodologies.

The advantages of EV over traditional methods include real-time result display, vote accuracy, and the elimination of long queues at polling stations. Furthermore, EVS minimizes the chances of fraud, violence, and disputed results that have plagued many African countries into wars, through unconstitutional takeovers, leading to loss of lives and properties [40]. EVS implementation requires voter registration through a secure system, ensuring only eligible individuals participate. This process involves completing a registration form, passing citizenship eligibility tests, and undergoing identity verification to qualify each citizen to vote. Election observers worldwide have recommended the adoption of EVS to reduce vote-rigging and its consequences, particularly in African nations where fraud and violence have marred traditional elections [43]. For instance, the Kenyan Electoral Commission's (IEBC) failure to update the national voters' register in a timely manner led to disputed elections while Brazil successfully introduced EVS to enhance accountability and transparency in its elections, demonstrating potential benefit of this technology [44].

The study proposes the implementation of EVS in Ghana, drawing from the International Foundation for Electoral Systems (IFES) case study report [45]. The primary contributions of this study include a comprehensive review of technologies, methodologies, and sustainability approaches to enhance EVS. The identification of relevant EVS characteristics to proposed a Design Science Research Methodology (DSRM) architecture for EVS evaluation and the development of a DSRM framework aimed to validate key approaches. Furthermore, electronic voting systems (EVS) vary in design and implementation, but there are several prominent methods and technologies commonly used to implement them [46] [19]. These methods aim to ensure secure, accurate, and transparent voting processes. The key methods and technologies used in electronic voting systems are enumerated in the subsequent section:

- **Direct Recording Electronic (DRE) Systems** [47]: DRE systems are one of the most common methods. They replace traditional paper ballots with electronic interfaces for voters to make their selections. Voters interact with a touchscreen, push-button, or other input methods to cast their votes electronically. These systems can store and tabulate votes electronically, which can speed up the vote-counting process.
- **Electronic Ballot Marking Devices (BMDs)** [48]: BMDs are used to assist voters with disabilities or language barriers by providing accessible interfaces. They generate a paper ballot with the voter's selections, allowing for a paper trail that can be used for audits and recounts.
- **Internet Voting** [45]: Some regions or countries have experimented with Internet voting, allowing voters to cast their ballots online without any boundaries. Internet voting offers convenience but presents significant security and privacy challenges.
- **Voter-Verified Paper Audit Trails (VVPAT)** [49] [50]: VVPAT is often used in conjunction with DRE systems. It provides a paper receipt or record of the voter's selections. Voters can review this paper record to verify their choices before it is stored securely for potential audits or recounts.
- **Blockchain Technology** [51, 52]: Some electronic voting systems utilize blockchain technology to enhance security and transparency. Blockchain can be used to create immutable and tamper-resistant records of votes, making it difficult to manipulate or hack the system.
- **Biometric Authentication**: Biometrics like fingerprint or facial recognition can be used to verify a voter's identity [53, 54]. This method enhances security but also raises privacy concerns and challenges related to the accuracy of biometric data.
- **Encryption and Secure Protocols** [31, 55]: Strong encryption is essential to protect the integrity and

confidentiality of votes during transmission and storage. Secure communication protocols ensure that data is transmitted securely between voting machines, servers, and central databases.

- **Multi-factor Authentication (MFA)** [56] [57]: MFA adds an extra layer of security by requesting voters to authenticate themselves using multiple factors, such as a voter ID and a password or biometric data.
- **Auditing and Verification Procedures** [58]: Robust auditing procedures, including post-election audits and risk-limiting audits, help ensure the accuracy and integrity of the electronic voting system. These procedures involve comparing electronic records to paper records to identify discrepancies.
- **Open Source Software** [59]: Some electronic voting systems use open-source software to allow transparency, peer review, and independent verification of the system's code and security.
- **Physical Security Measures** [60]: Physical security measures, such as tamper-evident seals and secure storage of voting machines, are crucial to prevent physical tampering with the equipment.

Implementing electronic voting systems requires a careful balance between accessibility, security, privacy, and transparency. The choice of method and technology can vary based on local regulations, available resources, and the specific needs of the voting population. Security and accuracy are paramount to maintaining trust in the electoral process, and constant vigilance is necessary to address the evolving threats and challenges in electronic voting. However, the major problem affecting the design and testing of the electronic voting system is the lack of unified method for testing the e-voting systems (i.e. artifacts). To address this problem, we proposed a novel framework for the Design Science Research Methodology (DSRM) to comprehensively evaluate Software Engineering artifacts to mitigate the problem based on these objectives:

1. To investigate and analyze e-voting systems across various domains.
2. To assess various performance constraints capable of enhancing overall performance.
3. To explore the most recent literature to identify gaps in current knowledge.
4. To assess the effectiveness of employing specific case study projects as illustrative examples, to showcase the stages that system developers should employ when evaluating e-voting systems to address the identified gaps.

The study is structured as follows: Section 2 provides background information and formally defines the problem. Section 3 showcases a systematic literature review and structured methodology and outlines the DSRM methodology and architecture for EVS development. Section 4 presents experimental evaluations of the proposed DSRM capabilities with two case study projects to establish a benchmark for future researchers to compare their research contributions with this study, section 5, discusses the results of the study and section 6, concludes with future research directions for transparent and secure EVS.

2. Systematic literature review

In an era marked by an increasing reliance on technology for various aspects of life, the domain of electronic voting systems (EVS) has gained significant prominence [61].
The systematic review investigates into important components of EVS artifacts. It focuses on the design and development processes of the e-voting systems as software engineering paradigms. The rise of EVS as an important tool for ensuring democratic processes has necessitated a comprehensive examination of the existing systems. It includes their strengths, weaknesses, and the methodologies employed in their implementation. With the aim of enhancing the reliability, usability, and security of EVS. This review investigates how a systematic literature review approach into existing e-voting systems across the globe and how design science can offer innovative solutions to the challenges facing electronic voting. By synthesizing a multitude of research findings and methodological concepts offer a systematic review to provide a holistic perspective on the potential advancements that can shape the future of electronic voting systems. We further look at countries where e-voting systems were used for elections to examine the implementation gaps based on the strengths and weaknesses.

2.1. Electronic voting systems

Electronic voting systems (EVS) represent a critical component of the democratic process, which offers an efficient means for electorates to select leaders for high office [62]. The evolution of voting mechanisms has transitioned from manual hand counting to more advanced systems involving paper, punch cards, mechanical levers, and optical-scan machines [63]. Recognizing the inefficiencies of these traditional systems, significant efforts have been invested in the last two decades to transition towards electronic voting (EV) systems [64].

However, the early stages of utilizing the Internet for voting were fraught with issues, including security vulnerabilities, inaccuracies, and unreliability, which eroded trust in EVS [65]. Addressing these problems is paramount to instilling confidence in electronic voting. Some experts have contended that Internet voting systems (IVS) have the potential to be the most secure and reliable globally, marking a significant milestone in computer history [66] [67] but these assertions are yet to be achieved globally.
Given the enormous benefits of EVS, it is imperative to survey the current global research papers to identify the underlying challenges within existing EVS. The historical context of voting systems highlights the progression from manual hand-counting to the use of mark-sense scanners at polling stations in the early 20th century. Voting technology emerged in 1959 to enhance the legitimacy and accountability of voting procedures [68]. The

optical mark vote tabulator was first developed by Votronic in 1965, followed by the implementation of punch-card electronic voting systems (EVS) in the late 20th century [69].

However, the popularity of punch card EVS waned shortly after the 2020 presidential elections in the United States due to the failure to meet stringent EV requirements [70]. The 1970s witnessed the invention of the electronic voting machine (EVM), and in 1974, the first direct-recording electronic (DRE) voting machine was introduced in the United States, which has been used in legally binding elections ever since [71]. Concurrently, the late 20th century witnessed some countries embracing technology in their national electoral processes, while others refrained from adopting EVS [72] which is eminent in some African countries.

The table below stated the countries that implemented the e-voting systems and their associated challenges [73].

Country	Voting Population	Election Type	Year Introduced	No. of the Elections Conducted	Problems Encountered
Estonia	Approx. 889,000	General, Local	2005	Multiple	Concerns about Cybersecurity, privacy issues.
Brazil	Approx. 147.1M	General, Local	1996	Multiple	Reliability, security, and fraud concerns.
India	Approx. 900M	General	2004	Multiple	Technical glitches, security concerns
Venezuela	Approx. 20M	General	2004	Multiple	Controversy over results, fraud allegations
United States	Approx. 257.6M	Some States	Varies by state	Varies by state	Concerns about hacking, voter access issues
Canada	Approx. 30.6M	Some Provinces	Varies by province	Varies by province	Privacy and security concerns
Switzerland	Approx. 5.4M	Some Cantons	Varies by canton	Varies by canton	Privacy concerns, cost
Netherlands	Approx. 13.1M	General	2007	Multiple	Reliability issues, hacking concerns
Belgium	Approx. 8.3M	General	1991	Multiple	Security vulnerabilities

Table 1: E-voting systems implemented in certain countries

2.2. Voter registration challenges

It is a noteworthy phenomenon that the percentage of eligible electorates who turn out to vote on election day remains unsatisfactory, primarily due to the cumbersome voter registration process in many African countries [40]. Consequently, legitimate citizens are often unable to vote. A report by the Pew Research Centre revealed that nearly one out of four eligible citizens, approximately 51 million individuals, were not registered to vote, hindering their ability to obtain voter ID cards and cast their ballots [45] [74].

Moreover, seemingly unrelated factors, such as weather conditions, have impacted voter turnout significantly [74]. Research spanning six decades of presidential elections in the United States from 1952 to 2012 found that even a mere 1mm of rain had a notable effect on voter turnout percentages across all states [75]. Apathy, anger, and fatigue have also deterred many electorates from participating in elections [76]. In response to these challenges, political researchers at Columbia University in New York City have argued that early education plays an important role in increasing voter engagement and participation in the electoral process [77, 78].

2.3. Requirement for Electronic voting

To ensure the verifiability of electronic voting protocols, EVS implementations have compelled voters to engage in multiple rounds of voting. This involves voters participating in the vote-counting process to verify the accuracy of their votes and ensure alignment with the tally sheets [79] [80]. Verifiability, in this context, refers to the capacity to prevent falsification of voting results. Universal verifiability was introduced to strengthen the auditing of elections through individual and universal verifiability, thereby enhancing the credibility of electronic voting [80]. Individual verifiability allows a sender to verify the delivery of a message, whereas universal verifiability ensures that anyone, including third parties, can later verify the proper execution of an election, including candidate acceptance [80]. Universal verifiability further extends to vote counting, enabling independent verification that all votes have been correctly tallied [81].

2.4. Electronic voting systems (EVS)

Electronic voting systems, particularly Direct Recording Electronic (DRE) voting systems, have undergone extensive scrutiny due to various security vulnerabilities and concerns [45] [82]. Critics have raised issues regarding the closed and restrictive nature of the software, deficiencies in examination and certification processes, susceptibility to hacker attacks such as denial of service (DOS) attacks, and the absence of voter-verified audit trails on paper to mitigate these issues [52].

The vulnerabilities exploited in these attacks stem from inherent weaknesses in contemporary computer designs, allowing malicious code to execute on the Internet, which include spoofing and denial-of-service attacks. These attacks can be initiated by individuals worldwide and often go undetected [83]. Although the concept of electronic voting systems (EVS) dates back to 1982, gained prominence only recently, capturing the attention of nations. The adoption of EVS began in the Netherlands and Belgium, followed by experiments in France in the mid-1990s. Italy, Spain, the Republic of Ireland, the United Kingdom, and other countries initiated pilot experiments with EVS in the early 2000s [84]. Thus, the adoption of the DSRM to evaluate e-voting systems once developed would mitigate the numerous problems encountered during the e-voting systems across the globe. The following sections, outlined the countries in which the e-voting systems were implemented and used during elections, along with the implemented technologies and the associated challenges.

2.4.1 Voting machine: Brazil

Brazil embarked on its EVS journey in 1985 through the Superior Electoral Court. In 1986, considerations for EV application design were initiated, involving usability and feasibility studies, economic factors, and fraud prevention mechanisms. The EVS was implemented in 1995 and was first used for municipal elections in 1996, remaining in use in Brazil to this day[84].

The development of the Brazilian EVS was a collaborative effort led by the Superior Electoral Court and a technical committee comprising researchers from the National Institute for Space Research (NISR) and the Aerospace Technical Centre (ATC) [69]. The adopted systems analysis and design science research approaches to define functional requirements, engaging stakeholders like citizens and IT companies is a key to EVS problem-free implementation. The Brazilian EVS encompassed voting, vote tallying, and identification processes, promoting transparency and accountability by allowing political parties access for auditing purposes. While these EVS systems gained acceptance and were used for vote counting, fraud prevention, and paper printing capabilities, technical challenges, particularly related to printer functionalities, eroded trust in the system. To address these shortcomings, the Brazilian Supreme Electoral Court provided financial support to developers, resulting in the development of a new biometrics-based EVS in 2011. This initiative, funded by the Electoral Court, introduced biometric identification into the electoral process in 2012 [19].

2.4.2. Remote internet voting (RIV) in Canada

Canada has implemented various methodologies for electronic voting systems, specifically for remote Internet voting (RIV) at the municipal and provincial levels. This system offers fully electronic voting options, including both paper and electronic ballots, providing flexibility for municipalities to adopt the approach as they see fit. Some municipal councils have restricted the use of electronic voting systems, while others have implemented varying levels of technical implementation [85].

At the national and provincial levels in Canada, the Election Act does not permit Internet voting (IV). However, certain Canadian provinces have established clauses to guide the testing of new equipment in by-elections. Ontario, for example, began planning IV testing in by-elections due to these provisions [86]. Ontario and Nova Scotia are among the provinces that allow Internet voting (IV). In Ontario, municipalities have been allowed to offer various voting methodologies since 2003, resulting in an increasing number of communities (98 out of 414) offering Internet Voting in elections. Voters are granted the freedom to choose their preferred voting channel. In Nova Scotia, the first implementation of Internet Voting (IV) occurred in 2006, with four municipalities adopting the practice. By 2012, fourteen municipalities had adopted IV for casting votes [87]. Additionally, certain communities in British Columbia have also embraced Internet voting (IV).

2.4.3. DRE Voting machine in Germany

In 2009, the German Constitutional Court (GCC) ruled that the use of Direct Recording Electronic (DRE) voting machines during parliamentary elections in Germany was unconstitutional. This decision was based on the constitutional requirement that all elections must be conducted publicly [88]. The DRE voting machines, being unable to ensure the transparency necessary for national elections, failed to allow citizens to scrutinize the determination of results. The Constitutional Court (CC) articulated that the process of casting votes and counting should be subject to public scrutiny without requesting specialized knowledge at all levels of elections. The EVS itself was not deemed unconstitutional; rather, it was recognized to improved transparency and accountability measures or legislative adaptations to ensure broader accessibility while maintaining transparency [88]. The GCC's action in bringing attention to the transparency shortcomings of DRE voting machines underscores the importance to replicate similar measures to enhance transparency and protect democracy in African politics.

2.4.4. Electronic voting machine (EVM) and remote internet voting (RIV) in India

Voting Machines (EVMs) were first piloted in 1982 in India and have since undergone modifications to enhance security and robustness. They have been in use since 2002 [89]. EVMs consist of two crucial units: a Control Unit and a Balloting Unit. The Control Unit, under the control of the Presiding Officer or a Polling Officer, operates the Balloting Unit placed inside the voting compartment. Instead of issuing a paper ballot, the Presiding Officer or Polling Officer activates the ballot button, allowing voters to cast their votes by pressing a button on the ballot unit corresponding to their chosen candidate and symbol. These systems offer a high degree of transparency, and the results are generally accepted without dispute by all candidates [90].

2.4.5. Remote internet voting (RIV) in Norway

The Norwegian Government and Parliament decided to test e-voting (EV) in 2008, leading to the development of an Internet Voting System (IVS). The first trial took place during local government elections in ten municipalities in September 2011 [91]. Encouraged by positive feedback from the initial trials, the government conducted another EV trial during the parliamentary elections in 2013. While these trials initially received positive outcomes without significant security concerns, they remained politically controversial [91]. Although there were no initial serious concerns, subsequent discussions revealed doubts about the security of Internet transmission of votes, particularly in terms of casting votes outside polling stations, as it raised concerns about the integrity of the vote [92]. Due to the lack of consensus in parliament and broader political support, Internet voting (IV) was not approved in June 2014 due to its implementation challenges. Consequently, the government opted for further EV pilot projects in Norway [92] to mitigate the challenges for broader acceptance.

2.4.6. Electronic voting machine (EVMs) in the Netherlands

Electronic voting machines (EVMs) were widely used in Dutch polling stations for over 20 years until the suspension in 2008, primarily due to a lack of trust in these machines [93] [94]. A subsequent report indicated that the Ministry of the Interior and Kingdom Relations, responsible for organizing elections, lacked in-house expertise, leading to excessive reliance on vendors and certification agencies for its operations [95] [96].
In 2013, a committee was established to investigate the future of EVs in the Netherlands. The committee recommended that the election process could benefit from EVS for vote counting and casting, presenting a feasibility study to the government [19] [97]. This study also aimed to safeguard elections in the Netherlands against foreign interference.

2.4.7. Remote internet (RIV) in Switzerland

In the year 2000, Switzerland embarked on the 'Vote Electronique' project, introducing remote Internet voting (RIV) at both cantonal and national levels [98]. This initiative led to the successful development and implementation of remote Internet Voting Systems (IVS) in three cantons. To oversee and guide this endeavor, a steering committee was formed in 2011, composed of decision-makers from the cantons, and federal administration representatives, and led by the Federal Chancellor [98]. The 'Vote Electronique' project, initiated in 2000, was meticulously planned and executed, involving over 150 EV trials at the federal level. Beyond the initial three cantons (Geneva, Neuchatel, and Zurich), additional cantons joined the Electronic Voting Projects (EVPs), enabling their citizens living abroad to participate in elections remotely [98, 99]. The focus of the testing initially centered on the use of EVS in referendums, later extended to parliamentary elections.

Switzerland introduced new legal requirements for EVS through two Federal Acts (Federal Act on Political Rights of 17.12.1976 and Federal Act on Political Rights of the Swiss Abroad of 19.12.1975). These acts were adopted by Parliament and further specified through two regulations, one being the 'Ordinary on Political Rights of 24 May 1978' adopted by the Federal Council (Government), and the other, 'Federal Chancellery Ordinary on Electronic Voting of 15.1.2014,' issued by the Federal Chancellery [98] [99].
The Swiss EV initiative, launched in 2002 with comprehensive legal support and recommendations, established stringent requirements for any Electronic Voting Systems (EVS) [100]:

- EVS should be user-friendly, secure and practical
- It should not disadvantage citizens without access to electronic communication systems.
- The electorate must have the freedom to express their opinions on federal and municipal disputes during elections.
- The technical architecture and infrastructure must be reliable
- The system must allow verification of ballots within a certain time frame
- It should prevent misuse, facilitate efficient vote counting, and protect voter anonymity.

These requirements led to legal provisions ensuring the security of EVS, including provisions that [100]:

- Only registered voters are permitted to cast votes.
- Legitimate voters can vote only once.
- No third party can systematically monitor, alter, or divert digital ballots or exert undue influence on the vote count.
- Voter anonymity is maintained, and individual or party verification of voters is prevented.
- Votes are counted and tallied before results are declared, with anti-fraud capabilities in place to safeguard the election process [101]

In Switzerland, three cantons—Geneva, Neuchatel, and Zurich—concurrently conducted pilot projects to evaluate remote e-voting (REV) [101]. These projects aimed to assess authenticity, feasibility, security risks, and cost-effectiveness. REV was primarily designed to provide an additional platform for voting in referendums and elections, with the goal of increasing voter turnout. Switzerland's complex political framework involves numerous voting procedures at federal, cantonal, and communal levels, resulting in multiple voting sessions each year. The registration process is highly efficient due to mandatory registration and systematic database updates.
The Swiss Internet infrastructure provides a robust foundation for e-government activities, and the use of the Internet among the population has significantly increased in recent years, from 28.8% in 2000 to 67.8% in 2007. It is advisedly recommended for the parliament of Ghana to adopt similar measures taken by Switzerland to enact new legal requirements for EVS in our national elections to set a standard for other Africa countries to benchmark their e-voting implementations.

2.4.7.1. Geneva pilot project

Geneva, one of the cantons at the forefront of electronic voting, introduced the world's first public Internet Voting System in 1995. This innovative system facilitated postal voting for a significant proportion of citizens (95%), exceeding the Swiss average [102]. Participation in postal voting increased from an average of 30%-35% to an average of 55% over eight years. In the digital voting process, each eligible voter received an electoral card at home containing the necessary information to cast vote. This process involved dividing the voting card into two parts: the left part allowed online voting, while the right part required information filling, signature, and birthdate entry to select a polling station for voting activation, typically done about a month before the voting session. When the voting period commenced, voters used their internet browsers to access a designated website and entered the 16-digit voting card number to initiate the process.

They then completed an online ballot similar to a paper ballot. The system provided an opportunity to review and modify choices before final submission. Voters confirmed their identity by entering a PIN code (hidden under a metallic film), followed by their birthdates which indicates the municipality of origin, all cross-verified with the central register. Voters received confirmation of the date and time of vote recording [102]. This process effectively prevented multiple voting, and the database system ensured that only registered voters were eligible. Additionally, it randomized the data in the electronic ballot box before reading aimed to prevent matching votes to voters, preserving voter anonymity.

2.4.7.2. Neuchatel pilot project

The Neuchatel Pilot Project pioneered a collaborative effort between the canton and communes to establish a diverse platform, which includes an e-government portal known as "guichet secure unique." This portal introduced Internet banking and issued user IDs, passwords, and transaction codes to citizens accessing various e-government services. Among the services offered through this platform was the Neuchatel e-voting system. Before each election, registered voters received the necessary voting materials at home, along with a specific code enabling them to cast their votes [103] [104]. The security protocols implemented were made to those of the Geneva Pilot Project. For the initial trial, online voting was initially made available to a small subset of eligible voters through the e-voting portal, serving as a limited sample. Similar to the Geneva case, participation among portal users was high, with voters encountering no significant issues when making their selections [104] [105].

2.4.7.3. Zurich pilot project

The canton of Zurich, with nearly one million registered voters, features numerous small collectives, some with fewer than 200 voters. Each commune manages its administrative system, electoral register, and vote counting. To accommodate e-voting, the system was designed to operate at the local level, with communes transmitting results to the canton. Zurich implemented a shared canton-wide voter database, regularly updated by communes [105] [106]. A unique aspect of the Zurich pilot trials was the option to use mobile phones for voting via SMS, a feature initially tested during the University of Zurich student parliament election [71]. The first national trial took place in the commune of Bulach [107]. Subsequently, communal elections occurred in Bulach in April 2006 using the same system as other e-voting trials. According to Beat Kocher, mayor of Bulach, the process proceeded smoothly, earning praise for its efficiency [105] [106]. In November 2006 and June 2007, the trials continued in Bertschikon, Bulach, and Schlieren.

2.4.8. Electronic voting in the United Kingdom

From 2000 to 2006, the UK Government conducted experiments with various e-voting systems in multiple elections, including those in May 2000, May 2002, May 2003, June 2004, and May 2006. These experiments encompassed a range of methods, including Internet, Interactive Voice-Responder, SMS, Kiosk Voting, Digital television voting, e-counting of paper ballots, smart cards for voter identification, and Polling station-operated e-registers of voters [108]. The security measures and methodologies employed in the UK closely paralleled those e-voting systems in other countries. Each voter was issued a unique vote reference number (VRN) for identification when using an e-voting channel, aimed at preventing multiple voting. On Election Day, an electronic register tracked all voting methods used in polling stations to ensure voters had not already cast their votes elsewhere or used e-voting channels. If a voter had used postal voting, their e-credentials were automatically disabled. To maintain exclusive access to the electronic register, ISDN (Integrated Services Digital Network) connections and laptops were utilized, allowing for communication between polling stations and the election office. This arrangement facilitated troubleshooting by staff and technicians [108].

In cases of temporary unavailability, polling stations were required to maintain paper records of voters who had cast ballots and update them later in the system while contacting the election office for verification. In the event of a permanent system failure, polling stations had to revert to traditional voting, without access to electronic polling stations. In 2003, the Government began issuing smart cards containing voter IDs to expedite voter identification [108].

The UK Government aimed to establish a robust framework for e-enabled General Elections after 2006; however, the pilot tests encountered numerous issues. Some challenges included are:

- Insufficient backup equipment.
- Inadequate laptop configuration before delivery.
- Limited technical support staff availability.
- Underestimation of time and resources required for setting up polling stations.
- Occasional communication challenges between polling stations and the election office.

These trials fell short of e-voting standards, and problems with electronic counting technology led to the abandonment of electronic counting in favor of traditional manual counting in most pilot areas. In other areas, electronic counting was completed much slower than expected due to insufficient planning and limited testing before the election. As a result, the UK was unable to establish a secure and stable e-voting framework [108] [109].

2.4.9. Remote internet voting (RIV) in Estonia

In 2001, Estonia initiated Internet voting, which gained legal approval in 2002. In 2003, the National Electoral Committee (NEC) began the actual EV project and conducted a rigorous public procurement process, awarding the contract to Cybernetica LTD to develop e-voting systems [45] [110]. This system employed features such as smart cards and electronic signatures to enhance security and robustness. The EVS was first tested in a consultative referendum in Tallinn, the capital city, in 2004.

Estonia's Internet Voting System offered multiple voting authentication methods are:

- **ID card with PIN codes:** Registered voters could authenticate themselves by entering PIN codes through a PC with internet access and a smart card reader, supported by ID card software.
- **Digital ID:** Registered voters were authenticated by providing a digital ID for electronic signature and voting.
- **Mobile ID:** The system authenticated registered voters through the Mobile-ID SIM card, utilizing PIN codes and certificates, a PC with an internet connection, and a mobile phone (without the need for a special card reader or software)

Voters could pre-test these authentication methods on the Electoral Committee's website to ensure they had the requisite software and identification devices before Election Day [50]. Internet Voting was first employed in municipal elections in 2005, with over nine thousand voters casting their votes online. The success of this initiative led to the legalization of remote Internet voting for all elections, including municipal elections in 2009 and 2013, national parliamentary elections in 2007 and 2011, and European Parliament elections in 2009 and 2014 [111] [112]. A dedicated Electronic Voting Committee was established in 2012 to oversee remote Internet voting, with the National Election Committee providing supervisory oversight over elections.

Estonia introduced a unique approach to prevent multiple or accidental voting. By implementing a public key infrastructure and utilizing identity cards for secure electronic personal identification, voters were required to authenticate themselves using their digital signatures and ID cards during the 2005 elections. This approach facilitated the issuance of over 800,000 voter ID cards and digital signatures [45] .

The aim was to ensure that electronic voting was as similar as possible to traditional voting, complying with election legislation and principles while maintaining the same level of security. Estonia endeavored to create a straightforward and efficient e-voting framework, focusing on key security measures:

- Ensure uniform, confidential electronic voting.
- Restrict voting rights to registered voters exclusively
- Guarantee that each voter could cast a single vote.
- Conceal the voter’s choice from any candidate or eternal party.
- Safeguard the secure, reliable, verification, and auditable compilation of votes.

To optimize election logistics, e-voting was authorized from the sixth to the fourth day preceding Election Day, to afford ample time for the administration of e-votes [45]. Estonia outlined six fundamental principles to govern the proper execution of e-voting within its electoral legislation. These guidelines were meticulously designed to:

- Enable voters to cast their electronic votes personally through the National Electoral Committee web page.
- Facilitate voter verification through identity cards to streamline digital identification.
- Immediately display a list of voters within the voter's electoral district of residence upon successful identification, ensuring a secure webpage.
- Enable voters to select their preferred candidate within their electoral district of residence on the webpage.
- Display the voter's vote in real-time on the webpage upon casting.
- Empower voters to amend their electronic votes in advance of Election Day, either electronically or at a polling station.

This system was strategically programmed to nullify any instances of multiple or inadvertent voting by the same individual. In the event of electronic vote compromise, voters were granted the option to cast their votes using the traditional system. Importantly, e-voting concluded four days before Election Day, allowing sufficient time for the government to communicate the necessity for a new, "traditional" voting session if issues arose. Votes were meticulously collected and cross-referenced with voter qualifications, ensuring the removal of invalid votes, including double votes and votes from ineligible voters. A vote-counter application was deployed to aggregate results from the re-casting of ballots.

Estonia's E-vote framework is exceptionally well-defined and reliant on individual ID cards for validation, exemplifying the commitment of nations to secure efficient electoral processes [45].

2.4.10. Electronic voting system in the United States

The United States has embraced a range of electronic voting systems (EVS) throughout its electoral history, which encompasses Direct-Recording Electronic (DRE) voting machines, optical scan systems, and punch-card voting systems [45, 113]. However, it was the highly consequential presidential election of 2000 that spurred the United States Congress to pass the Help America Vote Act of 2002 (HAVA) [114]. HAVA served as a catalyst for modernizing existing voting machines, with a specific emphasis on DRE voting machines and optical scan systems. Since 2012, the method of EVS in the United States has been divided into two primary types: DRE machines and optical scan systems equipped with paper trail capabilities for printing [114].

One notable chapter in the American approach into electronic voting was the Pentagon's initiation of an Electronic Voting System known as SERVE. However, the rollout of SERVE encountered temporary suspension, prompted by a comprehensive report issued by a panel of experts highlighting inherent security vulnerabilities within the system.

SERVE was conceived as a framework that provided resources to other computers within an Internet- and PC-based infrastructure. Yet, it grappled with a host of fundamental security issues, makiing it susceptible to various well-known cyber threats [114]. These vulnerabilities encompassed insider attacks, Denial of Service (DOS) attacks, data spoofing, automated vote-buying, and an array of other potential breaches. Notably, these security concerns were deeply rooted in both the design of the SERVE system itself and the hardware employed in the PCs associated with it. Consequently, the development of SERVE was abandoned, with a recommendation to discontinue pursuing this path until the fundamental PC infrastructure is addressed or until other unforeseen security challenges were effectively resolved [114].

3. Methodology

The study adopted a systematic literature review and structured methodology. The systematic literature review methodology has its roots in e-voting systems (EVS) and has gained substantial popularity in scientific research [115] [116]. It is also widely applied in the fields of management and Information Systems [116]. This methodology organizes research findings from existing bodies of knowledge to enhance content validity, fidelity, completeness, and overall quality and relevance within this specific research community. This, in turn, provides a valuable benchmark for other researchers [116]. We adhered to specific research questions as part of our approach to conducting the systematic literature review. The systematic reviews have uncovered a recurring issue: the majority of EVS encountered implementation failures due to the absence of a unified framework that developers could use to evaluate the system and this is the direction of this study. To address this challenge, we introduced a Design Science Research Methodology (DSRM) [117], designed to evaluate the efficacy of utilizing specific case study projects as illustrative examples. These case studies serve as practical models, demonstrating the stages that system developers should follow when assessing EVS to address the gaps identified in the literature.

The methodology employed in this research follows the principles of DSRM, originating from engineering and the sciences, particularly focused on artificial artifacts. DSRM is a problem-solving approach [118] [119] designed to yield effective research outcomes by creating innovative artifacts and generating design knowledge (DK) for real-world problem-solving [117]. This methodology has found applications across various domains, including engineering, computer science, business, economics, and is increasingly relevant in artificial intelligence and machine learning system design. The DSRM Framework serves as the foundation for developing any DSRM architecture and this is further elaborated in the following section.

3.1. Research framework and research questions

This systematic review is anchored on the comprehension of e-voting (EV) implementation within the contexts of countries around the globe. This study employs this objective by adopting the Input–Process–Output (IPO) model in Figure 1, a framework that has found widespread application in organizational behavior research [120] and has demonstrated effectiveness in reviews within the field of social science research [121]. This conceptual framework serves a dual purpose: firstly, it aids in explaining and gaining insight into the existing state of knowledge concerning EV implementation, and secondly, it provides a valuable roadmap for the development of research questions based on the implementation challenges and findings from the literature globally. Scholars have previously leveraged the IPO framework, and adapted variants, to investigate the preceding events and implications of various subjects [122, 123]. For instance, [123] employed an IPO perspective to conceptualize electronic word-of-mouth (eWOM) activity, examining the factors influencing eWOM (input), the platforms or systems facilitating eWOM (process), and the outcomes of eWOM (output). Similarly, [122] adapted the IPO framework into the preceding events–implication–intervention (PII) framework to explore the literature on fake online reviews in e-commerce. Their analysis covered the motivations behind posting fake reviews (preceding events), the mechanisms that influence fake reviews (implication), and the strategies employed by stakeholders to detect and respond to fake reviews (intervention). In alignment with these approaches, this study adopts an IPO perspective to conceptualize EV implementation in countries, as shown in Figure 1. Within this conceptual framework, e-voting system's implementation is outlined to be three fundamental components: 'Input,' 'Process,' and 'Output.' As follow:

- **Input:** It pertains to the 'preceding events,' outlining the motivations, reason, and drivers behind e-voting implementation.
- **Process:** It includes the difficulties encountered during the e-voting implementation journey, as well as the standards proposed to navigate this process successfully.
- **Output:** It characterizes the implications arising from the integration of e-voting system into election management.

Utilizing the IPO framework as our foundation, we formulate four research questions to be investigated in this study:

- **RQ1**: "What motivates countries to adopt electronic voting systems for electoral processes?" This question seeks to uncover the reasons, drivers, and motivations for e-voting adoption into election management as documented in the existing literature.
- **RQ2**: " What difficulties do countries encounter when implementing electronic voting systems?". This inquiry investigates into the 'implications' within the IPO framework, to identify and analyze the obstacles, problems, complications, and difficulties faced by countries throughout the e-voting implementation process.
- **RQ3:** " What are the recommended approaches for countries to implement electronic voting systems?". This research question focuses on the 'standards' outlined in the literature for the successful implementation of e-voting systems (EVS). It investigates best practices, recommendations, and suggestions for effective EVS integration.
- **RQ4:** "What is the impact of electronic voting systems on countries?". In this context, 'implications' refer to the mechanisms through which EV implementation influences electoral process around the globe. This

question seeks to understand the effects, impacts, and outcomes of EVS implementation for election management, drawing insights from the existing literature.

Through the exploration of these research questions within the IPO framework, we aim to gain a comprehensive understanding of EVS implementation within the global contexts.

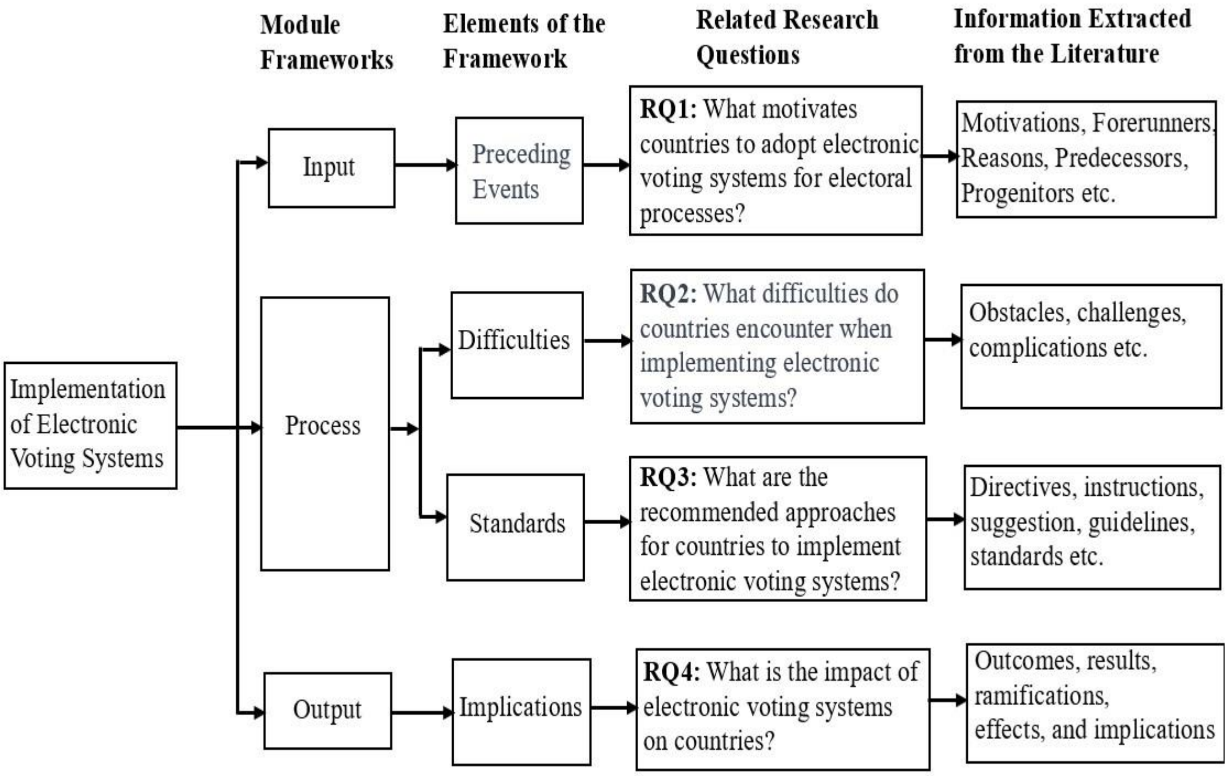

Figure 1: IPO conceptual framework for understanding EVS implications

3.2. Literature search and selection

This study breaks down the literature review protocol that outlines the methods employed for the systematic review before embarking on the actual review process [124]. A review protocol serves as a detailed roadmap, specifying the steps and procedures to be rigorously followed during the review [125]. It is crucial to have a predefined review protocol in place to minimize potential research biases and ensure the overall quality of the literature review [124] [125].

The research protocol for the forthcoming literature review is presented in Table 2. In the initial step of the literature review, we conducted searches in two prominent online databases: Web of Science (WoS) and Scopus. These two databases were selected due to their status as primary academic literature repositories, boasting extensive coverage dating back to 1945 and 1966, respectively [126].

SRL protocol elements	Description
Data Repository:	Web of Science (WoS) Core Collection, Scopus.
Search Query:	E-voting systems and applications related to Electronic Voting Systems (EVS) in general.
Information Retrieval Plan:	No publication date limit. Search term to be present in the title, abstract, and keywords. Articles to be ranked in Social Science Citation Index (SSCI) or Science Citation Index (SCI). Focus on research areas including business, economics, management, acc decision science, management science, information systems, management, and operations management.
Exclusion Parameters 1:	Articles relevant to the design or development of E-voting systems, models, methods, or applications (e.g., enhancing effective EVS technologies, security, accountability, and operational efficiency in social applications).
Exclusion Parameters 2:	Articles without full access. Extended abstracts (articles lacking full-text content). Articles using the term "E-Voting" with a different meaning. Conference papers, theses, textbooks, and book reviews.
Acceptance Criteria:	Research topics must relate to the four elements of E-voting implementation in countries for election management, including challenges, guidelines, and consequences. The context of the research must be clearly described.

Table 2: Literature Review Protocol

Furthermore, a significant proportion of the content within these databases is published in English [127]. It is worth noting that Burnham [126] has argued that Scopus and WoS complement each other as neither database is all-encompassing. To identify the most pertinent studies in this domain, we employed a set of keywords including 'e-voting systems,' 'e-voting,' 'election management systems,' 'election management,' 'online voting,' 'internet voting,' among others (as elaborated Table 2). These search terms were carefully chosen in accordance with the argument presented in Section 2, wherein we contended that e-voting systems should encompass functions related to cognition, cognitive automation, and learning. A paper was considered eligible for inclusion if any of these search terms appeared in its title, abstract, or keywords. The studies selected for review are exclusively full papers sourced from journals that are ranked in either the Social Science Citation Index (SSCI) or Science Citation Index (SCI). Conversely, conference papers, doctoral and master theses, textbooks, and book reviews were explicitly excluded from consideration.

Given that SSCI/SCI journals predominantly feature high-quality, peer-reviewed literature based on social science, information systems (IS) and management [128], representing advanced research outputs [129]. Our approach ensures the quality of the reviewed articles. In this study, we focus solely on journals since academic and industry professionals often turn to journals for information acquisition and the dissemination of novel findings, with journals symbolizing the pinnacle of scholarly research [130].

- **Search Strategy:** To ensure comprehensiveness, our literature review, positioned within the interdisciplinary domain s such as computer science and Information Systems (IS), spanning across other disciplines, and encompasses a broad spectrum of papers both within and beyond the Computer Science and IS disciplines [131]. As such, we gathered valuable insights from diverse fields, including business, economics, management, accounting, finance, decision sciences, management science, computer science, IS, and operations management.
- **Exclusion Criteria:** Our literature search considered papers that offers deep-insights into the evolution of e-voting system (EVS) research up until December 25, 2023, which marks the endpoint of our literature review. However, we refrained from exploring more technically-oriented papers on EVS since our review specifically focuses on issues pertaining to EVS implementation in specific countries where EVS were used in the electoral process. Exclusion Criteria 1 is framed to exclude papers that lack technical details of EVS, which includes the design or development of EVS models, systems, and applications. Exclusion Criteria 2 outlines further criteria for excluding papers that

- lack full access or full-text availability, as well as papers employing the term 'e-voting systems' with a
- definition that deviates from the one demonstrated in Section 2.
- **Inclusion Criteria:** We included papers that align with the four important elements of e-voting systems (EVS) implementation within the globe, namely preceding events, difficulties, standards, and implications.

Figure 2: Introduces the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram, which visually depicts the information flow through the distinct phases of our systematic review [132]. This comprehensive approach, based on our search strategy as shown above, ensures a rigorous and systematic review process.

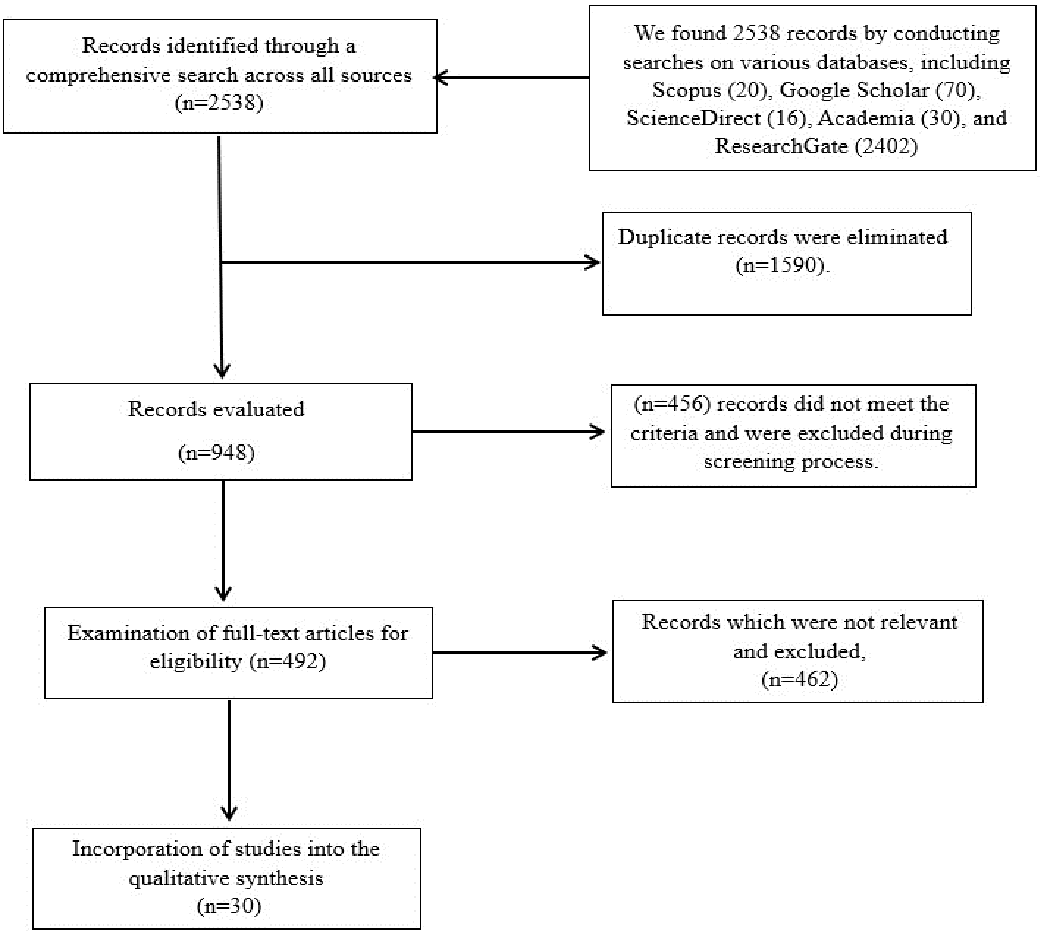

Figure 2: PRISMA flow diagram for the systematic literature review

3.3. Analysis of the selected literature on e-voting systems

Selected papers underwent thorough reading and analysis, with a subsequent extraction and coding of relevant data. The data extraction and coding process were based on descriptive analysis, encompassing various aspects:

- publication details (including publication years and outlets),
- research design (comprising settings and methods),
- study context (including the adopted theory, study theme, and topic), and
- elements aligned with the IPO framework (covering
- concepts related to preceding events, difficulties, protocols, and implications of e-voting systems (EVS) implementation around the globe).
- This section presents the findings of the literature analysis derived from the extracted and coded data.

3.3.1. Publishing Trends over time

Table 3 to Table 7: illustrates the frequency of publications from 2003 to 2023. Out of the 30 papers, 4 were published in 2009 and 2020, followed by 3 in 2007 and 2021, followed by 2 in 2004, 2011, 2016. Only one paper from 2003, 2006, 2008, 2010, 2012, 2014, 2017, 2018, 2019, 2022 that met the selection criteria. No papers meeting the selection criteria were found prior to 2003.

Table 3: Selected research articles related to EV implementations

Title of the article	Authors	Publication year	Weaknesses of the paper	Key findings
1. An architecture for e-voting systems based on dependable web services	A Omidi et al [8]	2009	Lack of real-world implementation or case studies to validate the proposed architecture	It presents an architectural framework for e-voting systems based on dependable web services
2. Electronic voting systems: Requirements, design, and implementation	GZ Qadah et al [15]	2007	It has a narrow focus on technical aspects without a broader consideration of usability, security, and legal aspects	It discusses the essential requirements, design considerations, and the implementation process of electronic voting systems
3. A Model for E-voting Systems Evaluation Based on International Standards: Definition and Experimental Validation.	M Prandini et al [27]	2012	The limited scope of international standards considered or a lack of extensive empirical validation of the proposed model.	It introduces a model for evaluating e-voting systems based on international standards. It provides a structured approach to assessing the quality and effectiveness of these systems.
4. E-Voting and the Need for Rigorous Software Engineering - The Past, Present and Future.	JP Gibson et al [16]	2007	Lack of specific software engineering methodologies or detailed case studies illustrating the need for rigor in the past, present, and future of e-voting.	It discusses the importance of rigorous software engineering practices in e-voting systems. It offers historical context and the future prospects of e-voting software.
5. E-voting Implementation in Nigeria: the Success Factors	SA Adeshina et al [19]	2020	Limited generalizability success factors are specific to the Nigerian context. It lacks a critical examination of challenges and failures.	It provides insights into the success factors associated with e-voting implementation in Nigeria, potentially highlighting the factors contributing to successful adoption.
6. How to Assess the Usability Metrics of E-Voting Schemes	K Marky et al [26]	2020	Lack of specific case studies or practical usability assessments	It discusses methods for assessing the usability metrics of e-voting schemes, potentially providing guidance on evaluating the user-friendliness of such systems.

Table 4: Selected research articles related to EV implementations

Title of the article	Authors	Publication year	Weaknesses of the paper	Key findings
7. Analysis of the Design Requirements for Remote Internet-Based E-Voting Systems.	H Alamleh et al [6]	2021	Has a narrow focus on design requirements without a comprehensive evaluation of other. aspects.	It focuses on the design requirements for remote internet-based e-voting systems.
8. Evaluating e-voting: theory and practice.	W Bokslag et al [1]	2016	It lacks empirical data and case studies to support the theoretical concepts.	It provides insights into the theory and practice of evaluating e-voting systems.
9. A Review of Electronic Voting Systems: Strategy for a Novel.	SE Adekunle et al [21]	2020	It lacks specific case studies or empirical data, as well as limited depth in technical aspects.	It provides an overview of electronic voting systems, emphasizing strategies for novel developments or improvements.
10. Development of Blockchain-based e-Voting System: Requirements, Design, and Security Perspective.	MJH Faruk et al [29]	2022	It lacks in-depth technical details and case studies demonstrating the practical implementation of the system.	It discusses the development of a blockchain-based e-voting system, covering requirements, design considerations, and security perspectives.
11. Requirements Engineering for E-Voting Systems.	K Daimi et al [2]	2006	It lacks practical guidance or case studies for requirements engineering in e-voting.	It discusses the requirements engineering process for e-voting systems, emphasizing the importance of capturing user needs and system specifications.
12. Managing Requirements for E-Voting Systems: Issues and Approaches.	K Weldemariam et al [20]	2009	It lacks specific case studies or practical examples for addressing requirements management issues.	It discusses the challenges and approaches in managing requirements for e-voting systems, emphasizing the importance of well-defined requirements. engineering.

Table 5: Selected research articles related to EV implementations

Title of the article	Authors	Publication year	Weaknesses of the paper	Key findings
13. A Systematic Review of	R Tas et al [7]	2020	It lacks an in-depth technical analysis and practical case studies evaluation of the E-voting systems	It offers a systematic review of the challenges and opportunities associated with using blockchain technology for e-voting systems.
14. Design of Blockchain-based e-Voting System for Vote Requirements.	S Choi et al [11]	2021	It lacks comprehensive technical details and practical implementation insights.	It discusses the design considerations of a blockchain-based e-voting system, focusing on meeting vote-related requirements.
15. Analysis of a Distributed e-Voting System Architecture against Quality of Service Requirements.	JP. Gibson et al [18]	2008	It lacks real-world case studies to demonstrate the impact of QoS on e-voting systems.	It discusses the design considerations of a blockchain-based e-voting system, focusing on meeting vote-related requirements.
16. Vote verification through open standard: A roadmap.	AFN. AI-Shammari et al [23]	2011	It lacks practical implementation details and case studies for evaluation.	It provides a roadmap for implementing voter verification using open standards, emphasizing transparency and reliability.
17. Scaffolding e-voting in developing countries.	M Maletic et al [28]	2019	It lacks limited empirical data from developing countries, without specific case studies to evaluate its validity.	It addresses the challenges in implementing e-voting in developing countries, including infrastructure limitations and digital literacy issues.
18. E-Voting: Same Pilots, Same Problems, Different Agendas.	M Liptrott et al [4]	2007	It lacks in-depth analysis or proposed solutions for the identified problems.	It discusses the recurring challenges faced in e-voting pilot projects, highlighting common issues and problems encountered across various agendas.

Table 6: Selected research articles related to EV implementations

Title of the article	Authors	Publication year	Weaknesses of the paper	Key findings
19. Electronic Voting System Usability Issues.	BB. Bederson et al [12]	2003	It lacks an in-depth analysis of specific solutions to address usability issues and fails to consider specific case studies on usability design.	It explores usability challenges in electronic voting systems
20. Risks of E-Voting.	TW. Lauer et al [3]	2004	It highlights risks but fails to offer concrete mitigation strategies based on specific case studies.	It discusses the various risks associated with electronic voting: tampering, technical failures, and inadequate security measures.
21. Software Vulnerabilities in the Brazilian Voting Machine.	DF. Aranha et al [9]	2014	The paper highlights software vulnerabilities but fails to delve into broader security issues with potential solutions and specific case studies.	The paper identifies and analyzes software vulnerabilities in Brazilian voting machines.
22. Internet Voting: The Canadian Municipal Experience.	N Goodman et al [13]	2010	The paper addresses specific threats to Canada but fails to cover threats relevant to other countries with	The paper identifies and assesses threats to electronic voting systems in the Canadian context.
23. Privacy Issues in an Electronic Voting Machine	AM. Keller et al [5]	2004	The paper failed to address other security aspects and potential solutions to privacy issues under specific case studies.	The paper explores privacy concerns associated with electronic voting machines.
24. Analysis of Electronic Voting System in Various Countries.	S Kumar et al [22]	2011	It has a limited availability of data to differentiate the contexts between countries with case studies.	The paper compares and analyzes electronic voting systems in different countries.

Table 7: Selected research articles related to EV implementations

Title of the article	Authors	Publication year	Weaknesses of the paper	Key findings
25. E-Voting: Security, Threats, and Prevention.	S Risnanto et al [24]	2021	The paper addresses security, it may not delve into usability or the practicality of implementing security measures.	The paper discusses the security of e-voting systems, with the threats and preventive measures.
26. The New Jersey Voting-Machine Lawsuit and the AVC Advantage DRE	AW. Appel et al [25]	2009	The paper addresses legal cases in New Jersey but fails to apply universally to all voting machines.	The paper discusses a lawsuit related to the AVC Advantage DRE voting machine in New Jersey.
27. Vote Selling, Voter Anonymity, and Forensic Logging of Electronic Voting Machines.	S Peisert et al [10]	2009	It addresses specific issues but fails to indicate broader usability and security aspects of e-voting based on case studies.	The paper investigates the issue of vote selling and its impact on voter anonymity in the context of electronic voting machines.
28. Online Voting System with Reliable Voter Authentication Protocols.	J Mutebi et al [17]	2018	The paper focuses primarily on authentication but overlooks other critical aspects of e-voting systems.	The paper focuses primarily on authentication but overlooks other critical aspects of e-voting systems.
29. Evaluating E-Voting: Theory and Practice	W Bokslag et al [1]	2016	The paper proposes evaluation methodologies but fails to provide concrete case studies and real-world examples.	The paper discusses the theoretical and practical aspects of evaluating e-voting systems.
30. The Need for Audit-Capable E-Voting Systems	S Mello-Stark et al [14]	2017	The paper was influenced by the specific audit features discussed but failed to vary features across e-voting systems.	The paper may emphasize the necessity of audit-capable e-voting systems for ensuring transparency and integrity.

3.4. The DSRM framework

This framework forms the conceptual underpinning that facilitates the understanding, execution, and evaluation of the Design Science Research Methodology [117, 133]. The formulation of research activities aimed at addressing real stakeholders, such as citizens or electorates with a vested interest in the development of e-voting systems, ensures research relevance. The foundation for the research study is built upon prior research, findings from researchers and practitioners, and the existing wealth of theories, frameworks, instruments, constructs, models, methods, and instantiations as depicted in Figure 3**:**

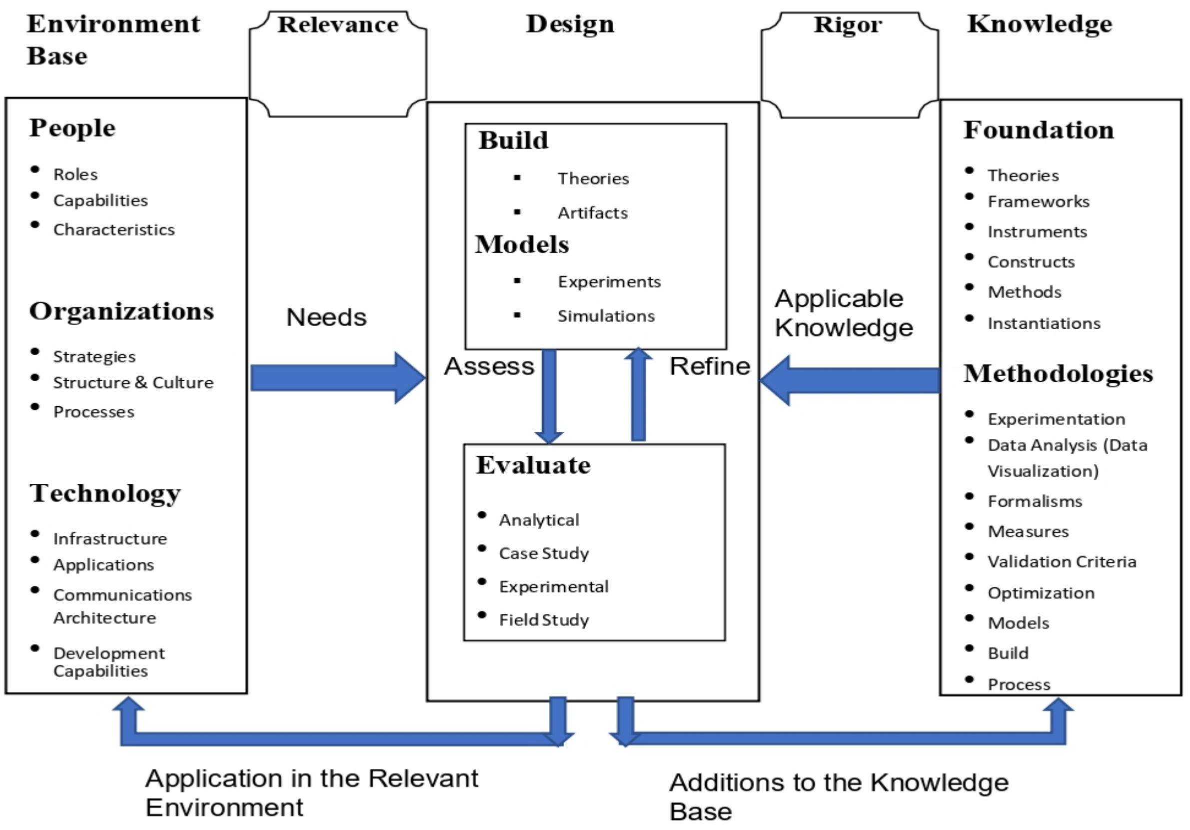

Figure 4: Amplified Framework for Design Science Research Methodology

As depicted in Figure 4, DSRM engages with relevant real-world problems across various application domains [134]. It places particular emphasis on providing solutions that demand empirical investigation, with active collaboration among researchers, practitioners, and industry partners using specific, pertinent technologies. DSRM is characterized by rigorous systems analysis within real-world context of organizations, institutions, government agencies, companies, and more, with the primary aim of identifying specific needs to be addressed serving as its starting point.

In some instances, the specific needs of the problem domain may already have been identified or studied. In such cases, DSRM makes derivations from these identified needs as the starting point. DSRM then scrutinizes the existing academic knowledge to assess the extent to which design knowledge is already available for solving the identified problem. This academic knowledge includes theories, frameworks, instruments, constructs, models, methods, instantiations, and encompasses methodologies such as experimentation, data analysis, formalism, measures, validation criteria, optimization, models, build, simulation and process for system design.

When existing knowledge is adequate enough to address the identified problem, a routine design process is employed, falling outside the scope of DSRM. However, DSRM becomes active when the need arises to develop an innovative solution, often building upon existing elements while combining, revising, and extending design knowledge to progress through the design activities aimed at problem-solving. These design activities include 'build' and 'evaluate' phases, iterating multiple times until the problem is adequately addressed.

DSRM offers a range of research methods to be applied, which is contingent on the specific research domain in question. For instance, in social science research, methodologies like interviews, surveys, literature reviews, and focus group discussions may be employed. In the fields of computer science and engineering, methods such as formal analysis, experimentation, modelling, simulation, and process modelling are often used to tackle identified problems.

3.4.1. DSRM process overview

DSRM projects are founded upon several process models [133], each tailored to address diverse projects in different domains. A well-recognized DSRM model is outlined in [133] [134], which consists of six key stages: problem identification and motivation, definition of objectives for the desired solution, design and development, demonstration, evaluation, and communication. Additionally, four entry points are considered: problem-centered initiative, objective-centered solution, design and development-centered initiation, and observing the outcomes of the solution (i.e. client/context initiation) is shown in Figure 5.

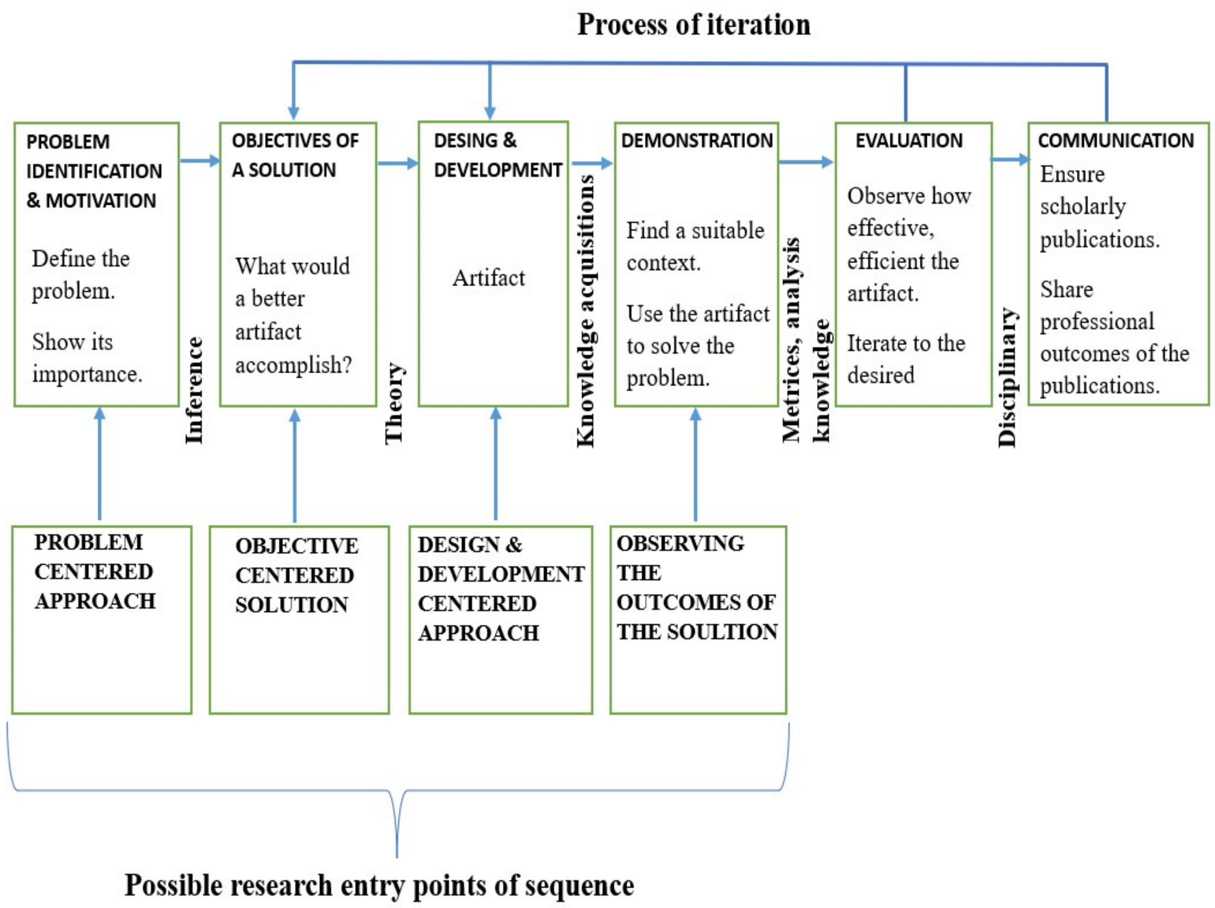

Figure 5: Design Science Research Methodology (DSRM) Process Model

The comprehensive DSRM process model is illustrated in Figure 5, above with brief descriptions provided for each DSRM activity. These stages guide the progression of the DSRM study from the initial identification of a problem to the subsequent evaluation activity, before implementation.

- **Activity Stage One: Problem Identification and Motivation**

This initial stage serves as the cornerstone, defining the e-voting research problem and justifying the precise solution. The solution in question achieves a dual purpose: firstly, it galvanizes researchers and stakeholders or users of the research to embark on the journey of pursuing the solution. Secondly, it provides stakeholders with a profound understanding of the researcher's grasp of the problem and the proposed solution's viability. The allocation of resources at this point it is contingent on the comprehension of the problem's status and its corresponding solution, all in service of fulfilling stakeholders' needs.

- **Activity Stage Two: Objective for a solution**

In the second stage, researchers pointed out specific objectives from the problem definition and existing knowledge. These objectives lay the groundwork for the development of e-voting systems, tailored to meet the stakeholder's requirements. These objectives may manifest quantitatively, aiming for a superior solution compared to existing e-voting systems, or qualitatively, explaining how the new artifact's characteristics will underpin solutions to the identified problems, ultimately facilitating the implementation of the e-voting system.

- **Activity Stage Three: Design and Development**

Transitioning to the third stage, the specific objectives derived from the problem definition take form in the shape of a DSRM artifact. This artifact is meticulously designed to cater to the stakeholder's needs, driving the development of the e-voting system. This phase further separates the artifact's precise functionality and architecture, aligning them with the established objectives of the e-voting system.

- **Activity Stage Four: Demonstration**

The fourth stage is dedicated to demonstrating the artifact's efficacy in addressing one or more instances of the problems identified in the first stage. We have a predefined methodology employed, which could include experimentation, simulation, case studies, proofs, or alternative approaches. The goal is to showcase how the artifact effectively tackles the problem at hand.

- **Activity Stage Fifth: Evaluation**

Moving on to the fifth stage, evaluation comes to the forefront. This stage quantifies how well the artifact aligns with the desired solution for the problem identified in stage one. A meticulous comparison is made between the predefined objectives of the proposed solution and the actual observed results of the e-voting system. The outcomes of this evaluation activity serve as a compass, guiding the researcher's decision-making process. Should the results fall short of realizing the desired solution, the researcher may iterate back to stage three, enhancing the artifact's effectiveness. Alternatively, they may opt to continue with communication and defer further refinements to subsequent projects.

- **Activity Stage Sixth: Communication**

In the final stage, communication takes center stage. This phase involves the comprehensive dissemination of both the problem's facets and the designed e-voting system artifact to stakeholders. These stakeholders are then empowered to make informed judgments about whether the e-voting system comprehensively addresses all the problems identified in the initial stages. Communication extends to a wider audience, including practicing professionals and research communities, with the goal of advancing collective knowledge and fostering a deeper understanding of the e-voting system and its important roles in the electoral process. The above stages would be used to perform a comprehensive evaluation of the two case study projects in subsequent sections. The evaluation of the two case studies demonstrate the proposed study on 'A Novel Framework for Evaluating Electronic Voting Systems Artifacts'.

3.4.2. DSRM evaluation enhancements

The DSRM has undergone refinements across various phases, particularly to ensure the validity of the proposed e-voting system solution. One area that has received heightened focus is the evaluation stages, which now facilitate concurrent evaluations during the intermediate steps of the design process. The DSRM process, as originally outlined to adhered to a linear progression wherein evaluation only occurred after the culmination of the design, development, and demonstration stages. This approach missed the opportunity for early-stage concurrent evaluation.

In [134], the author introduces the concept of concurrent evaluation, highlighting its significance in addressing different aspects of the design, as depicted in Figure 6. This research seeks to elaborate on DSRM activities within the process, affirming that each activity should advance toward the intended artifact in a unique manner, with potential for concurrent (or formative) evaluation. The introduction of concurrent evaluation at the design stages serves as a proactive measure to mitigate serious risks [134] [117]. By soliciting early feedback on the incremental steps leading to the final artifact, potential issues can be addressed in real-time, averting risks that might manifest at intermediate stages due to limited concurrent evaluations from a design perspective.

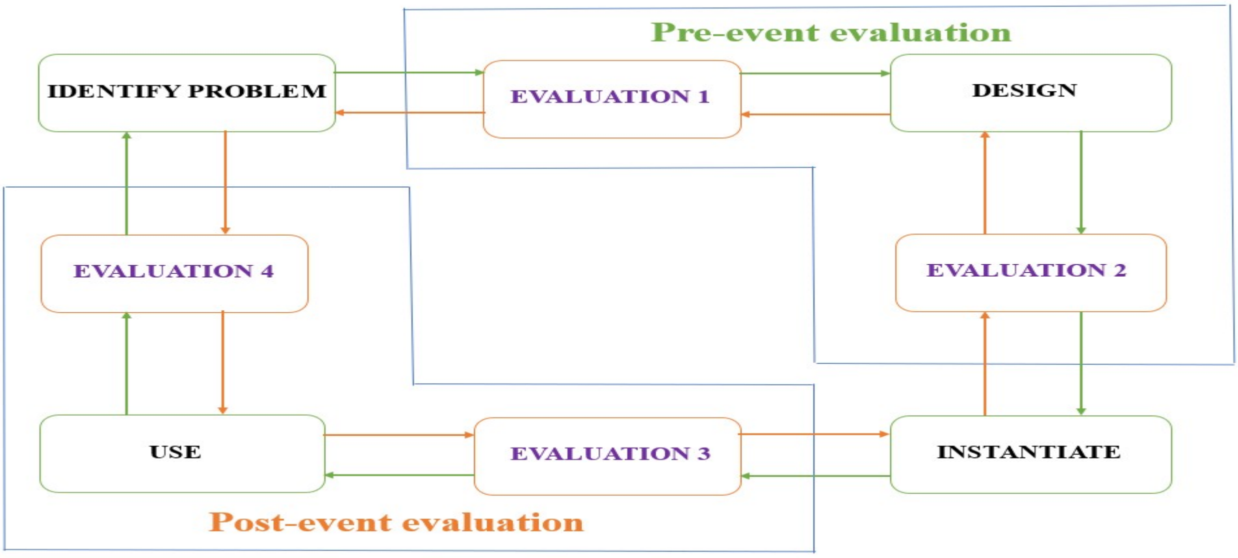

Figure 6: Evaluation activities for the DSRM Process

In [93], the author identifies four primary evaluation stages, denoted as Evaluation 1 through Evaluation 4, derived from typical DSRM activities, as illustrated in Figure 6. This diagram offers a cyclical representation of the high-level DSRM process, including activities such as problem identification, design, construction, and use. It emphasizes the importance of aligning each DSRM activity with a corresponding evaluation activity:

- **Evaluation 1:** Evaluating the problem identification: Assessment criteria encompass factors like importance, novelty, and feasibility.
- **Evaluation 2:** Evaluating the solution design: Criteria for assessment include simplicity, clarity, and consistency.
- **Evaluation 3:** **E**valuating the solution instantiation: Assessment criteria encompass aspects like ease of use, fidelity with real-world phenomena, and robustness.
- **Evaluation 4:** Evaluating the solution in use: Criteria for assessment involve factors like effectiveness, efficiency, and external consistency.

These evaluations occur at different points in the design process, characterized by pre-event and post-event evaluations. Pre-event evaluations are conducted before the instantiation of the specific artifact, which in this context is the e-voting system, whereas post-event evaluations take place after the artifact has been instantiated [134]. Importantly, there exist feedback loops from each evaluation activity back to the preceding design activity, forming a feedback cycle that runs counter to the DSRM cycle, as illustrated in Figure 6 above. This iterative feedback mechanism fosters continual improvement throughout the DSRM process until the desired results are achieved.

3.4.3. Development of the design knowledge framework (DKF)

The Design Knowledge Framework (DKF) serves as a primary tool in the formulation of comprehensive information concerning the problem at hand, the design solution, and the evaluation criteria, thereby ensuring the completeness and success of the e-voting system. This framework provides stakeholders with a means to gauge project progress from inception through completion, including stakeholder evaluation. To methodically execute the e-voting application, we must explain three fundamental components of the DKF: the problem space, the solution space, and the evaluation.

- **The problem space:** Encompasses the precise identification of the issue at hand, outlining the requisite steps for designing and implementing the e-voting system.
- **The Solution Space:** Orchestrates the creation of an innovative Design Science Research Methodology (DSRM) that guides the overall system design process until the e-voting system reaches its final form, primed for evaluation.
- **The Evaluation Space:** Is responsible for a methodical and collaborative evaluation involving the stakeholders for whom the e-voting system is intended. Once this evaluation space successfully satisfies all predetermined objectives, the e-voting system gains acceptance from the stakeholders for implementation. However, should specific objectives remain unaddressed, they are channeled back to the relevant stages for resolution and subsequently returned to stakeholders for further evaluation. This iterative process continues until the e-voting system finally attains approval from the stakeholders, signifying the conclusion of the project. As shown in the Figure 7 below.

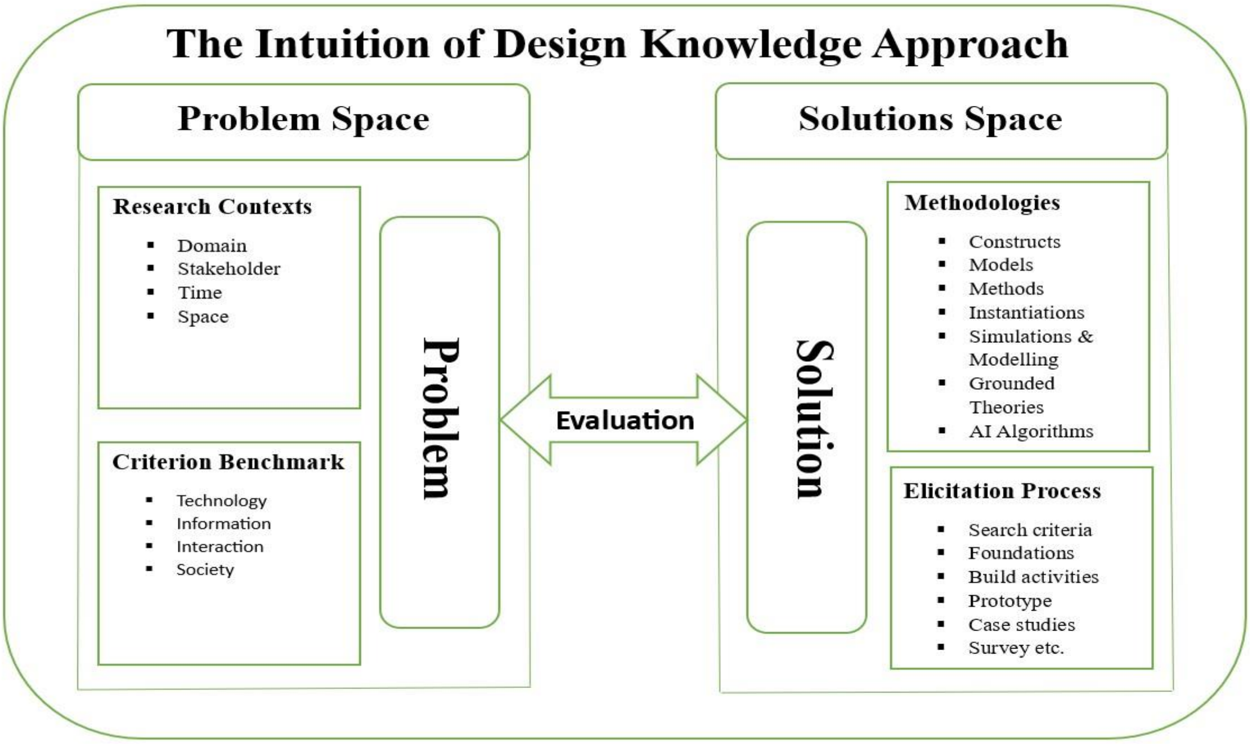

Figure 7: Formulation of Design Knowledge Framework (DKF) for a Specific DSRM Project

The graphical representation in Figure 7, encapsulates the core components of the DKF, outlining a conceptual model that encompasses these comprehensive concepts. This framework fosters a structured and holistic approach to the development, evaluation, and refinement of the e-voting system, ensuring its alignment with the needs and expectations of the stakeholders throughout the project's lifecycle.

4. Demonstration of the Design Science Research Project (DSRP) setting the foundation for the two case studies.

In this section, we aim to exemplify the application of DSRP from two distinct vantage points:

- Development of the DSRP Process Model
- Utilization of the DSRP Scenarios in Two Case Studies:

a) Information System (IS) Planning through DSRP.
b) Requirement Engineering with the DSRP Approach

4.1. Development of the DSRP process model

Within this section, we explain the six important processes that constitute the DSRP model:

- **Stage One: Problem Identification and Motivation**

This initial step underscores the need for a comprehensive DSRM process within the Information Systems (IS) research. The absence of such a process prompted the adoption of DSRM in the IS domain.

- **Stage Two: Defining the solution's objectives**

It is vital that the objectives of the solution align seamlessly with DSRM principles, grounding themselves in the state-of-the-art processes for conducting research. This stage also entails the development of a mental model to guide the generation of research output within the DSRM framework.

- **Stage Three: Design and Development**

Drawing inspiration from preceding literature, this phase acts as the driving force behind the creation of the six-step DSRM process models, as exemplified in this paper.

- **Stage Four: Demonstration**

This stage showcases the tangible outcomes of the process models through practical case studies, thereby translating theory into reality.

- **Stage Five: Evaluation**

Evaluation becomes paramount as it involves a careful comparison of the attributes of the DSRM process model against the predetermined objectives established earlier in the process.

- **Stage Six: Communication**

Effective communication serves as the bridge between the theoretical constructs of the DSRP and the real-world application. This approach finds expression through the two case studies and used the DSRP to evaluate two specific case studies on the Optical Clinic Management Systems (OCMS) and Electronic Voting System (EVS) to demonstrate how Software Engineering artifact should be evaluated to avoid operational system failures being the gaps discovered in the systematic literature review in this study. The following sessions demonstrate this approach.

4.2. Case study one: Leveraging on the critical success chain (CSC)

Drawing insights from CSC principles, this case study embarks on the development of valuable applications for emerging technologies. The DSRP methodology is harnessed to fulfilled the IS requirements of an eye clinic, situated in Ghana, thereby highlighting the instrumental role of DSRP in addressing critical IS needs.

4.2.1 Case study one: Implementing OCMS using DSRP approach

OCMS, a research initiative undertaken in Ghana, represents a pioneering effort in addressing critical e-Health applications. This innovative software application, designed for Optical Clinic Management System, leverages a comprehensive DSRM approach as a catalyst. OCMS is engineered to capture patients' daily records, expediting medical diagnoses and supporting healthcare professionals in prescribing medications based on up-to-date medical histories, all at the click of a button.

The DSRP framework was instrumental in exploring the challenges faced by hospital administration, highlighting the deficiencies in existing systems. Notably, traditional paper-based management systems were deemed unreliable and unsafe, making them unsuitable for medication prescription due to the risk of misplaced or disorganized patient records.

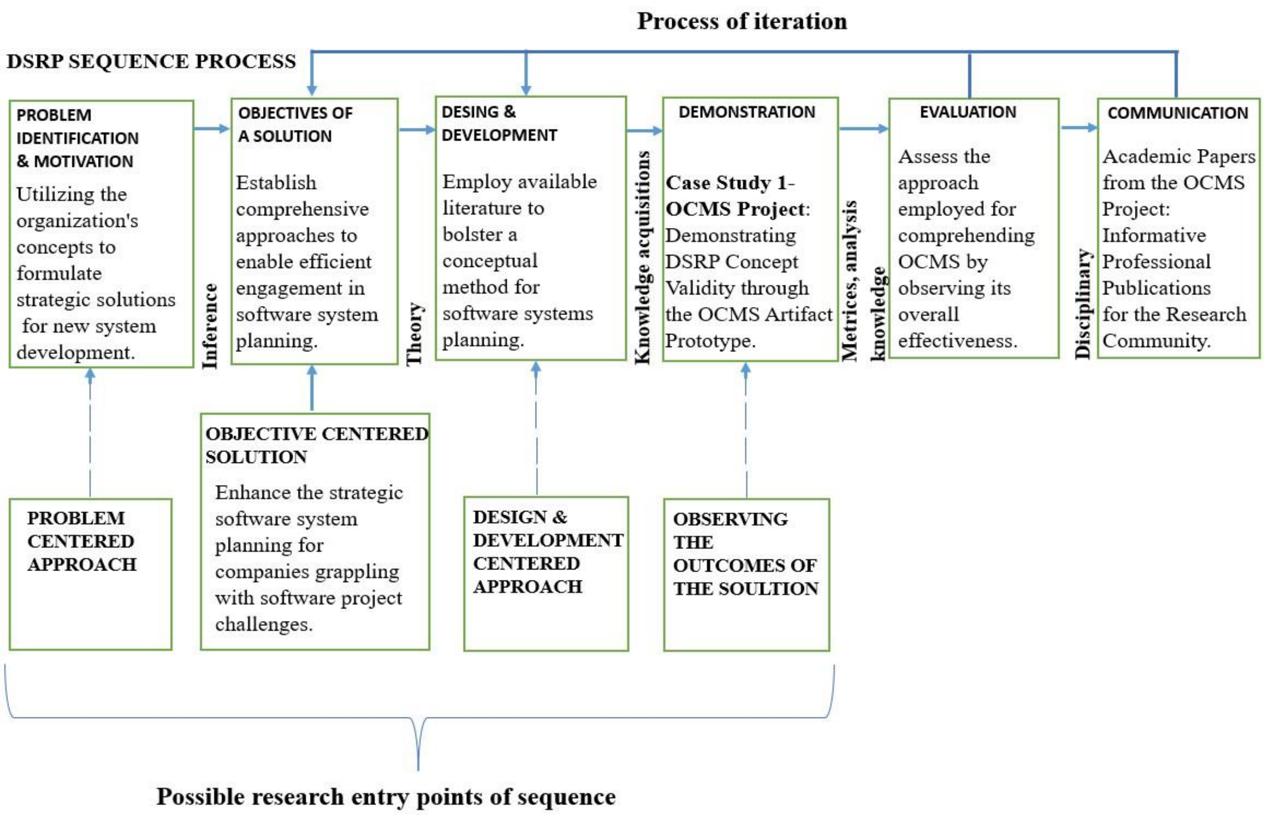

Figure 8: DSRM process for the OCMS study

- **Stage one: Problem Identification and Motivation**

In 2019, our team embarked on the OCMS project, tasked with developing a portfolio of potential applications to meet the Optical Clinic Management service needs. The objective was to generate innovative ideas for Information Systems (IS) projects, with a particular focus on enhancing hospital administration and strategic goals. Given the critical nature of healthcare, novel methods were deemed essential to perform effective evaluation of the OCMS.

- **Stage Two: Formulating Objectives**

Defining precise solutions within the DSRM framework became a paramount objective. These solutions were developed through a blend of quantitative and qualitative methods, seeking to address identified issues more effectively than current processes. Stakeholder engagement, including both patients and healthcare professionals, played an important role in shaping these objectives.

- **Stage Three: Design and Development**

This stage emphasized the interdisciplinary nature of DSRM cycles, fostering effective collaboration among project stakeholders. It involved designing the OCMS architecture based on eHealth service requirements and Service experience Blueprints. The process divided the project into multiple stages, allowing continuous refinement based on stakeholder feedback.

- **Stage Four: Demonstration**

Demonstration involved sequential testing of the OCMS from stages 5 to 6 within the design process. This phase collected valuable data to assess utility and usability, aligning with the project's overarching objectives. Various research methods, such as case studies and randomized control trials, were employed to gather comprehensive information.

- **Stage Five: Evaluation**

This stage compared the project's objectives, derived from users and stakeholders in stage two, against observed results, ensuring alignment with DSRM principles. The OCMS's impact on healthcare outcomes was assessed, including medication adherence, patient satisfaction, utility, and user intention.

- **Stage Six: Communications**

Upon completing the project, stage six focused on sharing the results with the research community and relevant stakeholders. Communication avenues included journal papers, conference presentations, workshops, seminars, and other forums. This paper, "A Model-Driven Optical Clinic Management System: A Systematic Software Engineering Approach [135]," serves as an example of knowledge dissemination within the research community.

The DSRM cycle emphasizes continuous improvement, allowing the artifact to return to stage three for enhancements or proceed to stage six upon meeting objectives. Additionally, outcomes from stage five contribute to the field's knowledge, enhancing good design principles, and advancing specific artifacts. Thus, the DSRM process is a valuable tool for IS project development, particularly in the healthcare sector. It enables the creation of innovative solutions, systematic development, and rigorous evaluation, ultimately leading to improved practices and the advancement of knowledge within the field. This study underscores the importance of DSRM in healthcare application development and its role in achieving impactful results.

4.2.1.1. Evaluation of the OCMS using DSRP

Objective Consistency: In this section, we will evaluate the OCMS model based on three key objectives:

1. **Consistency with Prior DSRM Theory and Practice**

The OCMS model aligns with prior DSRM concepts found in the Information Systems (IS) literature, reinforcing its consistency with established design and DSRM principles referenced in Figure 8. While this methodology has a broader scope than traditional DSRM processes, as it encompasses system-building activities, its five-step research process can be effectively mapped to the DSRM process. It is worth noting that various authors have employed diverse methodologies to address specific project domains, such as information system component design, intelligent computer-aided design systems, industrial design, engineering design, and guidelines for essential elements of design research. All these methodologies maintain consistency with the DSRP model.

2. **Systematic Process for DSRM in IS**

The DSRP model effectively provides a systematic process for conducting DSRM in the field of Information Systems. It has been successfully applied in two distinct projects, including the development of DSRP concepts demonstrated in the two case studies outlined in the "Demonstration" section of this study. These real-world applications validate the model's utility in various project scenarios, ensuring that it aligns well with specified objectives.

3. **Mental Model for Research Outputs**

The DSRP model offers a systematic and mental model for presenting research outcomes from a DSRM perspective. It serves as an effective template for developing research publications, including the current study. This acceptance underscores the DSRP model's effectiveness as a presentation template for future projects. Thus, the OCMS model, evaluated through the lens of DSRP, demonstrates alignment with established DSRM theory and practice in the IS field. It offers a systematic process for executing DSRM projects and provides a valuable mental model for organizing research outcomes. This evaluation reaffirms the DSRP model's effectiveness, usability, and consistency within the context of Information Systems research. The subsequent case study on the E-Voting project will undergo a comprehensive evaluation across seven stages to further illustrate its efficacy and usability.

4.3. Case study two: Implementing EVS projects using DSRP

The preprint article on Electronic Voting Systems (EVS), which was published in Computer Science Review as preprint [69], was given a substantial attention from both academic and industrial audiences, with over 700 readers engaging with the content. The novelty of the DSRM implementation for the full realization of EVS is attributed to the requirement engineering methods applied with the perspective of a diverse audience of end-users.

This case study investigates into Requirement Engineering (RE) methods. Through careful application of DSRP, we seeks to construct an artifact rooted in industry-standard OCMS [135] practices. The project, conducted in Ghana, serves as a yardstick on how DSRP can effectively address IS needs within a specific context.

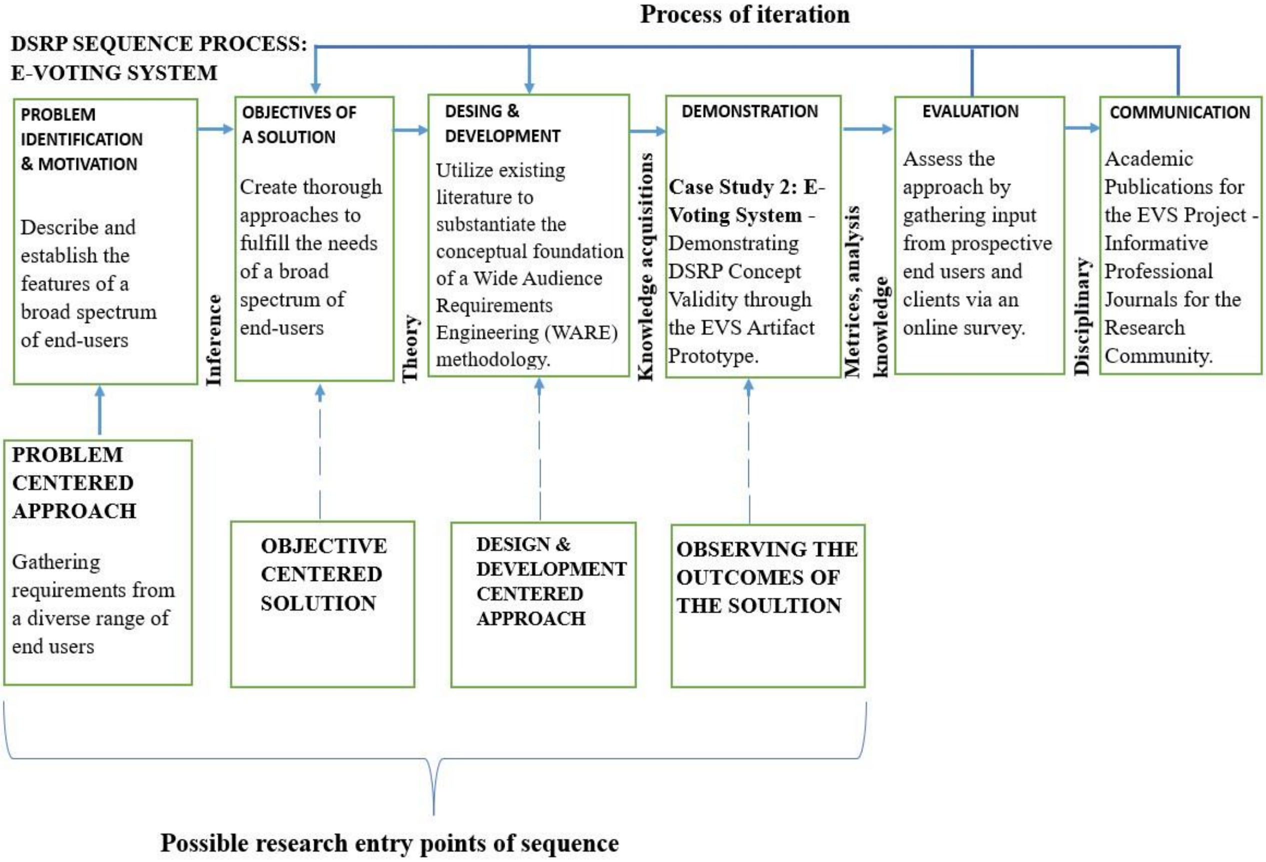

Figure 9: DSRM process for the E-Voting Systems study

- **Problem-centered Approach:** A method was developed to enhance the comprehension of system feature requirements by a broad spectrum of end-users, including researchers and practitioners not familiar with the DSRM paradigm. This approach aimed to bridge the gap between traditional requirements analysis and the understanding of the DSRM methodology and business models. The DSRM requirements engineering approach facilitated the investigation of problems within the context of EVS.
- **Problem Identification and Motivation:** Leveraging DSRM, the underlying problem in EVS was dissected from the viewpoint of a wide-ranging audience of end-users. This approach was consistent with the IS planning method used for both OCMS and EVS [95]. It recognizes the need for adopting requirements elicitation methods for implementing IS projects effectively among users who operate outside the IS research environment, firms, or organizations.
- **Objective of the Solution:** A comprehensive method was developed to facilitate the understanding of user preferences, values, and the rationale behind system features.
- This method engaged users with no affiliations to specific firms, organizations, or research communities, ensuring
- their participation in feature-level planning discussions for new applications.
- **Design and Development:** The design and development of a new method expanded upon the IS planning methodology, employing the Critical Success Chain (CSC) method.

The DSRM literature provided the foundational concepts for the Wide Audience Requirements Engineering (WARE) method [95]. This approach addressed initial challenges such as reaching widely dispersed end-users or mitigating issues arising from the lack of context awareness among end-users of the developed IS artifact. It led to the development of novel conceptual requirements engineering methods.

- **Demonstration:** WARE was tested in the context of EVS by applying the features outlined in EVS during real elections at a tertiary institution in Ghana. Approximately 1,550 students used the EVS to elect Student Representative Council (SRC) executives. These students represented diverse backgrounds and needs, highlighting the importance of the wide audience requirement engineering (WARE) approach adopted in DSRM.

Evaluation: WARE's significance and effectiveness were evaluated through a series of approaches. Initially, the EVS underwent a pilot test among 60 end-users during real-time voting to assess its robustness, security, and reliability. A Divide-and-Conquer Algorithm paradigm, commonly used in system development, was employed to evaluate individual components. The pilot phase achieved an impressive 97% acceptance rate, providing a strong endorsement for using the EVS during SRC elections. During these elections, 1,550 students utilized the system to cast their votes, effectively meeting the set requirements of WARE.

Communication: Among the two case studies presented in this review, OCMS has already been published (Azameti et al., 2022), while the second case study has been submitted to a journal for publication. It is currently accessible to the research community as a preprint. The findings have been disseminated to practitioners, industry partners, and specific research communities through channels such as book chapters and more.

In brief, the application of DSRM in the EVS project effectively addressed problems, engaged a diverse audience, and produced valuable outcomes, demonstrating the utility and the versability of the methodology in Information Systems research

5. Results and Discussion

The research findings from the study demonstrate the successful application of the Design Science Research Process (DSRP) in two distinct projects: the Optical Clinic Management System (OCMS) and the Electronic Voting System (EVS) based on the gaps identified in the systematic literature review by using the Unified framework to evaluate its efficacy. The key results are:

- **DSRP in OCMS:** The study showcases how DSRP was effectively employed to develop the OCMS, a comprehensive system designed to capture and manage patients' daily records in optical clinics. Through the iterative DSRP stages, the OCMS project identified the problem of paper-based record-keeping systems as unsafe and unreliable. It then formulated objectives for the solution, designed and developed the system, demonstrated its functionality, and conducted evaluations. The result was a well-received system that addressed the identified problem and achieved high acceptance among end-users.
- **DSRP in EVS:** The research further extends the application of DSRP to the Electronic Voting System (EVS). In this case, DSRP facilitated the understanding of end-user preferences, values, and system features through a Wide Audience Requirements Engineering (WARE) method. The EVS project successfully navigated problem identification, motivation,
- solution objectives, design, development, demonstration, and evaluation stages. Notably, the pilot test of the EVS during real elections at a tertiary institution received a 97% acceptance rate, signifying its robustness and reliability.
- **Consistency with Prior Literature:** The study demonstrates that DSRP aligns with concepts in prior literature on Design Science Research Methodology (DSRM) in Information Systems. It shows that DSRP can serve as a systematic and mental model for presenting research outcomes within the DSRM framework. The application of DSRP in OCMS and EVS contributes to the body of knowledge within the research communities and offers valuable insights for researchers and practitioners to benchmark their findings.

6. Conclusion and future work

6.1. Conclusion

The study concludes and showcases the effectiveness and versatility of the Design Science Research Process (DSRP) in the development of complex information systems. The two case studies, OCMS and EVS, illustrate how DSRP can address diverse problems, engage a wide audience of end-users, and lead to successful outcomes.

DSRP, when applied in OCMS, resulted in the creation of a patient record management system that significantly improved record-keeping in optical clinics, providing a safer and more reliable solution compared to paper-based systems. In the case of EVS, DSRP facilitated a Wide Audience Requirements Engineering (WARE) approach that allowed end-users with little familiarity with IS research to actively participate in the development of an electronic voting system. The pilot test during real elections demonstrated the reliability of the systems.

6.2. Future work

The research opens doors for future work in these areas:

1. **Further Methodological Development:** Researchers can continue to refine and expand the DSRP framework to address even more complex and diverse problem domains. Additional research can focus on enhancing the efficiency and effectiveness of DSRP stages and methodologies.
2. **Application in Different Domain:** DSRP's versatility allows for its application in various domains beyond healthcare and voting systems. Future research can explore its effectiveness in fields such as education, finance, and logistics.

3. **Evaluation of Wider Impact:** Future studies can delve deeper into the long-term impact of DSRP-developed systems, examining their effectiveness and benefits over extended periods.
4. **Dissemination of Knowledge:** Knowledge sharing remains crucial. Researchers should continue to communicate their findings through publications, conferences, and workshops to benefit practitioners, industry partners, and the wider research community.

In brief, the successful application of DSRP in OCMS and EVS underscores its potential as a valuable methodology for developing information systems. Future work can build upon this foundation to advance the field of Design Science Research and its practical applications.

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